Devils Lake Study Final Aquatic Impact Analysis Report

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FINAL AQUATIC IMPACT ANALYSIS REPORT

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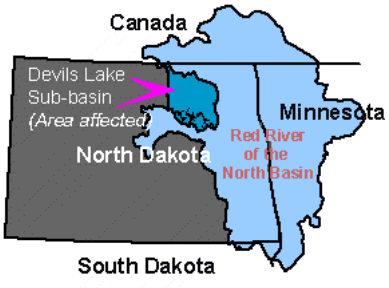

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ACRONYMS AND ABBREVIATIONS

300MOD50	1450 moderate future – 300 cfs constrained pumping
480MOD55	1455 moderate future – 480 cfs constrained pumping
µS/cm	micro Siemens per centimeter
asl	above sea level
AWQC	ambient water quality criterion
BSP	biologically significant periods
CCA	Canonical Correspondence Analysis
cfs	cubic feet per second
CV	coefficient of variation
FMHg	filtered methyl mercury
FTHg	filtered total mercury
ft/sec	feet per second
HA	hydrological alternation
HSC	habitat suitability criteria
IFIM	Instream Flow Incremental Methodology
IHA	Indicators of Hydrological Alteration
LC	lethal concentration
m	meter
m^2	square meter
MDH	Minnesota Department of Health
mg/l	milligrams per liter
MnDNR	Minnesota Department of Natural Resources
MOD50	1450 Moderate Future Baseline
MOD55	1455 Moderate Future Baseline
NAWQA	National Water Quality Assessment Program
NCBP	National Contaminant Biomonitoring Program
NDGF	North Dakota Game and Fish Department
ng/l	nanogram per liter
NTU	Nephelometric Turbidity Units
ppm	parts per million
PTHg	particulate total mercury
RVA	Range of Variability Approach
SD	standard deviation
TDS	total dissolved solids
TRV	toxicity reference value
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geologic Survey
UTHg	unfiltered total mercury
WET	wet future without overflow conditions
WETOF	wet future with overflow conditions
WSE	water surface elevation
WUA	Weighted Usable Area
YOY	young of the year

EXECUTIVE SUMMARY

GENERAL OVERVIEW

Project Description

The water level in Devils Lake has been rising over the past 15 to 20 years. If wet conditions continue, the expanding lake will affect surrounding communities. Congress has mandated that the U.S. Army Corps of Engineers (USACE) study the problem, develop alternatives, and assess the impacts of the alternatives.

Review of Alternatives

Three alternatives are considered in this report. Alternative 1 (300MOD50), would involve pumping 300 (cubic feet per second) cfs from the West Bay of Devils Lake into the Sheyenne River through a pipe constructed near Peterson Coulee. Pumping would occur between May and November throughout the project's operational life, but would be discontinued if sulfate levels in the upper Sheyenne River reached 450 milligrams per liter (mg/l) and/or river discharge reached 600 cfs. Under a moderate future, the lake level would rise to 1,450 above sea level (asl) and pumping would begin in approximately the year 2003. The water level in Devils Lake would then decline and pumping is predicted to be terminated in approximately the year 2024. To assess the effects of this alternative, the "with project" 300MOD50 pumping future was compared to the no outlet baseline in which climatic conditions are the same (lake level rises to 1,450 asl), but no water is pumped into the Sheyenne River (MOD50).

Alternative 2 (480MOD55) would involve pumping 480 cfs from the West Bay of Devils Lake into the Sheyenne River through a pipe near Peterson Coulee. Pumping would occur between May and November throughout the project's operational life regardless of the water quality and discharge in the Sheyenne River. Under a slightly wetter future (still considered moderate, with lake level rising to 1,455 asl), pumping would be conducted from 2003 through 2016. To assess the effects of this alternative, the "with project" 480MOD55 pumping future was compared to the no outlet baseline in which climatic conditions are the same (lake level rises to 1,455 asl), but no water is pumped into the Sheyenne River (MOD55).

Alternative 3 would involve no action or a "future without" an outlet scenario. Under wet future climatic conditions similar to those in the past 20 years, Stump Lake is predicted to naturally overflow into the Sheyenne River near Tolna, North Dakota. Assuming conditions similar to the last 20 years, the overflow is projected to occur near the year 2014 and would cease near the year 2025. To assess the effects of this alternative, conditions in the Sheyenne and Red Rivers with a natural overflow from Stump Lake (WETOF) were compared to a baseline in which climatic conditions are wet, but water does not overflow from Devils Lake into the Sheyenne River (WET).

The discharge of water from Devils Lake into the Sheyenne River, regardless of whether it occurs naturally or is the result of pumping, would affect water quality, hydrology, geomorphology, and habitat. Changes in these parameters would likely affect fish, mollusks, other invertebrates, algae, and macrophytes. The objectives of this study are to:

- Estimate how the water quality, hydrology, and geomorphology resulting from the three alternatives would affect, habitat, and biota in the Sheyenne and Red Rivers.
- Compare the impacts of these alternatives to baseline conditions under similar climatic futures.
- Develop a mitigation and monitoring plan.

Methods

To estimate changes in the aquatic biota of the Sheyenne and Red Rivers due to the three alternatives:

- Existing data on water quality, hydrology, habitat, geomorphology, and aquatic biota were compiled for the Sheyenne and Red Rivers.
- Future data for water quality, hydrology, and habitat were modeled for each alternative.
- The effects of these changes on the aquatic biota were estimated from species habitat and life history characteristics using available literature.

The USACE modeled water quality using HEC-5Q and discharge using HEC-RAS for each baseline and future. Daily data for October 1, 2000, to September 30, 2050, at USGS gage station points were provided. Since pumping and/or overflow were predicted to occur during only a portion of the time between 2000 and 2050, a ten-year period when pumping and/or overflow would occur was selected for analysis. The years 2005 to 2015 were used for 300MOD50 pumping and 480MOD55 pumping, and the years 2015 to 2025 were used for WETOF overflow. Three of the modeled water quality parameters—total dissolved solids (TDS), sulfate, and chloride—were summarized into minimum, maximum, average, and percent exceedence of water quality standards/guidelines and compared between baseline and future conditions for each alternative. Predicted hydrological changes were summarized using "Indicators of Hydrologic Alteration" (IHA). Parameters that changed between baseline and pumping/overflow and could impact aquatic biota were selected for comparison: monthly flow; variation in monthly flow; low flow magnitude, frequency, and duration; and difference in flow between fall and winter. Predicted depth and current velocity were modeled from existing channel configuration data and predicted discharge was modeled with Physical Habitat Simulation (PHABSIM). Predicted depth and velocity were compared to habitat suitability for shallow pool, slow riffle, fast riffle, raceway, medium pool, and deep pool fish guilds following Aadland (1993) and for low-gradient stream invertebrate diversity and tricopteran abundance guilds following Gore *et al.* (2001). WEST (2001) modeled geomorphology changes. However, the level of detail in the model was not sufficient for quantifying future erosion and deposition patterns that would influence biota. In particular, information on how channel morphology would change over time at the habitat transects and sedimentation rates for the alternatives were not available. Therefore, the magnitude of erosion and deposition was estimated as the difference in time that channel-forming flow is exceeded between baseline and pumping/overflow. A methyl mercury study

[U.S. Geologic Survey (USGS) and USACE preliminary data] is currently assessing the background levels of methyl mercury in the Sheyenne River and Devils Lake system. However, predictions of future increases or decreases in methyl mercury were not available at the time of this report.

COMPARISON OF ALTERNATIVES

300MOD50 Pumping

All three alternatives would have a negative effect on the existing fauna. However, the effects would be least with 300MOD50 pumping. In this alternative, water quality degradation would likely decrease algal and invertebrate diversity throughout the Sheyenne River, but should not affect fish and mollusks. Changes in habitat may benefit rheophilic species in Sheyenne River Reach 3, but could be detrimental to many of the fish species in Reach 5, as spawning, nursery, and adult habitat would be affected. The Red River fauna should not be affected by this alternative. When pumping stops, the communities would probably shift again in response to the change in water quality and habitat. The time required for habitat to stabilize after pumping stops would determine the time required for recolonization. Although that time cannot be estimated from this study, channel changes should be less in this alternative than under 480MOD55 pumping or WETOF overflow, and recolonization time is expected to be shorter than for the other alternatives.

Other Alternatives

The overall effects of 480MOD55 pumping and WETOF overflow would be similar in magnitude. Hydrology, habitat, and geomorphology changes would be greater with 480MOD55 pumping and water quality changes would be greater with WETOF overflow.

480MOD55 Pumping

With 480MOD55 pumping, macrophytes would be lost throughout most of the Sheyenne River because of scouring, deposition, and increased turbidity. Periphyton and epiphyton would also be lost because of scouring, deposition, increased turbidity, and increased water depth. The invertebrate community would be reduced to those species tolerant of sulfate, chloride, and unstable substrates. Unionids would probably be extirpated by water quality. Other mollusks would be reduced by water quality and/or unstable substrate, reduced periphyton, and reduced macrophytes. Fish species richness and abundance in Reaches 1 to 4 would probably be reduced by water quality and changes in habitat. In Reach 5, fish may be limited to transient individuals. Habitat for rheophilic adults would be available, but most of these species are simple lithophils that require clean substrate for spawning. Additionally, nursery habitat for most of these species would be limited, weedy cover would be lost, and invertebrate abundance would be reduced.

Recolonization potential of the Sheyenne River would be limited due to the lack of permanent tributaries, upstream migration blockage of Baldhill Dam, and the extent of habitat damage that may occur. Although water quality may recover to pre-pumping conditions, habitat throughout the river would have changed, and substrate may be left unstable. The lower Sheyenne River could recolonize from the Rush, Maple, and Red Rivers once habitat stabilizes. The upper reaches would require time to stabilize; however, fish and unionid species may not recolonize within the life of the project.

Red River Reach 1 could experience an increase in emergent and wetland fringe macrophytes as new shallow water zones are inundated with the higher flow. Increased depth would also favor phytoplankton over periphyton, but this is probably already the case. Fish should not be affected in the Red River. However, a decline in abundance and richness of sensitive mollusk and invertebrate taxa could be expected throughout the Red River. Unlike the Sheyenne River, the Red River has several large tributaries that harbor similar fish species to the Red River. Thus, as water quality improves, fish would probably recolonize within a few years. Invertebrates would also recolonize, as most species probably occur in tributaries, and have short life spans and mobile adult stages. If unionids were not severely affected in Red River Reach 2 and 3, unionids would probably recolonize Red River Reach 1 as fish recolonized from Reach 2 and 3. However, if unionids were decimated throughout the river, recolonization may not occur, as few unionids have been recently found in the lower reaches of tributaries due to high chloride levels and/or fluctuating water levels.

WETOF Overflow

Although flow increases that would affect hydrology, geomorphology, and habitat would occur with WETOF overflow, water quality would be degraded more than the other alternatives. Loss of macrophytes through burial and scouring is expected throughout most of the Sheyenne River. In Sheyenne River Reach 1, sensitive algae are likely to be extirpated by high sulfate levels. Periphyton and epiphyton could be lost due to scouring and burial. Intolerant phytoplankton would also likely be affected through Sheyenne River Reach 3. These effects should dissipate some in Reaches 4 and 5, but without information on the tolerance of most species, these effects are difficult to estimate. A decrease in richness and abundance of invertebrates sensitive to chloride and sulfate is expected throughout the Sheyenne and Red Rivers. In the Sheyenne River, even taxa tolerant to these variables may not tolerate the concentrations expected. Additionally, unstable habitat conditions in Reaches 1 and 3 would also negatively affect invertebrate survival. The extirpation of unionids, sphaeriids, and prosobranchs is expected in Sheyenne River Reaches 1 through 5 due to increased chloride levels and habitat instability. Fish species richness and abundance in Reaches 1 to 4 would be reduced by water quality and changes in habitat. In Reach 5, fish may be limited to transient individuals. Habitat for rheophilic adults would be available, but most of these species are simple lithophils that require clean substrate for spawning. Additionally, nursery habitat for most of these species would be limited, weedy cover would be lost, and invertebrate abundance would be reduced.

Recolonization potential of the Sheyenne River is limited due to the lack of permanent tributaries, upstream migration blockage of Baldhill Dam, and the extent of habitat damage that may occur. Although water quality may recover to pre-pumping conditions, habitat throughout the river would have changed and substrate may be left unstable. The lower Sheyenne River could recolonize from the Rush, Maple, and Red Rivers once habitat stabilizes. The upper reaches would require time to stabilize; however, fish and unionid species may not recolonize within the life of the project.

Water quality effects from WETOF overflow would extend throughout the Red River. However, hydrology, geomorphology, and habitat in the Red River should not be affected by WETOF overflow. Water quality changes may not affect macrophytes and algae. Some decline in richness and abundance of sensitive invertebrate taxa is expected throughout the Red River due to high chloride and sulfate levels. Chloride levels may occasionally exceed levels thought to limit unionids (100 mg/l), but should

be below this limit most of the year in Reach 1, and throughout the year in Reaches 2 and 3. However, chloride could reach up to 90 mg/l in Red River Reach 3. Thus, some decline in unionids and other mollusks might occur in Reach 1, and mollusks may be affected in Reaches 2 and 3. Degraded water quality in Red River Reach 1 may also result in the loss of an occasional year class of sensitive fish species, but should not affect recruitment in Reaches 2 and 3. As water quality improves, fish would probably recolonize within a few years. Invertebrates would also recolonize, as most species probably occur in tributaries, and have short life spans, and mobile adult stages. Unionids, however, may not recover. The lower reaches of most Red River tributaries do not harbor unionids due to water quality problems. If unionids were not severely affected in Red River Reach 2 and 3, unionids would probably recolonize Red River Reach 1, as fish recolonized from Reach 2 and 3.

MONITORING AND MITIGATION

Pre-operation Monitoring

All of the above predictions are based on modeled hydrology and water quality, available geomorphology information, and habitat modeling. Hydrology and water quality model data should be compared to actual available data (2000-2002) to verify modeled values. Most of the biotic information is fairly recent, but was not collected at the same time and location as data for the models. For the purposes of this analysis, modeled conditions at one or two locations within a reach were assumed to occur throughout the reach. Additionally, aquatic communities and habitats naturally vary over time. Therefore, additional baseline data would be needed to define average conditions and natural variability, and to relate existing biota to available habitat. Baseline monitoring should include establishing representative sample sites within each reach and sampling water quality, depth, flow, substrate, and biota (algae, macrophytes, fish, mollusks, and other invertebrates) on a seasonal basis for at least three years.

Metrics that should be evaluated for spatial and temporal changes for each sample site include;

- Algae - levels of chlorophyll a, and relative abundance of Chlorophyta, Bacillariophyta, Cyanobacteria, Euglenophyta, and Devils Lake taxa.

- Macrophytes - density and relative abundance of sago pondweed, Eurasian milfoil, cattail, arrowhead, sedge, rush, and willow communities, and abundance of submerged, emergent, and bank communities

- Invertebrates (including sphaeriids, and gastropods) - density and relative abundance of species sensitive to chloride and sulfate, each functional feeding group, each habitat preference, and each substrate preference. Rapid Bioassessment Protocol metrics that include richness measures, composition measures, tolerance/intolerance measures, feeding measures, and habit measures could be used.

- Unionids - distribution of unionids with respect to habitat, and density, species richness, recruitment, and mortality within unionid beds.

- Fish - biotic integrity metrics suggested by Goldstein *et al.* (1994); species richness and composition, trophic composition, reproductive guild, functional guild, and fish abundance and condition.

Pre-operation and Post-Operation Monitoring

Once an adequate baseline has been established, monitoring using the above methods should continue, but perhaps on a less frequent basis until pumping or overflow actually begins. Sampling should then be repeated on an annual basis (including a seasonal element) until biota stabilizes. Sampling frequency could then be reduced until pumping or overflow stopped. After pumping or overflow, monitoring should be reinitiated on an annual basis until biota again stabilizes.

Mercury

No information was available on how methyl mercury bioavailability would increase under the three alternatives. A relationship between the methyl mercury in surface water, sediment, and fish tissue should be established. Mercury levels in substrate subject to inundation during the alternatives need to be determined. A model should be developed to estimate the effects of this additional mercury release on fish and invertebrates.

Possible Mitigation

Increasing (or restoring) the storage capacity of the Devils Lake and Sheyenne River watersheds could perhaps help influence pumping levels and related impacts.

A healthy system can withstand more damage than an unhealthy system, whether it is an organism or an ecosystem. Enhancing the Sheyenne River watershed prior to pumping could potentially increase the river's ability to withstand impact and recover. Establishing riparian buffer throughout the river would be the first step in this process. This would decrease current erosion rates and reduce erosion due to alternatives. This buffer would also provide a sediment trap and nutrient/pesticide filter between the surrounding farms and the river. Other enhancement ideas could be developed with the assistance of North Dakota fish and wildlife agencies.

300MOD50 Pumping

Changes likely to occur with 300MOD50 pumping include increases in sulfate and chloride concentrations in Reaches 1 and 3 and habitat changes in Reaches 3 and 5 of the Sheyenne River. Reducing the concentration of chlorides such that levels do not exceed 50 mg/l and sulfates such that levels do not exceed 150 mg/l would probably protect all of the taxa in the Sheyenne River. However, this is not practical, as levels under MOD50 are expected to exceed these criteria, at least in Sheyenne River Reach 1. Under 300MOD50 pumping, sulfate would be limited to 450 mg/l and chloride is not expected to exceed 80 mg/l. These levels should be sufficient to protect tolerant invertebrates and most mollusks, and not inhibit fish reproduction. However, the effects of increased sulfate on algal species is unknown. Perhaps toxicity testing of sensitive algal species in Reach 1 of the Sheyenne River could be conducted and water quality limits adjusted accordingly.

The increased depth and velocity would likely cause habitat changes that would not severely reduce any communities but merely alter the species composition. The situation should be monitored as discussed above. The potential effects of scouring and deposition are not known, but baseline conditions are not expected to change by any order of magnitude. However, the magnitude of effects could be underestimated, and scouring and deposition could have greater effects than the other parameters. These effects should be modeled. If they are believed to be significant, something as simple as a slow increase in the pumping of water such that scouring is reduced, and a slow decrease such that animals are not left stranded, may mitigate this affect. However, this mitigation would also need to be modeled to estimate its efficacy.

480MOD55 Pumping and WETOF Overflow

The impacts of these alternatives would be more severe, particularly in Reach 1 of the Sheyenne River, which is essentially isolated from recolonization sources. Under both alternatives, water quality, scouring, deposition, and turbidity would be lethal to much of the aquatic community in the Sheyenne River, except very tolerant species.

Changes in hydrology could be mitigated by modifying discharge such that biologically significant hydrological parameters fall within or near Range of Variability (RVA) limits most of the time (Appendix J).

The effects of erosion, deposition, and turbidity are also likely to substantially modify the Sheyenne River aquatic biota. Perhaps the potential for adverse effects is overestimated, but it needs to be determined before designing mitigation.

It is possible, given this analysis, that the aquatic biota of Sheyenne River Reach 1 may be extirpated, and the aquatic biota through Reach 5 may be severely depleted with 480MOD55 pumping or WETOF overflow. If that were the case, stream rehabilitation measures to assist with stabilizing substrates and habitats would be needed. Once habitats are stabilized, macrophytes could be reintroduced. Invertebrates should recolonize from downstream or nearby systems with time. Fish and unionids would probably need to be reintroduced.

Relocating existing unionids communities out of the Sheyenne River is not recommended for several reasons:

- Most of the species in the upper reaches (anodontines) have a short life span (less than 10 years)
- Those with a longer life span (amblemines and lampsilines) are not rare in the Mississippi River basin.
- Finding, and moving unionids from one system to another is labor intensive and very costly.
- Survival rate of unionids moved to ponds is low (Newton *et al.* 2001).

However, unionids should be sampled and tested for genetic stock differences from those in the Maple River, Red River and nearby Mississippi River Basin Rivers. If differences are detected, salvage efforts may be worthwhile. If genetic stocks are not different, several techniques most of which are experimental at this time, could be used to reestablish unionids in the Sheyenne River. Unionids have successfully been reintroduced into areas where water quality was the initial cause of extirpation and has been improved, however, habitat had not been disturbed in these areas. Habitat rehabilitation has been less successful. By the time pumping or overflow ceases, methods for habitat rehabilitation and reintroduction may be better defined, or this would be an ideal opportunity for research into this possibility.

Methods for restocking fish and restoring fish habitat are well established. Additionally, fish are more mobile and resilient to change. Recolonization would eventually occur if habitat and water quality improve sufficiently to support fish. Habitat could be enhanced and fish stocked, particularly in Reach 1. The monitoring program should provide sufficient data to determine where enhancement is needed and what species need assistance with recolonization.

1.0 INTRODUCTION

1.1 BACKGROUND

The Devils Lake Basin, in northeastern North Dakota, is a 3,810-square-mile closed drainage basin in the Red River Basin. The water level in Devils Lake has been rising for several years. Substantial damages have occurred and additional damage is expected to occur if the lake continues to rise. The U.S. Army Corps of Engineers (USACE) has been charged by Congress with finding alternatives to prevent or reduce future damages. One alternative under review is an outlet to the Sheyenne River. Without an outlet, Devils Lake may rise to the point of naturally overflowing into Stump Lake, then into the Sheyenne River through Tolna Coulee (Figure 1-1). However, the water quality of Devils Lake is substantially different from that of the Sheyenne and Red Rivers.

The action being reviewed in this document includes constructing a closed pipeline from the West Bay of Devils Lake south of Minnewaukan through Peterson Coulee to the Sheyenne River (Figure 1-1). The operation of an outlet could affect the quantity and quality of the water as well as the physical characteristics of the Sheyenne and Red Rivers. Two operating alternatives for the outlet are addressed in this document:

1) A 300 cubic feet per second (cfs) flow constrained to the water quality criteria and channel capacity of the Sheyenne River at the insertion point.

2) A 480 cfs flow unconstrained by the water quality or channel capacity of the Sheyenne River.

Either alternative would operate for seven months a year from May through November for the project's operational life.

The "future without" alternative being addressed is the natural overflow of Devils Lake water to the Sheyenne River through Stump Lake (Figure 1-1).

River aquatic resources include physical habitat (depth, flow, channel morphology, substrate, and cover), water quality (total dissolved solids [TDS], sulfate, and chloride), and living organisms (fish, mollusks, other invertebrates, algae, and macrophytes). Both physical and water quality changes are expected in the Sheyenne River. Only water quality changes are expected in the Red River. Impacts resulting from biota transfer are being evaluated by others and are not addressed in this document.

1.2 PURPOSE

The objectives of this study are to:

- Estimate how the water quality, hydrology, and geomorphology resulting from the three alternatives would affect habitat and biota in the Sheyenne and Red Rivers (see Section 5).

- Compare the impacts of these alternatives to baseline conditions under similar climatic futures (see Section 2).

- Develop a mitigation and monitoring plan (see Section 6).

This impact assessment for the effects of a Devils Lake outlet on the Sheyenne and Red Rivers considers four interrelated components that drive river ecosystems: hydrology, geomorphology, water quality, and biology. Connectivity, a fifth component directly affecting river systems, was addressed in a previous groundwater study (Barr 1999a). This aquatic impact assessment is limited to "within channel" impacts. Since models do not exist that interrelate these components, each component and its effect on aquatic biota (fish, unionids, invertebrates, algae, and macrophytes) is analyzed separately and then qualitatively interrelated. The physical habitat features evaluated include discharge, variability in discharge, erosion (streambank and bottom), current velocity, substrate, depth, and in-stream cover. Water quality characteristics evaluated include sulfate, chloride, TDS, and mercury. Biological components include fish, mollusks, invertebrates other than mollusks, algae, and macrophytes.

1.3 ACKNOWLEDGEMENTS

Funds for this study were provided by the USACE, St. Paul District. Mr. Robert Anfang was the USACE technical manager. Ms. Leslie Knapp (Earth Tech, Inc.) managed the project. Ms. Heidi Dunn (Ecological Specialists, Inc.) was the primary author of the report and provided expertise on mollusks, other invertebrates, and fish. Mr. Deric Deuschle (Short Elliot Hendrickson, Inc.) evaluated aquatic macrophytes and algae, and Mr. Paul Leonard and Mr. Dale Jones (ENTRIX) conducted habitat modeling with assistance from Watershed Systems Group, Inc. Mr. Greg Seegert (EA Engineering, Science and Technology) evaluated fisheries resources, and Ms. Linda Clark (Earth Tech, Inc.) evaluated methyl mercury data. Mr. Mark Rothfork and Mr. Jeremiah Menk (Earth Tech, Inc.) and Mr. Eric Belt (Ecological Specialists, Inc) conducted GIS mapping for the project. Dr. Andre DeLorme (Valley City State University) provided data on benthic invertebrates.

2.0 DESCRIPTION OF "FUTURE WITHOUT" AND "WITH PROJECT" OPERATIONAL ALTERNATIVES

Two "with project" operating alternative and "future without" conditions were addressed in this analysis. These are described below.

2.1 "WITH PROJECT" OPERATIONAL ALTERNATIVES

"With project" conditions would include the construction of an outlet from the West Bay of Devils Lake south of Minnewaukan, North Dakota, through the Peterson Coulee to the Sheyenne River. This outlet would pump water from Devils Lake from May through November during the project's operational life into the Sheyenne River under one of the two operational alternatives described below.

2.1.1 Alternative 1 - 1450 Moderate Future - 300 cfs Constrained Pumping (300MOD50)/1450 Moderate Future Baseline (MOD50)

Alternative 1 (300MOD50, Table 2-1) would involve pumping 300 cfs from the West Bay of Devils Lake into the Sheyenne River through a pipe constructed near Peterson Coulee. Pumping would occur between May and November, but would be discontinued if sulfate levels in the upper Sheyenne River reached 450 milligrams per liter (mg/l) and/or the Sheyenne River discharge reached 600 cfs. Under a moderate future, the water level in Devils Lake would rise to 1,450 feet above sea level (asl) and pumping would begin in approximately the year 2003. The water level in Devils Lake would then decline, and pumping is predicted to be terminated in approximately the year 2024.

To assess the effects of this alternative, the "with project" 300MOD50 pumping condition was compared to the no outlet baseline a of 1,450 asl Devils Lake level that is a moderate future, referred to with the acronym MOD50 (Table 2-1). Under the 300MOD50 pumping future, water is predicted to be pumped from Devils Lake through the outlet beginning in the year 2003 and ending in the year 2024 to meet project objectives. If the water level in Devils Lake rises higher than 1,450, pumping 300 cfs under constrained conditions would not reduce the lake level sufficiently to meet project objectives.

With both the 300MOD50 pumping and MOD50 baseline futures, the water level in Devils Lake is predicted to rise to 1,450 asl in the year 2014. Modeled conditions tend to be drier than the last 50 years. This future assumes that climatic conditions for the first few decades would be similar to those of the past 10 years, then the dry cycle that occurred from 1950 through 1980 would resume.

The MOD50 baseline condition assumes that emergency measures currently underway in the project area would continue. Under MOD50 baseline conditions, Devils Lake would not reach the 1,459 asl level that would result in a natural overflow, and Devils Lake water would not be outlet to the Sheyenne or Red Rivers. The predicted changes from existing conditions pertaining to geomorphology, habitat, water quality, and biota are assumed to occur naturally under the modeled climatic conditions.

2.1.2 Alternative 2 - 1455 Moderate Future - 480 cfs Unconstrained Pumping (480MOD55)/1455 Moderate Future Baseline (MOD55)

Alternative 2 (480MOD55 pumping; Table 2-1), would involve pumping 480 cfs from the West Bay of Devils Lake into the Sheyenne River through a pipe near Peterson Coulee. Pumping would occur between May and November regardless of the water quality and discharge to the Sheyenne River. Under a slightly wetter moderate future, with the water level in Devils Lake rising to 1,455 asl, pumping would be conducted from 2003 through 2016.

To assess the effects of this alternative, the "with project" 480MOD55 pumping condition was compared to the no outlet baseline of a 1,455 asl Devils Lake level that is a moderate future, referred to with the acronym MOD55 (Table 2-1). Under the 480MOD55 pumping future, water is predicted to be pumped from Devils Lake through the outlet beginning in the year 2003 and ending in the year 2016 to meet project objectives.

With both the 480MOD55 pumping alternative and MOD55 baseline futures, the water level in Devils Lake is predicted to rise to 1,455 asl in the year 2014. Modeled conditions tend to be drier than the last 50 years. This future assumes that climatic conditions for the first few decades would be similar to those of the past 10 years, then the dry cycle that occurred from 1950 through 1980 would resume.

The MOD55 baseline assumes that emergency measures currently underway in the project area would continue. Under MOD55 baseline conditions, Devils Lake would not reach the 1,459 asl level that would result in a natural overflow, and Devils Lake water would not be outlet to the Sheyenne or Red Rivers. The predicted changes from existing conditions pertaining to geomorphology, habitat, water quality, and biota are assumed to occur naturally under the modeled climatic conditions.

2.2 "FUTURE WITHOUT" - WET FUTURE WITH NATURAL OVERFLOW (WETOF)/WET FUTURE WITHOUT OVERFLOW (WET) BASELINE

Alternative 3 involves a no action or "future without" an outlet scenario. Under wet future climatic conditions similar to those of the past 20 years, Stump Lake is predicted to naturally overflow into the Sheyenne River near Tolna, North Dakota. The probability that Devils Lake will reach 1,459 asl and overflow into the Sheyenne River in the next 50 years is approximately 9.4 percent. Assuming conditions similar to 1993 through 1999, the overflow is projected to occur near the year 2014 and cease near the year 2025. This model was used to assess the sensitivity of alternatives, although the probability of these exact climatic conditions is practically zero. To assess the effects of this alternative, conditions in the Sheyenne and Red Rivers with a natural overflow were compared to a baseline in which climatic conditions are wet, but water does not overflow from Devils Lake into the Sheyenne River. Wet future with natural overflow conditions (WETOF) were compared to the wet future without overflow baseline conditions, identified by the acronym WET (Table 2-1).

Both the WETOF overflow and WET baseline futures were modeled on the assumption that the recent wet period (1993 to 1999) would continue into the future. Input for the hydrologic models assumed that precipitation, evaporation, and inflow to the Sheyenne and Red Rivers would be similar to the recent period of record between 1993 and 1999. This seven-year flow sequence was repeated twice until Devils Lake reached its natural overflow level of 1,459 asl in the year 2014. The seven-year flow series

was then repeated (2015 to 2021) to simulate the effect of natural overflow water on the Sheyenne and Red Rivers. The remaining 19 years assumed that the climatic conditions that occurred from 1981 to 1999 would occur again from 2022 to 2040, and that climatic conditions that occurred from 1981 to 1990 would occur again from 2041 to 2050 (WEST 2001).

For purposes of establishing the WET baseline, discharge, water quality, and habitat were modeled for the Sheyenne and Red Rivers without the natural overflow. The wet future without the overflow assumes that Devils Lake is not in the basin.

2.3 EXISTING CONDITIONS

Existing conditions were used as background information only, not as an alternative or baseline condition. This report compares the impacts of a natural overflow or the operation of an outlet to the corresponding baseline condition that is based on similar climatic conditions.

3.0 SUMMARY OF AVAILABLE DATA (HISTORIC AND CURRENT CONDITIONS)

Numerous studies have been and are being conducted on the Sheyenne River and Red River of the North. A bibliography of studies conducted in the Devils Lake and Red River Basins and other reviewed literature is provided in Appendix A. The study sites of various researchers are located throughout the Sheyenne and Red Rivers. For purposes of discussion, the study area was divided into reaches based on physiographic regions and major tributaries. Available background information is discussed within each river reach.

The Sheyenne River was divided into five reaches based on physiographic region and biota (Figure 3-1):

- **Reach 1** - The Peterson Coulee to the headwaters of Lake Ashtabula near Cooperstown (glacial plains upstream of Lake Ashtabula).
- **Reach 2** - Lake Ashtabula.
- **Reach 3** - Baldhill Dam to downstream of Lisbon (glacial plains downstream of Lake Ashtabula).
- **Reach 4** - Downstream of Lisbon to upstream of Kindred (sand delta).
- **Reach 5** - Upstream of Kindred to the confluence with the Red River (glacial Lake Agassiz).

The Red River was divided into three reaches based on tributary in-flow and presence of National Water Quality Assessment Program (NAWQA) and U.S. Geologic Survey (USGS) gage stations (Figure 3-1):

- **Reach 1** - Confluence with the Sheyenne River to the Goose River near Caledonia, North Dakota.
- **Reach 2** - Goose River to the Turtle River near Oslo, North Dakota.
- **Reach 3** - Turtle River to Emerson, Manitoba, Canada.

3.1 WATER QUALITY

Water quality in the Red and Sheyenne Rivers is legally constrained by qualitative standards presented in the Boundary Waters Treaty and North Dakota's antidegradation policy. Specific concentration limits for some parameters have been established by North Dakota (ND) and Minnesota (MN) under the Federal Clean Water Act and the Boundary Water Treaty between the United States and Great Britain (Table 3-1). In 1969, specific water quality objectives were adopted by the United States and Canada as recommended by the International Joint Commission (IJC). The States of North Dakota and Minnesota also have water quality standards that apply to the Sheyenne and Red Rivers. Red River standards are the same in North Dakota and Minnesota; however, chloride, sulfate, and sodium standards in North Dakota are less strict in the Sheyenne than in the Red River (Table 3-1). North Dakota also has an antidegradation policy, stating that a discharge cannot degrade the quality of the receiving waters such that existing users are affected (USACE Water Quality Effects, no date). Regulated parameters include

sulfate, TDS, chloride, dissolved oxygen (DO), and fecal coliform. Dissolved oxygen and fecal coliform are not expected to change significantly with the outlet and overflow (USACE Water Quality Effects, no date).

Water quality in the Sheyenne and Red Rivers is related to geology and land use. The Sheyenne River primarily flows through the glacial plains, which are underlain by saline sedimentary bedrock aquifers (Stoner *et al*. 1998). The major dissolved solids in the Red River Basin (Stoner *et al*. 1998) include:

- Cations—calcium, magnesium, sodium, and potassium.
- Anions—bicarbonate, chloride, and sulfate.
- Trace elements—iron and manganese.
- Radionuclides—uranium, radium, and radon.

Agriculture is the major land use in the Red River Basin. Nutrients are generally low in the surface waters of the Red River Basin, but agriculture has increased the nitrogen and phosphorus levels in streams. Total nitrogen and total phosphorus are highest in the western (mean of 0.67 mg/l and 0.14 mg/l, respectively) and central (mean of 1.02 mg/l and 0.14 mg/l, respectively) portions of the Red River Basin, but do not exceed drinking water standards (Stoner *et al*. 1998).

Historical data on dissolved solids were available from USGS gage stations (Figure 3-1; Tables 3-2 and 3-3; Appendix B) in Devils Lake inlets (Channel A and Big Coulee), Devils Lake (East Bay and Main Bay), Sheyenne River (Cooperstown and Kindred), and Red River (Fargo, downstream of Fargo, Grand Forks, and Emerson). These data were also used by the USACE to predict future hydrological conditions. Average calcium levels in Devils Lake and the Sheyenne River were similar, ranging from 66.6 to 78.4 mg/l in Devils Lake, and 66.6 to 72.5 mg/l in the Sheyenne River. Average calcium levels in the Red River were slightly lower, ranging from 46.4 to 63.5 mg/l. Magnesium, sodium, potassium, carbonate, chloride, and sulfate levels were all higher in Devils Lake than in the Sheyenne River (Table 3-3). Total dissolved solids were also much higher in Devils Lake than in the Sheyenne and Red Rivers.

3.1.1 Total Dissolved Solids

This analysis focuses on TDS, sulfate, and chloride (Table 3-4) since these standards or guidelines are available and the trends in other dissolved solids appeared to be similar to these. Since North Dakota and Minnesota do not publish standards for TDS, the U.S. Environmental Protection Agency (USEPA) guideline of 500 mg/l was used for this analysis. Chloride and sulfates are thought to be detrimental to aquatic life. Potassium may also be detrimental to mollusks (Imlay 1973). However, some evidence indicates that chloride is more harmful or may increase the effects of potassium (USFWS 1999a). Cvancara (1967) attributed the lack of unionids in Red River tributaries to chloride levels greater than 100 mg/l. The Sheyenne River standard is 175 mg/l; however, the more conservative 100 mg/l is used for this analysis.

Total dissolved solids are a measure of the overall concentration of dissolved chemicals in water. Total dissolved solids were fairly high in the Sheyenne River, averaging 567 mg/l at Cooperstown and 533 mg/l near Kindred (Table 3-4). The water quality guideline of 500 mg/l was exceeded 75 percent and 68 percent of the time for the period of 1959-1999 for Cooperstown and 1972-1999 for Kindred (Table 3-4). Total dissolved solids remained fairly stable over the period of record, with the trend being toward a slight decline at Cooperstown, but a slight increase at Kindred with time (Appendices B-1 and B-2). Total dissolved solids were generally lower in the spring (Appendix B), due to dilution effects and the limited soil-water interaction during spring runoff over frozen soil (Lent and Zainhofsky 1995 in Wiche 1996). This effect appeared to be less in the lower Sheyenne (Kindred) than in the upper Sheyenne (Cooperstown). Very few values other than those from the spring were lower than the water quality guideline of 500 mg/l.

Total dissolved solids in the Red River were lower than in the Sheyenne River, averaging between 326 mg/l and 460 mg/l between Fargo and Emerson (Table 3-4). Although the range of TDS values was similar in the Red and Sheyenne Rivers (134 mg/l to 1,100 mg/l and 143 mg/l to 1,070 mg/l, respectively), Red River TDS seldom exceeded the water quality guideline of 500 mg/l except near Emerson (Table 3-4). Eastern tributaries of the Red River were generally lower in TDS than western tributaries due to the lack of sedimentary rock, and eastern tributaries have a dilution effect on Red River TDS and sulfate (Stoner *et al*. 1998). However, TDS increased as the river flowed toward Canada. Total dissolved solids at Fargo averaged 326 mg/l and exceeded guidelines only 1.4 percent of the time, whereas TDS at Emerson averaged 460 mg/l and exceeded guidelines 26 percent of the time (Table 3-4). Total dissolved solids have increased with time at Fargo, Grand Forks, and Emerson (Appendix B). Seasonal differences were not apparent at any of the gage stations on the Red River (Appendix B).

Sulfate is one of the anions found in the Red River Basin. Sulfate levels were particularly high in the Main Bay (2,629 mg/l) and East Bay (3,079 mg/l) of Devils Lake (Table 3-3). Sulfates were less concentrated in Channel A (257 mg/l) and Big Coulee (209 mg/l), which feed the West Bay; therefore, West Bay sulfate levels were lower than in the Main and East Bays (Figure 3-2). Stump Lake sulfate levels were higher (6,100 mg/l; Figure 3-2). Sheyenne River sulfate levels averaged 139 and 153 mg/l at Cooperstown and Kindred, respectively, and North Dakota water quality standards were not exceeded at either site (Table 3-4). However, the Minnesota and Boundary Water Treaty standard of 250 mg/l was exceeded 1.2 and 1.5 percent of the time at Cooperstown and Kindred, respectively. Sulfate levels have remained fairly constant at Cooperstown over the past 50 years, but appear to have increased at Kindred over the past 30 years (Appendix B). Similar to TDS, a seasonal effect of spring dilution was apparent at Cooperstown, but was much less pronounced at Kindred (Appendix B).

3.1.2 Sulfate

Sulfate levels in the Red River appear to be about half of the levels noted in the Sheyenne River (Table 3-4), probably due to the diluting affects of the eastern tributaries. The water quality standard for sulfate in the Red River is stricter (250 mg/l). However, this level has only been exceeded downstream of Fargo 0.9 percent of the time during the period of record. Sulfate levels appear to be increasing with time in the Red River, particularly at Fargo and Grand Forks (Appendix B).

3.1.3 Chloride

Chloride is also one of the anions found in the Red River Basin, and is particularly applicable to this project due to the high salinity of Devils Lake water. Similar to sulfate, chloride concentrations were high in Devils Lake Main Bay (566 mg/l) and East Bay (675 mg/l), and much lower in Channel A (23 mg/l) and Big Coulee (27 mg/l) (Table 3-3).

Sheyenne and Red River chloride levels were fairly low and did not exceed the water quality standard of 100 mg/l except at Emerson (Table 3-4). Chloride in the Sheyenne River seemed to increase in the downstream reach, averaging 16 and 29 mg/l at Cooperstown and Kindred, respectively. It was relatively stable over time at both Cooperstown and Kindred. The seasonal effect of high water dilution was apparent at both Sheyenne River sites (Appendix B).

Chloride levels in the Red River between Fargo (15 mg/l) and Grand Forks (10 mg/l) were lower than the Sheyenne River (16 to 29 mg/l) and also did not exceed water quality standards. However, chloride levels increased slightly over the period of record (Appendix B). A few spikes in chloride occurred during the period of record, particularly downstream of Fargo in late 1976. No seasonal trends were apparent (Appendix B).

Chloride levels at Emerson were much higher than in either the Sheyenne River or upstream in the Red River. Chloride levels averaged 55 mg/l, and exceeded water quality standards 15 percent of the time. High levels were observed primarily in 1980, and in 1986 to 1993. Chloride levels seemed to be particularly high in the late fall and winter, then declined in spring and summer (Appendix B).

3.2 HYDROLOGY

Devils Lake is a closed drainage system in the northwestern portion of the Red River Basin (Figure 1-1). The lake has fluctuated from a low of 1,400 asl to 1,459 asl, the level at which Stump Lake would overflow into the Sheyenne River (Figure 3-2), within the last 4,000 years. Geological evidence indicates that the lake basin naturally fluctuates between dry conditions and wet conditions, and should not be expected to remain stable for an extended period of time (Wiche *et al*. 2000a, and Wiche *et al*. 2000b). Geological records indicate that Devils Lake has overflowed into the Sheyenne River twice in the last 4,000 years. Since the establishment of a USGS gage station in 1867, Devils Lake has fluctuated from a low of 1,400.9 asl in 1940 to a maximum of 1,447.1 asl in 1999 (Wiche *et al*. 2000a). Devils Lake was in a dry phase during most of the 1900s, and reached a high of 1,425 asl in 1980, the highest level since 1870. A drought from 1987 to 1993 reduced lake elevation to 1,422.6 asl. Since 1993, Devils Lake has been in a wet phase and has risen 24.5 feet to a high of 1,447.1 asl in August 2000 (Wiche *et al*. 2000a). Contributing to the high water levels is the drainage of wetlands throughout the basin for agricultural use (USFWS 1999a).

Sheyenne and Red River discharge has also fluctuated over the past 50 years with the change in climatic conditions. Figures 3-3 (Warwick) and 3-4 (Emerson) show the typical discharge trends in the Sheyenne and Red Rivers, respectively. In the Sheyenne River, mean discharge was high (>200 cfs) in 1950, declined to <50 cfs between 1957 and 1964, fluctuated between approximately 10 and 125 cfs between 1965 and 1987, declined to <50 cfs in the late 1980s and early 1990s, then reached levels over 200 cfs between 1995 and 2000 (Figure 3-3). Although at a higher magnitude (1,000 cfs to 12,000 cfs), the same trends were apparent in the Red River. Discharge peaked near 11,000 cfs in 1950, was low (<4,000 cfs) from the late 1950s to early 1960s, fluctuated between 1964 and 1987 (2,000 to 8,000 cfs), declined

between 1987 and 1993 (<4,000 cfs), and increased between 1994 and 2000, reaching almost 12,000 cfs (Figure 3-4).

Richter *et al.* (1997) define a natural flow paradigm as "the full range of natural intra- and interannual variation of hydrological regimes and associated characteristics of timing, duration, frequency, and rate of change, that are critical in sustaining the full native biodiversity and integrity of aquatic ecosystems." The habitats and biodiversity in a stream are present in response to existing hydrological conditions. Lotic species need several different habitats to complete their lifecycles, and the availability of these habitats is dependent on the flow regime (Poff *et al*. 1997). Hydrological characteristics that are important for the maintenance and regeneration of stream habitats include seasonal patterns of flow; timing of extreme conditions; frequency, predictability, and duration of floods, droughts, and intermittent flow; as well as daily, seasonal, and annual flow variability and rates of change (Richter *et al*. 1997 and references therein). Species in a stream generally reflect the frequency and intensity of high and low flows (Poff *et al*. 1997, Stoner *et al.* 1998, Goldstein *et al.* 1996, Koel 1997). Highly variable streams tend to favor generalists, whereas more stable streams tend to favor specialists. Frequent floods and intermittency lead to trophically simple aquatic communities, whereas flood and flow predictability lead to trophic complexity (Poff and Ward 1989). Specifically, in the Red River Basin flow variability is highest and diversity lowest in the headwaters, and variability decreases and diversity increases downstream (Koel 1997). Flow variables that were found to correlate with the existing fish community include average annual discharge, mean monthly discharge, and average low discharge during May (Koel 1997), coefficient of variation of velocity, coefficient of variation of mean April flow, and mean annual frequency of high flow (Goldstein *et al.* 1996). Extended low flow can restrict mollusks, while higher discharge tends to increase mollusk diversity (Cvancara 1970a). The abundance, diversity, and species richness of other invertebrates is also highly affected by flow patterns (Kroger 1973, Gislason 1985, Irvine 1985, Weisberg *et al*. 1990, Morgan *et al.* 1991, Moog 1993, Parasiewicz *et al.* 1998).

To characterize the existing hydrological patterns that have formed the existing habitats and biota in the Sheyenne and Red Rivers, historical flow data (obtained from USGS gage stations) were summarized with Indicators of Hydrological Alteration (IHA) software (The Nature Conservancy 1997). Data for gage stations at Warwick, Cooperstown, Baldhill Dam, Lisbon, Kindred, Halstad, Grand Forks, and Emerson were available for 1971 through 1999. Therefore, this time frame was used for all stations. Indicators of Hydrological Alteration statistics are summarized in Table 3-5 (means) and Table 3-6 [coefficient of variation (CV)]. Detailed statistics are provided in Appendix C.

3.2.1 Reach 1

The Sheyenne River Reach 1 has the hydrological characteristics of a small, unregulated river, with periods of intermittent flows and high, flashy flows. Flow is generally high (average April discharge 382 cfs at Warwick and 742 cfs at Cooperstown) in the spring (March, April, and May), declines in June through August, and is lowest September through February (January low averaged 7.2 cfs at Warwick and 16.8 cfs at Cooperstown; Table 3-5). However, flow is highly variable in all months. The lowest variability occurs in December, January, and June (CV <100) and the highest variability occurs in August (CV >200; Table 3-6). Base flow falls to zero at both Warwick and Cooperstown. The number of zero days per year averages only 0.1 and 0.4, respectively; however, this is highly variable (CV=550 and 427, respectively). Low flow (exceeded 75 percent of the time, <3.5 cfs at Warwick and <10.0 cfs at Cooperstown) on the average occurred 3.9 and 3.3 times per year and lasted an average of 15.1 and 16.0 days, respectively. High flow (exceeded 25 percent of the time, 35 cfs at Warwick and 80 cfs at Cooperstown) occurred on the average 1.4 times per year and lasted 12.6 and 14.5 days, respectively. Variability in high and low flows was less than monthly average flows with a CV between 69 and 92. Low flow typically occurred in August and high flow typically occurred in April, and these extremes varied little in timing (CV=10 to 30 for low flow and 7 to 10 for high flow). Channel-forming flows were estimated at 520 cfs and 760 cfs at Warwick and Cooperstown, respectively (WEST 2001).

3.2.2 Reach 2

Lake Ashtabula was not summarized with IHA.

3.2.3 Reach 3

Although discharge is generally higher and variability slightly less in Reach 3, this reach of the Sheyenne is still fairly flashy. Discharge was highest in the spring, with an average April flow of 785 cfs and 944 cfs downstream of Baldhill Dam and at Lisbon, respectively. Highest flow was typically consistently (CV=15.5 and 9.9, respectively) recorded in April. Lowest average discharge occurred in September through January (72 to 92 at Baldhill Dam and 81 to 104 cfs at Lisbon), and the date of minimum discharge typically occurred in August and September, respectively (Table 3-5). As in Reach 1, the highest variability in discharge occurred in August (CV=240.7 and 252.8, respectively). Base flow reached a low of 0.1 cfs, but low flow (15 and 25 cfs, respectively) occurred more frequently at Lisbon (average of six times per year) and lasted longer on the average near Baldhill Dam (average 27.5 days) than in Reach 1. High flow events (150 and 175 cfs, respectively) occur slightly more often in this reach (average 1.7 times per year), but were slightly shorter in duration (averaging <12 days) than in Reach 1. The average rise rate (32 and 38 cfs) and fall rate (28 and 29 cfs) was greater than in Reach 1, and the number of flow magnitude reversals was higher in this reach (80 and 87 times per year, respectively). Channel forming flow was estimated at 880 and 980 cfs downstream of Baldhill Dam and at Lisbon, respectively.

3.2.4 Reach 4

No gage stations occur within Reach 4; however, hydrological conditions were likely intermediate between Reach 3 and Reach 5.

3.2.5 Reach 5

The Sheyenne River is larger in Reach 5, discharge is higher (monthly average between 95 cfs and 1,030 cfs), and variation in flow is less (CV=61 to 219) than in Reach 3 (Tables 3-5 and 3-6). However, other statistics are intermediate between Reach 1 and Reach 3. Highest average discharge (1,030 cfs) occurred in April, as did the date of maximum discharge. Variability in April discharge was slightly lower than in other reaches (CV=93.9), but the variation in date of high flow was very low (CV=10.2), similar to other reaches. The frequency of high flow (>200 cfs) events averaged 1.7 times per year and lasted an average of 13.2 days. The variation in these parameters was similar to the upstream reaches (CV=89 and 92.5, respectively). Channel-forming discharge was estimated at 920 cfs. Low flow, as in other reaches, occurred from September through February. Variability in mean monthly flow between September and February was slightly lower than other reaches (CV=61 to 112). Lowest flow was typically recorded in September, and low flow events (<50 cfs) occurred on the average of 4.4 times per year and lasted 19.1 days.

3.2.6 Red River

The Red River is larger than the Sheyenne River, and discharge was higher and less variable. Discharge in the Red River near Halstad (Reach 1) averaged between 525 and 8000 cfs (CV=59.8 to 165.8) (Table 3-5 and 3-6). This increases to 1200 to 14,000 cfs (CV=50.2 to 120.4) downstream of Grand Forks (Reach 2) and 1,200 to 17,000 cfs (CV=50.1 to 131.0) near Emerson (Reach 3). Low flow generally occurred in August and September and high flow in April, with little variation in date (CV=28.2 to 29.8 for minimum date and 9.1 to 10.5 for maximum date). Low pulses seemed to occur less frequently in the Red River (≤3 per year) than in the Sheyenne, and did not seem to last as long (average 13.7 to 15.9 days). High flow events, however, occur with a similar frequency (1.4 to 1.7 times per year) to the Sheyenne River, but seem to last longer (11.8 to 19.3), particularly in the lower Red River near Emerson.

3.3 GEOMORPHOLOGY

The geomorphology of the Sheyenne River was studied by WEST (2001), and is summarized in Table 3-7. The river was divided into 12 erosion segments based on physiography, habitat, and meander characteristics. Erosion segments correspond to aquatic impact reaches in this report as follows (Figure 3-1):

- Erosion segments L, K, J, I, H, G, and F are in aquatic impact Sheyenne River Reach 1.
- Erosion segments E and D are in aquatic impact Sheyenne River Reach 3.
- Erosion segment C is the same as aquatic impact Sheyenne River Reach 4.
- Erosion segments A and B are in aquatic impact Sheyenne River Reach 5.

WEST's report summarized the existing geomorphology in the Sheyenne River and predicted change under moderate conditions (MOD50) baseline and wet future natural overflow (WETOF). Moderate (MOD55) baseline conditions were not modeled.

WEST (2001) modeled channel geometry using cross-section data collected within each erosion segment and discharge measurements from USGS stations. Some of the cross-section data were collected in the same locations in 1940 and 1998 (precision cross-sections). Channel geometry (width, depth, and slope) was compared between years to determine the magnitude of recent changes. Geomorphology models were used to calculate the "regime channel" (channel at steady state) and discharge data from gage stations were used to calculate the "regime discharge" (channel-forming discharge).

WEST's report indicates that the upper portion of the Sheyenne River (Sheyenne River Reach 1) has not changed much in width, depth, or slope between 1940 and 1998. This section of the Sheyenne River appears to be at regime and should remain stable. However, discharge in this reach has nearly doubled since 1993 (Section 3.2) and some change in channel morphology would be expected with the higher flow. Downstream of Lake Ashtabula, the channel does not appear to be as stable. In Sheyenne River Reach 3 the river appears to be narrowing and deepening, while the channel in Reaches 4 and 5 appears to be widening and becoming shallower. Energy slope has remained stable in all reaches.

River planform (width, meander length, and meander amplitude) was similar between 1940 and 1998, indicating that the channel has not changed position in that time. WEST (2001) based this conclusion on the comparison of 1940 USGS topographic maps and 1998 photographs. The centerline in both cases was within the expected margin of error. Biologically meaningful measures present erosion and deposition were not addressed by WEST (2001).

3.4 METHYL MERCURY

3.4.1 Surface Water Concentrations

The USGS, through an agreement with the USACE, is studying the distribution of total mercury and methyl mercury at several sites in the Devils Lake Basin, the Sheyenne River Basin (including Lake Ashtabula), and the Red River of the North Basin (USGS 2001). The following sections summarize the preliminary results of the activities conducted from February through September 2001 (Tables 3-8 and 3-9).

3.4.1.1 Concentrations of Mercury in Lake Ashtabula

Water samples were collected from Lake Ashtabula during two rounds of sampling that represented under-ice conditions (collected March 13 to 15) and summer-heating conditions (collected August 1 to 7). Samples were collected one meter below the water surface and one meter above the lake bottom at each site and were analyzed for filtered methyl mercury (FMHg), filtered total mercury (FTHg), particulate total mercury (PTHg), and unfiltered total mercury (UTHg).

Samples collected during the second round have not yet been analyzed. For the first round of sampling, concentrations of filtered methyl mercury were less than 0.1 nanogram per liter (ng/l) near surface (Table 3-8), a concentration considered the upper end of the range of typical aquatic concentrations throughout the U.S. (0.3 mg/kg - USEPA fish tissue standard 2001). One near-bottom sample exceeded 0.10 ng/l, at 0.22 ng/l. In this sample, filtered methyl mercury comprised approximately 25 percent of the filtered total mercury, indicating that environmental conditions at this site are suitable for efficient

methylation. Conditions necessary for mercury methylation include adequate concentrations of dissolved sulfate and organic material and lack of DO (Krabbenhoft 1996). Methyl mercury is water soluble and bioavailable.

USEPA Region 6 has identified ecological toxicity reference values (TRVs) for surface water based on screening toxicity values developed and/or adopted by federal and/or state regulatory agencies (USEPA 1999). These TRVs are based on the dissolved concentration of the compound in surface water. The TRV for methyl mercury, 2.8 ng/l, is a secondary chronic value (SCV) calculated using the Tier II method in the Great Lakes Water Quality Initiative. The dissolved methyl mercury concentrations in the surface water samples collected from Lake Ashtabula during the first round were below the methyl mercury TRV. Methyl mercury was below the detection limit near the dam and 0.058 ng/l at the upper end of the lake (Table 3-8).

Concentrations of filtered and unfiltered total mercury were generally less than 1 ng/l and within typical ranges for water samples from uncontaminated aquatic environments (Krabbenhoft *et al*. 1999). The highest filtered (2.1 ng/l) and unfiltered (1.1 ng/l) total mercury concentrations occurred near the bottom at the North End of the lake. The analytical results indicate that near the dam most of the mercury in the lake is in the dissolved phase (unfiltered = 0.631 ng/l; filtered = 0.631 ng/l). However, at the northern end of Lake Ashtabula dissolved (0.532 ng/l) and particulate (0.545 ng/l) mercury were nearly equal (Table 3-8).

The USEPA Region 6 TRV for inorganic mercury (770 ng/l) is the federal chronic ambient water quality criterion (AWQC). The dissolved mercury concentrations in the surface water samples collected during the first and second rounds from Lake Ashtabula were below the inorganic mercury TRV. In North Dakota, all lakes must meet the standards for Class I streams – suitable for aquatic biota and recreation. The Class I chronic mercury standard for aquatic life is 910 ng/l and the human health value is 50 ng/l. The total mercury (FTHg plus PTHg) concentrations of <2.1 ng/l in Lake Ashtabula do not exceed the North Dakota standards.

3.4.1.2 Concentrations of Mercury in the Sheyenne and Red Rivers

River samples were collected during two rounds of sampling that represented spring runoff conditions (collected April 30-May 2, 2001) and summer base-flow conditions (collected July 24-26, 2001) (Table 3-9). Filtered methyl mercury concentrations were moderately elevated above the typical range in uncontaminated streams at the Sheyenne River near Warwick (Reach 1; 0.2 ng/l). Methyl mercury concentrations at other reaches of the Sheyenne and Red Rivers were at or less than 0.1 ng/l (Table 3-9). The dissolved methyl mercury concentrations in the river samples were lower than the methyl mercury TRV of 2.8 ng/l.

The highest concentration (17.8 ng/l), at Sheyenne River at West Fargo (Reach 5), might be considered moderately high. Concentrations in Reach 1 (2.4 ng/l) and Reach 2 (2.6 ng/l) of the Sheyenne River were almost an order of magnitude lower than in Reach 5. In the Red River, unfiltered total mercury concentrations were similar among the reaches, with concentrations in Reach 2 (5.7 ng/l) being slightly lower than in Reach 1 (13.0 ng/l) and Reach 3 (9.4 ng/l; Table 3-9). The unfiltered total mercury concentrations in the Sheyenne River (2.4 to 17.8 ng/l) and in the Red River (5.7 to 13.0 ng/l) were lower than the inorganic mercury TRV of 770 ng/l.

In the river samples, most of the mercury is inorganic and occurs in the particulate phase. Concentrations of filtered total mercury ranged from 0.96 to 2.3 ng/l, whereas particulate total mercury ranged from 0.97 to 16.3 ng/l in the Sheyenne River. In the Red River, filtered total mercury ranged from 1.3 to 1.9 ng/l and particulate mercury ranged from 4.4 to 11.5 ng/l. The particulate and total mercury concentrations were lower than the inorganic mercury TRV of 770 ng/l.

The Red River is classified by the State of Minnesota as 1C (drinking water), 2Bd (aquatic life and recreation), and 3B (industrial use). The drinking water standard for mercury is 2,000 ng/l. This value was not exceeded in the Red River samples (total mercury <13.1 ng/l). The Minnesota surface water standard for total mercury for 2Bd waters is 6.9 ng/l, based on consumption of fish and incidental ingestion of water while swimming. The total mercury concentrations in the Red River exceeded this value in Reach 1 (13.0 ng/l) and Reach 3 (9.4 ng/l) (Table 3-9). There is no mercury standard for industrial use waters.

The Red River is classified by the State of North Dakota as Class I and the Sheyenne River is classified as IA– suitable for aquatic biota and recreation. The highest total mercury concentrations in the Red (13.0 ng/l) and Sheyenne (17.8 ng/l) rivers did not exceed the chronic aquatic standard of 910 ng/l, the acute standard of 1700 ng/l, or the human health standard of 50 ng/l (NDDH 2002).

3.4.2 Concentrations of Mercury in Fish in the Red River

No data are available on concentrations of mercury in fish in Lake Ashtabula or the Sheyenne River. Background concentrations of mercury in fish in the Red River are presented in Table 3-10. The data are presented separately for the Red River upstream (from Fargo/Moorhead to the south) and downstream (north of Fargo/Moorhead). Most of the information presented below was taken from a USGS report published in 1995 (USGS 1995a).

3.4.2.1 Upstream Monitoring Sites

The Minnesota Department of Natural Resources (MnDNR) and the Minnesota Department of Health (MDH) have collected and analyzed catfish samples from the Red River near Wahpeton/Breckenridge and Fargo/Moorhead (MnDNR 1994). Mercury results for the 1990 samples are presented in Table 3-10.

In June 2000, the USGS analyzed samples from a variety of fish collected at Wahpeton. The predominant species of fish collected from this site was catfish.

3.4.2.2 Downstream Monitoring Sites

Since 1967, the U.S. Fish and Wildlife Service (USFWS) has been monitoring contaminants, including mercury, in fish through the National Pesticide Monitoring Program, which later became the National Contaminant Biomonitoring Program (NCBP) (Schmitt and Brumbaugh 1990). This program has reported data from a single location in the Red River at Noyes, Minnesota, near the Canadian border. The USGS has summarized the data for the years 1978, 1980, 1984, and 1986 (USGS 1995a). There had been a downward trend in the fish tissue concentrations of mercury since 1978. The data from the year 1984 are presented in Table 3-10; these data are representative of concentrations at the end of the 1978-1986 monitoring period.

The USEPA (1992) conducted a study over several years in which mercury concentrations were determined in fish collected in the Red River near Pembina, North Dakota. This site is close to the site sampled by the USFWS. The USGS (1995a) reported the data from this study for the year 1984.

In June 2000, the USGS analyzed samples of fish collected from the Red River at Grand Forks, North Dakota (USGS 2001). A wide variety of fish were sampled, including catfish (*Ictalurus punctatus*), carp (*Cyprinus carpio*), walleye (*Stizostidion vitreum*), and northern pike (*Esox lucius*).

3.4.2.3 Trends in Red River Fish Mercury Concentrations

The available data are not sufficient to draw conclusions regarding concentrations of mercury in fish in the upstream versus downstream Red River. More fish species were sampled in the year 2000. However, with the exception of channel catfish, far more fish of each species were sampled downstream than upstream. The 2000 data show that the range of mercury concentrations in catfish tissue is similar upstream and downstream.

The USGS (1995a) notes that although contaminants had been detected in fish tissues from the Red River, as of 1995 there had been no reports of acute effects or fish kills attributable to the contaminants. A bioassay conducted on effluents in the Red River Basin found potential toxicity at a few sites, but no causal factor was determined (Braidech and Monro 1988).

The USACE has established an Environmental Residue Database that provides some information that relates concentrations of mercury in fish tissue to adverse effects in the fish. A study on walleye (Friedmann *et al*. 1996) indicated that a level of 0.25 parts per million (ppm) wet weight (whole fish) was associated with impaired testicular development. Higher concentrations were associated with decreased length and weight of males but not females. No effects on ovaries were noted at any of the tissue concentrations measured in the study. The walleye tissue concentrations from the USGS 2000 sampling event (0.2 to 2.1 ppm) exceed 0.25 ppm; however, the sex of the fish is not indicated and the samples analyzed are plugs or fillets, not whole fish. No other studies are known to have investigated effects of mercury concentrations within the range detected in tissues of fish from the Red River.

From the standpoint of human health, for the year 2000 the State of Minnesota issued a fish consumption advisory for several species of fish in the Red River based on the concentrations of mercury in their tissues. North Dakota issued a similar advisory for largemouth and smallmouth bass, white bass,

northern pike, walleye, channel catfish, and yellow perch (North Dakota Department of Health [NDDH] 2002).

3.5 HABITAT

3.5.1 Sheyenne River

Stoner *et al.* (1993) provide a very thorough habitat summary of the Sheyenne River. The following is from p. 45, describing the Northern Glaciated Plains.

> "The landscape of this region is rolling hills through many moraines and has numerous prairie potholes, particularly in the western headwaters of the Sheyenne River Basin. Currently 90 percent of the land is used for agriculture; dry land farming, and livestock production. The natural vegetation is gone except where it has been encouraged through conservation efforts as in the Sheyenne National Grassland. Major crops in the ecoregion are wheat, sunflowers, and feed grains with corn and soybeans predominant in the southern portion. Riparian areas provide conditions for some trees and some non-woody vegetation including grasses, sedges, reeds, and cattails.
>
> The Sheyenne River is the major river in the ecoregion. Most (up to 90 percent) of the 1st and 2nd order streams (Kuehne 1962) are ephemeral. Significant habitat in these small ephemeral streams is in the hyporheic zone, the area of subsurface flow in the stream bed (Hynes 1970). During dry periods ephemeral streams appear as swales with a extensive growth of grasses, cattails, and some shrubs.
>
> The upstream reaches contain riffles, runs, pools, backwaters, and in-stream woody debris. The greatest habitat diversity is found in conjunction with moraines. The overall gradient of the Sheyenne River is 1.5 feet/mile, but upstream moraine areas have larger gradients. Substrates are variable and particle sizes correlate to gradient, velocity, and habitat type. Rocks and gravel are dominant in the riffles and runs of streams in the moraines while sand, silt, and fine organic matter are prevalent in the pools, backwaters and on the shallow sides of sharp bends and slow meander curves of streams.
>
> The only major impoundment on the Sheyenne River is Lake Ashtabula formed by Baldhill Dam, which regulates downstream discharges and maintains flow in the lower reaches year round. Lake Ashtabula discharges from the bottom waters (hypolimnion) and cool, potentially anoxic waters are released from the dam particularly during times of reservoir stratification during summer and early autumn. Numerous low-head dams also exist within this ecoregion."

The USACE conducted a reconnaissance of the Sheyenne River in June 1998 (Earth Tech, Inc. 1998). Cross-sections for habitat evaluation were selected within each erosion segment (Figure 3-1) based on the presence of riffles and raceways. These habitat types are typically the most productive and diverse in terms of fish, mollusks, and other invertebrates. Evaluating impacts to these areas should, therefore, represent the impacts to the most sensitive parts of the Sheyenne River. The selected cross-sections do not necessarily represent a typical cross-section of each reach and the results cannot necessarily be extrapolated to the entire reach.

The USACE selected habitat transects in Sheyenne River Reach 1 (L1, K3, J1, I4, H2, and F2), Sheyenne River Reach 3 (E2), and Sheyenne River Reach 5 (B3) (Figure 3-1). Depth, velocity, substrate, and cover data were collected at each transect (Appendix D). Data were collected during a low-flow period in October 1998 (Earth Tech, Inc. 1998).

3.5.1.1 Sheyenne Reach 1

Reach 1 of the Sheyenne River flows through the glacial plains. The Sheyenne River is meandering and sinuosity (river length divided by valley length) range from 1.0 in Segment J to 2.2 in Segment F (Appendix D). Sinuosity greater than 1.5 is considered meandering (Leopold *et al*. 1964 in WEST 2001). Gradient is highest in this reach, ranging from 1.1 to 1.4 feet/mile (WEST 2001). Land use is primarily agricultural (Appendix E). Riparian vegetation in the upper portion of Reach 1 consists primarily of grasses. Small trees and shrubs are present in some areas. Substrate is generally fine (silt-clay) and homogenous in slower-flowing areas, and coarse (boulder, rubble, cobble, gravel), stable, and heterogenous in faster-flowing areas. In-stream cover consists of emergent vegetation, undercut banks, and boulders, with woody debris present in areas where trees occur in the riparian zone. Most of the tributaries in Reach 1 are intermittent coulees. However, a few very small permanent coulees and creeks are present (Robinson Coulee, Colvin Coulee, Johnson Lake, Silver Creek, McVille Coulee, and Pickerel Lake Creek).

Segment L

Segment L is upstream of where Peterson Coulee enters the Sheyenne River (Appendix E-1). This segment of the Sheyenne River meanders through pastureland that has a slightly rolling topography and is vegetated primarily with grasses. Riverbanks are sloping (2:1 to 3.3:1, presented as a ratio of horizontal to vertical), but not high and are covered with grasses (Appendix F). Minimal bank erosion is apparent. In-stream cover consists of aquatic vegetation (both emergent and submergent), undercut banks, boulders, and some woody debris.

Habitat is rather diverse, consisting of shallow pool, medium pool, raceway, and slow riffle. A riffle/pool/raceway/pool/riffle sequence was selected for modeling, with transects established through each of these habitats and transition areas between habitats. Under fall and winter conditions (low flow) habitat is primarily shallow and medium pool, with some slow riffle (Figure 3-5). The proportion of raceway habitat increases with discharge, and only a small proportion of fast riffle habitat is present during low flow. Summer discharge is more variable than fall/winter, and as discharge increases, raceway habitat increases and shallow and medium pool habitats decline. Spring discharge is still more variable than summer. Raceway is the predominant habitat in spring, with fast/deep habitat also increasing with flow. Substrate is primarily silt-clay, gravel, and cobble near the banks and a mixture of cobble, gravel, sand, and silt-clay in the center of the channel, although gravel is the predominant substrate (Figure 3-6).

The channel is narrow and fairly deep, ranging from less than one foot near the riverbanks to over four feet mid-channel in some areas. Current velocity at the time of sampling in October 1998 (Earth Tech, Inc. 1998) was reversed along the banks and less than 0.3 feet/sec. in most areas, although

velocity did reach up to 1.5 feet/second (ft/sec) in the fast riffle area (Appendix D). Channel forming flow near Warwick was estimated at 520 cfs (WEST 2001).

Segment K

Segment K is downstream of where Peterson Coulee enters the Sheyenne River (Figure 3-1; Appendix E-2). Similar to Segment L, this section of the Sheyenne River meanders through pastureland and the riverbanks are vegetated with grasses (Appendix F). Banks are sloping, but not high (1.7:1 to 2.2:1), and erosion is minimal. In-stream cover, in the form of emergent and submergent aquatic vegetation, is present throughout the study site. Cover is also provided by boulders and undercut banks.

The relatively wide and deep channel present at Site K3 is not particularly diverse in terms of aquatic habitat. Most of the area is shallow and medium pool under normal flow conditions, although a shallower, rocky area is present that would form a riffle or run at higher discharge. At 1,000 cfs, water stays primarily within the channel (Appendix E-2). Substrate near the banks was primarily silt-clay, but was heterogenous, stable, and coarse in much of the channel, particularly in the riffle area (Figure 3-7; Appendix D). Depth ranged from less than 1 foot to 3.2 feet. Current velocity was slow (less than 0.2 feet/sec.) even in mid channel areas.

Segment J

Segment J is near Sheyenne, North Dakota (Figure 3-1; Appendix E-3). This segment also flows through grassland and the riverbanks are vegetated with grass. Although this area is similar in slope to the rest of Reach 1 (1.2 feet/mile), this is the least meandering portion of Reach 1 with a sinuosity of only 1.0 (Appendix D). Stream banks are fairly low (4.6:1 to 8.3:1) and bank erosion is minimal. At 1,000 cfs, water exceeds the banks on the north side and spreads out over the floodplain (Appendix E-3). Instream cover is provided by emergent aquatic vegetation (cattails) and submerged floating-leafed vegetation (pond-weed).

The relatively wide and deep channel present at Site J1 is not particularly diverse in terms of aquatic habitat. Habitat is limited to shallow and medium pool, and no riffle or raceway areas were observed. Bottom substrates were sand/silt (Yager 1998).

Segment I

Segment I is east of Sheyenne and west of Tolna, North Dakota (Figure 3-1; Appendix E-4). This segment also flows through grassland, but some trees are present in the riparian zone (Appendix F). This is the most meandering segment in Reach 1, with a sinuosity of 1.98 (Appendix D). The river gradient is 1.4 feet/mile. Riverbanks are sloping (3.5:1) to steep (0.1:1) and are higher than upstream areas. Water is mostly contained within the channel at 1,000 cfs (Appendix E-4). Some bank-sloughing is apparent. In-stream cover along banks includes boulders and woody debris as well as scattered aquatic vegetation (emergent). Boulders and vegetation are also present mid-channel.

Habitat is primarily shallow to medium pool, but slow riffle and raceway are also present. A riffle/pool/raceway/riffle sequence was selected for modeling with transects established through each of

these habitats and transition areas between habitats (Appendix E). Depth near the riverbank ranges from 0.1 to 0.6 feet and from 1 foot in the riffle to 3 feet in mid-channel pools. Substrate is heterogenous and very coarse, even near the banks, consisting of boulder, rubble, cobble, gravel, sand, and silt-clay (Figure 3-8). Current velocity in pools is less than 0.4 ft/sec, while riffle velocity is up to 1.2 ft/sec (Appendix D).

Segment H

Segment H is near Pekin and Tolna, North Dakota, where the Sheyenne River turns south (Figure 3-1). The river meanders with a sinuosity a 1.7 through a moderately forested riparian corridor. Most of the vegetation immediately along the river is grass (Appendix F). River gradient is slightly less than in Segment I at 1.1 feet/mile. Banks are sloping to steep (3.1:1 to 1.9:1). Inside bends are fairly flat and most outside bends are steep and sloughing. At 1,000 cfs, water inundates the lower part of the floodplain (Appendix E-5). Channel-forming flow near Cooperstown was estimated at 760 cfs (WEST 2001). In-stream near-bank cover includes boulders and woody debris, as well as scattered aquatic vegetation (emergent). Boulders also provide cover in the channel (Appendix D).

This site contains the most diverse habitat in Reach 1. A raceway/pool/riffle/pool/raceway sequence was selected for modeling, with transects established through each of these habitats and at transition areas between habitats (Appendix E). Spring flow results in a fairly equal mix of slow riffle, fast riffle, and raceway with moderate discharge, with raceway and fast riffle predominating at higher discharges (Figure 3-9). Summer and fall discharges typically result in a mix of shallow pool, slow riffle, fast riffle and raceway. During winter, low-flow habitat is mostly shallow pool and slow riffle (Figure 3-9). The substrate is a mix of boulder, cobble, gravel, and sand; however, gravel is the dominant substrate type (Figure 3-10). Silt-clay is minimal, even along the riverbanks. Depth ranges from 0.8 to 2.6 feet in the deepest parts of the channel. Current velocity is swift throughout the site, with back currents along banks, and flow in excess of 1 ft/sec in mid-channel (Appendix D).

Segment F

Segment F is the farthest downstream portion of Reach 1, occurring near Cooperstown, North Dakota, and upstream of Lake Ashtabula (Figure 3-1). Land use and the riverbanks are similar to Segment I, although the gradient (1.1 feet/mile) is similar to Segment H. The riparian zone consists primarily of grasses with scattered trees (Appendix F). The riverbanks are low (3.1:1) to steep (0.1:1), with bank sloughing apparent (Appendix D). In-stream cover consists primarily of woody debris.

Because of the width of the channel, habitat is rather homogenous despite the meandering nature of the stream and moderate gradient (Appendix D). Habitat is limited to shallow and medium pool, and no riffles or raceways are present. Depths range from 0.7 to 2.7 feet. Maximum current velocity is only 0.5 ft/sec Bottom substrates are sand/silt.

3.5.1.2 Sheyenne Reach 2

Reach 2 is also located in the glacial drift plains, but was modified by Baldhill Dam in 1951 (Johnson *et al*. 1974). Habitat is therefore lentic rather than lotic. Baldhill Dam impounds approximately 41.8 miles of the Sheyenne River and is up to 0.6 miles wide (Johnson *et al*. 1974). Water

depth is about 40 feet behind the dam, and decreases about one foot per mile upstream of the dam (Johnson *et al*. 1974). A minimum discharge of 3 cfs is maintained at all times. Since it is so shallow, the lake seldom stratifies (Johnson *et al*. 1974). The lake acts as a nutrient and sediment trap, and bottom material consists of "fine ooze" (Johnson *et al*. 1974). The decrease in flow and turbidity encourages the growth of macrophytes and algae. Baldhill Creek is the only permanent tributary that enters the Sheyenne River within the lake.

3.5.1.3 Sheyenne Reach 3

Reach 3 also flows through the glacial drift plain, but is downstream of Lake Ashtabula (Figure 3-1). The channel is less stable than in other reaches and appears to be narrowing and deepening (WEST 2001). This is perhaps the most scenic portion of the river, and a scenic highway borders the river valley. Although land use is still primarily agricultural, the river valley is wider and deeper than upstream of Lake Ashtabula, and the valley slopes are primarily wooded. Spring Creek near Kathryn, North Dakota, is the only permanent stream that flows into the Sheyenne River in this reach.

Segment E

Segment 3 begins downstream of Baldhill Dam, near Valley City, and extends to upstream of Fort Ransom. A pool/riffle/raceway/pool sequence was selected for modeling, with transects established through each of these habitats and at transitions areas between habitats (Appendix E).

The Sheyenne River in this reach meanders, with a sinuosity of 1.98, through a forested valley (Appendix E-5). However, the stream gradient is only 0.7 feet/mile in the sampled area. Stream banks are covered with grass and trees, but unlike upstream areas trees comprise 30 to 40 percent of the bank cover (Appendix F). Riverbanks are moderately sloped (2.1:1) to steep (0.5:1), and some bank sloughing is apparent but is less extensive than in Segment H. In-stream cover is abundant with overhangs, boulders, woody debris and scattered emergent aquatic vegetation. Due to the steeper valley in this area, 1,500 cfs water stays primarily within the riparian zone (Appendix E).

As with Segment H, habitat is diverse in the sampled area. However, habitat is not this diverse in most of Segment E (Yager 1998). At the higher spring discharges, habitat is primarily fast/deep and raceway (Figure 3-11). During the remainder of the year, discharge is variable. At moderate discharges (<50 cfs, 50 percent exceedence) habitat consists of shallow pool, medium pool and raceway. As discharge increases shallow pool decreases and raceway increases (Figure 3-7). Channel-forming flow downstream of Baldhill Dam was estimated at 880 cfs (Table 3-5).

Maximum depth ranges from 1.8 feet in raceways to over 4 feet in deeper pools. The substrate is primarily silt and clay near the banks but is more coarse and diverse in mid-channel. This segment had the highest measured current velocity at 4.2 ft/sec, despite the reduced gradient. Back currents are common along banks, and velocity ranges from less than 0.8 ft/sec in pools to over 4 ft/sec in raceways (Appendix D).

Segment D

Segment D is located in the glacial plain, just upstream of Lisbon and the transition to the sand delta, which borders Glacial Lake Agassiz (Figure 3-1). Habitat data were not collected in this area, but fairly diverse riffle and raceway habitat was observed, and substrates consisted of gravel, silt and boulders (Yager 1998).

3.5.1.4 Sheyenne Reach 4

Reach 4 flows through the sand delta, between Lisbon and Kindred (Figure 3-1). Habitat data were not collected in this reach because of the lack of sensitive habitat types, although habitat observations were recorded at Habitat Segment C2. Substrate and riverbanks in this area are highly erodable, and erosion between 1940 and 1998 averaged 2.3 feet/year in some sections (WEST 2001). Reach 4 contains a few unique spring-fed tributaries.

The relatively wide and deep channel present at Site C2 was not particularly diverse in terms of aquatic habitat. No riffle or raceway areas were observed. Bottom substrates were uncompacted sand, which suggests a constantly shifting habitat condition. In-stream cover in the form of woody debris (snags) was present (Yager 1998).

3.5.1.5 Sheyenne Reach 5

Reach 5 flows through Glacial Lake Agassiz and is in the same physiographic region as the Red River. Reach 5 extends from near Kindred to its confluence with the mouth of the Red River. Topography is very flat and the stream gradient is very low at 0.6 feet/mile. The river in this reach appears to be widening and becoming shallower (WEST 2001). The Maple River, which is a fairly large tributary, enters the Sheyenne River downstream of Fargo.

Segment B

Segment B extends from downstream of Kindred to near Horace (Figure 3-1). The sampled segment has the highest sinuosity (3.44) and the lowest gradient (0.6 feet/mile) of the sampled habitat segments. The channel is fairly wide and deep, and water at 1,500 cfs is maintained primarily within the riparian zone (Appendix E-6). Channel-forming discharge near Kindred was estimated at 920 cfs (Table 3-5). Land use is primarily agricultural (cropland). The riparian buffer consists of small trees and grass (Appendix F). In-stream cover is provided by overhangs and woody debris, although this portion of river may frequently be cleared of woody snags (Yager 1998). Woody debris is also common in mid-channel. The substrate is not diverse and is primarily silt-clay along the riverbanks, with some gravel and sand mid-channel. Habitat at lower spring and summer discharges and during winter and fall is dominated by medium pool and raceway, with some slow riffle and shallow pool (Figure 3-12). As flow discharge increases the channel becomes deep and fast, and shallow slow habitats diminish. Habitat diversity during low to moderate discharge is probably due to the variable depths and currents produced by woody debris in the channel. The primarily sand and silt portions of the substrate are probably eroded and deposited during higher flows, and habitat is likely not very stable.

Segment A

Segment A extends from near Horace to the mouth of Sheyenne River. This segment was similar to B and habitat data were not collected, but observations were recorded.

The relatively wide and deep channel present at Site A2 is not particularly diverse in terms of aquatic habitat. No riffle or raceway areas were observed. Bottom substrates are silt and clay, with very little rock present. In-stream cover in the form of woody debris (snags) is present; however, it appears this portion of the river is frequently manually cleared of woody snags (Yager 1998).

3.5.2 Red River

The Red River flows through Glacial Lake Agassiz. The area has little topographic relief, as the difference in altitude between Wahpeton, North Dakota, and Canada is only 350 feet (Koel 1997). Land use in the basin is primarily agricultural (Stoner *et al*. 1993). The river is sinuous, although no specific sinuosity factor is available. It is lacking in slope, resulting in no stream gradient. Streambanks are fairly straight and substrate consists of sand, clay, and silt. Woody debris is available for cover (Koel 1997). Habitat is primarily runs and bends. Unlike the Sheyenne River, the Red River has several large tributaries that enter the river within the project area. North Dakota tributaries include Sheyenne, Elm, Goose, Turtle, Forest, Park, Tongue, and Pembina Rivers. Minnesota tributaries include the Buffalo, Wild Rice, Sandhill, Red Lake, Snake, and Tamarac Rivers. Cities that discharge to the river include Fargo, Grand Forks, and Pembina.

A series of low-head dams occur on the Red River, which further reduces current velocity. The MnDNR has recently been rehabilitating these dams into raceways, which should improve flow and habitat diversity.

3.6 BIOTA

3.6.1 Fish

Fish have been collected at numerous locations throughout the Sheyenne and Red Rivers (Figure 3-13). Peterka and Koel (1996) reported 84 species of fish (77 native species and 7 introduced species) from the Sheyenne/Red River Basin (Table 3-11). Species common throughout the mainstem portions of both rivers include blackside darter (*Percina maculata)*, fathead minnow (*Pimephales promelas*), common shiner (*Luxilus cornutus*), white sucker (*Catostomus commersoni*), and Johnny darter (*Etheostoma nigrum*) (Goldstein *et al*. 1996). No federally listed species are present and only one species of management concern, greater redhorse (*Moxostoma valenciennesi)*, is present (USGS 1995a). A number of the species reported are restricted to lakes or tributaries within the basin.

Although no state or federally listed fishes are present, USFWS, using the Natural Heritage Program database, has identified several rare fish in the Sheyenne and/or Red Rivers. Many of these are also listed by the North Dakota Game and Fish (NDGF) (1994) as special concern (SC1 and SC2), threatened (T), or peripheral (P):

- Logperch (*Percina caprodes*) Red River only (SC2)
- Yellow bullhead (*Ameiurus natalis*) Red River only (SC2)

- Blacknose shiner (*Notropis heterolepis*) Mainly Tributaries (SC1)
- Pugnose shiner (*Notropis anogenus*) Tributaries (T)
- Northern redbelly dace (*Phoxinus eos*) Tributaries (SC1)
- River shiner (*Notropis blennius*) Lower Sheyenne River (SC3)
- Rosyface shiner (*Notropis rubellus*) Lower Sheyenne River (SC1)
- Greater redhorse (*Moxostoma valenciennesi*) Lower Sheyenne River (P)
- Banded killifish (*Fundulus diaphanus*) Lower Sheyenne River (P)

Other species listed as special concern in North Dakota (NDGF 1994) and found in the Red or Sheyenne Rivers or their tributaries include chestnut lamprey (*Ichthyomyzon castaneus*-SC1) and silver lamprey (*Ichthyomyzon unicuspis*-SC2), silver chub (*Macrhybopsis storeriana*-SC2), hornyhead chub (*Nocomis biguttatus*-SC1), flathead chub (*Platygobio gracilis*-SC1), trout-perch (*Percopsis omiscomaycus*-SC2), and river darter (*Percina shumardi*-SC2).

It should be noted that although these species are rare in North Dakota, with the exception of pugnose shiner they are common to abundant elsewhere in their respective ranges. Also, the fact that they are rare reveals nothing about their sensitivity. Logperch is restricted to the Red River and yellow bullhead is restricted to tributaries of the Red River and, as such, are not likely to be affected by the project. Blacknose shiner, pugnose shiner, and northern redbelly dace mainly inhabit the spring-fed tributaries in Reach 4 of the Sheyenne River. Since, with the possible exception of blacknose shiner, they are not regular inhabitants of the mainstem, these species are not at particular risk from the various project alternatives. River shiner, rosyface shiner, banded killifish, and greater redhorse inhabit the lower Sheyenne River and, as a result, could be affected by the project.

Environmental factors affecting fish distribution in the Red River Valley were studied by Goldstein *et al.* (1996) and Koel (1997). Water quality, hydrology, geomorphology, and habitat all play a significant role in fish distribution. Mean channel width, coefficient of variation of velocity, number of substrates, riverine wetlands, coefficient of variation of mean April flow, mean annual frequency of high flow, and frequency of erosion were environment variables most closely correlated with fish distribution (Goldstein *et al.* 1996). Koel (1997), using similar methods (ordination analysis), found residue (TDS), specific conductivity, average annual discharge, mean monthly discharge, average low discharge during May, and hardness to be the factors explaining most of the variance in fish distribution. Goldstein *et al.* (1996) provide a simplified summary of Red River fish species and factors correlated with distribution (Figure 3-14). Small stream fishes occurred in areas with low habitat volume, discharge variability, habitat diversity, and turbidity; forested riparian zones; and low dissolved oxygen. Large stream fishes tended to occur in areas with high habitat volume, discharge variability, habitat diversity, and turbidity, wetland riparian zones; and high DO (Figure 3-14).

The mainstem Sheyenne River, though considerably smaller than the Red River, supports the more diverse fish community. Species from all Goldstein *et al.*'s (1996) fish groups occur in all reaches of the

Sheyenne River, attesting to the variety of water quality, hydrology, and habitat conditions that exist throughout. At least 60 species have been reported from the Sheyenne River, most from the mainstem, compared to only 40 species from the mainstem Red River (Table 3-11 and Peterka 1978). Many of the species from the mainstem Sheyenne and Red Rivers are considered to be tolerant to habitat disturbance, temperature extremes, low DO, and other fluctuating environmental factors (Goldstein *et al*. 1996 and Table 3-12).

3.6.1.1 Sheyenne River

Reach 1 - Upper Sheyenne River

Approximately 30 of the 60 Sheyenne River species occur in the upper mainstem (Goldstein 1995, Table 3-11), where flows are often intermittent (Peterka 1978). Peterka (1978) suggested that low DO concentrations and periods of no flow are important factors contributing to the low species diversity in the upper Sheyenne. Fishes that are common in the upper Sheyenne River are creek chub (*Semotilus atromaculatus)*, common shiner, fathead minnow, white sucker, black bullhead (*Ameiurus melas*), and brook stickleback (*Culaea inconstans*) (Tubb *et al*. 1965). Most of these are considered to be generalists and can occur in a variety of habitats (Table 3-12) (Lyons 1992, Goldstein *et al.* 1996). Large river species are rarest in this reach. Peterka (1978) indicates that bigmouth shiner (*Notropis dorsalis*) is the only native species that has been eliminated from the upper Sheyenne River since the closing of Baldhill Dam. Trout-perch is the only North Dakota species of concern in Reach 1.

No permanent tributaries occur within Reach 1.

Twenty-five of the 30 species in the mainstem upper Sheyenne River have been reported as fish hosts for the nine species of unionids that occur in this reach (Appendix G). Species that have been reported as host for at least four of the upper Sheyenne River unionid species include creek chub, green sunfish (*Lepomis cyanellus*), pumpkinseed (*Lepomis gibbosus*), bluegill (*Lepomis macrochirus*), largemouth bass (*Micropterus salmoides*), white (*Pomoxis annularis*) and black crappie (*Pomoxis nigromaculatus*), yellow perch (*Perca flavescens*), and walleye (Appendix G-1).

Reach 2 - Lake Ashtabula

Twenty-seven species of fish have been reported from Reach 2, and 26 of these species (with the exception of bigmouth shiner) are also found upstream of the reservoir in Reach 1 (Table 3-11). Twenty-one of these species serve as hosts to the seven unionid species that have been found in Lake Ashtabula (Appendix G-2).

Reach 3 - Lower Sheyenne River, Glacial Drift Plains

Reach 3 is the most diverse reach of the Sheyenne River, with 51 species of fish having been reported (Table 3-11). Fishes that are commonly abundant in this reach are common shiner, spotfin shiner (*Cyprinella spilopterus*), bluntnose minnow (*Pimephales notatus*), shorthead redhorse (*Moxostoma macrolepidotum*), golden redhorse (*Moxostoma erythrurum*), smallmouth bass (*Micropterus dolomieui*), blackside darter, and Johnny darter (Peterka 1978). Species that are locally

common are creek chub, rosyface shiner, spottail shiner (*Notropis hudsonius*), sand shiner (*Notropis stramineus*), and white sucker (Peterka 1978). Ten species in this reach are listed as special concern, threatened, or peripheral in North Dakota NDGF (1994): chestnut lamprey, hornyhead chub, pugnose shiner, blacknose shiner, rosyface shiner, silver redhorse (*Moxostoma anisurum*), greater redhorse, trout-perch, banded killifish, and river darter (Table 3-11). Peterka (1978) attributes the abundance and diversity of fish in this reach to good habitat quality, namely large amounts of gravel and numerous riffles.

No permanent tributaries drain into the Sheyenne River within Reach 3.

Of the 51 species reported in this reach, 38 may serve as hosts to the 11 or 12 unionid species that have been reported from Reach 3 (Appendix G-3).

Reach 4 - Lower Sheyenne River, Sand Delta

This reach also supports a fairly high fish diversity (39 species, Table 3-11). This is a transition area between the predominantly hard substrates of Reach 3 and the soft substrates in Reach 5. This area is unique in that several spring-fed tributaries enter the river in this reach. As a result, some small-stream species [e.g., blacknose dace (*Rhinichthys atratulus*)] or clear water species [e.g., blacknose shiner, blackchin shiner (*Notropis heterodon*), and northern redbelly dace] are essentially restricted to this area. Although some of these species have been reported from the mainstem Sheyenne River, most are waifs from the tributary streams, except for possibly the blacknose shiner. Species common in the Reach 4 mainstem are spotfin shiner, sand shiner, bigmouth shiner (*Notropis dorsalis*), bluntnose minnow, shorthead redhorse, and white sucker. Six species in this reach are listed as special concern, threatened, or peripheral in North Dakota (1994); blacknose shiner, rosyface shiner, northern redbelly dace, silver redhorse, greater redhorse, and trout-perch. Of the 39 fish species reported, 29 may serve as hosts for the 11 or 12 unionid species that have been reported in Reach 4 (Appendix G-4).

Reach 5 - Lower Sheyenne River, Glacial Lake Agassiz

Because of less habitat diversity and more homogenous substrates, this reach possesses fewer species (32 species, Table 3-11) than the other downstream reaches. However, the fish fauna is a mix of large-river species and smaller-stream species (Table 3-11). A number of large-river species are either restricted to or most abundant in this reach (Peterka 1978; Table 3-11): freshwater drum (*Aplodinotus grunniens*), goldeye (*Hiodon alosoides*), channel catfish, silver chub, emerald shiner (*Notropis atherinoides*), sauger (*Stizostedion canadense*), and bigmouth buffalo (*Ictiobus cyprinellus*). Only three species in Reach 5 (silver chub, silver redhorse, and trout perch) are of special concern in North Dakota. Of the 32 fish species in this reach, 21 may serve as fish hosts for unionids (Appendix G-5). Because the Red River contains either common, widespread species or those preferring large rivers as described below, the lower reaches of the Sheyenne River would not be expected to be important as a migration route from the Red River to the upper Sheyenne River.

Fish species have been reported from two tributaries that drain into the Sheyenne River within this reach, the Rush River and Maple River (Ryckman 1991, Goldstein *et al*. 1996). Fourteen species and 28 species have been reported from the Rush and Maple Rivers, respectively (Table 3-13). Most of these species are common to both of these tributaries and the lower Sheyenne River. Only brown bullhead

(*Amierus nebulosus*) and blackside darter were found in the tributaries but not in either Reach 4 or 5 of the Sheyenne River. In contrast, many of the special concern species in the lower Sheyenne were not reported from these tributaries: blacknose shiner, rosyface shiner, and trout perch (Tables 3-11 and 3-13).

3.6.1.2 Red River

Reaches 1, 2, and 3 of the Red River all lie within the Red River Valley ecoregion (Goldstein 1995). Because all three reaches are in the same ecoregion and habitat diversity throughout the study area is low, similar fish communities occur among the three reaches.

Species richness is lower in the Red River than in the smaller Sheyenne River, likely due to a lack of habitat diversity within the Red River. However, the Red River supports an internationally known trophy channel catfish fishery (Stoner *et al*. 1993, USFWS 1999a). The MnDNR is also in the process of reintroducing lake sturgeon (*Acipenser fulvescens*) into the Red River (USFWS 1999a). Approximately 50 species have been documented from the mainstem Red River (Table 3-11). The Red River contains 15 species that are widely distributed throughout the Sheyenne and Red River areas: black bullhead, white sucker, brook stickleback, northern pike, common shiner, longnose dace (*Rhinichthys cataractae*), spottail shiner, sand shiner, fathead minnow, creek chub, tadpole madtom (*Noturus gyrinus*), trout-perch, black crappie, walleye, and blackside darter (Table 3-11). In addition to these widespread, often common species, the Red River possesses 12 species that are typically restricted to large rivers: emerald shiner, river shiner, silver chub, flathead chub, quillback (*Carpiodes cyprinus*), bigmouth buffalo, silver redhorse, goldeye, mooneye (*Hiodon tergisus*), river darter, sauger, and freshwater drum (Table 3-11). Species of special concern in the Red River include chestnut and silver lamprey, silver chub, rosyface shiner, flathead chub, silver and greater redhorse, and trout-perch (Table 3-11). Species sensitive to environmental disturbance are uncommon (Lyons 1992).

Several tributaries that harbor a diversity of fish flow into the Red River. Only two of the species in Reach 1 were not reported from Reach 1 tributaries (silver chub and river shiner), both of which of are special concern in North Dakota. Only four of the fish species in Red River Reach 2 were not found in Reach 2 tributaries: goldeye, river shiner, flathead chub, and logperch; all North Dakota special concern species (except goldeye). Fifty species were found in Reach 3, three of which were not reported from tributaries (silver redhorse, burbot, and logperch, Table 3-13).

Of the 50 fish species in the Red River, 30, 29, and 33 may be serving as fish hosts for unionids in Reaches 1, 2, and 3, respectively (Appendix G-6).

3.6.2 Mollusks

Most of the Sheyenne and Red River mollusk data were collected by Cvancara in the 1960s and 1970s (Cvancara 1970a, Cvancara and Freeman 1975, Cvancara 1976). Data from these studies were compiled in "*Aquatic Mollusks of North Dakota*" in 1983 (Cvancara 1983). Kreil *et al*. (unpublished manuscript) resampled most of Cvancara's Red and Sheyenne River sites in 1991. Many of these stations were near habitat transects (Figure 3-15). A few unionids were also collected during recent benthic invertebrate sampling (Earth Tech, Inc., and DeLorme) and noted during field reconnaissance (Dunn, pers. obs.). A species list by reach is provided in Table 3-14.

Cvancara (1983) reported 44 aquatic mollusk species in North Dakota: 13 unionid species (Unionidae), 9 fingernail clams (Sphaeriidae), and 22 snail species (Gastropoda). The northeast region of North Dakota, which includes the Sheyenne and Red Rivers, is the most species rich and harbors the highest density of mollusks in the state (Cvancara 1983). All 13 unionid species, 7 of the sphaeriid species, and 17 of the gastropod species have been collected in the Sheyenne and Red Rivers (Table 3-14). The only unionid species not common to both rivers are *Lasmigona compressa* which was found only in the Sheyenne River, and *Potamilus ohiensis*, which was only found in the Red River. Six of the seven Sphaeriidae species have been found in the Sheyenne River, while only *Sphaerium transversum* have recently been reported as live specimens by Cvancara (1983) and have been found live only in the Red River. Only 12 and 6 of the 17 gastropod species are recorded as extant in the Sheyenne and Red Rivers, respectively (Table 3-14).

Most of the mollusk species found in the Red and Sheyenne Rivers are considered tolerant to organic enrichment and disturbance (Barbour *et al*. 1999). Most of the gastropods are pulmonates (air breathers), and some sphaeriids can survive within the hyporeic zone for extended periods.

3.6.2.1 Sheyenne River

Reach 1

Reach 1, the upper reach of the Sheyenne River, is the most diverse with respect to sphaeriids and gastropods, and harbors eight of the 13 unionid species. Most of the unionid species in this reach are typical small-stream species (Table 3-14). Cvancara (1983) classifies *Amblema plicata* and *Fusconaia flava* as large-river species. However, these species are also found in small permanent streams in most areas of the Midwest (Cummings and Mayer 1992). Likewise, the sphaeriids and gastropods are primarily small stream-species. Sphearidae are fairly abundant in this reach, and comprise 13 percent of the invertebrates collected recently by Earth Tech, Inc., and DeLorme. Recent gastropod collections include *Amnicola limosa*, *Cincinnatia cincinnatiensis*, *Ferrissia* sp., *Gyraulus parvus*, and *Physa gyrina* (Earth Tech, Inc., and DeLorme). Unionid species recently collected include *F. flava, Anodontoides ferussacianus*, *L. compressa*, *Pyganodon grandis*, and *Lampsilis siliquoidea* (Dunn and DeLorme, pers. obs.). Unionids were also noted during habitat sampling within habitat transects in segments L, K, J, I, and H. These areas all had a diversity of habitats, including shallow pools and riffles or raceways.

Few mollusks have been found upstream of Reach 1 and tributaries to this reach are intermittent. Cvancara (1983) had a few sites upstream of Reach 1 but found only shells of *L. siliquoidea* and *P. grandis*. More recently Earth Tech, Inc., and DeLorme sampled three sites upstream of Peterson Coulee and found live *L. siliquoidea*, *Psidium* sp., *Sphearium* sp., *Ferrissia* sp., Planorbidae, *Physa* sp., and *Valvata tricarinata* (Table 3-15).

Reach 2

Reach 2 of the Sheyenne River includes Lake Ashtabula. Lake Ashtabula has not been sampled for unionids since Cvancara's survey in 1974 (Cvancara and Freeman 1975). Most unionid species prefer flowing water, and only four unionid species were found live within Reach 2 (Table 3-14). Thinner-shelled species, such as *P. grandis* and *Lasmigona complanata,* are adapted to lentic situations.

Lampsilis siliquoidea is an ubiquitous species that tolerates a wide variety of habitats and is not uncommon to reservoirs. *Amblema plicata* can also be found in lakes but is less tolerant of lentic conditions than the other species recorded from the lake.

Reach 3

Reach 3 is still within the drift plains but is downstream of Lake Ashtabula and begins to take on the character of a larger river. It is also less hydrologically flashy than upstream habitat, and habitat stability is often the most important factor for unionid colonization (Maio and Corkum 1995, Hardison and Layzer 2001). Unionids were noted during habitat sampling at Segment E, where habitat consisted of riffles, raceways, and shallow pools. A juvenile *P. grandis* was recently collected in this reach by Earth Tech, Inc., and DeLorme. *Sphaerium* sp. were found by Earth Tech, Inc., and DeLorme but were not as abundant as in Reach 1. Gastropods recently collected include *A. limosa*, *C. cincinnatiensis*. *G. parvus*, *Physa* sp., and *Probythinella lacustris* (Earth Tech, Inc., and DeLorme).

Unionid species richness increases while Sphaeriidae and gastropod species richness declines in Reach 3. Unionid species found in the lower Sheyenne River but not in the upper Sheyenne include *Quadrula quadrula* and *Potamilus alatus*, both of which are typical of larger streams. Interestingly, both of these species seem to be increasing their range in other parts of the country and are some of the first species to recolonize areas where water quality, substrate, and flow have improved to the point where unionids can be supported (ESI 2000). *Quadrula quadrula* was not reported from the lower Sheyenne River by Cvancara (1976) but was found by Kreil *et al*. (unpubl. man.) in 1991 and 1992. Similarly, most of the gastropods and sphaeriid species found in this reach are more typical of permanent small and large rivers (Table 3-14).

Reach 4

Reach 4 is a small reach within the sand delta. Although substrate is sandier and more erodible in this reach, unionids are still present. The presence of unionids indicates that at least a few areas within the reach have stable channels. In contrast, many of the gastropod and sphaeriid species that historically occurred in this reach are no longer present. Earth Tech, Inc., and DeLorme did not find any unionids, sphaeriids, or gastropods in his recent samples. However, only one site within this reach was sampled.

Reach 5

Reach 5 is in the Glacial Lake Agassiz region. The river in this reach is very low gradient and most of the substrate is clay. Nevertheless, unionids still seem to be present. The unionid, sphaeriid, and gastropod communities in Reach 5 are similar to Reach 4. One unionid (*Lampsilis cardium)* and a few sphaeriids were recently found (Earth Tech, Inc., and DeLorme). The gastropods *Gyraulus* sp., *Lymnaeidae*, and *P. gyrina* were also present (Earth Tech, Inc., and DeLorme).

Mollusks have been reported from the one permanent tributary stream that flows into the Sheyenne River, the Maple River (Table 3-15). No recent data on mollusks were found for the Maple River; however, Cvancara (1983) found evidence of five Unionidae, four Sphaeriidae, and eight Gastropoda. All of the species found in the Maple River are typical of intermittent and small streams, and the mollusk fauna was not as diverse as in Sheyenne River Reach 5. All of the unionid species found in the Maple River were also reported from Sheyenne River Reach 5 (*A. ferussacianus*, *F. flava*, *L. siliquoidea*, *L.*

complanata, and *P. grandis)*. However, larger river taxa that occur in the lower Sheyenne River have not been found in the Maple River (*A. plicata*, *L. cardium*, *Ligumia recta*, and *P. alatus*). In contrast, only one of the Sphaeriidae species (*S. transversum*) and two Gastropoda species (*P. gyrina* and *P. integra*) were found in both the lower Sheyenne and the Maple Rivers (Tables 3-14 and 3-15). Both *Physa* sp. are tolerant of a wide variety of habitats, while *S. transversum* is most commonly found in small to large permanent streams.

3.6.2.2 Red River

Reach 1

In contrast to the Sheyenne River, species richness declines in the downstream reaches of the Red River. Twelve unionid species, and five gastropod species were found in Reach 1. Smaller stream species, such as *L. compressa,* were not found in the Red River. *Potamilus ohiensis*, however, was found in Red River Reach 1 but not in the Sheyenne River or further downstream in the Red River. Cvancara (1983) lists this species as mostly occurring in small streams. However, it is common in marginal flow areas of larger rivers such as the Mississippi River (Dunn, pers. obs.). The gastropod species found alive in this reach were also found live in Reach 3 of the Sheyenne River but appeared to be extirpated from the lower Sheyenne River (Table 3-14). *Sphaerium transversum* was collected throughout the lower Sheyenne River.

All of the unionid species found in Red River Reach 1 have also been found in tributaries of this reach. Three species were found in Bois de Sioux River, 13 species including one species not found in Reach 1 (*Actinonaias ligamentina*) were found in the Otter Tail River (MN), four species were reported from the Wild Rice River (ND), eight species were reported from the Red River south of Fargo, North Dakota, seven species were found in the Buffalo River, and 11 species were reported in the Wild Rice River (MN) (Table 3-15). However, unionids appear to be absent from the lower reaches of many of these rivers. In both the Red River upstream of Fargo and the Bois de Sioux River, unionids were not found within 30 miles upstream of the mouth of the Otter Tail River, Minnesota (Cvancara 1983). Cvancara (1983) also did not report any unionids in the lower 50 miles of the Wild Rice River (ND). The lower Otter Tail River may still support unionids. Hanson *et al*. (1984 in Goldstein 1985) found 11 unionid species downstream of Orwell Dam on the Otter Tail River. Hart (1995) also sampled the Otter Tail River, but his furthest downstream site was upstream of Orwell Reservoir. Cvancara (1983) reported unionids near the mouth of the Buffalo River and Wild River (MN), but no unionids near the mouth of the Elm River.

Cvancara (1983) also reported three species of Sphaeriidae in the Wild Rice River (ND), one of which (*S. transversum*) also occurs in Reach 1 of the Red River. Of the 10 Gastropoda reported by Cvancara (1983) in the Wild Rice River (MN) and Red River south of Fargo, five also occur in Reach 1 of the Red River; *Ferrissia rivularis*, *Heliosoma trivolvis*, *P. gyrina*, *P. integra*, and *P. lacustris*.

Reach 2

Unionid species richness declines to 10 species in Red River Reach 2, and only one live sphaeriid species and two live gastropod species were found in this reach (Table 3-14). Relative abundance was also

noticeably lower in the reach according to Cvancara (1970a), and evidence of a recent unionid die-off was found downstream of Grand Forks by Kreil *et al*. (unpublished manuscript).

Mollusks have been reported from the three permanent tributaries in this reach: Goose River, Sand Hill River, and Red Lake River (Table 3-15). Cvancara (1983) and Cvancara *et al*., (1981) reported 13 unionid species, and unionids were found near the mouth in these tributaries. Red Lake River is possibly the best unionid stream in the Red River Valley (Cvancara *et al*. 1981). Four Sphaeriidae species and four Gastropoda species were also reported by Cvancara (1983) in the Goose River. Thus, most of the species found in Red River Reach 2 have been found in tributaries to this reach. Only *H. trivolvis* and *P. integra,* which were in Reach 2, were not found in tributaries by Cvancara (1983).

Reach 3

Nine species of unionids, but no gastropods or snails were reported from Red River Reach 3. Cvancara (1976) indicates that unionid density was highest in the reach of the Red River between the Tamarac River and the Canadian border, presumably due to better water quality. Cvancara (1976) gave no explanation for the lack of sphaeriids and gastropods.

Several of the streams flowing into Red River Reach 3 support mollusks (Table 3-14). However, unionids were not found near the mouth of most of these rivers due to high chloride (Turtle River, Forest River, and Park River) or prolonged periods of low flow (Snake River, Middle River, and Tamarac River) (Cvancara 1983). Only the Tongue and Pembina Rivers in the northern part of this reach were reported to harbor unionids in their lower reaches (Cvancara 1983).

3.6.3 Other Invertebrates

Invertebrates were studied in Lake Ashtabula by Peterka (1972), and are studied in the Red River as part of the NAWQA program (Lorenz 1998 in Schmidt 1999). Invertebrate studies were also conducted in Red River tributaries (Turtle River, Neel 1985; Forest River, Stoaks 1975), in Goldstein (1995), and general community characteristics of Red River Valley invertebrates were summarized by Goldstein (1995). Invertebrates in Red River Valley streams are primarily filterers and gatherers, as the main energy input is from leaves, woody debris, and algae. Lowest species richness and density occurs in sand substrate (14 taxa and 160/square meters [m^2]). Gravel and sand substrate is intermediate: 34 taxa and 2,185/m^2. The highest species richness and density occurs in gravel substrate with aquatic vegetation: 68 taxa and 6573/m^2 (Goldstein 1995). In Neel's (1985) study of the Turtle River, which is a North Dakota tributary of the Red River, over 50 percent of the invertebrate taxa were Hydropsychidae caddisflies. Corixidae (Hemiptera-water boatmen), Elmidae (Coleoptera-riffle beetles), Sphaeriidae (fingernail clams), *Stenonema* sp. (Heptageniidae mayflies), and Chironomidae (Diptera, midges) were also very abundant. A study of Sheyenne River invertebrates in currently underway (Earth Tech, Inc., and DeLorme). Preliminary results were similar to Neel (1983) with respect to dominant taxa. Preliminary results of this study are provided in Table 3-15. Sites sampled for invertebrates by Earth Tech, Inc., and DeLorme are shown in Figure 3-16.

3.6.3.1 Sheyenne River

Reach 1

Earth Tech, Inc., and DeLorme sampled 10 sites within Reach 1 (Figure 3-16). Eighty-nine taxa were collected, and dominant groups by relative abundance include dipterans (36 percent), emphemeropterans (29 percent), crustaceans (12 percent), coleopterans (9 percent), tricopterans (5 percent), oligochaetes (4 percent), and hemipterans (3 percent) (Table 3-16). Most of the invertebrate taxa in Reach 1 occur in the depositional habitats (oligochaetes, chironomids, hemipterans, *Caenis* sp., *Hexagenia limbata*), or macrophyte beds *(Dubiraphia* sp.). Species in this reach that are more typical of erosional habitats (tricopterans, and *Stenacron* sp.) are considered tolerant to low DO (Barbour *et al*. 1999). The invertebrate fauna, as with the fish fauna, is probably limited in this reach by extreme variation in flow, and lack of flow in summer and fall.

Reach 2

Invertebrate sampling in Lake Ashtabula has been limited to Peterka (1972). Only a few lentic taxa were found: Tubificidae, Hirudinea, *Chaoborus* sp., Chironomidae. One species of mayfly was reported (*Trichorythodes minutus*) and this species is typically found in depositional areas of streams (Table 3-16). Tricoptera were reported, but not identified to species (Table 3-16).

Reach 3

Reach 3 contains a higher diversity of habitats and water is more permanent. The invertebrate fauna reflects these conditions, as 70 taxa were collected in only five samples. Diptera (29 percent) were still the main taxonomic group (primarily Chironomidae), but hemipterans (28 percent) were very abundant, perhaps due the presence of more permanent pool habitat. Ephemeropterans (20 percent) were slightly less abundant, but large river taxa such as *Ephoron* sp. were collected. Tricopterans (12 percent) were more abundant, but this group was still dominated by a few tolerant species (*Cheumatopsyche* sp. and *Ceretophyche* sp.). Earth Tech, Inc., and DeLorme found fewer taxa in this reach, but only sampled five sites as opposed to the 10 sites sampled in Reach 1 (Figure 3-16).

Reach 4

Earth Tech, Inc., and DeLorme only sampled one site in Reach 4 (Figure 3-16), but found 32 taxa. The area is surprisingly diverse with respect to invertebrates, considering the erosional nature of the substrate. The number of invertebrates collected was much lower than other reaches. Only 213 animals were collected at this site compared to 500 to 1000 animals per site in other reaches (Table 3-16). Ephemeropterans (55 percent) were the dominant group at the sampled site, but most of the species collected are typically found in depositional habitats. Woody debris is common in this reach and probably provides good habitat for ephemeroptan species. Tricopterans (14 percent) were the second most abundant group. Four genera were fairly abundant: *Branchycentris* sp., *Hydropsyche* sp., and *Cheumatopsyche* sp., which are typical big river riffle species, and *Nectopsyche* sp., which are typically associated with macrophytes. Dipterans (12 percent), hemipterans (5 percent), and oligochates (4 percent) were still abundant. However, most of the Hemipterans were *Sigara* sp. rather than *Trichocorixa* sp and *Callicorixa* sp. Odonates (1 percent) and plecopterans (2 percent) were also found in this reach.

Reach 5

Two sites were sampled in Reach 5 (Figure 3-16) and 52 taxa were collected. Ephemeropterans (56 percent) and tricopterans (20 percent) were the most abundant taxa. Species richness within these groups was also fairly high, as 12 ephermeroptera taxa and six tricopteran taxa were found. Dipterans (13 percent) and oligochaetes (4 percent) were also fairly abundant.

3.6.3.2 Red River

Lorenz (1998 in Schmidt 1999) recorded 207 taxa from the Red River. This high species richness is undoubtedly a result of more intensive sampling and a greater number of taxa identified to species in the Red River than in the Earth Tech, Inc., and DeLorme study. Some differences occur between the taxa list of the Sheyenne and Red Rivers. Most of the species reported only in the Sheyenne River were limited to one site, and the same is probably true for taxa listed in the Red and not the Sheyenne River.

3.6.4 Algae/Periphyton

Information on algae and periphyton in the Sheyenne and Red Rivers is restricted to a few reports, and information about the diversity, density, and composition of the algal communities is generally lacking. The exception to this is a study conducted by Phillips *et al.* (2000), which specifically examined the existing algal composition and statistically evaluated the distributions to several physical and chemical parameters. These are the most comprehensive data available and provide fundamental information of algal dynamics in the Sheyenne River. Data on algae in the Red River Basin were collected as part of the NAWQA under the USGS. The USGS data are from a comprehensive study of the entire Red River Basin and does not contain site-specific information on algae in the Sheyenne River. Species lists of phytoplankton and periphyton in the Sheyenne River by reach are provided in Appendix H-1 and H-2. A list of Red River phytoplankton and periphyton is provided in Appendix H-3.

The results of the Phillips *et al.* (2000) report indicated that the composition of both phytoplankton (suspended algae) and periphyton (attached to substrate) communities varies longitudinally and

seasonally. Chrysophytes (*Chrysococcus* spp., *Kephyrion* spp.), cryptomonads (*Rhodomonas* spp., *Chroomonas acuta*), green algae (*Monoraphidium* spp., *Raphidonema* spp., *Actinastrum* spp.), and several euglenoids dominate Reach 1 due to better water quality, diversity of habitats, and greater light penetration. The greatest diversity is located in the upper portions of this reach. As Reach 1 approaches Lake Ashtabula, the number of phytoplankton species declines. Reaches 3, 4, and 5 have similar species of cryptomonads and green algae, but have markedly different diatom assemblages. Lake Ashtabula itself influences the algal community in the Sheyenne River. Several "lake species" such as *Fragilaria capucina* var *mesolepta* and *Stephanodiscus remerii*, were only collected below Lake Ashtabula. The nuisance, bloom-causing, green algae (*Aphanizomenon flos-aquae*) was also collected within and below Lake Ashtabula. Seasonally, diatom species in Reach 1 were shown to shift from *Rhoicosphenia curvata* and *Bacillaria paradoxa* in the spring and early summer to *Navicula tripunctata* var. *shizinoides* in the fall. The green algae *Stigeoclonium* spp. was predominant year-round throughout the Sheyenne River.

The relationship between algal species composition and water quality was examined using Canonical Correspondence Analysis (CCA) (Phillips *et al*. 2000). The water quality parameters selected included pH, nitrate+nitrite, orthophosphate, arsenic, iron, calcium, potassium, chloride, aluminum, sulfate, hardness, bicarbonate, sodium, TDS, conductivity, and alkalinity. Aluminum, pH, arsenic, sulfate, hardness, and orthophosphate explained most of the variance for phytoplankton. Orthophosphate, pH, arsenic, nitrate+nitrite, hardness, and sulfate explained most of the variance in periphyton. While both were statistically significant, the relationship between phytoplankton and water quality was easier to distinguish than the relationship between periphyton and water quality. It is presumed that changes in pH, arsenic, sulfate, hardness, and orthophosphate will have the most significant effect on the algal community in the Sheyenne River.

3.6.5 Macrophytes

Information on aquatic macrophytes in the Sheyenne and Red Rivers is sparse. Existing data are primarily in the form of species accounts by regional survey (*i.e.*, Barker and Goetz 1977, Dix and Smeins 1967, Godfread 1976, Meinke 1991, Stevens 1963). Many of these studies do not identify the specific waterbody where the species were observed, leading to a poor representation of the existing flora in the Sheyenne and Red Rivers. Additionally, few studies have been conducted in the last 20 years. Anecdotal evidence (Bonnie Alexander, Valley City State University) has been helpful but does not allow for quantitative analysis of existing conditions.

A summary of the available data has been provided in Appendix H-4. Because of the scattered data, reach-specific information on the composition of the macrophyte community is not available. However, macrophytes were observed (but not identified) during habitat sampling at most of the habitat sites (see Section 3.5).

In general, aquatic vegetation occurs in shallow areas with stable bottom substrates and sufficient light penetration. Turbidity and water depth are major influences on macrophyte distributions. Submerged vegetation (primarily *Potomogeton* spp.) were most common in the upper Sheyenne, and portions of Lake Ashtabula. Emergent vegetation (*Typha latifolia*, *Scirpus validus*, *Sagittaria latifolia*, and *Lythrum salicaria*) were found throughout the Sheyenne River but restricted to the river margins. Aquatic macrophytes are uncommon in the Red River due to the high turbidity (Renard *et al.* 1986,

Stoner *et al.* 1993). Where possible, wetland plants such as sedges (*Carex* spp., *Cyperus* spp.), rushes (*Eleocharis* spp.), and willows (*Salix* spp.) have colonized the intermittently exposed banks. The lack of significant backwater areas limits the area aquatic macrophytes can colonize. Numerous adjacent wetlands and hardwood forests are found along the Sheyenne River; however, since these areas occur outside of the stream channel, alteration of these habitats is not considered in this document.

3.7 SUMMARY OF EXISTING CONDITIONS OVERVIEW

3.7.1 Sheyenne River

The Sheyenne River within the study area (Highway 30 to Red River confluence) flows through glacial plains, sand delta, and Glacial Lake Agassiz. Water quality is affected by the underlying sulfate rock and land use is primarily agricultural.

3.7.1.1 Reach 1

Reach 1 meanders through the grasslands of the glacial plains. Water quality is moderate. Total dissolved solid guidelines and methyl mercury standards are exceeded, but sulfate and chloride are well below water quality standards. The channel in Reach 1 is within "regime" and should be fairly stable. Hydrology is that of a small stream, with dry periods that limit fauna during summer and fall. Several areas with riffle, raceway, and pool were identified in this reach. Both emergent and submerged macrophyte beds are common in shallow areas of Reach 1. Algal species are very diverse and are dominated by Chrysophytes, cryptomonads, green algae, and euglenoids. A total of 30 fish species have been recorded from this reach, and most fish are small-stream species that are tolerant of fluctuating hydrological and habitat conditions. Unionids are found throughout the reach (presumably in raceways, shallow pools, and riffles), and sphaeriidae are common in the upper reach, comprising 13 percent of recent invertebrate samples. Other invertebrates common in the area include primarily tolerant taxa that occur in depositional areas (dipterans, crustaceans, mayflies). Only a few very small permanent tributaries feed the Sheyenne River in this reach. However, invertebrates, fish, and mollusks have been found in the Sheyenne River upstream of Peterson Coulee.

3.7.1.2 Reach 2

Reach 2 (Lake Ashtabula) is affected by Baldhill Dam. Submerged macrophytes are common throughout Lake Ashtabula, while emergent species appear around the edges of the lake. Algae are abundant and are dominated by planktonic species. Blooms of filamentous algae (*Aphanizomenon flow-aquae*) occur periodically. Most fish species were found in both Reach 1 and Reach 2. However, bigmouth shiner was found in the lake, but not upstream of the lake, and rainbow trout (*Onchorynchus mykiss*), golden shiner (*Notemigonus chrysoleucas*), river shiner, sand shiner, and brook silverside were found in the upper river but not in the reservoir (Table 3-11). Sediments are organic matter and silt, and invertebrate communities are those typically found in soft substrates (primarily oligochaetes and dipterans). Baldhill Creek is the only permanent tributary in this reach.

3.7.1.3 Reach 3

Reach 3 meanders through the glacial plains but is downstream of Baldhill Dam. The Sheyenne River is larger, and the river valley is wider and steeper. Land use is primarily agricultural, but the river valley slopes are covered with trees. Water quality is similar to Reach 1 in that TDS exceeds guidelines, but sulfate and chloride are well below standards. The river is not in "regime" in this area and appears to be in the process of becoming narrower and deeper. The area supports a higher discharge and experiences less hydrologic variability as compared with Reach 1. Areas of raceway, riffle, and pool are also present in this reach. Macrophytes occur along the riverbanks, and woody debris is common in the channel. This area supports the highest diversity of fish and also supports a diversity of unionids and invertebrates, probably a result of habitat diversity and hydrological stability. Sphearíidae are not as common as in Reach 1. Spring Creek, near Kathryn, North Dakota, is the only permanent tributary to Reach 3.

3.7.1.4 Reach 4

Reach 4 meanders through the sand delta. The channel in this reach is also not in "regime" but is becoming wider and shallower. Substrate in this reach is primarily sand and is more erodible than upstream reaches. Vegetation is sparse in this reach and further downstream because of high turbidity and unstable substrate. Submerged pond weeds (potamogetons) are occasionally observed. Algae species are influenced by Lake Ashtabula and are composed of several "lake-like" species. Diatom communities have very different species compositions above and below Lake Ashtabula. Reach 4 has a high fish diversity due to several spring-fed tributaries that feed into this reach. Many of the unique fish species found in the reach are primarily residents of these streams. This reach also appears to be a transition zone between the smaller river species in Reach 3 and the larger river fauna of Reach 5. Despite the erosional nature of the substrate, unionids and a diversity of invertebrates have been collected. Ephemeropterans and tricopterans are the dominant invertebrate taxa.

3.7.1.5 Reach 5

Reach 5 meanders through the Glacial Lake Agassiz Region. This reach has the highest sinuosity and least gradient of the Sheyenne River reaches in the study area. The channel in Reach 5 is also widening and becoming shallower. Banks are high and straight, but raceway and medium pool habitat are found under summer and fall conditions. Water quality is similar to upstream reaches, with TDS above guidelines and sulfate and chloride below standards. Fish species richness is lower (32 species) because of the rather homogenous habitat, but several large river species that occur sporadically in Reach 3 and 4 are common in Reach 5 (goldeye, silver chub, emerald shiner, bigmouth buffalo, channel catfish, and freshwater drum). One unionid was recently found and Sphearíidae were infrequently collected. Ephemeropterans, tricopterans, dipterans, and oligochaetes dominated the invertebrate fauna. Plecopterans were found only in Reach 5. The Maple River, the only major tributary to the Sheyenne River, flows into the river within this reach. Both fish and mollusk species have been reported from the Maple River. All of the unionid species in the Maple River are also in the Sheyenne, but four of the species in Reach 5 of the Sheyenne River are not in the Maple River. Most of the fish species found in the Maple River are also found in Reach 5 of the Sheyenne River; however, a few of the special concern fish species that occur in Reach 5 have not been reported in the Maple River (blacknose shiner, rosyface shiner, and trout-perch).

It is not likely that the lower reaches of the Sheyenne River function as an important migration corridor. Similarly, it is unlikely that these reaches function as important spawning areas for Red River fishes. Channel catfish, however, is one species that likely moves into the lower Sheyenne River in some numbers and some spawning likely takes place in the lower reaches of the Sheyenne.

3.7.2 Red River

The Red River, like the lower Sheyenne River, flows through Glacial Lake Agassiz. Although the Red River is larger than the lower Sheyenne, it is very similar in character. Land use is primarily agricultural; however, the cities of Fargo/Moorehead, Grand Forks, and Emerson appear to affect water quality. Water quality is better in the Red than in the Sheyenne River because of the dilution effects of the several large tributaries that enter the river from the less saline basin in Minnesota. Total dissolved solids exceed guidelines less than 10 percent of the time, except near Emerson. Neither sulfate nor chloride exceeds water quality standards. Despite the habitat homogeneity of the Red River, 50 species of fish have been reported and the river supports an international class channel catfish fishery. Additionally, MnDNR has recently re-introduced Lake Sturgeon and converted several low head dams into riffle and raceway habitat. Twelve species of unionids have been collected in this reach, but the snail and sphaeriid populations seem rather depauperate. Over 200 taxa of invertebrates have been found in the Red River, including a diversity of emphemeropterans, tricopterans, and plecopterans.

Upstream of the confluence with the Sheyenne, the Otter Tail River (ND) and the Bois de Sioux River combine to form the Red River. Unionids have been reported from these rivers, but the status of unionids in the lower reaches of these rivers (near Red River Reach 1) is uncertain. Three tributaries flow into the Red River within Reach 1: Elm River, Buffalo River, and Wild Rice River (MN). Unionids have been found in the lower reaches of the Buffalo and Wild Rice Rivers but not in the Elm River. Only 28 species of fish have been reported in Red Reach 1 tributaries compared with 47 within Red River Reach 1. Many of the larger river taxa (goldeye, mooneye, silver chub, and channel catfish) have not been reported from tributary streams.

Tributaries in Reach 2 include Goose River (ND) and Sand Hill and Red Lake River (MN). Unionids have been found in all three of these rivers. Not all fish taxa in Red River Reach 2 were found in tributary streams (33 of 50), but larger river species do occur in the Goose River.

Tributaries of Reach 3 include Turtle, Forest, Snake, Middle, Park, Tamarac, Two, Tongue, and Pembina Rivers. However, unionids were not found near the mouth of most of these rivers because of high chloride (Turtle River, Forest River, and Park River) or prolonged periods of low flow (Snake River, Middle River, and Tamarac River) (Cvancara 1983). Only the Tongue and Pembina Rivers in the northern part of this reach were reported to harbor unionids in their lower reaches (Cvancara 1983). Only 44 of the 50 fish species in Reach 3 of the Red River were found in tributary streams.

4.0 METHODOLOGY

4.1 IMPACT ANALYSIS FRAMEWORK

Based on previous studies, available data, and the comparison of water quality, discharge, hydrologic, geomorphologic, and habitat models, the following methods were used to assess impacts to aquatic biota of the Sheyenne and Red Rivers to the Canadian border (Figure 4-1).

Within each of the river reaches, historical data on physical habitat, water quality, and biota were compiled and evaluated to identify existing conditions (see Section 3). Historical and present distribution of flora and fauna and the factors that might influence distribution were compiled from literature. Future hydrology (HEC-RAS/TABS-2) and water quality (HEC-5Q) conditions with and without outlet operation and natural overflow were modeled by the USACE and data were provided in the form of a time series output. The output from HEC-RAS/TABS-2 was used as input to physical habitat modeling (PHABSIM) to estimate changes in habitat. The PHABSIM model was used to calculate changes in WUA with predicted changes in depth and water velocity over time. Indicators of Hydrologic Alteration were used to compare changes in hydrology. Predicted baseline (pre-impact) and operation/overflow (post-impact) daily flows were summarized by IHA into biologically meaningful parameters. Means and variability in these parameters were compared to determine hydrological changes due to operation/pumping. WEST (2001) evaluated changes in geomorphology, which can substantially affect biota. However their study results were not of sufficient scale to be useful in this analysis. A methyl mercury study is ongoing (USGS preliminary report 2001). However, no results were available on predicted changes in methyl mercury concentrations due to operation/overflow at the time of this report. Literature was reviewed for tolerances and habitat preferences of selected species/groups. Literature was also reviewed on the impacts of water quality, hydrology, geomorphology, and habitat changes to biota. Impact evaluation matrices were developed to summarize differences in hydrology, geomorphology, habitat, and water quality between baseline and operational/overflow conditions. Hydrological, geomorphologic, water quality, habitat, and biota effects on aquatic biota were qualitatively and quantitatively interrelated for the time frames of maximum impact and recovery (after pumping or overflow). The potential for recolonization of the Sheyenne and Red River was evaluated. A pre-, during, and post-operation mitigation and monitoring plan was developed.

4.2 SELECTION OF TIME PERIODS WITHIN THE 50-YEAR MODELING LIFE FOR ANALYZING CHANGES IN HYDROLOGY AND WATER QUALITY

The USACE HEC-RAS, HEC-5Q, and TABS-2 models generated most of the data used in this analysis. Input for these models was obtained from USGS gage stations. Output from the models spanned a 50-year period from 2000 to 2050. For each future, pumping (300MOD50 or 480MOD55) or the natural overflow (WETOF) only occurs during a portion of the 50 years. Under the 300MOD50 flow, pumping occurs between 2003 and 2024 (Figure 4-2). Under the 480MOD55 flow, pumping occurs between 2003 and ends in 2016 (Figure 4-3). Under the WETOF, overflow from Stump Lake occurs between 2014 and 2025 (Figure 4-4). Using all 50 years in this analysis would dilute summary statistics. Therefore, a ten-year time frame for each future was selected to represent the operation/overflow conditions: 2005 to 2015 was the ten-year period selected for both of the moderate futures and 2015 to 2025 was selected for the wet future. All summary statistics were based on these time frames.

4.3 COMPILATION AND ANALYSIS OF WATER QUALITY DATA

This analysis focuses on TDS and two of its major constituents, sulfate and chloride. These parameters were selected based on the potential for exceeding water quality standards and guidelines in North Dakota, Minnesota, and at the Canadian border, as well as the potential toxicity effects to aquatic biota. Future levels of these parameters were predicted at HEC-5Q "control points," which in general correspond to USGS gage stations (Table 4-1). Future data were provided for MOD50 baseline, 300MOD50 pumping, MOD55 baseline, 480MOD55 pumping, WET baseline, and WETOF overflow in the form of a database of daily values from October 1, 2000 to September 31, 2050. Operation years were selected from the database of values and summarized. Each parameter (TDS, sulfate, and chloride) was summarized as a total and monthly mean, minimum, and maximum, and percent of time exceeding standards. Student t-tests were used to compare baseline to future for each alternative at each control point. Yearly and monthly values were also averaged and plotted to detect trends over season and time. Mean and maximum values were compared to existing toxicity levels for fish, unionid, and invertebrate species that occur in the study area.

4.3.1 Fish

Literature was reviewed to estimate how concentrations of TDS, sulfates, and chlorides would affect Red River Basin fish species (Table 4-2). Compared to most contaminants, the toxicity of TDS, sulfates, and chlorides to fish is low. The "toxicity" of TDS is likely due to osmotic stress (Sorensen *et al*. 1977). Sulfates and chlorides are the most common anions contributing to TDS, while sodium is the most common cation. Total dissolved solids are not a sensitive indicator of toxicity because toxicity varies depending upon the principal anions comprising the dissolved salts (Reed and Evans 1981). Similarly, the cation present affects the overall toxicity of both TDS and chlorides, with sodium salts generally less toxic than potassium, calcium, or magnesium salts (USEPA 1988).

The concentrations at which TDS, chlorides, and sulfates are acutely toxic are well above those predicted for any of the possible Devils Lake scenarios. Therefore, this report concentrates on determining whether the chronic (long-term) thresholds for any of the resident fish species might be exceeded.

4.3.1.1 Total Dissolved Solids

Reed and Evans (1981) reported 96-hour LC50 values of TDS to largemouth bass, bluegill, and channel catfish ranging from 13,000 to 17,500 mg/l. The LC50 is the Lethal Concentration (LC) at which 50 percent of the organisms die in the specified time period; in this case 96 hrs. Reed and Evans (1981) stated "The use of TDS as an indicator for the protection of aquatic life has little merit without considering the constituent concentrations of the dissolved solids." Even at Cooperstown in Reach 1 of the Sheyenne River where TDS concentration will be highest, the maximum predicted TDS value (3369 mg/l) will be well below the acute levels reported by Reed and Evans (1981). Thus, acute TDS toxicity is not an issue.

Several studies have examined the effect of various TDS levels on the growth and survival of Devils Lake and or Sheyenne River fishes (Peterka 1972, Peterka and Violett 1988, Hendrickson 1990, Koel 1993, and AScI 1998). These studies measured specific conductance as a surrogate for TDS. Among the species tested, several species included brook stickleback, fathead minnow, common carp,

and yellow perch were found to be quite resistant, with no effects on growth or reproduction ranging from 5,300 microsemens per centimeter (µS/cm) for yellow perch to 12,000 µS/cm for brook stickleback (Peterka and Violett 1988). In Devils Lake, TDS values are approximately 90 percent of specific conductance values (Koel 1993, AScI 1998), indicating that for resistant species, TDS levels up to 4,800 mg/l should have no effect on growth or survival.

Among resident species in Sheyenne and Red Rivers, white bass and crappie appear to have intermediate sensitivity to TDS, while walleye, northern pike, and white sucker are the most sensitive species (Peterka 1972, Peterka and Violett 1988, Hendrickson 1990, and Koel 1993). For the purpose of this assessment, the latter three species are representative of other sensitive species within the Sheyenne River fish community.

Total dissolved solid levels exceeding 1,000 mg/l could affect reproduction of sensitive fish species (Tables 4-2) such as northern pike, walleye, and white sucker, as well as, several of the species of concern in North Dakota, such as hornyhead chub, pugnose shiner, blacknose shiner, logperch. However, tolerant species such as fathead minnow, brook stickleback, common carp, yellow perch, and two North Dakota special concern species (silver chub and flathead chub) should not be affected unless levels reach over 4,800 mg/l.

4.3.1.2 Sulfate

As is the case for the other constituents considered, few bioassays have been conducted using sulfates. Reed and Evans (1981) exposed channel catfish, bluegill, and largemouth bass to varying sulfate concentrations for 14 days. Ninety-six hour LC50 values for all three species were 11,000 to 12,000 mg/l. Fourteen-day LC50s were 10,000 to 11,000 mg/l. In commenting on the Illinois sulfate standard of 500 mg/l, Reed and Evans (1981) concluded the 500 mg/l standard was "more than adequate for the protection of aquatic life" and that a sulfate standard of 1,000 mg/l was "more reasonable based on the results of this study." No bioassay studies that have determined the chronic toxicity of sulfates were located.

Koel (1993) evaluated the effects of Devils Lake water on the reproductive success of several fishes. This water contained significant amounts of sulfates. At 1,800 µS/cm Koel (1993) found modest reductions in hatching success to sensitive fishes (e.g., northern pike), but no effect on tolerant species (e.g., common carp). Based on the analytical results Koel (1993) provided, a specific conductance value of 1,800 µS/cm would equate to a sulfate level of about 600 mg/l. Specific conductance values of about 3,300 µS/cm (equivalent to approximately 1,000 mg/l as sulfate) adversely affected the hatching success of more species, though tolerant species like common carp were unaffected at this sulfate level. Because the Devils Lake water Koel (1993) was testing contained not only sulfates, but also elevated TDS and chloride concentrations, it is difficult to interpret exactly what level of sulfate is injurious to fish. Because the lowest level Koel tested (approximately 600 mg/l sulfate) had little or no impact to the tested species and the other constituents certainly contributed to the slight reduction in hatching success noted for sensitive fishes, sulfate concentrations less than 600 mg/l should have little or no effect on fish populations. At the next level tested (approximately 1,000 mg/l sulfate) at least some of the effects noted by Koel were probably due to sulfate; thus, 1,000 mg/l sulfate represents a moderate risk to fish populations, at least to sensitive species. This is a somewhat more conservative approach than the one

recommended by Reed and Evans (1981). Sulfate concentrations greater than 1,500 mg/l are likely to affect a variety of species (Table 4-2).

Lastly, it should be noted that the sulfate standards adopted by many states are based not on aquatic toxicity concerns but on drinking water concerns. For example, the 250 mg/l sulfate standard originally proposed in the "green book" (NTAC 1968) was based on taste and concerns that at somewhat higher levels sulfates can act as a laxative. To our knowledge, no data has ever been reported to justify these lower limits on the basis of toxicity to aquatic organisms.

4.3.1.3 Chloride

U.S. Environmental Protection Agency (1988) has established acute (short-term; hours or days) and chronic (long-term; weeks or months) chloride criteria of 860 mg/l and 230 mg/l, respectively. These criteria are largely the result of the higher sensitivities of macroinvertebrates, particularly *Daphnia,* to chlorides. The lowest genus mean acute value for fish reported by USEPA (1988) was >5000 mg/l. In the 1980s, several states sponsored studies to determine appropriate chloride water quality criteria. Reed and Evans (1981) conducted bioassays to determine the tolerance of bluegill, channel catfish, and largemouth bass to chlorides. They concluded that the Illinois chloride water quality criteria of 500 mg/l was "more than adequate for the protection of aquatic life" and further concluded that maximum concentrations of 800 mg/l chloride were "more reasonable standards based on the results of this study." Birge *et al*. (1985) used a combination of lab bioassays and field studies to determine appropriate chloride limits for the State of Kentucky. Based on the laboratory phase of their study, they recommended a 30-day average chloride criterion of 600 mg/l. However, based on subsequent field validation studies, Birge *et al*. (1985) concluded, "the chloride acute and chronic values derived from the laboratory tests in reconstituted water were judged to be too low for establishing realistic water quality criteria." They reported that chloride was about twice as toxic in reconstituted (i.e., lab) water compared to natural stream water. Water effects ratio testing such as this often reveals that criteria derived solely from laboratory bioassays are overly restrictive. Birge *et al*. (1985) reported, based on faunistic (i.e., field) surveys, that long-term exposure to mean concentrations of 1,100 mg/l chloride produced "detectable impact on natural biotic communities."

Based on this literature, concentrations that would have chronic effects on fish reproduction were established for comparison with predicted water quality conditions. Sensitive fish could be affected by TDS levels greater than 1000 mg/l, whereas tolerant taxa should not be affected unless TDS exceeds 4800 mg/l (Table 4-3). Chronic exposure to sulfate and chloride levels less than 500 mg/l and 600 mg/l, respectively, should not affect sensitive fish. Levels greater than this may affect reproductive success. The LC50 concentrations of 11,000 mg/l and 5000 mg/l, respectively, would probably affect most of the fish in the Sheyenne and Red Rivers (Table 4-3).

Specific water quality criteria data were lacking for most Red River fish species. If toxicity data were available, these data were used to group species into tolerant, intermediate, and sensitive to TDS, sulfate, and chloride. For species without data, groupings were based on Koel's (1997) Canonical Correspondence Analysis (CCA) results. Species that plotted in the positive portion of CCA axis 2 (which correlated with higher TDS [residue]) were considered tolerant, those near the axis were considered intermediate, and those plotting in the negative portion of CCA axis 2 were considered sensitive (Table 4-4). Groups are summarized in Table 4-5.

The USEPA establishes water quality criteria based on protecting 95 percent of the genera that have been tested. The assumption is that protection of all but five percent of the tested genera will also be protective of most of the untested members of the community. The same assumption was made here, i.e., protection of the most sensitive of the Sheyenne River genera should protect most (though not necessarily all) of the untested genera.

4.3.2 Mollusks

Water quality is often cited as a reason for declining unionid, sphaeriidae, and gastropod populations. However, toxicity testing of unionids has barely begun, and no tests were found relating water quality contaminant levels to sphaeriidae and gastropods. Only one paper was found relating chlorine to unionids, Gouldraeu *et al.* (1993). However, this study tested monochloramine (the major chlorine constituent in wastewater) rather than chloride. Toxicity varied with species, the toxic level (LC50) to *Villosa iris* (a fairly sensitive species in the subfamily Lampsilinae) was 84 µg/l and to *Pleurobema unicale* (a thicker-shelled Ambeminae species) was 252 µg/l. The USEPA's ecotox database was searched for gastropod, sphearii d, and unionid toxicity tests without any success. However, Cvancara (1967, 1970a, and 1983) lists levels of sulfate and chloride at areas with and without mollusks. Unionids and sphearii ds seem to be limited to areas with chloride less than 100 mg/l and sulfate less than 1,300 mg/l. Pulmonate gastropods are more tolerant. *Physa jennessi* was found in an area with chloride greater than 3,500 mg/l, and *Stagnicola elodes*, *Physa gyrina*, and *Physa jennessi* were found in water with sulfate of 3,300 mg/l (Cvancara 1983). Prosobranch gastropods are less tolerant of poor water quality (Fuller 1974), but no tolerance levels were identified (Table 4-6).

Cvancara's observed 100 mg/l chloride and 1,300 mg/l sulfate were used as guidelines for evaluating water quality effects on unionids and sphearii ds (Table 4-3). Cvancara's 3,500 mg/l chloride and 3,300 mg/l sulfate were used as guidelines to evaluate water quality effects on pulmonate gastropods. No information was found with respect to prosobranch responses to these parameters, but Harman (1974) listed several prosobranchs as sensitive to chloride. Prosobranchs are more sensitive to poor water quality than pulmonates (Harman 1974), and some species may be as sensitive as unionids. Prosobranchs were therefore included with the sensitive mollusks for water quality evaluation (Table 4-5).

4.3.3 Other Invertebrates

U.S. Environmental Protection Agency's ecotox database was also searched for TDS, chloride, and sulfate with respect to the other invertebrate species found in the Sheyenne and Red Rivers (Table 3-16), with no positive results. Some data were found with respect to compounds containing chloride and sulfate, but no toxicity levels were found for chloride or sulfate. Barbour *et al.* (1999) compiled general sensitivity information on many Sheyenne and Red River invertebrate species (Table 3-16). Hart and Fuller (1974) compiled levels of sulfate and chloride under which several invertebrate species have been collected. The USEPA (1998) chloride acute and chronic values for aquatic life, which take into account invertebrates and plants, are 860 mg/l and 230 mg/l, respectively.

Dominant Sheyenne River species included the groups Elmidae (Coleoptera), Chironomidae (Diptera), Corixidae (Hemiptera), Hydropsychidae (Tricoptera), and Tricoptera (Table 3-16). Chloride and sulfate tolerance data from Hart and Fuller (1974) was compiled for dominant species within these groups

(Table 4-7). Average and high historical concentrations of TDS, sulfate, and chloride in the Sheyenne River were compiled. Historically, TDS was fairly high (approximate average 550 and maximum near 1,000 mg/l), sulfate was moderate (average 150 mg/l, maximum 360 mg/l), and chloride was fairly low (average 30 mg/l, maximum 76 mg/l; Table 3-4).

The upper concentration at which taxa were found in Hart and Fuller (1974) or in the Sheyenne River were used to classify dominant invertebrate taxa and establish sensitivity levels (Table 4-7). Total dissolved solids concentration for evaluation could not be established. The sulfate concentrations listed by Hart and Fuller (1974) seemed to fall into two groups – those that were recorded from areas <150 mg/l and those that were reported from areas >450 mg/l (Table 4-7). These are the dominant taxa in the Sheyenne River, where average sulfate concentration is approximately 150 mg/l and maximum is near 360 mg/l. Thus, they are currently surviving chronic exposure to at least 150 mg/l and acute exposure of at least 360 mg/l. Concentrations of 150 mg/l and 450 mg/l sulfate were therefore selected to represent the upper limit that would not affect sensitive and tolerant taxa, respectively (Table 4-3). Chloride concentrations of reported invertebrates also seemed to fall into two groups. The sensitive species upper reported concentrations were 30 mg/l (*Dubiraphia* sp.), 56 mg/l (Hemiptera), 72 mg/l (some of the Emphemeroptera), and 185 mg/l (*Macrohychus* sp.). Average chloride in the Sheyenne River where these species are abundant is approximately 30 mg/l, and maximum is 74 mg/l (Table 4-7). Most of the other dominant taxa have been reported from chloride concentrations over 2000 mg/l. Thus, 50 mg/l and 2000 mg/l were the concentrations selected to represent the upper limit that would not affect sensitive and tolerant invertebrate taxa (Table 4-3). The selected criteria are not supported by toxicity data and are merely broad estimates. This should be considered when interpreting data.

Sensitivity among the taxa differed particularly with respect to chloride and sulfate. Therefore each taxon could not be classed as either sensitive or tolerant to TDS, sulfate, and chloride. The effects of each parameter on each taxon were evaluated separately, then the effects were combined.

4.3.4 Phytoplankton and Periphyton

No specific sensitivity information was found with respect water quality effects to phytoplankton and periphyton (Table 4-8). However, Sheyenne River water and West Bay Devils Lake water were shown not to inhibit algal growth (AscI 1998).

4.3.4.1 Total Dissolved Solids

Specific tolerance levels of algal species to TDS concentrations were not available. The algal survey of the Sheyenne River by Phillips *et al*. (2000) found that TDS concentrations did not significantly explain the variance in either phytoplankton or periphyton distributions. Based on this data, it is expected that the overall algal community would be unaffected by increased TDS concentrations. However, certain sensitive species, which may be under represented in an algal survey, may still be affected.

4.3.4.2 Sulfate

While specific tolerance limits were not identified, Phillips *et al*. (2000) did find a significant relationship between algal distributions and sulfate concentrations. Most of the algal groups have such wide ranging species that it is difficult to classify a general tolerance level. With the exception of a few taxa, Chlorophytes and Bacillariophytes prefer lower sulfate concentrations. Cyanophytes were found across the entire range of sulfate sampled, while the Euglenophytes tended to be found at higher sulfate sites. Specifically, the diatoms *Cymbella muellerii* and *Nitzschia* sp. and the chrysophyte *Kephyrion skujae* were identified from sites with low sulfate concentrations, while the Euglenoid *Phacus acuminatus* and the green algae *Dictyosphaerium ehrenbergianum* were identified at sites with high sulfate concentrations (Phillips *et al*. 2000).

4.3.4.3 Chloride

The study on algae in the Sheyenne River by Phillips *et al.* (2000) did not specifically investigate the response of algae to chloride concentrations. Research by Leland (1995) and VanDam and Mertens (1995) have indicated that algal community structure is strongly influenced by salinity and ionic composition. Prepas and Trew (1983) have generally set a threshold of 1000 mg/l to separate algal species that are salt-tolerant from those that are not. Data on specific species present in the Sheyenne River were not available. It is assumed that sensitive species could be affected by high clorides, while most species would show no effect. The impacts would be greatest in Reach 1 where sulfates and chlorides would increase the most, and the greatest diversity of algae exist.

Since specific tolerance limits with respect to TDS, sulfate, and chloride were not available and species specific information was not available for each reach, periphyton and phytoplankton groups were rated intolerant or intolerant to changes in water quality based on available literature (Table 4-9; Table 4-5). Specific taxa within these groups may be more or less tolerant to water quality changes, however this analysis had to be limited to groups and general tolerance due to lack of specific information.

4.3.5 Macrophytes

Specific tolerance levels of macrophytes to levels of TDS were unavailable (Table 4-8). Submerged species are generally more sensitive to changes in water quality than emergent or wetland species due to their greater exposure (Adamus 2001).

Most of the submerged macrophyte species present in the Sheyenne River are tolerant of the existing TDS concentrations and are expected to withstand the concentrations modeled under any of the pumping scenarios. The pondweeds (*Potomogeton*) are the most common submerged flora in the Sheyenne and Red Rivers. Sago pondweed (*Potamogeton pectinatus*) and curly-leaf pondweed (*Potamogeton crispus*) are the most aggressive and most tolerant of the pondweeds and would be expected to have no noticeable change in abundance due to increased TDS concentrations. Many of the macrophyte species in the Sheyenne River are also present in Devils Lake. These common species would not be affected under any pumping scenario.

Sulfate tolerance levels were unavailable for macrophytes. It is generally believed that most species present in the Sheyenne and Red Rivers are tolerant to high sulfate concentrations.

Chloride tolerance levels were also unavailable for macrophytes. It is generally believed that most species present in the Sheyenne and Red Rivers are tolerant to high chloride concentrations. Some data has examined the response of macrophytes to road salt and found that it is highly variable depending on genetics, life stage, duration of exposure, temperature, and many other environmental factors (Adamus 1990). Haller *et al*. (1974) found that the common reed (*Pragmites communis*) had high tolerances to chloride concentrations, but the seedlings were much lower. It is not known if the reed grass (*Phragmites australis*) present in the Sheyenne River also has this relationship. This may indicate that the timing of the pumping in summer and fall will lessen the impact on macrophytes. Both broad-leaved (*Typha latifolia*) and narrow-leaved (*Typha angustifolia*) cattails are present in the Sheyenne River. Research by McNaughton (1966) has found that narrow-leaved cattail are more tolerant of chloride than broad-leaved cattail. The hybrid cattail (*Typha glauca*) is also tolerant of increased chloride concentrations. All of these cattail species are aggressive, but dominance may shift to narrow-leaved and hybrid species under high chloride levels. This is particularly true for the upper reaches where the impacts would be greatest, and possibly Lake Ashtabula with its abundant emergent vegetation.

Species currently in Devils Lake that tolerate high salinity may also become more abundant. Halophytes such as cordgrass (*Spartina* sp.) and alkali grass (*Pucchinella pungens*) may increase in dominance in the upper reaches. Isabelle *et al.* (1987) found that purple loosestrife seeds (*Lythrum salicaria*) were also tolerant of road salt in snow melt. This aggressive, invasive species may take advantage if sensitive species become reduced. Submerged vegetation appears to be tolerant of higher chloride concentrations and should not be affected. In general it is believed that the concentrations of chloride will not have an effect on most species present in the Sheyenne or Red Rivers.

As with periphyton and phytoplankton, specific tolerance limits with respect to TDS, sulfate, and chloride were not available and species specific information was not available for each reach. Macrophyte classes were rated intolerant, moderately tolerant, and intolerant to changes in water quality based on available literature (Table 4-9; Table 4-5). Specific taxa within these groups may be more or less tolerant to water quality changes, however this analysis was based on orders and general tolerance due to lack of specific information.

4.4 COMPILATION AND ANALYSIS OF HYDROLOGICAL DATA

The USACE used HEC-RAS to predict future conditions in the form of a time series of daily discharges at each of the "control points": Devils Lake input (Highway 30), Sheyenne Reach 1 (Cooperstown), Sheyenne Reach 3 (Baldhill Dam and Lisbon), Sheyenne Reach 5 (Kindred), Red River Reach 1 (Halstad), Red River Reach 2 (Grand Forks), and Red River Reach 3 (Emerson). Output from the HEC-RAS model was provided as mean daily discharge from October 1, 2000, to September 31, 2050. Data from the selected time frames for each alternative were used as input for the IHA analysis.

Indicators of Hydrologic Alteration were used to reduce hydrology data into biologically meaningful parameters and compare these parameters using "natural" variability between baseline and operational/overflow conditions.

Indicators of Hydrological Alteration is a method developed by The Nature Conservancy for assessing the degree of hydrologic alteration due to human influence within an ecosystem (Richter *et al*. 1996); Richter *et al.* (manuscript) expanded the software to include "Range of Variability Approach" (RVA). This analysis takes into account the hydrological variation that shapes microhabitat in a stream over time. Parameters used are those considered to be ecologically significant. A series of biologically relevant hydrologic attributes that characterize intra-annual variation are calculated and then used to analyze inter-annual variation due to human alteration.

The selected parameters are based on five fundamental characteristics of hydrologic regimes (Table 4-10; Richter *et al.* 1996):

1. **Magnitude** - The magnitude of the water condition at any given time is a measure of the availability or suitability of habitat and defines such habitat attributes as wetted area or habitat volume, or the position of a water table relative to wetland or riparian plant rooting zones.

2. **Timing** - The timing of occurrence of particular water conditions can determine whether certain life-cycle requirements are met or can influence the degree of stress or mortality associated with extreme water conditions such as floods or droughts.

3. **Frequency** - The frequency of occurrence of specific water conditions such as droughts or floods may be tied to reproduction or mortality events for various species, thereby influencing population dynamics.

4. **Duration** - The duration of time over which a specific water condition exists may determine whether a particular life-cycle phase can be completed or the degree to which stressful effects such as inundation or desiccation can accumulate.

5. **Rate of Change** - The rate of change in water conditions may be tied to the stranding of certain organisms along the water's edge or in ponded depressions, or the ability of plant roots to maintain contact with groundwater supplies.

A full description of the model and examples of use are found in Richter *et al.* (1996), Richter *et al*. (1997), Richter *et al.* (manuscript), and The Nature Conservancy (1997). The model is available from Smyth Scientific Software. This software was designed to use existing data and compare hydrological variability before and after alteration. In this case, it was used to compare baseline conditions and pumping or overflow conditions.

The four model steps included:

1. Defining the data series for pre- and post-impact periods in the ecosystem of interest.

2. Calculating values of hydrological attributes – calculation of ecologically relevant parameters (Table 4-8) for each year in each data series (one set for pre-impact and one for post-impact) (Appendix I).

3. Computing inter-annual statistics (RVA) – measures of central tendency and dispersion for the 32 parameters in each data series are calculated for values in Step 2, producing 32 measures of central tendency and 32 measures of dispersion.

4. Calculating values of hydrologic alteration – the 64 inter-annual statistics between pre- and post-impact data are compared and presented as a percentage deviation of one time period relative to the other (Appendix J).

The RVA target range can be set for a specific management goal. The default is the mean ±1 standard deviation (SD), which is normal variation. This RVA is calculated pre- and post-impact and compared statistically as [(Observed minus Expected)/Expected)] × 100 to calculate the post-impact hydrological alteration from pre-impact conditions for each parameter. Observed is the number of years the hydrological parameter fell within the target range and the expected is the number of years the parameter is expected to fall within the target range.

Baselines (MOD50, MOD55, and WET) were used as the pre-impact values and 300MOD50, 480MOD55, and WETOF were used as the impact values. The time period selected was 2005-2015 for MOD50 and MOD55, and 2015-2025 for WET. Richter *et al*. (1997) cautions against using less than 20 years of data in this analysis, as a lesser time period may not reflect the full range of hydrological variability natural to the system. However, the 10-year periods selected represent the time of operational or overflow conditions. Using a longer time period might dilute the effects of operation or overflow.

The RVA range used was the default ± 1 SD. Baseline data were used as expected, and operation and overflow data were used as observed. Hydrological alteration (HA) is zero when observed values fall within the expected RVA range. A positive HA indicates that the observed values fell within the expected range more frequently than anticipated (less variability in the data), and negative HA indicates that annual values fell outside the target range more frequently than expected. In this case, either the observed and expected means are different or the observed variation is higher than expected (Richter *et al*. manuscript). An HA value of zero to 33 percent represents little to no alteration, 34 to 67 percent represents moderate alteration, and 68 to 100 percent represents a high degree of alteration.

The expected target values can be used to define a management goal and used to mitigate impacts.

To visualize the effect of discharge changes on habitat, a range of seasonal discharge table (mean ±1 SD; Appendix I) was placed on spatial niche and percent WUA by guild graphs. Seasons were summarized as winter (December, January, and February), spring (March, April, and May), summer (June, July, and August), and fall (September, October, and November). In some cases, extremely high variation in

discharge was predicted and the value of (mean ±1 SD) was less than the minimum or greater than the maximum predicted flow. In these cases, minimum or maximum predicted flow was shown on the table.

Flow exceedence curves for 2000 to 2050 were developed for the MOD50 baseline, 300MOD50 480 pumping with a 1,450 asl moderate future baseline, and WETOF overflow by WEST (2001). However, these projections include the entire 50-year period rather than the 10-year period on which this analysis is based. These projections were not sufficient for this analysis. Therefore, the discharge that is exceeded 99 percent, 95 percent, 90 percent, 75 percent, 50 percent, 25 percent, 10 percent, 5 percent, and 1 percent of the time was calculated for each baseline and future based on the same daily flows used in IHA analysis.

The biotic communities were qualitatively evaluated with respect to their expected response to changes in the flow magnitude, timing, frequency, duration, and rate of change resulting from pumping or overflow. Literature discussing general responses of aquatic biota to hydrology were reviewed to facilitate analysis.

- Fish- Kroger 1973, Hvidsten 1985, Bain *et al*. 1988, Aadland 1993, Travnichek and Maceina 1994, Bradford *et al.* 1995, Scheidegger and Bain 1995, Bradford 1997, Poff *et al*. 1997, Adams *et al.* 1999, Liebig *et al.* 1999, Farmer and Layzer 2001, Freeman *et al.* 2001, Saltveit *et al*. 2001, Weyers *et al.* 2001.

- Mollusks- Cvancara 1967 and 1983, Hart and Fuller 1974, Vannote and Minshall 1982, Miller *et al.* 1984, Thorp and Covich 1991, Layzer *et al*. 1993, Layzer and Madison 1995, Strayer 1999, Hardison and Layzer 2001.

- Other invertebrates- Fisher and LaVoy 1972, Kroger 1973, Trotzky and Gregory 1974, Irvine and Henriques 1984, Gislason 1985, Irvine 1985, Troelstrup and Hergenrader 1990, Weisberg *et al.* 1990, Morgan *et al*. 1991, Moog 1993, Jalon *et al.* 1994, Blinn *et al.* 1995, Valentin *et al.* 1995, Englund and Malmqvist 1996, Parsiewicz *et al*. 1998.

- Periphyton and phytoplankton- Adamus 1990, Poff *et al*. 1997, Growns and Growns 2000.

- Macrophytes- Whitlow and Harris 1979, Keddy *et al.* 1986, Langrehr and Dukerschein 1994, Rogers and Theiling 1999, Merritt and Cooper 2000.

4.5 COMPILATION AND ANALYSIS OF GEOMORPHOLOGY DATA

Geomorphologic changes could affect important habitat parameters such as depth, width, substrate, and current velocity. How much the channel will change appears to be dependent on its deviation from regime channel. Regime channel will differ between baseline and with project operation; however, future baseline is also expected to differ from historic conditions (WEST 2001). The magnitude of the differences between regime channel (depth, width, slope, meander length and width, and erosion rate) at baseline conditions and under operational conditions were compared to estimate how these changes would affect biota.

Changes of a few inches in depth or channel width could result in substantial changes in habitat if they occur over a short period of time. An erosion rate on this small of a scale was not predicted in the WEST (2001) study.

WEST calculated the channel-forming "regime" flow for points within Sheyenne Reach 1 (L1, K3, J1, I4, H2), Reach 3 (E2), and Reach 5 (B2) (Figure 3-1). WEST predicted future changes in channel geometry and planform for 1,450 asl moderate future compared to 300 cfs constrained flow pumping and 480 unconstrained pumping. They also evaluated changes in geometry and planform of a wet future with overflow compared to 300 cfs and 480 cfs pumping (Tables 4-11 and 4-12). However, the predicted changes were calculated based on a channel-forming flow estimated for the years 2000 to 2050. This value was held constant throughout the analysis. The models did not take into account channel changes that may now be occurring due to climatic changes or the change from wet years to dry years in the moderate future.

Changes were predicted to occur in channel width, depth, meander length, and meander amplitude (Tables 4-11 and 4-12). However, the utility of these predicted changes for this study is questionable. WEST concludes that the channel would change somewhat in geometry and planform between baseline and operation or overflow conditions. WEST also conclude that the change between historical conditions and future moderate baseline conditions would be greater than the difference between baseline and operation. The changes in meander length and amplitude are predicted to occur over the next 300 years. The changes in channel geometry are expected to occur within the 50-year life of the project. WEST considered the change in channel width significant (which was up to a few feet). However, they attributed the change in depth (which was calculated to be a few inches), as within the margin of model error. When viewed as percentages, both width and depth changes are of the same magnitude, so they both may be within the margin of error or both significant. WEST results are presented as a comparison of channel configuration with and without pumping. However, these results do not estimate the minor changes in erosion and deposition that could impact aquatic communities.

As a means of estimating whether the erosion (and deposition) rate would be greater or lesser with future conditions, the percentage of time discharge would exceed the channel-forming flow was calculated for each alternative and compared to baseline. The channel-forming discharge is the discharge at which the greatest erosion occurs or the channel is formed (WEST 2001). If this flow is reached or exceeded more frequently, more erosion should occur. This theory was discussed with USACE geomorphologists. The USACE concurred that this frequency would provide a qualitative measure of erosion that could be compared between alternatives. For the purpose of qualitative analysis, deposition was assumed to be of an equal magnitude to erosion.

Since the erosion and deposition rates and patterns have not been modeled, the effects of erosion and deposition to the aquatic biota can only be qualitatively assessed based on available literature. In general, for fish, siltation has the greatest effect on the simple lithophilic spawners (Lyons 1992, Ohio EPA 1987, Simon 1991, Goldstein *et al*. 1994). Spawning guilds of Red and Sheyenne River fish species were compiled from Ohio EPA (1987) (Table 4-4). Increased turbidity that accompanies erosion might also affect some of the species less tolerant of turbidity. Turbidity tolerance based on discussions in Peterka and Koel (1996) and Becker (1983) is also compiled on Table 4-4.

Mollusks and other invertebrates are also affected by erosion and sedimentation. To evaluate possible erosion and sedimentation effects on invertebrates, habitat and feeding requirements for Sheyenne and Red River invertebrate species were compiled from Merritt and Cummings (1996). Information on the effects of sedimentation and erosion on invertebrates and mollusks was found in Fuller (1974), Harman (1974), Brown (1991), McMahon (1991), Kohlhepp and Hellenthal (1992), Moog (1993), Jalon *et al.* (1994).

Plant communities are also affected. Effects of erosion and deposition on macrophytes was found in Peck and Smart (1986), Sparks *et al* (1990), Fischer and Claflin (1995), and Rogers and Theiling (1999).

4.6 COMPILATION AND ANALYSIS OF METHYL MERCURY DATA

Preliminary results of methyl mercury testing were presented in Section 3.0. Estimates on how methyl mercury might change in the system due to more frequent inundation of sediments containing mercury at higher sulfate levels was not available. Therefore, these effects on biota could not be analyzed.

4.7 COMPILATION AND ANALYSIS OF PREDICTED CHANGES IN HABITAT

This section describes the analytical framework that was used to evaluate the impacts of different stream flow conditions produced by the various operational alternatives on the in-stream habitat for fish and macroinvertebrates in the Sheyenne River. Physical Habitat Simulation (PHABSIM) concepts from the In-stream Flow Incremental Methodology (IFIM), available hydraulic and habitat data, and habitat preferences of representative aquatic biota were used to produce estimates of physical habitat impacts for each flow scenario and river compartment. These estimates were then used along with other data, such as seasonally important biological processes and habitats, to quantify impacts to in-stream habitat for each operational alternative. Changes in biota due to habitat changes were estimated based on current literature (Bain and Boltz 1989, Bowen *et al*. 1998, Gore *et al*. 2001, and Freeman *et al.* 2001).

4.7.1 Approach

The following steps were applied to complete the analysis of in-stream aquatic habitat impacts:

- **Step 1 - Model Selection:** The first step was the evaluation of available data that could be used with the available data that could be used with PHABSIM to produce estimates of physical habitat over a sufficient range of flows to adequately address the expected range of flows.

- **Step 2 - Species and Biological Criteria:** Habitat-use guilds of Sheyenne and Red River fish and macroinvertebrates were selected based on their physical habitat preferences. Hydraulic conditions at selected Sheyenne River sites were predicted using available hydrologic data.

- **Step 3 - Habitat Modeling:** Habitat vs. flow relationships were predicted for selected guilds based on hydraulic model results and the habitat preferences of Sheyenne River fish and invertebrates.

- **Step 4 - Habitat Time Series:** Time series of predicted alternative and baseline conditions were combined with habitat vs. flow relationships to produce habitat time series (daily in-stream habitat values) for each river compartment.

- **Step 5 - Habitat Duration Indices:** Habitat vs. flow relationships were summarized for each operational scenario using habitat duration values, which is the percent of time that various habitat conditions are met or exceeded.

- **Step 6 - Seasonal Considerations:** Seasonally important biological processes and habitat modeling results were considered to address potential impacts of each of the operational alternatives.

- **Step 7 - Habitat Impact Metrics:** Selected in-stream habitat impact results were identified to be carried forward into further summary analyses.

4.7.2 Methods

4.7.2.1 Model Selection

The PHABSIM concepts from the IFIM, available hydraulic and habitat data, and habitat preferences of representative aquatic biota were used to produce estimates of physical habitat impacts for each flow scenario and river compartment.

The IFIM is a hierarchical, modular approach designed to assess the effects of incremental changes in flow on habitat for aquatic biota. This habitat-based approach quantifies the amount of potential habitat for various species of aquatic biota at various discharges, in this case fish and benthic macroinvertebrate guilds.

The one-dimensional model that is normally used with PHABSIM was replaced by a two-dimensional model (TABS2) already partially developed by the USACE. Depth and velocity data collected at the habitat transects were collected at very low flows, which limits the range of simulation with the one-dimensional hydraulic model (Earth Tech, Inc., 1998). The TABS2 model used by the USACE appeared suitable for hydraulic modeling of a wider range of flows, but calibrations were not completed for flows lower than 100 cfs, a critical flow range for evaluating potential impacts to aquatic communities in the Sheyenne River. The two-dimensional model was selected since it provided the possibility of simulating critical flows less than 100 cfs with further calibration and also provided the largest range of simulated flows.

4.7.2.2 Habitat Study Reach Selection

For the purpose of evaluating impacts to physical habitat, the entire length of the Sheyenne River was divided into five river reaches based on different physiographic regions (see Section 3.0). Each reach is comprised of erosion segments (Figure 3-1) that were selected based on the presence of relatively homogenous habitat types (similar frequencies of riffles, runs, and pools, and similar substrate and cover types). Habitat data (depth, velocity, substrate, and cover) was collected at eight of the 12 erosion habitat

segments (Earth Tech, Inc. 1998). Subsequently, TABS2 modeling was completed at seven habitat segments.

The river reaches and the corresponding habitat segments that were used in the current modeling analysis are listed in Table 4-13. Sheyenne River Reaches 3 through 5 represent the downstream portion of the Sheyenne River. Habitat Segment B was used to represent Reach 5 and Habitat Segment E was used to represent Reach 3. Since there are no habitat segments within Reach 4, data from Reaches 3 and/or 5 were applied to Reach 4 to determine potential impacts.

Reaches 1 and 2 represent the upstream portion of the Sheyenne River. Reach 2 consists of Lake Ashtabula, which was not modeled for physical habitat impacts. Reach 1 is represented by six habitat segments (F, H, I, J, K, and L) and TABS2 modeling was completed on five of the six segments in Reach 1 (Table 4-14). Data from two habitat segments (L and H) were used to represent potential habitat impacts upstream of (L) and within (H) Reach 1. Data for Site L was modeled to represent background conditions and H was chosen to examine potential impacts from the proposed project scenarios. Habitat Segments L and H were chosen because:

- They represent the upstream and downstream ends of Reach 1.
- They have the greatest diversity of meso-habitat types (riffles, pools, and runs; Table 4-12).
- They have a higher proportion of productive substrate types (such as cobble and gravel) within Reach 1 (Figures 3-6, 3-7, 3-8, and 3-10).
- Initial review of TABS2 modeling indicated that these two habitat reaches could be modeled relatively efficiently.

Modeling of the other habitat segments would not produce results that would significantly change or enhance the results from Habitat Segment L and H alone.

4.7.2.3 Species and Biological Criteria

Aquatic communities (fish and benthic macroinvertebrates) occurring in the Sheyenne River were evaluated to determine the most appropriate species or groups of species that should be used to evaluate impacts from the proposed scenarios.

Fish were related to appropriate habitat guilds and evaluated using a standard IFIM modeling approach. Aadland (1993) identified six habitat preference guilds for 114 fish species-life stage combinations in six Minnesota streams. Sheyenne and Red River fish species were placed into these six habitat guilds (shallow pool, medium pool, deep pool, slow riffle, fast riffle, and raceway) following the findings of Aadland (1993; Tables 4-4, 4-15, 4-16). Other fisheries references were reviewed (Pflieger 1975, Becker 1983, Peterka and Koel 1996) for Red River Basin fish species not placed in guilds by Aadland (1993). Where appropriate, guilds were assigned to life stages for these species based on life history information (Tables 4-4, 4-15, and 4-16). Habitat suitability information, however, was only available for the species categorized by Aadland (1993), and inferences from habitat models should be cautiously evaluated; as many other factors influence biota distribution and abundance besides habitat.

Other IFIM studies in the region (Houston Engineering 1997a, U.S. Department of the Interior 1999) adapted a similar guild approach for determining impacts of altered flow regimes to aquatic communities.

The amount of any particular habitat may increase or decrease depending on operational scenario and season, and it is not uncommon for one or more habitat types in a given habitat reach to increase while other habitat types in that same reach simultaneously decrease. This makes interpretation of these changes difficult, as the preferred habitat of some species will increase while the preferred habitat of other species simultaneously decreases. Table 4-16 provides the habitat preferences of many Sheyenne and Red River fishes. An examination of this table reveals several facts about each habitat guild.

Shallow Pool (Sensitive habitat guild)

This guild is inhabited primarily by young of the year (YOY) and juvenile fishes. Thus, this habitat serves as an important nursery area and is considered to be one of the most important habitat guilds.

Medium Pool (Moderately sensitive habitat guild)

This habitat is preferred by the largest combination of species/life stages. Although it includes a large number of species/life stages, many of those identified are either habitat generalists (e.g., channel catfish, largemouth bass, and orangespotted sunfish) or are primarily lentic species (e.g., crappies, yellow perch) whose abundance in the river is probably low naturally. Given their more adaptable nature and the fact that they show less fidelity to lotic conditions, members of this guild are viewed as less sensitive than those in the shallow pool guild. However, several of the species listed as special concern in North Dakota require the macrophyte beds that occur in shallow and medium pools (blacknose shiner, pugnose shiner, banded killifish) or use medium pools during part of their life (trout-perch, hornyhead chub, rosyface shiner).

Deep Pool (Least sensitive habitat guild)

This guild contains the fewest species. The deep pool guild is dominated by habitat generalists (e.g., white sucker and largemouth bass) or lentic species (e.g., black crappie). Because it is used by the fewest species and most of those that use it are not particularly sensitive, this is viewed as the least sensitive guild.

Slow Riffle (Sensitive habitat guild)

This guild contains the second highest number of species/lifestages and the greatest number of spawning species. Given the number of species in this guild and the number of those that spawn in this habitat, slow riffle is considered a sensitive habitat. Since spring is the period when this habitat would be most used for spawning, spring is an especially critical period for this guild. However, it is likely that species displaced from the shallow pool guild will find the edges of shallow riffles to be a suitable alternative to their preferred habitat.

Fast Riffle (Sensitive habitat guild)

Because few obligate riffle species are present in the Red and Sheyenne Rivers, this habitat is preferred by only a few species. However, for any obligate riffle dwellers, this habitat is critical. Longnose dace and stonecat (*Noturus flavus*) would be such species. Although Aadland (1993) has assigned adult and juvenile logperch to the fast riffle guild, its habitat requirements are quite broad and, as a result, is not at as much risk as the other species in this guild. Furthermore, logperch occur only in the Red River, so the risks to this species under any of the project alternatives are negligible. Fast riffle is also used by redhorse species in the spring for spawning. Because of its rarity in the Sheyenne River and its use for spawning and for obligate riffle species, fast riffle is considered a sensitive habitat.

Raceway (Moderately sensitive habitat guild)

This guild is dominated by adult species, especially among the suckers. It is likely that some species preferring fast riffles can successfully use raceway habitat as an alternative and vice versa.

Given the overlap between the shallow pool and slow riffle guilds, between the medium and deep pool guilds, and between the fast riffle and raceway guilds, at least one member of each of these three habitat pairs should be present in reasonable amounts to support a diverse fish community. Lastly it should be noted that the Sheyenne River is dominated by species relatively tolerant to a variety of water quality and habitat conditions (Peterka 1978, Ohio EPA 1987, Goldstein *et al.* 1996, Table 4-4). Given this, it is reasonable to expect that the fish assemblage, as a whole, will be less sensitive to habitat alterations than if it was dominated by habitat specialists.

Gore *et al*. (2001) developed habitat suitability curves for tricopterans, emphemeropteras, high-gradient stream invertebrate diversity and low-gradient stream invertebrate diversity. The tricopteran guild was selected to represent a swift-water invertebrate guild and the low-gradient stream diversity was selected to represent the benthic invertebrate community of the Sheyenne River.

A few studies have developed habitat suitability criteria for unionid mussels (Hart 1995, Johnson 1995). Additionally, unionid habitat suitability criteria have been developed for Minnesota tributaries of the Red River (S. Johnson, personal communication). However, the use of PHABSIM modeling and habitat criteria for unionids has been criticized (Gore *et al*. 2001). Unionids are sedentary animals. PHABSIM assumes that the animals being modeled can move with the habitat. Over time unionids will colonize suitable habitat, but active movement is generally limited to a few meters (Dunn *et al*. 2000). Unionids are typically found in areas with sufficient flow to prevent sedimentation but without enough flow to render the substrate unstable (Vaughn 1997). This is typically raceway habitat or the transition zone between riffles and pools. Under PHABSIM, the location of this habitat could change with discharge, but still be considered usable. However, the unionids would probably not move and still occupy the area of the old raceway, which could be scoured, desiccated, changed to an unsuitable or suitable habitat, or remain unchanged in its value to unionids. Therefore, PHABSIM was not selected to model changes in habitat effects to unionids.

To accurately assess the impacts of habitat changes on unionids, the change in habitat features within areas currently occupied by unionids needs to be tracked under various discharge conditions. Unionids were noted at most of the habitat transects (Appendix D); however, the distribution of unionids with

respect to habitat cells was not recorded. Methods similar to those used for the erosion/habitat transects could be used. Three or four representative transects would be needed through the area occupied by unionids. At each interval along the transect, depth, current velocity, substrate, shear stress, and unionid density and species composition should be recorded.

4.7.2.4 Habitat Modeling

The two basic components of stream habitat simulation are hydraulic and habitat simulation. Hydraulic simulation is used to describe the area of a stream having various combinations of depth and velocity as a function of discharge. Habitat modeling consists of converting hydraulic simulation results into predicted habitat values for each species and life stage based on their habitat suitability indices. The resulting index of habitat quality is WUA, which is expressed as area of suitable habitat per 1,000 feet of river length (feet^2/1,000 feet). The theory and details of these methods are discussed in detail by Bovee and Milhous (1978), Stalnaker *et al*. (1995), Bovee (1982), and Milhous *et al*. (1984).

Hydraulic simulations were originally developed by the USACE for each habitat reach (Table 4-11) using the TABS2 model. The model results were then enhanced to simulate a wider range of flows. The hydrodynamic modeling at habitat reaches B3, E2, and L1 used FESWMS3 (a finite element model from the Federal Highway Administration) and habitat reach H2 used STAGR (a 2-D/quasi-3-D model used extensively in research mode by USGS). Output from FESWMS and STAGR (i.e. the predicted depths and velocities) were used to make estimates of habitat WUA for each of the guilds identified.

Hydraulic Simulation

The primary feature of the hydraulic simulation model is the ability to simulate a broad range of flow conditions for each node with a single set of velocity data. Both models solve the two-dimensional vertically averaged flow equations using a spatially variable, scalar eddy viscosity that emphasizes vertical diffusion of momentum. The two major elements of the hydraulic simulation model are the prediction of water surface elevation to compute depths and velocities for the entire habitat reach over a range of flows of interest.

The following steps were performed in completing the hydraulic modeling:

- RMA/TABS2 (2-D finite element hydrodynamic numerical model; Resource Management Associates) model files were obtained from the USACE for the habitat sites (B, E, H, I, J, K, and L).

- TABS2 hydraulic models (e.g., grid files, boundary condition files, solution files) were reviewed, adequacy determined, and changes made as necessary to improve model results. The original model runs were not completed for flows less than 100 cfs. The model was re-calibrated to predict flow less than 100 cfs. The re-calibration process included using the measured water surface elevation (WSE) and corresponding discharge data from the field and the stage discharge relationship from the HEC-2. This re-calibration was performed using the most recent version of PHABWin.

- Existing hydraulic (water surface elevation) information provided by HEC-2 and the habitat field transect data were tabulated to develop a more refined understanding of hydraulic boundary conditions for calibrating the habitat sites.

- Depth and velocities were predicted using FEWMS and STAGR for all cells within each habitat reach (B, E, H, and L) for the following flows: 5, 20, 50, 75, 100, 250, 500, 1,000, 2,000, and 4,000 cfs.

For the calibration process in FESWMS and STAGR, the models were run at the observed flow, and the observed WSE from the field were quantitatively compared to the modeled WSE (from the model output). Certain variables (wetting/drying control, the eddy viscosity, and the Mannings n's) were adjusted within the model to achieve a modeled WSE that accurately (within ± 0.01 meter [m]) represented the observed WSE. Within the STAGR model all of these variables could be adjusted as well as a roughness modifier. The STAGR model was used for habitat Segment H because it performed better in more complex situations. Habitat Segment H was an extremely low gradient habitat reach and as a result the FESWMS model was not able to utilize the slope of the channel (even after assigning the boundary conditions) and accurately simulate the direction of the flow.

Habitat Simulation

Hydraulic simulation results were converted into a measure of habitat for each fish species life stage using WINHAB2D. The habitat modeling consisted of associating each node in the mesh with an area (the area of the computational cell) and then calculating the habitat suitability for each cell based on the optimum and usable ranges of depth and velocity criteria ranging between zero and one (1=completely suitable, 0=not suitable) for each guild.

WINHAB2D is a two-dimensional habitat model that parallels the application of PHABSIM modeling except that it is computed on a node-by-node basis from the habitat suitability criteria (HSC) values. The algorithm to compute the available habitat using hydraulic model output and the HSC was developed at Utah State University.

4.7.2.5 Habitat Time Series

The habitat-flow relationships are predicted from physical habitat area available at a given flow. Variability in flow and resulting variability in habitat is a natural component of streams and rivers that influence stream fishes (Poff *et al*. 1997). Habitat frequency analysis (Bovee 1982; Sale *et al*. 1982) can be used to characterize the variability of habitat experienced by fishes and can quantify the frequency with which specific habitat values are achieved under natural conditions.

Methods for habitat frequency analysis conducted for the present study are illustrated in Figure 4-5. Given the predicted flow record for each operational scenario, a synthetic habitat record was developed by converting each discrete flow event (i.e., average daily discharge) into its corresponding WUA value. The result of this step is called a habitat time series. The Habitat Time Series module of PHABSIM was used to complete this task. Three distinct biologically significant periods (BSP) were run to represent spring (BSP1=March 1 to June 15), summer (BSP2=June 15 to September 15), and fall (BSP3=September 15 to November 15) conditions.

4.7.2.6 Habitat Duration Indices and Seasonal Considerations

Frequency duration tables and curves were developed for each guild for the entire 10-year period of evaluation and/or for critical seasons (e.g., spring, winter, etc.) so that habitat could be evaluated among alternatives and compared to each baseline (Appendix K and L).

Although annual habitat frequency analysis can be done, the seasonal changes in fish habitat requirements require a seasonal approach to capture important shifts in habitats used by different species and life stages. For instance, during the spring species may use different habitats for spawning than during the summer or fall. By examining habitat frequency by season, important changes in habitat between scenarios can be quantified.

To account for the seasonal changes in habitat within the Sheyenne River, habitat time series were completed for the following seasons:

- Spring (March 1 to June 15)
- Summer (June 16 to September 15)
- Fall (September 16 to November 15)

Biologically important time periods were derived from literature review and contacts with local experts. Important seasonal time periods to the fish communities of the Sheyenne River and the rational for the selection are presented below.

Spring (March 1 to June 15)

Spring is representative of spawning periods for many species of fish in the Sheyenne River. Northern pike are the earliest spawning species (mid to late March). If appreciable amounts of adjacent macrophyte beds or wetlands are present, then seasonal flooding of these areas in the spring would be important to this species. Darters, redhorse, and white suckers spawn in mid spring (mid April to mid May). These species are primarily simple lithophiles and need clean hard substrates of cobble and gravel. Riffles are important to these species, especially for spawning.

Most of the cyprinids and centrarchids are late spring, early summer spawners. The majority of species in these families are fairly general in their habitat requirements. However, the centrarchids are all nest builders and can be adversely affected by significant fluctuations in water levels. Channel catfish are also late spring to early summer spawners that spawn in cavities, especially hollow logs. Species that are quite migratory during the spawning season and benefit from moderate to high flows (at the right time) are northern pike**,** white sucker, channel catfish, white bass (*Morone chrysops*), all the redhorse, sauger, and walleye.

Summer (June 16 to September 15)

Summer is an important time for late spawning species as well as an important period for rearing and growth of YOY of various fish species that spawned in spring. Floods and high flows in the early or mid-summer are usually detrimental to most nest-building species, especially centrarchids. This is the period when most of the growth occurs and when the size of year class strength is determined. Riffles are likely important during this period because of their productivity and thus utilization during this period by benthic insectivores (e.g., some darters, shorthead redhorse, stonecat and longnose dace) would be expected. During this period, run/raceway areas are occupied by another guild. Representative of species likely to prefer this habitat type include shorthead redhorse, greater redhorse, bigmouth shiner, rosyface shiner, sand shiner, and flathead chub.

To the extent they are present, backwaters serve as nursery areas. Thus, it is important that sufficient depth is maintained in these areas during the summer.

Fall (September 16 to November 15)

During this season, fish begin to move from shallow, productive summer feeding areas to deeper and slower winter refugia. Walleye and sauger often move considerable distances in the fall. Catfish and smallmouth bass, depending on the system, can also move considerable distances during this period. Because this is a transition period, it is difficult to establish any particular habitat that is critical during the fall; however, since this season is considered a typical low-flow period during the year, it is an important season to determine potential impacts to the fish community.

Winter (November 16 to February 28)

During the winter, feeding is greatly reduced or even eliminated in some species. Fast water areas are little used because of the metabolic costs associated with inhabiting them. Most species seek out deep, slow areas. If any backwater or off-channel areas are present, they would be important as winter refugia. During the winter, large numbers of fish may crowd into small areas. It is important that such areas have sufficient depth to maintain adequate dissolved oxygen throughout the winter period and that depth is maintained throughout the winter. Pools and backwaters would be the critical habitats during the winter. Substrate and cover are probably not particularly important.

While winter is an important biological time period, project operations (i.e., augmented flows) do not occur during this time period; therefore, winter was not evaluated separately for the habitat time series analysis. However, the lack of project operation could affect the availability of deep pool refugia. An analysis of how these habitats change during winter low flows would be useful in evaluating the impacts of reduced (or unenhanced) winter flow.

4.7.2.7 Habitat Impact Metrics

Selected metrics that best described the impact on selected important habitats during different seasons were summarized. Metrics include average and maximum seasonal differences in habitat percent maximum WUA, 20 and 80 percent exceedance for WUA, rapid declines or changes in habitat availability with discharge and rapid declines or changes in WUA for each guild with flow.

Differences between alternatives are evaluated in detail in Section 5 using these habitat impact metrics.

4.8 EVALUATION OF RECOLONIZATION POTENTIAL

Recolonization potential for each reach is dependent on the extent of damage to the habitat and biotic communities, and sources of recolonizing biota. The extent of habitat damage was compared among the alternatives. The fauna in tributaries to the Sheyenne and Red River was reviewed as a colonization source.

5.0 EFFECTS OF OPERATIONAL SCENARIOS AND FUTURE WITHOUT PUMPING

Three of the modeled water quality parameters, TDS, sulfate, and chloride, were summarized and compared between baseline and future conditions. Predicted hydrological changes were summarized using IHA. Physical habitat simulation concepts from the IFIM, available hydrological and habitat data, and habitat preferences of representative aquatic biota were used to produce estimates of physical habitat impacts.

Habitat modeling assumes that the channel retains the same basic shape in the future, which would probably not be the case. WEST (2001) modeled geomorphology changes. However, the level of detail in the model was not sufficient for quantifying future erosion and deposition patterns that would influence biota. In particular, information on how channel morphology would change over time at the habitat transects and sedimentation rates for the alternatives was not available. Thus, percent of time channel-forming flow is exceeded was used as a measure of erosion/deposition magnitude.

A methyl mercury study (USGS and USACE preliminary data) is currently assessing the background levels of methyl mercury in the Sheyenne River and Devils Lake system. However, predictions of future increases or decreases in methyl mercury were not available at the time of this report.

5.1 ANTICIPATED GENERAL CHANGES AND IMPACTS ON BIOTA

Many factors affect biological communities in a complex riverine ecosystem. The current aquatic biota in the Sheyenne and Red Rivers is a result of many years of interaction of water quality, hydrology, geomorphology, habitat, inter-connectivity to the floodplain and groundwater, and biotia. These factors were simplified for this analysis. Factors considered include changes in water quality, hydrology, geomorphology, and habitat between baseline and operation/overflow conditions. Each of these factors is considered separately, and the consequences of changes in these factors on biota is considered separately, then as interactions. While the changes in water quality, hydrology, and habitat were modeled based on actual data, the effects of these changes on aquatic biota can only be estimated based on existing literature and biological expertise. Although the best available information was used in predictions of biotic changes, these predictions are only estimates. Monitoring will be required to determine how the alternatives will impact Sheyenne and Red River biota.

5.1.2 Water Quality

Water quality was characterized by TDS, sulfate, and chloride. The concentrations of these parameters would increase with operation or overflow compared to baseline conditions.

5.1.2.1 Total Dissolved Solids

The parameter TDS is expected to increase under all three alternatives, and modeled values for all three alternatives were significantly different ($p<0.001$) between baseline and operation/overflow conditions at all sites except Highway 30. With operation/overflow conditions, average TDS would be above the 500 mg/l guideline in the Sheyenne River, and the percent of time TDS is above this guideline would increase in the Red River (Figures 5-1, 5-2, and 5-3). The increase would be most apparent in the low-flow seasons of summer and fall, but would still be apparent in most months (Appendix M). The

modeling showed that at Cooperstown, TDS increases would be minor in January through April, however, downstream of Baldhill Dam, TDS would increase throughout the year (Appendix M).

The TDS is not expected to increase above levels toxic to fish (Table 4-2), but could exceed levels that might affect reproductive success of fish and survival of sensitive mollusks. Changes in TDS are not expected to affect common species of periphyton, phytoplankton, or macrophytes (Table 4-8).

5.1.2.2 Sulfate

Sulfate concentrations would also increase significantly ($p<0.001$) at all sites with all three alternatives. Under 300MOD50, pumping would be restricted by the Sheyenne River sulfate standard of 450 mg/l. Therefore, neither the average nor the maximum sulfate concentrations predicted for this alternative would exceed the 450 mg/l standard in the Sheyenne River or the 250 mg/l standard in the Red River (Figure 5-1). Average sulfate concentrations with 480MOD55 pumping would also be less than 450 mg/l and 250 mg/l in the Sheyenne and Red Rivers, respectively. However, maximum concentrations would exceed standards throughout the Sheyenne and Red Rivers (Figure 5-2). With WETOF overflow, average sulfate concentrations would exceed the Sheyenne River standard, and maximum concentrations will exceed the Red River standard (Figure 5-3).

The increase in sulfate might reach levels that affect the survival of sensitive invertebrates with 300MOD50 pumping, levels that could affect the survival of tolerant invertebrates with the 480MOD55 pumping, and levels that could affect the reproduction of sensitive fish with WETOF overflow. No sulfate tolerance limits were available for periphyton and phytoplankton, but in general the higher sulfate levels that would occur with pumping and overflow would tend to favor Euglenophytes over Chlorophytes and Bacillariophytes (Table 4-8). Most macrophyte species in the Sheyenne River are tolerant to sulfate and should not be affected by increases in sulfate due to pumping or overflow (Table 4-8).

5.1.2.3 Chloride

Chloride would also increase in concentration with pumping or overflow. The increase would occur with all alternatives, and chloride concentration with operation/overflow is significantly different ($p<0.001$) at all sites with all alternatives. Average and maximum chloride concentrations are predicted to be less than the 100 mg/l guideline with 300MOD50 pumping (Figure 5-1). Average chloride would remain less than this guideline with 480MOD55 pumping, but maximum concentrations would exceed this guideline throughout the Sheyenne River (Figure 5-2). With WETOF overflow, average chloride concentration is predicted to be greater than the 100 mg/l guideline at Cooperstown and Baldhill Dam, and less than the guideline at Kindred and in the Red River. However, maximum concentrations would exceed the guideline at Kindred and Halstad (Figure 5-3). As with TDS, a seasonal trend in increased chloride concentration would be seen at Cooperstown with pumping, but downstream of Baldhill Dam the increase is seen throughout the year (Appendix M). With WETOF overflow, increased chloride concentration would be increased at all sites during all seasons (Appendix M).

The increase in chloride could be sufficient to affect the survival of sensitive invertebrate species with the 300MOD50 pumping, and affect survival of sensitive invertebrates and mollusks with 480MOD55 pumping and WETOF overflow. The increase in chloride might also affect the community composition

of algae and macrophytes. Levels would probably not decimate these communities as a whole, but shifts in species composition toward the more tolerant taxa would be expected.

5.1.3 Hydrology

The IHA was developed as tool for assessing changes in stream flow variability in river ecosystems. The integrity of flowing waters (maintenance of biodiversity) is largely dependent on their natural dynamic character (Poff *et al*. 1997). Five critical components of hydrology regulate ecological processes in rivers and streams—magnitude, frequency, duration, timing, and rate of change of hydrologic conditions (Poff *et al*. 1997). A summary of the effects of changing hydrological conditions on aquatic organisms is presented in Table 5-1. High- and low-flow events often serve as ecological bottlenecks that present critical stresses and opportunities for river species. Thus, the species in a stream reflect the frequency and intensity of disturbance events caused by flow (Poff *et al.* 1997). Increases in the variation of flow magnitude can result in stranding or wash-out of aquatic organisms, disruption of life cycles, and alteration of stream energy flow (Poff *et al.* 1997). Prolonged low-flow can concentrate aquatic organisms, resulting in stress, increased disease, and predation (Poff *et al*. 1997). Prolonged high-flow can result in the loss of shallow productive habitats (Poff *et al.* 1997).

The IHA summarizes magnitude, frequency, duration, timing, and rate of change in hydrology between pre-impact (baseline) and post-impact (pumping/overflow). Mean monthly flow in winter and spring should not increase with pumping, while summer and fall flow would increase (Table 5-2). With WETOF overflow, mean monthly flow would increase in all seasons. Variation in monthly flow would increase in all seasons except spring. Low-flow mean and variation should increase with all alternatives (Table 5-2). In contrast, high-flow mean and variation would be changed little, if at all (Table 5-2).

With respect to the timing of critical flow events, dates of minimum flow may occur earlier (pumping) or later (overflow). However, the timing of low-flow events simply shifts a few weeks from late summer to late winter, which are not critical times for most aquatic biota. No change is predicted in the timing of high-flow events, which typically serve as life cycle cues (Poff *et al*. 1997). Low-pulse events are expected to be fewer due to pumping and overflow; however, the duration and variability in duration of low-flow events could increase (pumping) or decrease (overflow). Extended duration of low flow could concentrate aquatic organisms, reduce plant cover, and increase physiological stress (Table 5-1). High-pulse frequency and duration, and variability of these parameters, on the other hand, may increase only slightly (Table 5-2). Prolonged inundation could lead to changes in vegetation and loss of riffle habitat (Table 5-1). The rate of change (the magnitude and frequency) of river rises and falls is not predicted to change (pumping) or may decrease (overflow), and no adverse biological effects are expected (Table 5-2).

Fish are very mobile and less susceptible to flow variation than invertebrates. Increasing flow with pumping or overflow would affect habitat availability and distribution, which is discussed separately (Section 5.1.4 Habitat). Other possible effects include stranding, disruption of spawning, and physiological stress associated with increased flow variability (Table 5-1).

5.1.3.1 Monthly Average Discharge

Winter

During the winter, most species are very lethargic and try to conserve energy by inhabiting slack water areas. Mean winter discharge would not increase with pumping, but might increase with overflow, and variability in winter flow could increase. Additionally, the change between fall and winter flow would be increased with the pumping alternatives. If populations increase in response to increased habitat volume, winter space might become a limiting factor.

Spring

Some species use high flow as a cue to initiate spawning migrations. The amount of water pumped or overflowing the lake would be small compared to flood flows, so the cycle would still be present—it would just begin and end at somewhat higher flows. The same triggers should still be present, so impacts seem unlikely.

Summer

Summer can be a stressful time for fish due to a combination of high water temperatures and crowding due to low flows. Crowding also increases the predation risk to smaller species. An elevation in "base" flows during the summer due to either pumping or an overflow would reduce crowding and therefore tend to reduce this stress. The decrease in flow variability might also reduce stress.

Fall

Flows in the fall, especially early fall, tend to be quite low. Increasing flows during this time might decrease the stress of low flow and as with summer, decreased variability might also reduce stress.

5.1.3.2 Annual Extremes

Unless the rate of pumping is increased or decreased gradually, there would be fairly rapid changes in flow in the Sheyenne River, especially near the point of discharge. Given their mobility, fish typically follow the flow up or down and impacts are usually negligible. The most commonly cited concern relative to rapid changes in flow is in regard to stranding during rapid flow decreases (Table 5-1). When stranding occurs, it typically occurs in off-channel areas (e.g., oxbows, backwaters, side channels, etc.). Given the morphometry of the Sheyenne River, where such off-channel features are rare, the chances of stranding are small. Another possibility for adverse effects would be the disturbance or desiccation of nests or eggs deposited on the stream bottom. Members of the sunfish family build nests, sometimes in shallow water. If nests were built during artificially high flows, a rapid decline in those flows could leave the nest dry, force the guarding male to abandon it, or increase the chances of predation of either eggs or fry.

Hydrological regimes appear to play an important role in unionid distribution. Although quantifying the effects of hydrology has eluded most malacologists to date (Layzer and Madison 1995), most unionid species are typically found in areas with sufficient flow to prevent sedimentation but without enough flow to render the substrate unstable (Vaughn 1997). These conditions generally occur at the head and foot of riffles and in raceways. Some species are adapted to swift water and some to lentic situations (Watters 1994a). In most rivers and streams, unionids are not found along the shallow margins of streams that are periodically desiccated during low flow, nor are they found mid-channel, where flow has

scoured fine sediments from protected microhabitats (Strayer 1999). Changes in seasonal flows could change the location of suitable habitat (Gore *et al*. 2001). Changes in timing, magnitude, and duration of annual extremes could effect which areas of the stream bed are scoured or desiccated in any particular season.

Sphaeriids and pulmonate gastropods are adapted to variable environmental conditions; however, these mollusks could be flushed during high flows (Hart and Fuller 1974). Increased hydrological variation may be of some benefit to these groups.

Prosobranch gastropods are more common in stable environments; however, desiccation seems to be their limiting factor (Brown 1991). Since they are mobile, prosobranchs may not be adversely affected by increased hydrological variability as long as water is available. Therefore, prosobranchs could benefit from the increase in flow magnitude.

Other benthic invertebrates could have a variety of responses to increased flow and increased flow variability (Table 5-1). In general, discontinuities in flow disrupt natural cycles of drift and feeding (Weisberg *et al*. 1990). Sudden changes in current velocity tend to increase invertebrate drift (De Jalon *et al.* 1994), resulting in decreased benthic biomass (Moog 1993). Reduced flow could lead to decimation of invertebrates in dewatered areas (Weisberg *et al.* 1990). Additionally, reduction of current velocity could be detrimental to rheophilic invertebrates such as most caddisfly and some mayfly species (Moog 1993). Weisberg *et al*. (1990) found a three-fold decline in chironomids and hydropsychid caddisflies with reduced winter flow. Increases in flow also seem to alter invertebrate behavior. Moog (1993) found that invertebrates may react to the increase in groundwater that accompanies a natural increase in flow, whereas they are not alerted to take an evasive response without this cue. High flow can also result in bottom scour, which dislodges biota (Weisberg *et al.* 1990). Some invertebrate taxa, such as amphipods, are adapted to ephemeral habitats, and may be out-competed with higher flow levels (Weisberg *et al*. 1990), whereas chironomids and hydropsychids tend to increase with flow stability (Weisberg *et al.* 1990).

Aquatic macrophytes are strongly influenced by changes in flow (Table 5-1). The effects of flooding depend on the flooding depth, frequency, duration, plant species present, sediment type, and velocity (Adamus 1996). Most species prefer slow currents or no flow conditions and can change their morphology in response to changes in flow (Rogers and Theiling 1999, Merritt and Cooper 2000). The greatest abundance and diversity of macrophytes in riverine systems occurs in the backwater or slack water areas. Submerged and floating-leaved plants often have little or no adverse reaction to increased water levels (Adamus 1996), however, increased flow can be detrimental if plants are physically removed and scoured out with the increased velocity, or depth becomes too great for adequate light penetration (Rogers and Theiling 1999, Langrehr. and Dukerschein 1994). The velocity at which scouring occurs is dependent on the plant species, the density of the bed, and the soils present. Emergent and fringe species can be suffocated (Rogers and Theiling 1999) or suffer from the development of toxic soil conditions (Whitlow and Harris 1979). However, the increased flow may also allow the expansion of submerged and emergent species through newly created habitats. In the Sheyenne River this may include expansion of the pondweeds (*Potamogeton* sp.) and cattails (*Typhus* sp.). Many emergent and wetland plants require exposure of soils for germination and would be negatively affected with reduced shallow areas. Eurasian water milfoil (*Myriophyllum spicatum*) in Lake Ashtabula is believed to be controlled through

freezing of exposed plants in winter (Bonnie Alexander, personal communication). Increased water depth may allow this plant to survive and spread.

Deviations in seasonal and annual hydrologic cycles from normal regimes may reduce overall species richness (Hartog *et al*. 1989). Taxa that are more aggressive, exotic, clonal, and/or annuals may replace native species and perennials, particularly grasses and sedges. Depending on the initial vegetation, the replacement species are often cattails, bulrushes, arrowhead, and pondweeds (Adamus 1996). These species also tend to have rigid stems and can endure long period of exposure (Adamus 1996). Many of the invasive species are already present in the Sheyenne River system and might be limited to expansion and not new occurrences.

Increased flow may have mixed effects on algal communities (Table 5-1). In areas with increased water depth, phytoplankton may increase while periphyton decreases because of reduced light penetration. Overall production may increase due to an increase in habitat. Inundation has also been shown to effect algae by diluting nutrients, reducing nitrogen mobilization via oxidation, and increasing competition with vascular plants (Adamus 1996). Growns and Growns (2001), however, did not find changes in periphytic diatoms under regulated flow. Most algal species are resilient to water level fluctuations and may not be significantly impacted by changes in hydrology. The loss of macrophyte beds under high flow velocity may have significant impacts on algae through the loss of substrate for epiphytes and a general loss of habitat and flow diversity (Table 5-3).

5.1.4 Geomorphology

Changes in hydrology would change channel geomorphology. Changes in geometry and planform between baseline and pumping conditions are expected to be slight (<5 percent; Table 4-11 and 4-12). The magnitude of channel-forming flow would increase slightly, and the percent of time that the predicted baseline channel-forming flow is exceeded would increase (Table 5-4). Width and depth are expected to increase somewhat, and channel slope is expected to decrease in most areas. These changes may be slight, but would result in increased erosion and subsequent deposition. However, the expected amount and rate of change is not known, as the patterns of erosion and deposition were not modeled. Changes in channel planform are also expected. However, these changes are predicted to occur over a period of 300 years. Nevertheless, increased erosion and deposition can be expected within the life of the project.

Increased erosion and deposition could potentially adversely affect fish due to increased turbidity, sedimentation, and scouring. Increased sedimentation could, in turn, lead to increased embedment or even the complete burying of hard substrates (i.e., gravel, cobble, and boulder) (Table 5-5). Species that would be most affected would be those requiring clean, hard substrates for either spawning (e.g., simple lithophils—shorthead redhorse, golden redhorse, white sucker, etc.) or those that depend on such substrates throughout their life-cycle (e.g., stonecat and longnose dace) (Table 5-6). Scouring and deposition could also eliminate macrophytes, which are used for spawning (northern pike) and are the preferred habitat of many North Dakota special concern species (pugnose shiner, blackchin shiner, blacknose shiner, banded killifish; Table 5-6). Turbidity is also likely to increase, and many of the North Dakota special concern species and most of the redhorse in the Sheyenne and Red Rivers are intolerant of high turbidity (Table 5-6).

There are no data that translate the predicted increase in bed load material to a biologically meaningful measure such as degree of embedment, amount of hard substrate that will be buried, loss of macrophytes, or increase in turbidity. If the increased bed load merely results in additional amounts of fine material in areas that already are depositional in nature, then few or no impacts would be expected (Table 5-6). On the other hand, if this material settles out predominantly in areas that currently provide clean hard substrates, then the impact could be significant. Similarly, slight erosion may remove sediment that is now limiting to rheophilic biota, whereas scouring may deplete the interstitial spaces needed for invertebrate burrowing, decreasing productivity, which in turn could affect fish abundance (Table 5-3). Currently there is no way to determine where in this range potential impacts will occur.

Changes in erosion and deposition that are expected to occur under the alternatives will probably have the greatest impact on unionids. Complex hydrological parameters such as shear stress correlate more closely with unionid abundance than most other physical parameters (Hardison and Layzer 2001). Scouring can render substrate unsuitable for unionids. Sedimentation and increases in turbidity can also negatively affect unionids (Table 5-6).

Substrate disturbance resulting from erosion could dislodge unionids, alter currents, and resuspend sediment. Increased turbulence and turbidity have been shown to affect unionids (Payne and Miller 1987, Aldridge *et al*. 1987) and other filter feeding benthic invertebrates (Newcombe and MacDonald 1991). Increased turbulence and resuspended silt have been shown to reduce growth (Yokley, 1976), feeding rates (Miller *et al*. 1984 Aldridge *et al*. 1987), oxygen consumption, and nitrogen excretion (Aldridge *et al*. 1987). Sedimentation is extremely detrimental to unionids, and is implicated in the decline and extinction of numerous species (Stansbery 1971). Silt can clog unionid gills and filtration systems, preventing respiration and causing nutritive stress. Ellis (1936) showed that most unionids died when covered by as little as 1.3 to 5.1 cm of silt.

However, some scouring could reduce sedimentation in areas otherwise unsuitable for thicker-shelled unionids such as most Ambleminae and Lampsilinae, and minor deposition is tolerable by most of the species found in the Sheyenne River. Some species, primarily the Anodontinae (*P. grandis*, *A. ferussaccianus*, *L. compressa*) are adapted to softer substrates due to their thinner shells.

Sphaeriidae prefer finer substrate than unionids and would not be as affected by sedimentation (McMahon 1991). However, the redistribution of substrates may change the physical location of suitable sphaeriid habitat, and scouring of substrates would also dislodge sphaeriids.

Species richness of gastropods is related to substrate diversity (Harman 1974, Brown 1991). Erosion and deposition of substrate could reduce substrate diversity, thereby affecting gastropod diversity. Additionally, silt cover curtails egg development (Harman 1974). Thus, snail diversity could be affected by the alternatives.

Composition of the invertebrate community could change with increased erosion and deposition (Kohlhepp and Hellenthal 1992, Moog 1993, De Jalon *et al.* 1994). However, the changes could differ depending on functional feeding group and habitat preference (Kohlhepp and Hellenthal 1992). Kohlhelpp and Hellenthal (1992) found that increased sedimentation reduced te density of two filter feeders but increased te density of a third. Gatherer/collectors seemed to increase with sedimentation for five of six species, whereas shredder density decreased for two species and increased for one species

(Table 5-5). Most of the dominant benthic invertebrates in the Red and Sheyenne Rivers are gatherer/collectors and occur in depositional areas. If depositional habitat were to increase these species could benefit. However, repeated scouring and deposition, which generally occurs in highly variable systems would tend to reduce overall diversity and abundance (Moog 1993, Jalon *et al*. 1994).

Changes in geomorphology may have significant impacts on aquatic macrophytes. Probably the greatest impacts would occur as a result of increased turbidity and substrate instability. Increased turbidity reduces light penetration and therefore reduces the available habitat for vegetation. Because of this, increased turbidity can lead to a shift in community structure from submerged species to floating leaved or emergent species (Hough and Forwall 1988). High turbidity can also favor invasive or exotic species (Morin *et al*. 1989). Highly disturbed, sediment-laden wetlands are often dominated by giant reed grass (*Phragmites australis*) and reed canary grass (*Phalaris arundinacea*) (Adamus 1996). Lloyd *et al.* (1987) have documented that a 25 Nephelometric Turbidity Units (NTU) increase in turbidity in a shallow riverine wetland can reduce production of algae and submerged aquatic macrophytes by 50 percent, and a 5 NTU increase in turbidity reduced productivity in a lake by 80 percent. Reduced productivity is a function of reduced light penetration and deposition of sediment on leaf surfaces (Rogers 1994).

High concentrations of phytoplankton can mimic the effects of turbidity and are usually a result of eutrophication (Adamus 1996). Submerged plants typically have a short period during the spring when they must grow enough to reach the water surface before turbidity or algal blooms stunt their growth (Adamus 1996).

Currently, turbidity is relatively high in the Sheyenne River and very high in the Red River. Many of the existing macrophytes, including water plantain (*Alisma plantago*), coontail (*Ceratophyllum demersum*), elodea (*Elodea candensis*), and the pondweeds (*Potamogeton crispus, P. pectinatus, P. perfoliatus*), are generally tolerant of turbid conditions and would not be expected to show significant negative effects (Davis and Brinson 1980). Turbidity-tolerant species are characterized by rapid growth during the early spring, summer leaf canopies, and winter tubers or rhizomes (Engel and Nichols 1994).

Geomorphology changes would also include changes in bottom substrate and a shift in erosional and depositional habitats. Shifting bottom substrate can expose or scour macrophyte beds and cause a loss of vegetation (Rogers and Theiling 1999, Fischer and Claflin 1995). Macrophyte beds often take many years to recover (Rogers 1994). Deposition may also smother existing macrophyte beds and bury the plants. The impact of burial varies by species, with the more aggressive and invasive species having a greater tolerance. Stiff-stemmed emergents (cattails, giant reed grass) are least affected by sedimentation (Adamus 1996). Van der Valk (1981) found seedling mortality of some emergent species under accumulations of 5 cm per year. Severe deposition may even shift macrophytes from submerged to emergent or wetland species as water depth is decreased. This conversion may only happen, however, if the substrate is stable. A constantly shifting substrate can deter the establishment of aquatic vegetation.

Vegetation itself can affect the rate of geomorphic change. Macrophyte beds can collect sediment and may act as a transition zone from suspended to deposited material (Rogers and Theiling 1999). Establishment of vegetation reduces erosion and stabilizes the banks. The establishment or removal of vegetation would have significant effects on the entire system as it would influence the location and rates

of geomorphic change. Changes in geomorphology would influence the changes in habitat and all of the biotic interactions in the river system.

Algae are also susceptible to changes in geomorphology. Since algae are primary producers, increased turbidity decreases production. Shade tolerance varies widely among algal species, but generally turbidity has a greater impact on periphyton than on phytoplankton (Adamus *et al.* 2001). Turbidity can have secondary effects on algae by shading out macrophytes used by epiphytic algae. The effects of sedimentation and burial on algal species is not well documented, although it is assumed that benthic species are more impacted (Adamus *et al.* 2001). Low biomass and density of algae, or shifts in species composition, may be used as a bioindicator of elevated sedimentation (Adamus 1996). Algae are generally more tolerant of turbidity than macrophytes (Adamus 1996).

Because algae are short-lived and can adapt to changing conditions quicker than other biota, they may be able to remain stable. The greatest impact to algae may be a loss of macrophytes and shallow riffle areas. Loss of macrophytes would rapidly reduce the number of epiphytic algal species in favor of phytoplankton and benthic species. This may result in an overall decline in species richness, but a possible increase in biomass, in areas where macrophytes shaded out benthic species (Seelbach and McDiffett 1983).

5.1.5 Habitat

Research has shown that both long-term flows and short-term fluctuations can have a negative impact on fish and invertebrate populations; however, there is often insufficient biological data (spatial and temporal) to demonstrate a direct relationship between population change and artificial changes in stream flow on individual river systems (Parasiewicz and Dunbar 2001). Instream Flow Incremental Methodology was designed to represent habitat potential, not standing stocks. However, clear population linkages have been demonstrated for major long-term studies of rivers, where physical habitat can at times be a key limiting variable.

For the Devils Lake Study, a two-dimensional hydraulic model was used to simulate flow conditions for each of the study reaches. Two-dimensional models have recently experienced rapid development and represent the state of the art for the IFIM methodology. In the past 20 years, the IFIM methodology has undergone considerable improvements and enhancements and has been widely accepted by water resource managers around the world. The IFIM approach represents a flexible tool for the integration of biological information into the water resource planning process.

Physical habitat variables are clearly not the only factors affecting abundance and health of organisms in rivers. As stated previously, water quality, energy inputs, and biotic interactions are also important considerations. The use of IFIM provides an effective assessment tool that can predict the impact of an anthropogenic disturbance on stream-flow variability and is relatively easy to use and develop for a particular study. Instream Flow Incremental Methodology study results should be interpreted within a broader context, taking into account other physical (hydrology, sedimentation and erosion), chemical (water quality), and biological factors (inter- and intra-specific interactions).

General changes in habitat that are likely to occur with pumping or overflow include a decrease in slow, shallow habitats and an increase in faster, deeper habitats. This change would generally be greatest in

the typical low-flow months of summer and fall, and least in the spring. In general, with 300MOD50 pumping, mean discharge and the range of discharge is very similar between baseline and pumping conditions (Appendix I). With WETOF overflow, flow variability would increase. Shallow slow habitats would not be lost, but would occur less frequently, and faster, deeper habitats would increase in size and frequency. At 480MOD55 pumping, shallow, slow habitats would decrease significantly and be replaced by faster, deeper habitats during summer and fall.

As discussed elsewhere, it is difficult to predict quantitatively how the changes in habitat availability would affect fish and invertebrate abundance. Tables 5-1 and 5-7 provide a summary of recent literature regarding the biological response of biotic communities to changes in flow and habitat. Fish species representative of each habitat guild are identified in Table 4-16. Habitat and general feeding guilds of the dominant invertebrate taxa are provided in Table 5-8. These tables provide a guide as to which species are included when referring to habitat guilds, tolerances, and feeding preferences. In general, the increase in fast water habitats should result in a shift toward more rheophilic species. However, flow would not only increase but also become more variable. Thus, the shallow, slow habitats would still be present, but would occur with less frequency, and habitat would change more frequently. Generalists, which utilize a variety of habitats, would probably not be negatively affected, but specialists may decline in abundance. Generalists presently dominate the communities in the Red and Sheyenne Rivers.

5.2 300 CFS CONSTRAINED PUMPING (300MOD50) COMPARED TO THE 1450 MODERATE FUTURE BASELINE (MOD50) – 2005-2015

5.2.1 Water Quality Conditions

Pumping 300 cfs of Devils Lake water into the Sheyenne River (300MOD50) would moderately degrade Sheyenne River water quality and slightly degrade Red River water quality as compared to baseline (MOD50) conditions. Water quality would be affected to the Canadian border (Figure 5-1).

5.2.1.1 Total Dissolved Solids

Total dissolved solid levels would increase such that the 500 mg/l guideline would be exceeded more frequently under pumping conditions throughout the Sheyenne River and at Halstad and Emerson in the Red River (Figure 5-1). In Reach 1 (Cooperstown), mean TDS concentration would increase 30 percent, and the guideline of 500 mg/l would be exceeded by 5 percent more frequently with pumping than without (Table 5-9). However, TDS concentrations would only increase May through December (Appendix M-1). In Reach 3 (Baldhill Dam), mean TDS would increase a similar amount (32 percent); however, 500 mg/l would be exceeded over two times as often as with no pumping (Table 5-10), and increased concentrations of TDS would be apparent in all months of the year (Appendix M-1). The increase in mean TDS would be less in the lower Sheyenne River (21 and 16 percent at Lisbon and Kindred, respectively); however, the guideline would still be exceeded 45 and 31 percent more often, respectively (Tables 5-9 and 5-10). Under baseline conditions TDS is low in the Red River, and guidelines are seldom exceeded (Figure 5-1). With pumping, mean TDS would increase only 2 to 5 percent in the Red River, but this difference is statistically significant ($p<0.001$).

Although TDS would increase under 300MOD50, the increase would likely not affect fish and mollusks. Average TDS would be well below the chronic value of 1,000 mg/l thought to be affecting reproduction

of sensitive fish and survival of sensitive mollusks throughout the Sheyenne and Red Rivers (Figure 5-1; Appendix M-1). No information with respect to invertebrates and TDS was available. However, maximum expected TDS concentrations with pumping are expected to only slightly exceed current conditions (Table 3-4). Therefore, invertebrates are not likely to be affected (Table 5-11). No specific information with respect to macrophytes and TDS was available. Most of the species present in the Sheyenne and Red Rivers are believed to be tolerant to elevated levels of TDS and should not be affected. Algae are also believed to be tolerant of the modeled TDS concentrations under the 300MOD50 pumping and should not be affected (Table 5-11).

5.2.1.2 Sulfate

Sulfate levels would moderately increase with 300MOD50 pumping compared to MOD50 baseline conditions. Accoeding to the model, average sulfate would increase over 50 percent at Cooperstown and Baldhill Dam, over 40 percent at Lisbon, and over 30 percent at Kindred (Table 5-9). Sulfate concentration is also expected to increase (12 percent, 7 percent, and 5 percent in the Red River near Halstad, Grand Forks, and Emerson, respectively). However, the water quality standards of 450 mg/l and 250 mg/l are not expected to be exceeded in the Sheyenne and Red Rivers, respectively (Table 5-10). Maximum expected sulfate is 429 mg/l near Cooperstown (Reach 1) (Table 5-10). Monthly average sulfate also is not expected to exceed standards with 300MOD50 pumping (Appendix M-2). However, average sulfate in June through December at Cooperstown is almost double the concentration expected under MOD50 baseline conditions.

This projected increase in sulfate is not expected to affect most aquatic animals. No effects of sulfate on fish have been demonstrated at <600 mg/l (Table 4-2) and mollusks have been collected in areas with sulfate up to 1300 mg/l (Table 4-6). Most of the common invertebrates in the Sheyenne River have previously been collected at sulfate levels near 450 mg/l (Table 4-7). However, a few common species (*Macronychus* sp., *Hexagenia* sp., and *Pentagenia* sp.) are listed as sensitive to sulfate in Hart and Fuller (1974). These taxa are currently present in Reaches 1 and 5 of the Sheyenne River (Table 3-16), where maximum sulfate levels of 290 and 360 mg/l have been reported (Table 3-4). However, the increase in average sulfate to over 250 mg/l in June through December at Cooperstown might affect these sensitive taxa and result in a community shift toward more tolerant taxa (Table 5-11). Macrophytes are not expected to be affected by increases in sulfate concentrations; however, some changes in the algal community are expected. Although most of the algal taxa should be unaffected, Phillips *et al.* (2000) did find a significant relationship between sulfate concentrations and algal distributions. This suggests that some of the more sensitive taxa (diatoms *Cymbella muellerii* and *Nitzschia* sp.) may be affected. Taxa associated with higher sulfate concentrations (*Phacus acuminatus* [euglenoid] and *Dictosphaerium ehrenbergianum* [green algae]) may become more abundant. Effects may be limited to Reach 1 (average sulfate 253 mg/l), but could extend throughout the Sheyenne River (average sulfate at Kindred 192 mg/l). Toxicity tests on specific species would be needed to answer this question.

5.2.1.3 Chloride

Chloride levels in the Sheyenne River are expected to double with 300MOD50 in Reach 1 and at Baldhill Dam (Tables 5-9 and 5-10, Figure 5-1). A more than 60 percent increase is expected in Reach 5. Red River increases in chloride would be similar in magnitude to sulfate, with increased chloride of 12, 9, and 4 percent at Halstad, Grand Forks, and Emerson, respectively (Table 5-9 and Figure 5-1).

However, water quality levels would not exceed standards. In Reach 1 (Cooperstown), chloride concentrations would double in the period June through December (Appendix M-3). During all months, chloride concentrations would be greater with 300MOD50 pumping than with MOD50 baseline conditions in the Sheyenne River downstream of Baldhill Dam (Appendix M-1).

The increase in chloride with pumping might have some effect on sensitive invertebrates, but is not expected to affect the fish community. Chronic exposure to <600 mg/l of chloride has not been shown to affect the fish species tested (Table 4-7). The highest chloride concentration in the study area (240 mg/l) occurs now in Reach 3 of the Red River (Table 3-4). Most of the species considered sensitive to water quality, such as northern pike, hornyhead chub, white sucker, and walleye (Table 4-5), are present in Red River Reach 3. Thus, the 240 mg/l maximum and 55 mg/l average chloride do not appear to affect sensitive Red and Sheyenne River fish. Maximum chloride expected with 300 cfs pumping is 80 mg/l (40 mg/l average) in Reach 1 (Table 5-10), which is well below 600 mg/l.

Unionids and sphaeriids are also unlikely to be affected by increased chloride, as 100 mg/l (the limiting level for unionids and sphaeriids; Table 4-3) would not be exceeded at any site throughout the year (Table 5-11, Figure 5-1, Appendix M-3).

Some of the common invertebrate taxa in the Sheyenne River, including *Dubiraphia* sp., Corixidae, *Caenis* sp., *Hexagenia* sp. and *Pentagenia* sp., are very sensitive to chloride (Table 4-7). These taxa may be affected by chloride levels higher than 50 to 75 mg/l, which could occur occasionally in Reaches 1 and 3 of the Sheyenne River and Reach 3 of the Red River (Figure 5-1). The monthly average TDS at Cooperstown from June through November is also expected to exceed 50 mg/l (Appendix M-3), which could be lethal to sensitive invertebrate taxa in Reach 1 (Table 5-11). The loss of these sensitive taxa would probably decrease invertebrate species richness in Sheyenne River Reach 1. However, other less sensitive taxa may increase in abundance, and density may not be affected.

Macrophytes would probably not be affected by increased chloride concentrations expected with 300MOD50. The most sensitive algal species may be negatively impacted, but chloride concentrations did not explain algal distributions in the Phillips *et al.* study (2000). The general threshold of 1,000 mg/L for salt-tolerance (Prepas and Trew 1983) would not be exceeded, and therefore only minor impacts would be anticipated. Impacts, if any, would be limited to Reach 1.

5.2.1.4 Summary

The increased concentrations of TDS, sulfate, and chloride expected with 300MOD50 pumping are not likely to affect fish, mollusks, or macrophytes, but might be lethal to sensitive invertebrates and shift algal communities in Sheyenne River Reach 1 (Table 5-11). This might result in a loss of invertebrate and algal species richness. No changes in primary production, trophic levels, or DO would be expected. The occasional increase in chloride above 50 mg/l in Sheyenne River Reaches 1 and 3 might also affect sensitive invertebrates. However, the acute lethal chloride concentrations for these species are not known. The 50 mg/l concentration would also occasionally be exceeded in Red River Reach 3; however, this is expected regardless of pumping (Figure 5-1). High sulfate levels might affect sensitive algal species throughout the Sheyenne River. The acute lethal concentration for Sheyenne River algal species, however, is not known.

5.2.2 Hydrology Conditions

Hydrology varies little between the MOD50 baseline and 350MOD50 pumping (Table 5-11, Appendices I and J). In Reach 1 (Cooperstown), only two hydrological variables would differ significantly between the MOD50 baseline and 300MOD50 pumping—low pulse count and low pulse duration. Low pulse count would be less variable with pumping. Without pumping, 0 to 7 low-flow events are expected per year (mean 3.2); with pumping, 0 to 6 low-flow events are expected per year (mean 2.2; Appendix I and J). Low-flow duration is expected to increase in length and variability. Without pumping, low-flow events are expected to last 0 to 55.7 days (mean 21.3); with pumping, low-flow events are expected to last 0 to 79.5 days (mean 27.3). However, the magnitude of low-flow only differs in Reach 1. The magnitude of low flow (>75 percent exceedence flow) would increase from 21 to 25 cfs (17 percent). However, high-flow magnitude (>25 and >10 percent exceedence flow) would increase 26 and 24 percent, respectively, at Cooperstown (Reach 1), 15 and 20 percent, respectively, downstream of Baldhill Dam, 11 and 17 percent, respectively, at Lisbon, and 8 and 14 percent, respectively, at Kindred (Table 5-12).

In the Red River, no significant change is expected in hydrological conditions. Changes in Red River high- and low-flow magnitude differ less than 10 percent between the MOD50 baseline and 300MOD50 pumping in most cases (Table 5-12).

Since change in hydrologically important parameters would be minimal, biota would be expected to respond similarly to these parameters under MOD50 baseline and 300MOD50 pumping conditions (Table 5-13). However, the frequency of habitat availability is expected to change somewhat (see Section 5.2.4).

5.2.3 Geomorphology Conditions

WEST (2001) predicts that the Sheyenne River channel would remain stable under 300MOD50 pumping (Table 4-11). Channel-forming flow, width, depth, meander length, and meander amplitude are all expected to change less than 5 percent. However, the change in width could be up to 3 feet in Reach 1. It is not clear whether this projected increase is real or within the model's margin of error. Additionally, this change was predicted based on the average channel-forming flow for the 50-year project life. Since pumping would occur less than 50 percent of the time, these impacts may be underestimated.

Channel-forming flow would be exceeded less than 10 percent of the time under both MOD50 baseline and 300MOD50 pumping conditions; thus, only slight, if any, increases in erosion and deposition would be expected (Table 5-13).

5.2.4 Habitat Conditions

Compared to the MOD50 baseline, little change in discharge and therefore habitat would occur with 300MOD50 pumping (see Section 5.2.2). Variability and range in discharge would be very similar under both the MOD50 baseline and 300MOD50 pumping. Therefore, the percentage of WUA exceeded 80 percent of the time for most habitat guilds would be similar under the MOD50 baseline and 300MOD50 pumping (Table 5-15; Appendices K and L). However, slight increases in mean monthly discharge are expected in May through September (Table 5-12), and the magnitude of high-flow events (>25 percent exceedance) would increase throughout the Sheyenne River. The greatest differences in mean monthly discharge would be seen in Reaches 3 (Habitat Segment E) and 5 (Habitat Segment B) rather than Reach 1 (Habitat Segment H) (Tables 5-15 and 5-16). The average change in percent WUA between the MOD50 baseline and 300MOD50 pumping is predicted to be less than 11 percent at Segment H and E, but up to 32 percent at Segment B (Table 5-16). The maximum change in percent WUA between the MOD50 baseline and 300MOD50 pumping is predicted to be 32 percent (increase in summer fast riffle), 69 percent (increase in summer fast riffle), and 81 percent (decline in summer fast riffle) at Segments H, E, and B, respectively.

5.2.4.1 Habitat Segment H

Potential Habitat Reductions

In Habitat Segment H, the 300MOD50 pumping alternative would result in only minor reductions of habitat when compared to the MOD50 baseline (Table 5-14, Figure 5-4). Reduction in available habitat primarily would occur during the summer and fall for the shallow pool guild. The shallow pool guild would realize the most percent WUA at 20 cfs, which would occur less often with 300MOD50 pumping (Table 5-12; Figure 5-4). The shallow pool guild percent WUA would decrease by a maximum of 10 percent and an average of 3 percent during the summer, and would decrease by a maximum of 14 percent and an average of 7 percent during the fall. However, the maximum decrease in shallow pool in both seasons would occur approximately 50 percent of the time (Appendix K and L). Most of the time (80 percent) the exceedence percent WUA of shallow pool would be similar between baseline and operating conditions (22 percent and 22 percent in summer and 31 percent and 27 percent in the fall, respectively) (Table 5-15).

Potential Habitat Enhancements

In Habitat Segment H, the 300MOD50 pumping scenario would result in minor increases in fast riffle and raceway guilds in summer and fall when compared to its baseline because of the increased magnitude of flow in these seasons (Table 5-16; Figure 5-4). The maximum percent WUA would be greatest at 75 to 500 cfs for the fast riffle guild and at 250 to 500 cfs for the raceway guild (Figure 5-4), and these flows would be more frequent during summer and fall with pumping (Table 5-12). However, the 80 percent exceedence value for maximum percent WUA would increase from only 2 to 3 percent for fast riffle and

0 to 0.1 percent for raceway (Table 5-15). So, most of the time these fast water habitats would be limited under both MOD50 baseline and 300MOD50 pumping. Medium pool percent WUA also would increase slightly with pumping, but on average would increase less than 10 percent (Table 5-16). Medium pool percent WUA would be highest between 50 and 250 cfs (Figure 5-4). The 80 percent exceedence maximum WUA would increase in summer from 19 percent with the MOD50 baseline to 29 percent with pumping, and in the fall would increase from 23 percent to 39 percent with 300MOD50 pumping (Table 5-15).

Maximum WUA would be similar between the MOD50 baseline and 300MOD50 pumping in all seasons (average less than 5 percent and maximum less than 15 percent) (Table 5-16).

Possible Changes in the Fish Community

Most of the common species in Reach 1, including black bullhead, brook stickleback, creek chub, fathead minnow, trout-perch, and common shiner, can utilize a variety of habitats but are most commonly found in pools (Table 4-16). Thus, changes in pool habitat would have the most effect on Reach 1 fish species.

During the spring, the average change in the percent WUA for all guilds is predicted to be less than 3 percent (Table 5-16, Figure 5-4). These small changes should not affect the fish community. During the summer and fall, nursery habitat is expected to be similar between MOD50 baseline and 300MOD50 pumping (Table 5-16). The percent WUA of slow riffle, raceway, medium pool, and fast riffle habitat would increase slightly with 300MOD50 pumping (Table 5-16). Medium pool is the only habitat where the 80 percent exceedence percent WUA would increase with pumping, but only in the fall. Thus, the fish community should remain similar under both MOD50 baseline and 300MOD50 pumping.

Possible Changes in the Invertebrate Community

Since percent maximum WUA should remain the same for both the benthic invertebrate diversity guild and tricopteran guild, 300MOD50 pumping is unlikely to have much effect on the invertebrate community.

5.2.4.2 Habitat Segment E

Potential Habitat Reductions

The only habitat guild that would be reduced with 300MOD50 pumping in Segment E is shallow pool (Table 5-16, Figure 5-5). Shallow pool percent WUA would decline to less than 50 percent with an increase in flow to only 100 cfs, and percent WUA would be less than 10 percent with 250 cfs (Figure 5-5). Since these flows would occur more frequently with pumping (Table 5-12), shallow pool would be decreased with pumping most of the time. During summer under baseline and pumping, the percent WUA exceeded 80 percent of the time for the shallow pool guild would decrease from 20 percent to 9 percent (Table 5-15). The shallow pool guild would have a maximum decrease in percent WUA of 28 percent and an average decrease of 9 percent during the summer, and a maximum decrease of 24 percent and an average decrease of 4 percent during the fall (Table 5-15).

Potential Habitat Enhancements

Fast riffle and raceway percent WUA would increase with increased discharge up to 500 cfs (Table 5-16 and Figure 5-5). The fast riffle and raceway would be most notably enhanced during the summer: the fast riffle guild would experience a maximum percent WUA increase of 69 percent and an average increase of 11 percent. The raceway guild would experience a maximum percent WUA increase of 35 percent and an average increase of 11 percent. However, the increase in these habitats would occur at a low frequency. Percent WUA exceeded 80 percent of the time would only increase from 0 (baseline) to 1 percent (pumping) in the summer (Table 5-15). However, percent WUA exceeded 20 percent of the time would increase from 6 percent to 35 percent with pumping for fast riffle and from 76 percent to 96 percent for raceway in the summer (Table 5-15).

Neither low-gradient nor Tricoptera habitat would be much affected in Segment E by 300MOD50 pumping. Both groups percent WUA would be over 70 percent with discharge of 20 to 250 cfs (Figure 5-5).

Possible Changes in the Fish Community

The fish community in Reach 3 currently reflects the more stable flow and habitat conditions that are present downstream of Baldhill Dam. Dominant species include bluntnose minnow, golden redhorse, Johnny darter, common shiner, rosyface shiner, shorthead redhorse, and smallmouth bass (Table 4-16). Many of the North Dakota special concern species also occur in this reach including, trout-perch, hornyhead chub, pugnose shiner, blacknose shiner, rosyface shiner, banded killifish, silver redhorse, and greater redhorse (Table 4-16). Many of these species depend on the shallow and medium pool for nursery areas and fast riffle and raceways for spawning.

Increases in percent WUA for fast riffle and raceway are likely to benefit rheophilic species such as redhorses, smallmouth bass, longnose dace, rosyface shiner, and stonecat. Most other species in this reach are either generalists or prefer quieter water situations, which should not change substantially.

Possible Changes in the Invertebrate Community

The invertebrate fauna in Reach 3 is more diverse than in Reach 1 because of the greater habitat stability. Diptera (29 percent) and Ephemeroptera (20 percent) are still abundant but are represented by a variety of species (Table 3-16). Amphipods and coleopterans are less abundant, but hemipeterans (28 percent) and tricopterans (12 percent) are more abundant. Although most species are still generalists and tolerant, this area supports a more diverse and rheophilic community than in Reach 1. Since percent WUA for tricopteran and low-gradient invertebrate diversity is not expected to change much with increased flow, the invertebrate community would probably not be affected by 300MOD50 pumping in Reach E.

5.2.4.3 Habitat Segment B

Potential Habitat Reductions

In Habitat Segment B, habitat degradation associated with the 300MOD50 pumping when compared to the MOD50 baseline would be more severe for all habitat guilds than in upstream habitat segments (H and E). This is primarily because of the low proportion of shallow pool, slow riffle, fast riffle, and deep pool under all discharges and the decrease in these productive habitats at discharges greater than 100 cfs (Figure 5-6). As discharge increases, the amount of unproductive (deep fast) habitat would increase, and other habitats would be reduced accordingly. Habitat degradation would occur for most biologically important habitat guilds in at least one season (Table 5-16). The fast riffle, raceway, and deep pool guilds would experience degraded habitat during the spring and summer. In the spring, riffle and raceway are important spawning habitats for many of the Reach 5 fish species. According to the model, the percent WUA exceeded 80 percent of the time for fast riffle would decline from 12 percent to 1 percent and for raceway would decline from 43 percent to 16 percent in the spring. In summer, fast riffle and raceways are used by adults and juvenile fish. The 80 percent exceedence percent WUA would decline from 10 to less than 1 percent for fast riffle and from 25 to 6 percent for raceway during the summer. A lower percentage of the time (20 percent exceedence), fast riffle would decline from 87 percent to 6 percent in summer (Table 5-15). Slow riffle guild habitat degradation would be most substantial during the summer when it is used by many species for nursery habitat, with a maximum 65 percent decrease and an average 30 percent decrease (Table 5-16). The percent WUA exceeded 80 percent of the time would decline from 70 percent to 7 percent (Table 5-15).

Similar to Habitat Segments H and E, maximum percent WUA with 300MOD50 pumping would not decrease for either benthic macroinvertebrate group during any seasons in Habitat Segment B.

Potential Habitat Enhancements

Habitat enhancement associated with 300MOD50 pumping when compared to the MOD50 baseline in Habitat Segment B would not be as common or as notable as enhancement in the upstream habitat segments (H and E). No habitat guilds would be enhanced more than 15 percent in any season.

Benthic macroinvertebrate guilds would experience habitat enhancement in spring and summer. The magnitude of the enhancement would be highest during the spring. The low-gradient guild would experience a maximum increase in percent WUA of 52 percent and an average increase of 19 percent during the spring while the Trichoptera guild would experience a maximum increase in percent WUA of 42 percent and an average increase of 20 percent (Table 5-16). The 80 percent exceedence value for percent WUA in the spring would increase from 27 to 76 percent and 24 to 66 percent for low-gradient and tricopteran guilds, respectively (Table 5-16).

Possible Changes in the Fish Community

Habitat in Reach 5 is rather homogenous and fish species richness is lower than other reaches of the Sheyenne River. Common species include mostly large river taxa such as freshwater drum, goldeye, channel catfish, silver chub, emerald shiner, sauger, and bigmouth buffalo (see Section 3.6.1.1). Most of these species occur in deeper runs and pools.

Substantial declines in the amount of fast riffle (average 48 percent) and slight decline in raceway habitat (13 percent) are predicted in the spring most of the time with pumping activity (Tables 5-15 and 5-16). These declines are likely to adversely affect spawning for some species (e.g., shorthead redhorse); however, fast riffle does not appear to be an important habitat type at Segment B (Figure 5-6). Species most likely to be affected would include longnose dace, common shiner, sand shiner, and various redhorse (Table 4-16).

During the summer there would be declines in the amount slow riffle, fast riffle, raceway, and deep pool habitat (Table 5-15 and 5-16). Given that there would be declines in both slow-water nursery habitat and productive fast-water habitat, it would seem that the fish community in this habitat segment could be substantially affected. Likely effects would include poor year class strength due to the loss of nursery habitat and reduced growth due to the loss of prey in fast water habitat.

In contrast to a consistent decline in all habitat types during the summer, only minor changes are predicted during the fall (Tables 5-15 to 5-16). Because these changes are minor (in both magnitude and frequency), no significant changes to the fish community are likely during the fall.

The change in availability of summer nursery habitat seems to be the factor that would most affect fish in Reach 5.

Possible Changes in the Invertebrate Community

Dominant invertebrate taxa in Reach 5 are Ephemeroptera (57 percent), Diptera (13 percent), and Tricoptera (20 percent) (Table 3-16).

The slight increases in flow with 300MOD50 pumping that would occur in spring and summer are predicted to slightly improve tricopteran guild (rheophilic species) and overall benthic invertebrate diversity. The WUA for both of these guilds is greatest at 250 to 500 cfs (Figure 5-6).

5.2.6 Summary of 300 cfs Constrained Pumping (300MOD50) Compared to the 1450 Moderate Baseline (MOD50)

5.2.6.1 Sheyenne River Reach 1

The 300MOD50 pumping is predicted to reduce water quality in Reach 1, but have little effect on hydrological parameters, erosion, deposition, turbidity, or habitat availability (Table 5-18).

Concentrations of TDS, sulfate, and chloride are not expected to reach levels that would affect fish. However, increased sulfate levels could affect sensitive algal species and invertebrate taxa such as

Dubiraphia sp. and *Macronychus* sp. Thus, a decline in invertebrate and algal species richness is expected with 300MOD50 pumping that might not occur with MOD50 baseline (Table 5-18). The magnitude of these changes and their effects on other organisms in this reach is difficult to predict without more specific toxicity data. Additionally, other factors such as changes in nutrient levels with 300MOD50 pumping that were not considered in this study, could affect Reach 1.

When pumping is no longer necessary (approximately 2024 under this modeled future), water quality under the 300MOD50 and MOD50 baseline should be the same. If modeled changes are fairly accurate, biota responds to these changes as predicted, and changes in invertebrate and algal composition do not affect organisms further up the food chain, then the invertebrate and algal taxa should change to reflect the improvement in water quality.

5.2.6.2 Sheyenne River Reach 2

Water quality is the most likely component to change in Lake Ashtabula. However, since changes are not likely to be severe in the upper reach of the Sheyenne River, Lake Ashtabula should also be minimally affected. Likewise, the fishery of Lake Ashtabula should not be affected, as increased TDS, sulfate, and chloride would be well below toxic levels for the species present. Sensitive invertebrates are the most likely taxa to be affected. Current species level data are not available for Lake Ashtabula, but in general, invertebrate species sensitive to chloride and sulfate would be likely to decline and more tolerant species would become more abundant.

5.2.6.3 Sheyenne River Reach 3

When comparing 300MOD50 to MOD50, differences in water quality and habitat for some guilds is apparent. Sulfate and chloride concentrations would increase to levels that may affect sensitive invertebrate taxa, which will likely reduce species richness. The level of sulfate and chloride tolerated by algal taxa in this reach is not known. However, sulfate is not expected to increase as much as in Reach 1 (average approximately 250 mg/l in Reach 1 compared to 200 mg/l in Reach 3), and most of the sensitive algal taxa are limited to Reach 1. Therefore, algal composition may not change in Reach 3. Habitat available for fast riffle and raceway fish guilds would increase somewhat in Reach 3. This may improve habitat for fast water species in this reach such as longnose dace, stonecat, rosyface shiner, redhorse species, and smallmouth bass. Thus, changes in Reach 3 due to pumping could include loss of invertebrate species sensitive to chloride and sulfate, an increase in invertebrate species tolerant to these parameters, particularly those that prefer erosional habitats such as hydropsychid caddisflies, and an increase in rheophilic fish species (Table 5-18).

When pumping ceases in 2024, swifter water habitats would decline and slack water habitat would increase. Since the pumping effects would be minor to moderate, species that occurred in the area prior to pumping are still likely to exist in lower abundance. Species should eventually shift back toward pre-pumping communities, or would shift to whatever habitat conditions would prevail under baseline conditions.

5.2.6.4 Sheyenne River Reach 4

Water quality, hydrology and habitat were not modeled for Reach 4, but impacts intermediate to Reach 3 and 5 would be expected. Increased sulfate may be sufficient to affect sensitive invertebrate species, however, most invertebrate taxa in Reach 4 are fairly tolerant of reduced water quality conditions (see Tables 3-16 and 4-7). Habitat in Reach 4 is less stable and diverse than in other reaches, therefore species in this reach are tolerant of a variety of habitat conditions. Thus, few if any changes are expected in the Reach 4 aquatic biota.

5.2.6.5 Sheyenne River Reach 5

Reach 5 is in the same physiographic region (Glacial Lake Agassiz) as the Red River. Conditions in this river reach differ considerably from Reaches 1 and 3, and thus impacts also would tend to differ. Sulfate, chloride, and TDS would not increase to concentrations that would affect the taxa in this reach. However, habitat changes would be more substantial than in upstream areas. Most of the fish species in this reach are generalists, and should not be affected by this change. Some decline in redhorse, longnose dace, sand shiner, and common shiner might be seen because of the loss of spawning, nursery, and adult habitat for some of the species.

Unlike other Sheyenne River reaches, two permanent tributaries feed into Reach 5—Rush and Maple Rivers. No fish species are restricted to Reach 5, and most of the species occur either in the Maple and Rush Rivers or in Red River Reach 1. If 300MOD50 pumping ceases as predicted in the year 2024, the biota should shift back toward pre-pumping conditions if the channel configuration has not changed.

5.2.6.6 Red River

Changes in the Red River are expected to be limited to water quality. The TDS levels would increase to a level that exceeds standards 8 percent, 0 percent, and 14 percent more frequently than under baseline conditions at Halstad, Grand Forks, and Emerson, respectively. However, this increase would be dramatic in that under baseline conditions, these standards would only be exceeded 2 percent, 0 percent, and <1 percent, respectively. Sulfate and chloride would only be increased slightly (<10 percent) over baseline conditions.

The increase in chloride and sulfate should not affect aquatic life. Aquatic communities should remain similar during and after 300MOD50 pumping.

5.3 480 CFS UNCONSTRAINED PUMPING (480MOD55) COMPARED TO THE 1455 MODERATE FUTURE BASELINE (MOD55)

Under 480MOD55, pumping would be needed from approximately year 2003 to 2016 to accomplish project objectives.

5.3.1 Water Quality Conditions

Pumping 480 cfs of Devils Lake water into the Sheyenne River unconstrained by water quality or flow (480MOD55) would substantially affect Sheyenne River water quality and moderately affect Red River water quality, as compared to baseline (MOD55) conditions (Figure 5-2, Table 5-19).

5.3.1.1 Total Dissolved Solids

In the Sheyenne River, mean TDS is expected to exceed the 500 mg/l guideline with or without pumping; however, the frequency of exceeding this guideline would increase with pumping (Figure 5-2). In Reach 1 (Cooperstown), mean TDS under this moderate future is expected to exceed the guideline 78 percent of the time (Table 5-19). Exceedence would occur in all seasons except spring (Appendix M-4). Under 480MOD55 pumping, percent exceedence would increase to 85 percent and mean TDS would exceed the guideline in all but April in Sheyenne River Reach 1. Mean TDS would increase 109 percent(Baldhill) to 74 percent (Lisbon) in Reach 3 and 63 percent in Reach 5. Maximum concentrations would increase at a similar magnitude (Table 5-20). The percent increase would be lower in the Red River, but concentrations would still increase by 35, 25, and 17 percent at Halstad, Grand Forks, and Emerson, respectively (Table 5-19). At Halstad, the guideline would be exceeded 62 percent of the time with 480MOD55 pumping (Figure 5-2). Percent exceedence would also be increased at Grand Forks (from 0 to 18 percent with 480MOD55 pumping) and at Emerson (from 11 to 38 percent with 480MOD55 pumping; Figure 5-2).

Sensitive fish that are late spawners (such as centrarchids and some cyprinids) could experience a decline in reproductive success with chronic exposure to 1,000 mg/l TDS (Tables 4-2 and 4-4). Mean overall TDS concentrations would not exceed 1,000 mg/l (Figure 5-2); however, some monthly means throughout the Sheyenne River would exceed 1,000 mg/l (Appendix M-4). Chronic exposure to 1,000 mg/l is expected to occur in Reach 1 from June through November, in Reach 3 from September through February, and in Reach 5 from October through February. High levels in September through February should not affect most fish species (Table 4-5). However, in Reach 1 species that spawn in June, July, and August, which includes many of the cyprinids and centrarchids, would probably be affected by high TDS (Table 5-21).

No information on the effects of high TDS were found for mollusks and other invertebrates in the Red River Basin. However, since sensitive fish seem to be more tolerant to TDS than other aquatic animals, some effects to sensitive invertebrates and mollusks might be expected. No information on effects of high TDS on macrophytes or algae was available. Given the high concentrations expected, it is assumed that some sensitive taxa would be negatively affected by 480MOD55 pumping throughout the Sheyenne River. This could promote changes in abundance and diversity of algae, macrophytes, and invertebrates (including mollusks).

5.3.1.2 Sulfate

Under MOD55 baseline conditions, sulfate is not expected to exceed the Sheyenne River (450 mg/l) or Red River (250 mg/l) standards (Figure 5-2). Mean sulfate under 480MOD55 pumping conditions would also not exceed these standards, although mean sulfate concentration would approach this standard during August through November in Reach 1, and October through February in Reach 3 (Appendix M-5).

Mean monthly sulfate concentrations are not expected to exceed standards in Sheyenne River Reach 5 or in the Red River (Appendix M-5). However, maximum sulfate concentrations would exceed standards throughout both rivers (Figure 5-2; Table 5-20). Maximum sulfate would exceed standards 20 to 42 percent of the time in the Sheyenne River and 5 to 16 percent of the time in the Red River (Figure 5-2).

Although sulfate standards would be exceeded with 480MOD55 pumping, the concentrations reached would probably not be high enough to affect sensitive fish and mollusks (Figure 5-2). However, increased sulfate levels may be sufficient to affect both sensitive and tolerant insect taxa. Sulfate concentrations in the Sheyenne River have historically reached 360 mg/l and 290 mg/l in Reaches 1 and 5, respectively (Table 3-4). Thus, most of the taxa currently in the river should be tolerant to similar levels. However, mean sulfate is predicted to exceed 330 mg/l and maximum sulfate would exceed 550 mg/l in the Sheyenne River (Table 5-20). Invertebrate taxa tolerant to sulfate, such as Chironominae, Corixidae, hydropsychid tricopterans, ephemeropterans (*Baetis* sp., *Labiobaetis* sp., *Caenis* sp., and *Stenonema* sp.), and elmids (*Dubiraphia* sp. and *Stenelmis* sp.) seem to be limited to less than 570 mg/l sulfate (Table 4-7). More sensitive invertebrates (*Macronychus* sp., *Hexagenia* sp., and *Pentagenia* sp.) seem to be limited to less than 150 mg/l (Table 4-7). Thus, invertebrates throughout the Sheyenne River and sensitive taxa in the Red River may be affected by an increase in sulfates caused by 480MOD55 pumping (Table 5-21).

Macrophytes in general are tolerant of the expected sulfate concentration. Sensitive taxa, however, may be negatively affected. Sulfate has been identified as a key variable explaining the variance in algal distributions. Algal species would likely shift to those species than can tolerate the increased sulfate concentrations. The more sensitive taxa (diatoms *Cymbella muellerii* and *Nitzschia* sp.) may be reduced or possibly extirpated, and taxa associated with higher sulfate concentrations (*Phacus acuminatus* [euglenoid] and *Dictosphaerium ehrenbergianum* [green algae]) may become more abundant. However, the sulfate tolerance levels for Sheyenne River species are not known. Levels could be sufficient to affect even tolerant algae taxa throughout the Sheyenne River, and perhaps into Red River Reach 1 (Table 5-20).

5.3.1.3 Chloride

Mean chloride levels would be increased from less than 20 mg/l to over 60 mg/l with 480MOD55 pumping, and the water quality standard of 100 mg/l would be exceeded 29 percent, 33 percent, and 7 percent more frequently than under MOD55 baseline conditions in Sheyenne River Reaches 1, 3, and 5, respectively (Table 5-19; Figure 5-2). In Reach 1 (Cooperstown), mean chloride would approach the 100 mg/l standard in June through November (Appendix M-6). Downstream of Baldhill Dam, mean chloride would be greater than 75 mg/l in September, October, November, and March, and greater than 100 mg/l in December, January, and February (Appendix M-6). At Kindred (Reach 5), mean chloride would be greater than 75 mg/l in October through January (Appendix M-6). Mean chloride would also be increased in the Red River by 80 percent, 76 percent, and 35 percent at Halstad, Grand Forks, and Emerson, respectively (Table 5-19). However, the 100 mg/l standard should not be exceeded. Mean chloride is predicted to be less than 35 mg/l (Table 5-20) and monthly averages would only exceed 50 mg/l at Halstad in October, November, and December (Appendix M-6).

Fish should not be affected by the increase in chloride, even in Reach 1 of the Sheyenne River. Maximum chloride is predicted at 128 mg/l (Figure 5-2), and even sensitive fish species should not be affected until levels reach near 1,000 mg/l (Table 4-2).

Unionids, sphaeriids, and possibly prosobranch gastropods would probably be affected by the increase in chloride levels, at least in Reaches 1 and 3, where monthly means would approach 100 mg/l consistently (Appendix M-6). This part of the benthic fauna may be extirpated. Levels in Sheyenne River Reach 5 would also exceed the 100 mg/l standard intermittently. Levels of chloride acutely toxic to these groups are not known. Adult unionids can close their valves and withstand acute toxicity, however the length of time they can remain anaerobic would vary with species. The thick-shelled amblemines, such as *A. plicata*, *F. flava*, and *Q. quadrula*, and thicker-shelled lampsilines, such as *L. cardium*, *L. siliquoidea*, and *L. recta*, can remain closed longer than the thinner-shelled anodontines such as *P. grandis* and *A. ferussaccianus* and lampsilines (*P. alatus* and *P. ohiensis*). Additionally, juvenile unionids and glochidia (larval unionids), sphaeriids, and prosobranchs cannot tightly close their valves and avoid acute toxicity events. Thus, the extirpation of these mollusks may occur more slowly in Reach 5 but would probably occur. In the Red River, mean chloride is predicted to be lower than the 100 mg/l that limits sensitive mollusks. However, maximum concentrations of 87 mg/l, 70 mg/l, and 91 mg/l are expected at Halstad, Grand Forks, and Emerson, respectively. These high levels may affect juvenile unionids, sphaeriids, and prosobranchs, and some decline in the molluscan fauna in the Red River may occur.

Pulmonate gastropods have been found in areas with 3,500 mg/l chloride. However, they are able to avoid acute events by crawling out of the water. Their resistance to chronic exposure is not known.

Some of the dominant invertebrates are particularly sensitive to chloride (*Dubiraphia* sp., Corixidae, *Caenis* sp., *Hexagenia* sp., and *Pentagenia* sp.). These taxa would most likely be extirpated from Reaches 1 to 3 in the Sheyenne River, and possibly from Reach 5. However, more tolerant taxa within these groups (*Stenelmis* sp. and *Baetis* sp.) would probably replace the more sensitive taxa.

Specific chloride tolerance levels are not available for macrophytes or algae; however, some effects would be expected. Sensitive taxa would probably be reduced in number and species richness, which would reduce diversity. More tolerant species would become established.

5.3.1.4 Summary

Effects of water quality changes would be greatest in Reach 1. Elevated concentrations of TDS, sulfate, and chloride may result in the loss of late spawning sensitive fish, unionids, sphaeriids, prosobranch gastropods, sensitive insect species, sensitive macrophytes, and sensitive algae (Table 5-21). Some of the tolerant invertebrate groups may also be affected by chronic high sulfate concentrations that would occur in this reach. Some invertebrates, probably pulmonate gastropods, tolerant fish species, and late-spawning sensitive fish species are likely to survive. However, the loss of forage fish (cyprinids and centrarchids) and invertebrates may deplete the food source of the remaining fish species. Halophiles such as cordgrass (*Spartina*) and alkali grass (*Pucchinella pungens*) may increase in dominance. Invasive species from Devils Lake such as the flowering rush (*Butomus umbellatus*) would likely also become established. Algal species may also shift towards more unpalatable species. The loss of algal diversity and decreased water quality may also increase the occurrence of noxious blooms.

The TDS levels would decrease in Sheyenne River Reach 3 compared to Reach 1 such that fish should not be affected. Effects on fish in Reach 2 would probably be intermediate between Reaches 1 and 3. Sensitive mollusks and invertebrates would probably be extirpated through Reach 3, and some reduction in population levels of some species may be seen throughout the Red River. Even tolerant invertebrate taxa would probably experience some reduction in population levels throughout the Sheyenne River, and a few species in the Red River could be adversely affected. Macrophytes in Reaches 2 and 3 should be unaffected by the decreased water quality. Sensitive algae would likely be reduced or extirpated (Table 5-21).

5.3.2 Hydrology Conditions

The 480MOD55 pumping would have a considerable effect on Sheyenne River hydrology (Table 5-22, Appendices K and L). Summer and fall (June through December) mean discharge and variation in discharge would be highly increased throughout the Sheyenne River. Red River discharge would increase somewhat, but not significantly over MOD55 baseline conditions. The average flow of the 90-day low-flow is expected to increase, but the increase would only be significant in Sheyenne River Reaches 3 and 5, mainly because of MOD55 baseline variability in Reach 1. Fewer low-flow events are expected in Sheyenne Reach 1 and 3, and low-flow duration is expected to increase in Sheyenne River 3. The magnitude of low-flow (>75 percent exceedence) and high-flow (>25 percent exceedence) events in Reach 1 would increase considerably between MOD55 baseline conditions and 480MOD55 pumping conditions—24 cfs to 70 cfs and 167 cfs to 582 cfs, respectively. Although not as dramatic, low- and high-flow magnitude would also increase in Reaches 3 and 5 (Table 5-22). The 75 percent exceedence flow would increase from 39 to 147 cfs in Reach 3 and from 109 to 228 cfs in Reach 5. The 25 percent exceedence flow would increase from 238 to 671 cfs and 373 to 778 cfs in Reaches 3 and 5, respectively (Table 5-22).

The most significant effect of the increase in flow in the Sheyenne River may not be the summer and fall increase, but the lack of change in winter. The average rate of rise is expected to be less variable with 480MOD55 pumping in Sheyenne Reach 1, whereas the average rate of fall is expected to be less variable downstream of Baldhill Dam. In Sheyenne Reach 5, increase or decrease in flow (flow reversals) is expected less frequently. However, these are average conditions over the year. A better measure of this effect would be the average rate of rise and fall in December through February. With MOD55 baseline at Cooperstown, discharge would decline from an average of approximately 55 cfs in the fall to 25 cfs in the winter. With 480MOD55 pumping this decline would be from over 400 cfs to 25 cfs (Appendix I and J).

The fish community in the Sheyenne River may be enhanced by hydrologcal changes due to 480MOD55 pumping during summer and fall, because of less stressful conditions with higher and less variable discharge. The biggest effect would be on fish habitat, which is discussed below. Other effects would include changes in the magnitude, duration of increase flow, and frequency of low-flow events (Table 5-23). Low-flow is one of the factors currently limiting fish in the Sheyenne River, particularly upstream of Lake Ashtabula (Goldstein *et al*. 1996, and Koel 1997). Low-flow magnitude would increase with 480MOD55 pumping and low-flow frequency would decrease. However, the decline in flow between December and January could result in stranding of fish and limit the availability of winter habitat. Unless the rate of pumping is decreased gradually, flow could change rapidly in the Sheyenne River between December and January. During most of the year, fish typically follow the flow up or

down and impacts are usually negligible. However, fish metabolism is slowed in winter and fish could be trapped beneath the ice when flow declines.

Monthly discharge and annual extremes would be more favorable to unionids, but decline in winter flow with 480MOD55 pumping could leave unionids stranded (Table 5-23). The decline in flow between fall and winter could be substantially greater with 480MOD55 pumping than under 300MOD50 pumping or WETOF overflow and could affect unionids, which are less mobile than fish and have a longer life span than most other invertebrates. Any unionids, sphaeriids (which typically inhabit shallower areas), and gastropods that might have moved or migrated into the more favorable habitat created in the summer and fall would be stranded on the bank when discharge decreases. Stranded mollusks would be more susceptible to predation, desiccation, and freezing.

Much like the fish and mollusks, increased flow would be favorable to most invertebrate taxa. Taxa that thrive in ephemeral habitats, such as amphipods, would probably decline, but the increased availability of habitat with increased summer and fall flow, and decreased variability in flow, could enhance most taxa. However, the lack of flow in the winter may be devastating to most groups, leaving many invertebrates to be frozen or desiccated (Table 5-23).

Algal species would also be affected by the changes in hydrology (Table 5-23). Increased discharge would favor phytoplankton species and may make conditions too deep for some periphytic species. In winter, exposed algae may be prone to desiccation. Some species are adapted to periodic desiccation and can form protective cell walls, sheaths, spores, or cysts. Frequent draw-downs would ultimately favor those species capable of withstanding exposure. This would decrease algal abundance and diversity, and may have trophic consequences. Water level draw-downs can concentrate nutrients and produce algal blooms. Algal blooms in winter may cause significant reductions in DO and have impacts on other biota.

Changes in hydrology would have mixed effects on macrophytes (Table 5-23). Submerged species may expand their range into new areas; however, some habitat may also be lost if water levels are too deep during the growing season. Emergent and wetland species would be pushed further up the banks, possibly adding new area, or may be removed if shallow water habitat is lacking. Rapid changes in flow in winter would leave many species exposed to desiccation in winter. The zone that fluctuates between exposure and inundation would be disturbed annually and could likely be vegetated by invasive species such as cattail and purple loosestrife.

5.3.3 Geomorphology Conditions

WEST (2001) predicted that the change in channel geometry and channel planform would be less than 5 percent between MOD50 and 480MOD50 (modeled with baseline lake elevation of 1450 asl) (Table 4-12). However, this change predicted an average channel-forming flow for the 50-year project life. Since pumping would occur less than 50 percent of the time, these impacts are probably underestimated.

Under the 480MOD55 pumping, channel-forming flow would be exceeded at least two times as often as under baseline conditions throughout the Sheyenne River (Table 5-24). This discharge would probably cause an increase in erosion and deposition. The magnitude of this change is not known. It is probably

safe to assume that erosion and deposition would be greater with 480MOD55 pumping than with MOD55 baseline or 300MOD50 pumping.

Increases in erosion and deposition from this alternative could be severe (Table 5-5). Increased bed load movement could potentially affect fish adversely because of increased turbidity or sedimentation. Increased sedimentation could, in turn, lead to increased embedment or even the complete burying of hard substrates (i.e., gravel, cobble, and boulder). Fish species that would be most affected would be those requiring clean, hard substrates for either spawning (e.g., simple lithophils - shorthead redhorse, golden redhorse, white sucker.) or those that depend on such substrates throughout their life-cycle (e.g., stonecat and longnose dace). Unionids require stable substrate, and erosion and deposition could result in substrate instability. Substrate movement would continually disturb unionids and other invertebrates. This would most likely result in extirpation of the unionid fauna. Sphaeriids, gastropods, and other invertebrates would also be negatively affected by the substrate instability and disturbance. Macrophytes would be removed due to scour or burying by sediment and leave portions of the river unvegetated. Loss of attachment surface for macrophyte beds would hasten erosion and would have significant trophic impacts. Cover for fish and epiphytic algae would also be lost. Attached algae could be prevented from colonizing and the increase in turbidity and flow would discourage phytoplankton production. Bank erosion would also result in loss of macrophytes along the river's edge and continued disturbance would prevent recolonization.

5.3.4 Habitat Conditions

Summer, winter, and fall discharge would increase with 480MOD55 pumping compared to MOD55 baseline (Table 5-22). With 300MOD50, average flow would increase but the range of variability would remain similar. With 480MOD55, mean flow would increase and the minimum flow expected in summer and fall would be greater than the maximum flow expected under MOD55 (Figures 5-4, 5-5, and 5-6). Thus, summer and fall habitat with 480MOD55 would differ substantially from habitat under MOD55. Both fast riffle and raceway would increase throughout the Sheyenne River in summer and fall. Changes in slower habitats (slow riffle and pools) would vary among reaches and among seasons.

5.3.4.1 Habitat Segment H

Potential Reductions

The 480MOD55 pumping alternative would result in habitat degradation for the slow riffle in both summer and fall and the shallow pool in the fall, when compared to MOD55 baseline (Table 5-25 and Figure 5-4). Slow riffle percent WUA would be less than 60 percent in Segment H when discharge increases to 100 cfs (Figure 5-4). Summer flow is expected to vary from 462 to 797 cfs. At these flows, percent WUA would be less than 30 percent (Figure 5-4). The slow riffle habitat would be degraded substantially in summer and fall, with a maximum percent WUA decrease of 63 percent and an average decrease of 26 percent during the summer, and a maximum decrease of 56 percent and an average decrease of 33 percent during the fall (Table 5-25). However, this magnitude of change would occur at a fairly low frequency in summer. The 80 percent exceedence values for slow riffle in summer would decline from only 36 to 32 percent with MOD55 baseline and 480MOD55 pumping, respectively (Table 5-26). This decline would be more substantial during the fall, when 80 percent exceedence percent WUA for slow riffle would decline from 50 to 32 percent, respectively (Table 5-26). Shallow

pool habitat would be reduced in the fall, with a maximum percent WUA decrease of 59 percent and an average decrease of 22 percent (Table 5-25). As with slow riffle, this change in magnitude would not be frequent. The 80 percent exceedence for fall shallow pool would decline from 29 to 25 percent, respectively (Table 5-26).

Maximum percent WUA would decrease for both guilds of benthic macroinvertebrates during the summer and fall with the increase in flow. During the fall, the low-gradient guild would experience a maximum 54 percent decrease and an average 32 percent decrease in maximum WUA, while the Trichoptera guild would experience a maximum 42 percent decrease and an average 29 percent decrease (Table 5-25). The 80 percent exceedence for percent WUA would decrease more than 15 percent for the low-gradient guild and 20 percent for the tricopteran guild (Table 5-26). Differences would be slightly lower during the summer, with the low-gradient guild experiencing a maximum 49 percent decrease and an average 21 percent decrease in maximum WUA, while the Trichoptera guild would experience a maximum 43 percent decrease and an average 24 percent decrease (Table 5-25). Additionally, the 80 percent exceedence for both guilds in summer would decline less than 10 percent with 480MOD55 pumping (Table 5-26).

Potential Enhancements

The 480MOD55 pumping would result in habitat enhancement in Habitat Segment H for the fast riffle, raceway, and medium pool habitat guilds when compared to MOD55 baseline with the increased flow in summer and fall (Tables 5-25 and 5-26). Fast riffle and raceway percent WUA would increase with the increase in fall and summer discharge (Figure 5-4). During the summer and fall, the fast riffle guild would experience a maximum 89 percent and 95 percent increase and an average 42 and 50 percent increase, respectively, while the raceway guild would experience a maximum 86 and 92 percent increase and an average 63 and 72 percent increase in maximum WUA, respectively (Table 5-25). The 80 percent exceedence for fast riffle percent WUA would increase from 2 percent to 89 percent in the summer and 2 percent to 95 percent in the fall (Table 5-26). The 80 percent exceedence for raceway percent WUA would increase from 0 to 86 percent and 0 to 92 percent in summer and fall, respectively (Table 5-26). The medium pool guild would be enhanced during the summer and fall, with the most notable enhancement a maximum 60 percent increase and an average 22 percent increase in WUA during the fall. The shallow pool guild habitat would be enhanced only during the summer, with a maximum 44 percent increase and an average 24 percent increase in maximum WUA. This summer increase would occur most of the time, as the 80 percent exceedence would increase from 22 to 63 percent with 480MOD55 pumping.

Maximum WUA would not increase for either guild of benthic macroinvertebrates during any season in Habitat Segment H under the 480 cfs unconstrained operation when compared to its baseline.

Possible Changes in the Fish Community

Most of the common species in Reach 1 (black bullhead, brook stickleback, creek chub, fathead minnow, trout-perch, and common shiner) can utilize a variety of habitats, but are most common in pools (Table 4-16) and can out-compete other species under variable habitat conditions. These species are typical of hydrologically unstable conditions. With the increase in flow during summer and fall, this reach would be more stable, and species that require more habitat stability (redhorse and many of the minnow species in Reach 3) may out-compete the smaller stream fauna.

The most important habitats for spawning are slow and fast riffle (Table 4-16). In the spring, fast riffle percent WUA would be slightly increased most of the time (Tables 5-25 and 5-26). However, most of the species that would benefit from this increase (redhorses) do not appear to occur in Sheyenne River Reach 1 (Table 3-11).

During the summer, the amount of slow riffle habitat is predicted to decrease, one habitat type (deep pool) would not be affected, and the other four habitat types are predicted to increase (Table 5-25). Based on an increase in the amount of most habitat types, especially shallow pool habitat, which is particularly important in lotic systems (Freeman *et al*. 2001), the habitat changes predicted for this reach of the river during the summer would likely enhance the survival of juvenile and YOY for most species (Table 4-16).

During the fall, the amount of shallow pool and slow riffle habitat is predicted to decrease (Tables 5-25 and 5-26). These slow-water resting/nursery areas are not as important in the fall as in the summer, but decline in these habitats could affect survival of juveniles and YOY. However, the magnitude of the decline is not expected to be high most of the time. For example, the 80 percent exceedence percent WUA for shallow pool in the fall is expected to only decline from 29 percent to 25 percent (Table 5-26), whereas 20 percent exceedence percent WUA for shallow pool is expected to decrease from 67 percent to 25 percent with 480MOD55 pumping (Table 5-26). Conversely, the amount of fast riffle, raceway, and medium pool habitat is predicted to increase substantially, which would enhance most of the adult and juvenile rheophilic species, as well as the adult and juvenile minnows, sunfish, catfish, walleye, and northern pike (Table 4-16). Thus, some year classes of suckers, minnows, and sunfish may show poor recruitment, but adults of most of these species should be more likely to survive. Additionally, habitat conditions could attract more rheophilic species that are now uncommon in this reach and these species could out-compete the smaller stream species that now exist here (Table 5-27). However, additional species would have to immigrate from downstream of Lake Ashtabula.

Possible Changes in the Invertebrate Community

As with fish, most of the invertebrate fauna in Habitat Segment H prefer depositional habitats. With an increase in discharge in summer and fall, habitat diversity and therefore invertebrate diversity would be expected to increase. Likewise, the abundance of rheophilic taxa would also be expected to increase. However, habitat modeling predicts a decline in both groups. Diversity is expected to be highest at 20 and 50 cfs and decline at the higher flows, while tricopteran abundance is expected to be greatest between 20 and 100 cfs. Discharge would exceed these values most of the time in both summer and fall (Figure 5-4), which may lead to a decline in invertebrate diversity and a decline in rheophilic species

abundance. This would probably be due to the increase in current velocity, as preferred current velocity of many species may be exceeded.

5.3.4.2 Habitat Segment E

Potential Reductions

As discharge increases, shallow pool, slow riffle, and medium pool would decline at Habitat Segment E (Figure 5-5). The most substantial habitat degradation would occur for the medium and shallow pool habitats followed by the slow riffle habitat guild (Table 5-25 and Figure 5-5), when comparing the 480MOD55 pumping to MOD55 baseline. Shallow pool percent WUA would decline below 50 percent with 100 cfs, and medium pool and slow riffle would decline to less than 50 percent at 250 cfs (Figure 5-5). Reduction in habitat would occur in all three seasons (spring, summer, and fall), although the most substantial negative changes in maximum percent WUA would occur during the summer and fall for each of these guilds. During the summer, maximum percent WUA for the shallow pool guild would decrease a maximum of 80 percent and an average of 41 percent (Table 5-25). Medium pool percent WUA would decline a maximum of 79 percent and an average of 40 percent in summer and the percent WUA exceeded 80 percent of the time would decline from 40 to 15 percent (Tables 5-25 and 5-26). During the fall, there would be a maximum decrease of 90 percent and an average decrease of 27 percent in maximum percent WUA for the shallow pool guild and a maximum decrease of 72 percent, and an average decrease of 46 percent in maximum percent WUA for the medium pool guild. The decline in slow riffle percent WUA would average 21 percent and 23 percent in the summer and fall, respectively.

The maximum percent WUA would be fairly high for both the low-gradient and tricopteran guilds at the discharges expected during summer and fall at Segment E (Figure 5-5). Only a slight decline for the low gradient invertebrate guild is expected with 480MOD55 pumping (Tables 5-25 and 5-26).

Potential Enhancements

Fast riffle and raceway habitat guilds are expected to increase with the increase in flow due to 480MOD55 pumping (Figure 5-5). Deep pool guild would also increase with discharge near 250 cfs, but would decrease at higher discharges (Figure 5-5). Increases in fast riffle and raceway habitat would occur during all three seasons (spring, summer, and fall), although the most substantial increases in maximum WUA would occur during the summer and fall for each of these guilds. Enhancement in deep pool and raceway habitat would occur most notably during the summer. During the summer, maximum percent WUA would increase 85 percent and average would increase 48 percent for the raceway guild, and maximum percent WUA would increase 49 percent and average would increase 31 percent for the medium pool guild. The fast riffle habitat guild would experience similar notable enhancements during the summer and fall, with a maximum 99 percent increase and an average 81 percent increase during the summer and a maximum 97 percent increase and an average 81 percent increase during the fall. These enhancements would be substantial most of the time. For example, percent WUA exceeded 80 percent of the time would increase from less than 5 percent to greater than 80 percent for both fast riffle and raceway guilds.

The Trichoptera benthic macroinvertebrate guild would experience habitat enhancement during the summer and fall. Although the enhancement would be similar between both seasons, the maximum enhancement would occur during the summer, with a maximum 32 percent increase and an average 13 percent increase in maximum WUA. The low-gradient group maximum WUA would not increase during any season.

Possible Changes in the Fish Community

The fish community in Sheyenne River Reach 3 currently reflects the more stable flow and habitat conditions that are present downstream of Baldhill Dam. Dominant species include bluntnose minnow, golden redhorse, Johnny darter, common shiner, rosyface shiner, shorthead redhorse, and smallmouth bass (Table 4-16). Many of the North Dakota special concern species also occur in this reach: trout-perch, hornyhead chub, pugnose shiner, blacknose shiner, rosyface shiner, banded killifish, silver redhorse, and greater redhorse (Table 4-16). Hornyhead chub, pugnose shiner, and banded killifish have only been reported from Reach 3 of the Sheyenne River (Table 3-11). Many of these species depend on the shallow and medium pool for nursery areas and fast riffle and raceways for spawning (Table 4-16).

Only minor discharge would be added to Habitat Segment E during the spring compared to baseline flow and variability. Some increase in fast riffle habitat used for spawning by some Reach 3 species, including redhorse and rosyface shiner, is expected; however, the 80 percent exceedence for spring fast riffle would be 0 whether pumping or not pumping (Table 5-26). Therefore, the benefits to fast water spawning would only be occasional. Likewise, the declines in habitat expected during the spring would occur infrequently and are not expected to affect spawning success.

During the summer and fall, the increase in flow would change habitat considerably. The large increase in riffle and raceway habitat certainly would benefit species or life stages preferring these habitats, such as longnose dace, redhorse, stonecat, and smallmouth bass, among others (Table 4-16). Conversely, the substantial decline in nursery habitat (i.e., shallow and medium pools and slow riffles) would likely adversely affect shiners, sunfish, and YOY redhorse. The decline in nursery habitat could result in slower growth and/or increased predation due to crowding. Additionally, these pools are used by many of the North Dakota special concern species: hornyhead chub, pugnose shiner, blacknose dace, and banded killifish. Thus, a community shift toward rheophilic species and a loss of pool species might be expected. However, many rheophilic species need the shallow slow-water habitat as juveniles and YOY. Thus, a decrease in recruitment of rheophilic species would be expected, which may lead to a decline in their abundance.

The pattern and magnitude of changes established during the summer would be duplicated nearly exactly in the fall (Tables 5-25 and 5-26). Shallow slow habitats are also important during the fall. Unless juvenile and YOY sunfish, catfish, and walleye find alternative nursery habitat, the fish fauna in this area could be limited to those species that spend their entire life cycle in fast-water habitat. Only two species on Table 4-16 (stonecat and logperch) use only fast riffle and raceway, and logperch currently does not occur in Reach 3 (Table 3-11). While others undoubtedly occur in the area, many of the species now within Segment E may not be able to reproduce and/or successfully recruit young under the modified conditions (Table 5-27).

Possible Changes in the Invertebrate Community

Invertebrate diversity is expected to decline slightly in Habitat Segment E due to the increased flow that would reduce habitat diversity. However, the decline should be moderate. The increase in flow would be of benefit to rheophilic species to a certain extent. Thus, the community may shift from one dominated by depositional dipterans and ephemeropterans, to more rheophilic dipterans (such as Simulidae), and ephemeropterans (such as *Stenacron* sp.). Hydropsychid caddisflies would also probably increase in relative abundance.

5.3.4.3 Habitat Segment B

Potential Reductions

As discharge increases in Habitat Segment B, a high proportion of the habitat would become fast and deep, and productive nursery habitats would be substantially depleted (Figure 5-6). During spring this normally occurs in Habitat Segment B, and little change in habitat over MOD55 baseline is expected. In summer and fall, however, shallow, medium, and deep pools would decline (Table 5-25). The most substantial habitat degradation would occur for the medium and deep pool habitats, followed by the shallow pool habitat guild (Table 5-25), when comparing 480MOD55 pumping to the MOD55 baseline. During summer, the medium pool guild would experience a maximum decrease of 83 percent and an average decrease of 40 percent in maximum WUA. The deep pool guild would experience a maximum decrease of 94 percent and an average decrease of 48 percent in maximum WUA. The shallow pool guild would experience a maximum 66 percent decrease and an average 26 percent decrease in maximum WUA. During fall, the medium pool guild would experience a maximum decrease of 88 percent and an average decrease of 45 percent in maximum WUA, and the deep pool guild would experience a maximum decrease of 90 percent and an average decrease of 46 percent in maximum WUA.

Despite the decline in habitat diversity, the low-gradient benthic macroinvertebrate guild would experience minor habitat degradation during spring and summer (maximum <15 percent).

Potential Enhancements

The most substantial potential habitat enhancement would occur for the slow riffle and raceway habitats, followed by the fast riffle habitat guild (Table 5-25). These habitats would be enhanced during each season (spring, summer, and fall), although habitat enhancement would be greatest during the summer and fall. The slow riffle guild would experience a high magnitude of habitat enhancement during both the summer and fall, with a maximum increase in WUA of 78 percent and an average increase of 43 percent during the summer and a maximum increase of 79 percent and an average increase of 39 percent during the fall. Similarly, the raceway guild would experience a maximum increase in WUA of 71 percent and an average increase of 42 percent during the summer and a maximum increase of 72 percent and an average increase of 38 percent during the fall. The magnitude of enhancement to fast riffle habitat would increase with season. The highest magnitude would occur during the fall, with a maximum increase in WUA of 61 percent and an average increase of 22 percent. The increase in slow riffle and raceway would occur most of the time. The 80 percent exceedence percent WUA for slow riffle would increase from 6 and 15 percent to 84 and 89 percent in the summer and fall, respectively (Table 5-26). A similar magnitude of increase would be seen in the 80 percent exceedence for raceway (Table 5-26). However, the increase in fast riffle habitat would not occur as often. The

80 percent exceedence only would increase from 0 and 14 percent to 4 and 19 percent during summer and fall, respectively (Table 5-26).

Regarding the benthic macroinvertebrate groups, the trichopteran guild would experience slight habitat enhancement primarily during the fall, with a maximum increase of 35 percent and an average increase of 7 percent in maximum WUA. However, the 80 percent exceedence for both tricopteran and invertebrate diversity under both 480MOD55 pumping and MOD55 baseline would be greater than 60 percent throughout the year (Table 5-26).

Possible Changes in the Fish Community

Habitat in Sheyenne River Reach 5 is rather homogenous and fish species richness is lower than other reaches of the Sheyenne River. Common species include mostly large river taxa such as freshwater drum, goldeye, channel catfish, silver chub, emerald shiner, sauger, and bigmouth buffalo (see Section 3.6.1.1). Most of these species occur in deeper runs and pools.

During the spring, spawning habitat for some species would be slightly increased (raceway). Pool habitat would decline, but pools are not as important during spring. During the spring, the predicted changes should favor those species preferring fast water (catastomids), especially those that need it for spawning, while those preferring slow water (channel catfish, emerald shiner) are likely to be affected adversely.

While fast water habitats are important in the spring, slow water habitats are important summer and fall nursery areas. With 480MOD55 pumping, shallow, medium, and deep pool habitats would decline, which will deplete nursery areas for most Sheyenne River fishes and spawning habitat for late spawning centrarchids. Slow riffle habitat would increase, and this habitat provides nursery area for some minnows, catfish, and redhorse. The increases in both fast riffle and raceway habitat would likely benefit those species utilizing fast water areas. The fact that the amount of both medium and deep pool habitat is predicted to decline substantially suggests that species preferring these habitats may be affected adversely due to competition for food resources and possibly increased predation. However, many of the species in these guilds are habitat generalists, suggesting that impacts might be less than would be expected given the magnitude of the changes.

Overall, a decline in cyprinids, centrarchids and other pool species might be expected. Additionally, recruitment of redhorse and other rheophilic species may be reduced. If rheophilic species survive to adults, their habitat would be enhanced.

It should be noted that the habitat changes predicted during all seasons under 480MOD55 are very similar to those predicted for a natural overflow (WETOF). The patterns for these two scenarios track almost exactly during all three seasons. During the spring, the magnitude of most of the predicted changes is also similar. In the summer and fall, the magnitude of the predicted changes is noticeably higher for 480MOD55 pumping. This suggests that the predicted effects on fishes would be more substantial (either beneficial or adverse) under 480MOD55 pumping than under WETOF. Because the magnitude of the changes within the fish are extremely difficult to predict, an alternative interpretation of the predicted changes in the amount of habitat is that impacts (again either positive or negative ones) would be more likely under the 480MOD55 pumping than under WETOF.

Possible Changes in the Invertebrate Community

The increase in flow during summer and fall in Segment B is only expected to have a minor affect on the invertebrate community. Some increase in rheophilic species (hydropsychid caddisflies) would be expected.

5.3.6 Summary of 480 cfs Unconstrained Pumping (480MOD55) Compared to the 1455 Moderate Future Baseline (MOD55)

5.3.6.1 Sheyenne River Reach 1

Water quality, hydrology, geomorphology, and habitat are expected to differ between 480MOD55 pumping and MOD55 baseline in Reach 1.

Macrophytes would be significantly impacted in Sheyenne River Reach 1 (Table 5-28). Increased turbidity may reduce abundance and habitat because of reduced light penetration and phytosynthetic potential. Submerged and emergent macrophytes may not remain established as deeper pools develop. Fast riffle habitat would also reduce macrophyte abundance because of increased scouring. Species would be reduced to areas of slow run or shallow pools where water velocity and depth are more moderate. Fringe species (typically a community of willows, sedges, and rushes) may also be affected. Increased water depth and velocity would likely remove the shallow marsh, wetland, and woody shrubs along the banks of the river. Exposure of these banks may lead to additional bank erosion and habitat changes.

Impacts would be mostly caused by changes in hydrology, including potential scouring or uprooting of macrophyte beds (i.e., submerged pondweeds), increased water depth, which may drown existing emergent vegetation, and desiccation and destruction of beds exposed in late fall and winter. Submerged species would be reduced the most. Exposing more area and expanding the wetted perimeter may create some additional habitat, but the species colonizing the new habitats would likely be more aggressive and tolerant of the increased disturbance rates and decreased water quality. Species of concern include reed canary grass (*Phalaris arundinacea*), purple loosestrife (*Lythrum salicaria*), giant reed grass (*Phramites australis*) and flowering rush (*Butomus umbellatus*). All of these species have been identified in the basin and can readily inhabit disturbed areas. With the changes in hydrology, Reach 1 may begin to have communities similar to the existing communities in Reaches 3, 4, and 5. The loss of macrophytes would also affect the colonization area available for epiphytes, food and cover for invertebrates, and cover for fish (Table 5-28).

Algal species would also likely decline in abundance and diversity in Reach 1. Changes in water quality would likely extirpate or reduce the abundance of at least some of the sensitive taxa, which would shift the overall taxa to those more tolerant of the degraded conditions. These tolerant taxa may not be as palatable to fish, invertebrates, and mollusks. The loss of algal diversity and decreased water quality may also increase the occurrence of noxious blooms. Increased flow would favor phytoplankton species and may make conditions too deep for some periphytic species. In winter, exposed algae may be prone to desiccation. Some species are adapted to periodic desiccation and can form protective cell walls, sheaths, spores, or cysts. Annual draw-downs may ultimately favor those species capable of withstanding exposure. This would decrease algal abundance and diversity, and may have trophic

consequences. Water level draw-downs can concentrate nutrients and produce algal blooms. Algal blooms in winter may cause significant reductions in dissolved oxygen and have impacts on other biota.

Many of the invertebrate taxa in this reach are sensitive to either sulfate or chloride. Concentrations of these parameters are expected to reach levels that would extirpate the sensitive fauna and possibly some of the more tolerant taxa, reducing species richness (Table 5-28). Those not affected by water quality changes would probably be affected by unstable substrate, decreased habitat suitability, increased turbidity, declining winter water levels, and decreases in macrophytes and algae. This would reduce the invertebrate species to those very tolerant of high chloride and sulfate and able to survive in unstable substrate. Of the species found in Reach 1, these may include Nematoda and a few species of oligochaetes and chironomids. The loss of invertebrates would undoubtedly affect the fishes.

Most of the mollusks (unionids, sphaeriids, and prosobranchs) would be extirpated by the high chloride levels that are predicted with 480MOD55 pumping.

Fish would also likely decline in abundance and diversity because of the decline in reproductive success of some species due to water quality, siltation of spawning habitat, and lack of shallow pool and slow riffle nursery habitat. Lack of macrophytes would also affect northern pike and brook stickleback. Species listed in Table 4-11 and not affected by the above factors include fathead minnow, creek chub, black and brown bullhead, tadpole madtom, trout perch, white bass, smallmouth bass and white and black crappie. However, these species may be affected by lack of prey items and winter freezing.

After pumping stops, slower flowing, shallow habitats would return and this upper reach would be less hydrologically stable. In addition, the channel would have changed, probably becoming wider and deeper, such that the reduced water levels would result in less available wetted habitat during low-flow conditions. Unionids would probably not survive the pumping conditions. Only a few small permanent tributaries drain into Reach 1, and their suitability as unionid refugia is unlikely. Fish hosts are prevented from carrying glochidia upstream past Baldhill Dam. Unless unionid refugia occur in the small tributaries, this fauna is unlikely to recolonize. As conditions improve, the fish and invertebrate fauna would eventually invade from Lake Ashtabula. Recolonizing species would be dependent upon species remaining in Lake Ashtabula and habitat types that form once pumping stops. The length of time required for recolonization would depend on the time required for the channel to stabilize, which is not known.

5.3.6.2 Sheyenne River Reach 2

Water quality and turbidity would be the most likely factors to change in Lake Ashtabula. Changes may be severe, as water quality standards would be exceeded both upstream and downstream of the lake. The increased TDS, sulfate, and chloride levels would be well below toxic levels for the fish species present. However, changes in water quality would likely affect the algal composition, macrophyte composition, and invertebrate composition (including mollusks). Sensitive invertebrates, mollusks, algae and macrophytes would not likely survive water quality conditions in Reaches 1 and 3, and thus would probably not likely survive in Lake Ashtabula (Table 5-28). Water quality in Lake Ashtabula, however, may not affect fish reproduction.

Water quality should improve when pumping stops in the year 2016. However, the fauna remaining in Lake Ashtabula would be those species tolerant to the poorer water quality conditions.

5.3.6.3 Sheyenne River Reach 3

Changes in water quality, hydrology, geomorphology, and habitat in Reach 3 would be of a magnitude similar to or greater than Reach 1. Water quality degradation would be slightly less, but changes in habitat would be greater. Additionally, Reach 3 supports a more diverse fish and invertebrate community than Reach 1.

Increased flow would likely remove some of the macrophyte species through scouring or increased water depth. Turbidity may further limit macrophytes. Increased flow may allow expansion of existing vegetation into previously uncolonized areas. However, these areas would be disturbed by decrease in flow during winter. These changes may benefit aggressive species such as cattail and purple loosestrife.

Algal species would likely decline in abundance and diversity in Reach 3. Changes in water quality may shift the overall taxa to those more tolerant of the degraded conditions. Increased flow would favor phytoplankton species and may make conditions too deep for some periphytic species. Additionally, reduced abundance of macrophytes would reduce epiphyton. In winter, exposed algae may be prone to desiccation.

The invertebrate community would probably be reduced to those species tolerant of water quality changes and unstable substrate. The invertebrate community in Reach 3 currently consists of a fairly diverse mix of dipterans (several families rather than mainly chironomids), ephemeroptera (19 taxa), hemipterans (Corixidae), and tricopterans. Both tolerant and intolerant taxa occur in each of these groups (Table 4-7). Habitat for rheophilic invertebrates should improve (hydropsychid caddisflies, some of the ephemeropterans, simulid dipterans); however, the scouring and deposition of substrate may negate the improvement in habitat conditions for these species. The amount of scouring and deposition may be the factor that determines what invertebrate species survive. At this point, scouring and deposition are expected to be worse than under MOD55 baseline, but the magnitude has not been determined.

Unionids, sphaeriids, and prosobranch gastropods would likely be extirpated from this reach due to increased sulfate and chloride concentrations.

Although water quality changes are not expected to affect fish species, many of the fish species in this reach, including several North Dakota special concern species, would be negatively affected by scouring and deposition, habitat changes, and possible declines in invertebrate abundance and macrophyte beds. Of the common species in this reach (common shiner, spotfin shiner, bluntnose minnow, shorthead redhorse, golden redhorse, smallmouth bass, blackside darter and Johnny darter), common shiner, both redhorses, and blackside darter are simple lithophils that would be negatively affected by depositional substrate in spawning areas. Of the North Dakota special concern species in this reach, hornyhead chub and rosyface shiner could be negatively affected by increased turbidity; pugnose shiner, blacknose shiner, and banded killifish could be negatively affected by the loss of weed beds; and silver redhorse, greater redhorse, and river darter (simple lithophils) could be affected by depositional substrate in spawning areas. Habitat changes would reduce the community further to species that live entirely in fast water

areas; however, if substrate is deposited in these areas or substrate is unstable, these habitats are of little use, particularly if invertebrates are depleted. Additionally, any fish trapped in shallow pools when discharge is reduced in the winter may freeze.

When pumping stops, the channel would have changed somewhat in configuration due to erosion and deposition. If the fish fauna are depleted during pumping, species from downstream may recolonize according to available habitat. Thus, the fish fauna could change from the diverse fish fauna that now occurs in this area to a less diverse fauna such as in Reach 5 (Table 3-11). Some of the North Dakota special concern species are primarily inhabitants of spring-fed tributary streams and may be able to reinvade after pumping stops if habitat is suitable. Invertebrates would likely drift in from Lake Ashtabula. However, only tolerant fauna would be likely to survive the lowered water quality in the lake. Invertebrates should also be able to reinvade from tributary streams. Diversity should increase with time, as habitats re-stabilize and species invade from tributaries and downstream areas. Unionids would not likely survive pumping. Most of the unionid species found in Reach 3 prior to pumping may still occur in the Red River. Recolonization of unionids would follow recolonization of fishes. As with Reach 1, the time required for recolonization wold be dependent on the time required for habitat to stabilize, which is currently unknown.

5.3.6.4 Sheyenne River Reaches 4 and 5

Impacts to Reaches 4 and 5 would also be due to changes in water quality, hydrology, scouring. deposition, turbidity, and habitat, which should be similar to or slightly less than in Reach 3. However, overall impacts to Reaches 4 and 5 should be less than Reach 3 because of the lower habitat variability and species richness in Reaches 4 and 5.

Macrophytes are sparse in this reach due to high turbidity, relatively deep water, and unstable substrate. Changes in habitat do not favor the establishment of macrophytes. Increased flow in the summer and fall may improve habitat for some fringe areas and help establish wetland and emergent vegetation, but this would be a long-term process. Existing macrophyte beds would likely be removed or buried because of scouring and deposition expected with the increased flow.

The algal community would be affected similarly to Reach 3. Attached algae and epiphytes would be depleted by increased scouring, turbidity, and substrate instability.

Differences in water quality may be less between 480MOD55 pumping and MOD55 baseline in these reaches than in upstream reaches, but increased chloride and sulfate would be sufficient to reduce invertebrate species richness. Habitat for rheophilic taxa is expected to increase, however, this habitat may not be useful because of scouring and deposition.

Scouring and deposition would likely render habitat unsuitable for unionids. Sphaeriids and prosobranchs may also be reduced by habitat instability.

The fish community in Reach 5 is not particularly species rich compared to Reach 3; however, many of the species in this reach are simple lithophilic spawners (emerald shiner, sauger, and redhorse), and some need the shallow, medium, and deep pools as adults or juveniles (channel catfish, northern pike, sunfish, and minnows), which would be almost eliminated from at least the Habitat Segment B area. In addition

to reduced habitat availability, food sources (algae and invertebrates) would also be depleted. The cumulative effects of these factors could severely deplete the fish fauna in Reach 5.

When pumping stops, this Reach should be the first to recolonize. Since habitat is similar to the Red River, Red River fish and invertebrate species would likely be those to recolonize. The Maple River may also serve as a refuge and source of recolonizing fish and invertebrates. As with other Sheyenne River reaches, the time for recolonization would be dependent on the time required for habitat stabilization.

5.3.6.5 Red River

Both water quality and hydrology would be affected in the Red River, although the impacts would be greatest in Reach 1. Increased flow is only expected in Reach 1. Channel morphology of the Red River essentially precludes shallow water habitat. Thus, macrophytes are not common. If shallow water areas are created, macrophytes may have an opportunity to colonize. The increased flow would also benefit phytoplankton over periphyton. However, this is probably already the case in the Red River. Changes in sulfate and chloride may be sufficient throughout the Red River to affect the abundance of invertebrates, including mollusks (Table 5-28). A shift to tolerant species and a decline in species richness would be expected. The increased low flow magnitude, frequency, and duration may be less stressful to fish, at least in Reach 1.

Most of the species currently in the Red River would likely remain during pumping, although in different frequency depending on their tolerance to water quality and hydrology changes. As water quality and hydrology return to baseline conditions, the fauna should follow. None of the species should be extirpated, and many of the fish and probably invertebrate species occur in Red River tributaries. Unionids, however, are lacking in the lower end of most tributaries and may not be able to recolonize if decimated. However, they are not expected to be significantly affected by water quality, as chloride in Reach 1 is not expected to exceed 100 mg/l, and monthly averages would only exceed 50 mg/l in a few months (Figure 5-2 and Appendix M-6).

5.4 WET FUTURE WITH NATURAL OVERFLOW (WETOF) COMPARED TO WET FUTURE BASELINE (WET)

Under WETOF, Stump Lake is expected to rise to 1459 asl and overflow in approximately the year 2013. Overflow is predicted to cease in approximately the year 2025.

5.4.1 Water Quality

A Stump Lake natural overflow (WETOF) in the Sheyenne River would substantially affect water quality compared to baseline (WET) conditions (Figure 5-3).

5.4.1.1 Total Dissolved Solids

Mean TDS would be over two times as high with overflow throughout the Sheyenne River and would increase 45 percent, 30 percent, and 21 percent in the Red River in Reaches 1, 2, and 3, respectively (Tables 5-29 and 5-30). Mean TDS would exceed the 500 mg/l guideline at all sites with the exception of Grand Forks (Figure 5-3), and would be near the guideline at Grand Forks (463 mg/l). Mean monthly

TDS would exceed 500 mg/l in all months throughout the Sheyenne River—in all but April and May at Red River Reach 1, in November through February in Red River Reach 2, and in July through February in Red River Reach 3 (Appendix M-7).

The elevated TDS would probably affect most of the biota. Throughout the Sheyenne River sensitive fish may experience some reproductive failure (reduced survival of fry or hatching success), as they would be chemically exposed to levels of TDS over 1,000 mg/l, but tolerant fish should not be affected since exposures would not exceed 4,800 mg/l (Figure 5-3; Table 5-31). This could decrease species richness, result in the loss of several North Dakota protected species, and result in a Sheyenne River fish community of tolerant species such as fathead minnow, common carp, and yellow perch (Table 4-5). Mean TDS in the Red River would not exceed 1,000 mg/l, but concentrations could occasionally reach 1,000 mg/l in Reach 1 (Figure 5-3). Channel catfish historically have occurred in areas with higher TDS levels (Koel 1997); however, their tolerance to the predicted TDS levels in not currently known. Unionids, sphaeriids, and prosobranchs are also likely to be affected, since their tolerance is typically less than sensitive fish. Pulmonates may be able to survive. Sensitive invertebrates would also probably be affected by higher TDS levels, and diversity would likely decline with WETOF. This loss of invertebrate fauna, if biomass is affected as well as diversity, would also likely affect food availability for the remaining fish species. No information on effects of high TDS on macrophytes or algae was available. Given the high concentrations expected it is assumed that most sensitive taxa would be negatively affected, and possibly extirpated. Moderately tolerant taxa may also be impacted. This could promote changes in abundance and diversity, favoring the most tolerant species.

5.4.1.2 Sulfate

Sulfate levels in the Sheyenne River are expected to be elevated 200 to 400 percent over WET baseline conditions, and over 50 percent in the Red River (Table 5-29). Mean sulfate would exceed the 450 mg/l standard in the Sheyenne River, and monthly mean sulfate would exceed this standard in Reach 1 except in June, in Reach 3 from July through March, and in Reach 5 from October through March (Appendix M-8).

Long-term exposure to over 500 mg/l may have a slight affect on the reproductive success of sensitive fish (Table 4-2). Mean sulfate exceeds this level with overflow (Figure 5-3), and reduced survival of fry or hatching success of sensitive fish in Reach 1 could be experienced (Northern pike, spottail shiner, white sucker, golden shiner, centrarchids)(Table 4-5). Unionids and sphaeriids seem to be limited to 1,300 mg/l sulfate. This level would be exceeded at least part of the time in Sheyenne Reaches 1 and 3. Perhaps the biggest effect of elevated sulfate would be on invertebrates. The standard of 450 mg/l probably protects tolerant invertebrate taxa and 150 mg/l probably protects sensitive taxa. Mean sulfate would exceed both of these criteria throughout the Sheyenne River, and all monthly means would exceed the 150 mg/l criteria. Thus, loss of invertebrate diversity and abundance will probably occur throughout the Sheyenne, with only the very tolerant species surviving. This loss of invertebrates is also likely to affect the remaining fish species. In the Red River, the 150 mg/l criterion is exceeded at least part of the time. Thus, invertebrate diversity would probably also be reduced in the Red River. Tolerance levels of macrophytes to sulfate concentrations are not available. It is assumed that sensitive taxa, however, would be negatively affected. Algal species would shift to those species than can tolerate the increased sulfate concentrations. This would be most noticeable in the upper reaches of the Sheyenne River, but would also be recognized as Lake Ashtabula taxa become similar to Devils Lake taxa.

5.4.1.3 Chloride

Mean chloride is expected to increase 400 to 750 percent with WETOF overflow over WET baseline (Table 5-29). Mean chloride is estimated by the model at 139 mg/l, 111 mg/l, and 89 mg/l in Reaches 1, 3, and 5, respectively (Table 5-30). Mean monthly chloride would exceed 100 mg/l in all but April in Reach 1, from August through March in Reach 3, and from October through March in Reach 5 of the Sheyenne River (Appendix M-9). In the Red River, means (both monthly and total) would not exceed the standard, but the standard may be exceeded a few times (0.3 percent) at Halstad.

Chloride appears to be most limiting to unionids and sphaeriids, and probably prosobranch gastropods. These groups are not expected to survive in Reaches 1 and 3 of the Sheyenne River, and would probably be affected in Reach 5. Periodic elevation of chloride over 100 mg/l in Red River Reach 1 and near 100 mg/l in Reaches 2 and 3 may also affect sensitive mollusks. Other sensitive invertebrates would also probably be extirpated from the Sheyenne River and may be affected in the lower Red River. Elevated chloride levels should not affect fish. No information on effects of high chloride on macrophytes or algae was available. Given the high concentrations expected, it is assumed that most sensitive taxa would be negatively affected, and possibly extirpated. Moderately tolerant taxa may also be impacted. This could promote changes in abundance and diversity favoring the most tolerant species. Impacts would be greatest in Reaches 1-3. The most sensitive algal species may be affected below Reach 3. No impacts are expected in the Red River.

5.4.1.4 Summary

Changes in water quality due to overflow are likely to negatively impact the reproductive success of sensitive fish fauna throughout the Sheyenne River, and possibly into Red River Reach 1 (Table 5-31). Unionids, sphaeriids and prosobranchs are likely to be extirpated, at least from Sheyenne Reaches 1 through 3, and maybe affected in Reach 1 of the Red River. Sensitive invertebrate taxa are also likely to be extirpated and many tolerant invertebrate taxa negatively affected throughout the Sheyenne River. Sensitive invertebrate taxa would also likely be affected in the Red River. The loss of invertebrates could also negatively affect the remaining fish taxa, which could also affect host availability for any remaining unionid species (Table 5-3). Taxonomic composition of algae and macrophytes would also likely result from water quality changes. Sensitive taxa would probably be extirpated in the upper reaches and would probably at least decline throughout the Sheyenne River. This could result in a shift toward unpalatable algal species, and loss of food and cover for mollusks, fish, and invertebrates (Table 5-3).

5.4.2 Hydrology

Hydrology would be moderately to highly affected by WETOF overflow compared to WET baseline conditions in the Sheyenne River (Table 5-32, Appendices I and J). Discharge would be moderately increased in the summer and fall, and moderately to highly increased in the winter throughout the Sheyenne River. The magnitude of minimum flow would be highly increased in Reach 1 of the Sheyenne River, and moderately increased downstream to Kindred. Low-discharge events would be moderately to highly reduced and shortened.

Red River hydrology should not be substantially affected by WETOF overflow.

The increase in flow and increase in low-flow magnitude, frequency, and duration in the Sheyenne River could positively affect the biota by reducing stress and increasing habitat availability (Table 5-33). Summer and fall flow would increase moderately, which is a potential positive effect for fish, mollusks, and fast water invertebrates. Both low-flow frequency and duration would decrease, which should decrease the stress associated with low-flow conditions (crowding, low DO, competition for food resources and living space, increased predation). Macrophytes may benefit by expanding their range into newly created shallow water areas, and desiccation in winter should not occur with this alternative. The decrease in flow variability may also enhance macrophytes, as they would be disturbed less frequently by fluctuating water levels. Increased flow and depth throughout the year would benefit phytoplankton production over periphyton.

5.4.3 Geomorphology

WEST (2001) did not model channel geometry and planform under WET baseline conditions. Therefore, the change in channel shape between WET baseline and WETOF overflow cannot be compared. Likewise, the channel-forming flow under wet baseline was not estimated, so the change in exceedence cannot be determined.

For the purpose of comparison, the percent exceedence of moderate channel-forming flow was compared (Table 5-34). WET baseline percent exceedence of moderate channel-forming flow would be higher than under the 480MOD55 baseline. Thus, erosion under the WET baseline is expected to be higher than with a moderate future MOD50 or MOD55 baseline. However, the difference between percent exceedence for WET and WETOF would be less than the difference between MOD55 and 480MOD55. Thus, erosion would be greater with WETOF overflow than with WET baseline. However, the change would not be as dramatic as with the 480MOD55 pumping alternative.

Increased bed load movement could potentially affect fish adversely because of increased turbidity or sedimentation. Increased sedimentation could, in turn, lead to increased embedment or even the complete burying of hard substrates (i.e., gravel, cobble, and boulder). Fish species that would be most affected would be those requiring clean, hard substrates for spawning (e.g., shorthead redhorse, golden redhorse, white sucker, etc.) or those that depend on such substrates throughout their life-cycle (e.g., stonecat and longnose dace). Unionids require stable substrate, and erosion and deposition could result in substrate instability. Substrate movement would continually disturb unionids and other invertebrates. This would most likely result in extirpation of the unionid fauna. Sphaeriids, gastropods, and other invertebrates would also be negatively affected by the substrate instability and disturbance.

Attached algae could be prevented from colonizing, and the increase in turbidity and flow would discourage phytoplankton production. Bank erosion would also result in loss of macrophytes along the river's edge, and continued disturbance would prevent recolonization. Unfortunately, at this point no data are available that translate the predicted increase in bed load material to a biologically meaningful measure, such as degree of embedment, the amount of hard substrate that would be buried, or increase in turbidity.

If the increased bed load merely results in additional amounts of fine material in areas that already are depositional in nature, then few or no impacts would be expected. However, if this material settles out predominantly in areas that currently provide clean hard substrates, then the impact could be significant. At this point, there is no way to determine which scenario is more likely.

5.4.4 Habitat

In contrast to the pumping alternatives, with overflow mean discharge would increase in all seasons, and discharge variability would decrease in spring, summer, and fall throughout the Sheyenne River. The increase in flow would reduce the availability of slow-water and shallow habitats and increase the availability of swift-water habitats.

For WETOF overflow compared to WET baseline, the most substantial reductions would occur for the slow riffle guild in the upstream (Segment H) portion of the Sheyenne River and for the shallow pool and medium pool guilds in the downstream segments (B and E, Table 5-35). Changes in maximum WUA for WETOF overflow would decrease substantially farther downstream for the slow riffle guild and increase substantially farther downstream for the medium pool guilds. The shallow and deep pool guilds would experience the most substantial change in maximum WUA in the middle Reach, Habitat Segment E.

The most substantial increases in habitat availability would occur for the fast riffle and raceway habitats for all segments and all seasons. Changes in medium pool habitat would also be observed for Habitat Segment H, as would changes in deep pool habitat for Habitat Segment E and slow riffle habitat for Habitat Segment B (Table 5-35).

Seasonally, differences between WET baseline and WETOF overflow would be least in the spring and greatest in the summer.

Changes in maximum WUA for both benthic macroinvertebrate groups would be small relative to the changes in the other habitat guilds, but would be noteworthy for Habitat Segment H. Low-gradient benthic macroinvertebrate diversity and Trichoptera diversity would have the largest maximum WUA difference during the summer and fall. Differences between WETOF overflow and WET baseline would be smaller moving downstream to Habitat Segments E and B.

5.4.4.1 Habitat Segment H

Potential Reductions

In Habitat Segment H, as reflected in Table 5-35 and 5-36, WETOF overflow compared to WET baseline would result in habitat degradation for the slow riffle guild during the spring, and both the slow riffle and shallow pool guilds during the summer and fall. During the spring, the slow riffle guild would experience a maximum 24 percent decrease and an average 6 percent decrease in maximum WUA. Conditions for the slow riffle guild would further degrade during the summer, with a maximum 31 percent decrease and an average 15 percent decrease. In summer, this decline would occur most of the time. The 80 percent exceedence for percent WUA for slow riffle would decline from 44 percent to 31 percent (Table 5-36). Additionally, the shallow pool guild maximum WUA would decrease by a maximum of 26 percent and an average of 7 percent. However, this change would not be as frequent. Percent WUA 80 percent exceedence for shallow pool would only change from 21 percent to 20 percent in summer (Table 5-36). During the fall, the slow riffle guild habitat degradation would remain similar to summer conditions. Comparing fall with summer, the higher average difference and lower maximum difference during the fall indicates the shallow pool guild would experience more consistent habitat degradation through time.

Maximum WUA would decrease for both groups of benthic macroinvertebrates during summer and fall in Habitat Segment H. During summer, the low-gradient guild would experience a maximum 31 percent decrease and an average 15 percent decrease in maximum WUA, while trichoptera would experience a maximum 24 percent decrease and an average 13 percent decrease in maximum WUA. However, the 80 percent exceedence percent WUA would change less than 10 percent for both groups in summer. Average and maximum fall decline in percent WUA would be similar in magnitude to summer for both groups (Table 5-35). However, the 80 percent exceedence percent WUA would decline from 60 to 46 percent for the low-gradient guild, and 81 to 62 percent for the tricopterans guild (Table 5-36).

Potential Enhancements

In Habitat Segment H, WETOF overflow compared to WET baseline would result in habitat enhancement for the shallow pool guild during the spring, and for the fast riffle, raceway, and medium pool guilds during all three seasons studied (spring, summer, and fall; Table 5-35 and 5-36). During the spring, the shallow pool guild would experience a maximum 25 percent increase and an average 11 percent increase in percent WUA. However, the 80 percent exceedence percent WUA would increase less than 10 percent (Table 5-36). The medium pool guild would only experience slight enhancements (average less than 5 percent) throughout the year; the greatest enhancement to this guild would occur during the spring, with a maximum 45 percent increase. The change in 80 percent exceedence for medium pool guild percent WUA would also be less than 10 percent between WETOF overflow and WET baseline. In addition to enhancements during spring, the raceway guild would experience enhancements during summer and fall, with the most substantial enhancement occurring during summer with a maximum 49 percent increase and an average 27 percent increase. Raceway would become a much more important habitat in the spring with WETOF overflow, as 80 percent exceedence percent WUA would increase from 14 to 45 percent. In summer, 80 percent exceedence percent WUA would only increase from 2 to 16 percent, and in fall from 2 to 5 percent (Table 5-36). The fast riffle guild would experience the greatest enhancement in average and maximum WUA during fall, with a maximum

59 percent increase and an average 26 percent increase in the maximum WUA. However, the 80 percent exceedence for fast riffle would increase from 20 to 91 percent in the summer and from only 19 to 39 percent in the fall (Table 5-36).

There would be no habitat enhancement for either group of benthic macroinvertebrates during any season in Habitat Segment H.

Possible Changes in the Fish Community

During the spring, the amount of slow riffle habitat would decrease somewhat and the amount of shallow pool habitat would increase by a similar amount (Table 5-35). Because these two habitats support rather similar assemblages, these changes would not likely affect the overall fish community. At the same time, the amount of raceway would increase considerably most of the time, and medium pool and fast riffle habitat would increase less frequently but to a greater extent (Tables 5-35 and 5-36). The increases in fast riffle and raceway habitat should improve spawning conditions for rheophilic species, which are not very common in Reach 1 under present conditions.

During the summer, both the shallow pool and slow riffle habitats would decrease, along with a concurrent increase in the amount of fast riffle and raceway (Table 5-35). The increase in fast riffle and raceway habitats should benefit the rheophilic fishes that are currently limited in Reach 1 (Table 3-11). On the other hand, slow riffles and shallow pools function as significant nursery areas of most species, and spawning areas for centrarchids. However, the decline in the 80 percent exceedence percent WUA for these habitat would be low (less than 5 percent) to moderate (less than 15 percent) (Table 5-36). Thus, year class strength in some years may be poor due to reduced amounts of nursery and spawning habitat.

The pattern and magnitude of changes established during the summer would be duplicated nearly exactly in the fall (Tables 5-35 and 5-36). Shallow slow habitats are less important during the fall. The loss of some shallow pool and slow riffle may affect recruitment of species currently within this reach (mostly sunfish and minnows). But the increase in fast water habitats in both summer and fall would favor rheophilic species. Therefore, a shift in community composition would be expected with changes in habitat associated with overflow.

Possible Changes in the Invertebrate Community

Benthic invertebrate diversity and tricopteran abundance may decline slightly with habitat changes due to overflow. Maximum WUA in Habitat Segment H would decline when flow increases above 100 cfs and 250 cfs for invertebrate diversity and tricopteran abundance, respectively (Figure 5-4). Percent exceedence for 200 cfs would increase from 25 percent with WET baseline to 50 percent with WETOF overflow (Table 5-32)

5.4.4.2 Habitat Segment E

Potential Reductions

Habitat Segment E, when compared with upstream Habitat Segment H, would experience more substantial habitat degradation for the shallow and medium pool guild, but less substantial habitat degradation for the slow riffle guild with the increased flow expected with WETOF overflow. The most substantial negative changes in maximum WUA would occur during spring, summer, and fall for the shallow pool guild, and during the summer for the medium pool guild. During the spring, maximum WUA for the shallow pool guild would decrease a maximum of 57 percent and an average 11 percent. During summer, the medium pool guild would experience a maximum 31 percent decrease and an average 18 percent decrease.

Of the benthic macroinvertebrate groups, the low-gradient group percent WUA would be slightly reduced, but less than 10 percent as an average and less than 15 percent maximum (Tables 5-35 and 5-36).

Potential Enhancements

In Habitat Segment E, fast riffle, raceway, and deep pool guilds would experience habitat enhancements during all three seasons studied (spring, summer, and fall). The most substantial positive changes in maximum WUA would occur during the summer for the fast riffle. During the summer, there would be a maximum 92 percent increase and an average 30 percent increase in maximum WUA for the fast riffle guild. The raceway guild habitat would enhance with a maximum 46 percent increase and an average 19 percent increase. However, the 80 percent exceedence percent WUA difference between WET baseline and WETOF overflow would be less than 10 percent except for deep pool (17 to 29 percent) in the spring, raceway (3 to 33 percent) and deep pool (0 to 13 percent) in the summer, and raceway (37 to 51 percent) and deep pool (19 to 36 percent) in the fall (Table 3-36).

Of the benthic macroinvertebrate groups, the Trichoptera group would experience very slight habitat enhancement in Habitat Segment E (<5 percent average and <20 percent maximum).

Possible Changes in the Fish Community

The fast riffle and raceway needed for spring spawning would increase slightly, which may lead to higher spawning success of species such as silver and shorthead redhorse and rosyface shiner (Table 5-37). Slow riffle, which is also important spawning habitat for golden and greater redhorse and some minor species, is not expected to change. Thus, overall spawning success in Segment E might increase in some years (Table 5-37).

Similar to the results seen in Habitat Segment H, slow riffle and shallow pool habitat would decrease somewhat during the summer and fall (Tables 5-35 and 5-36). These decreases in nursery habitat may affect year class strength of most species in this reach. In the summer and fall, the amount of fast riffle and raceway habitat would increase, which should prove beneficial to the raceway and riffle specialists. The decline in medium pool habitat could affect habitat availability for some of the North Dakota special

concern species, and nursery area for some of the rheophilic species; however, these species may be able to utilize the deeper pool as a substitute.

Overall, the fish community composition may shift from a mix of slow- and fast-water species to mainly rheophilic species. However, some of these species may be reduced by year class failure because of lack of nursery areas in some years. The loss of shallow and medium pool habitats could affect the abundance of North Dakota special concern species.

Possible Changes in the Invertebrate Community

The invertebrate community should not be substantially affected by changes in habitat. Slight increases and declines in percent WUA would occur with each season, however, the 80 percent exceedence for percent WUA would be greater than 60 percent for both groups in summer and fall (Table 5-36).

5.4.4.3 Habitat Segment B

Potential Reductions

In Habitat Segment B, habitat degradation associated with WETOF overflow when compared to WET baseline would be less severe for the shallow pool guild, and similar for the medium guilds than those in upstream Habitat Segments H and E. Deep pool guild would decline in Reach B compared to the increase seen in Reaches H and E (Table 5-35). On the average, all declines would be >20 percent and maximum decline would be <40 percent (Table 5-35). The most substantial decline would occur in maximum WUA during the summer for the shallow, medium, and deep pool guilds. During the summer, the medium pool guild would experience a maximum 39 percent decrease and an average 18 percent decrease in percent WUA, while the shallow pool guild would experience a maximum 24 and an average 12 percent decrease. The deep pool would experience a maximum 30 and an average 12 percent decrease in maximum WUA. However, the decline in 80 percent exceedence percent WUA would only be greater than 10 percent in the fall for shallow pool (26 to 8 percent) and medium pool (26 to 8 percent) (Table 5-36).

Similar to Habitat Segment E, the percent WUA for the low-gradient invertebrate group would only decrease slightly (average <5 percent; Table 5-35).

Potential Enhancements

In Habitat Segment B, habitat enhancements associated with WETOF overflow when compared to WET baseline would be less pronounced for the fast riffle and raceway guilds than those in upstream Habitat Segments H and E. Additionally, slow riffle would increase rather than decrease in this segment. Enhancements for slow riffle, fast riffle, and raceway guilds would remain fairly similar between the summer and fall. During the summer, the slow riffle guild would experience an average 14 percent increase in maximum percent WUA, while the fast riffle guild would experience an average 17 percent. The raceway guild would experience an average 13 percent increase in maximum WUA. The predicted 80 percent exceedence in percent WUA indicates that the slow riffle enhancement would occur most of the time in summer and fall (Table 5-36), and raceway would be enhanced most of the time in spring,

summer, and fall. The 80 percent exceedence for fast riffle would differ less than 10 percent in any of the studied seasons (Table 5-36).

Similar to Habitat Segment E, the Trichoptera group would experience slight habitat enhancement in Habitat Segment B. The small magnitude of enhancement would be similar for all seasons, and 80 percent exceedence in summer and fall percent WUA would be near or above 80 percent for both invertebrate groups (Table 5-36).

Possible Changes in the Fish Community

During the spring, changes in percent WUA for all groups is expected to be minor; thus, spawning should not be affected.

The patterns during the summer and the fall suggest there would be a decline in pool habitat but an increase in riffle/raceway habitats. Thus, some quiet water YOY (e.g., sunfish, shiners, and golden redhorse) may not be as successful as those that use slow riffle (e.g., shorthead redhorse, silver redhorse, and channel catfish) as a nursery area. Additionally, the abundance of adult fish species, such as channel catfish, that use pool habitat during summer and fall may also be affected. A shift would be expected from pool species to rheophilic species (Table 5-37).

Possible Changes in the Invertebrate Community

With the loss of pool habitat, overall diversity of low gradient invertebrate species may be reduced. However, the abundance in rheophilic species is not expected to change (Table 5-37).

5.4.6 Summary Of Wet Future With Natural Overflow (WETOF) Compared To Wet Future Baseline (WET)

5.4.6.1 Sheyenne River Reach 1

Water quality, hydrology, geomorphology, and habitat are expected to differ between WET baseline and WETOF overflow in Reach 1. Water quality effects may be worse, as TDS, sulfate, and chloride levels would be almost double (TDS), to more than double (sulfate and chloride), the concentrations expected with 480MOD55 pumping (Tables 5-20 and 5-30). Flow, on the other hand, is not expected to increase as much; therefore, changes in hydrology, geomorphology, and habitat are not expected to be as great.

Macrophytes would be significantly impacted in Reach 1 (Table 5-38). Increased turbidity may reduce abundance and habitat because of reduced light penetration and photosynthetic potential. Submerged and emergent macrophytes may not remain established as deeper pools develop. Fast riffle habitat would also reduce macrophyte abundance because of increased scouring. Species would be reduced to areas of slow run or shallow pools, where water velocity and depth would be more moderate. Fringe species (typically a community of willows, sedges, and rushes) may also be affected. Increased water depth and velocity would likely remove the shallow marsh, wetland, and woody shrubs along the banks of the river. Exposure of these banks may lead to additional bank erosion and habitat changes.

Impacts would be mostly caused by changes in hydrology, including potential scouring or uprooting of macrophyte beds (i.e., submerged pondweeds) and increased water depth, which may drown existing emergent vegetation. Submerged species would be reduced the most. Exposing more area and expanding the wetted perimeter may create some additional habitat, but the species colonizing the new habitats would likely be more aggressive and tolerant of the increased disturbance rates and decreased water quality. Species of concern would include reed canary grass, purple loosestrife, giant reed grass, and flowering rush. All of these species have been identified in the basin and can readily inhabit disturbed areas. With the changes in hydrology, Reach 1 may begin to have communities similar to those existing in Reaches 3, 4, and 5. The loss of macrophytes would also affect the colonization area available for epiphytes, food and cover for invertebrates, and cover for fish (Table 5-38).

Algal species would also likely decline in abundance and diversity in Reach 1. Changes in water quality would likely extirpate or reduce the abundance of at least some of the sensitive taxa, which would shift the overall taxa to those more tolerant of the degraded conditions. These tolerant taxa may not be as palatable to fish, invertebrates, and mollusks. The loss of algal diversity and decreased water quality may also increase the occurrence of noxious blooms. Increased flow would favor phytoplankton species and may make conditions too deep for some periphytic species.

Many of the invertebrate taxa in this reach are sensitive to either sulfate or chloride. Concentrations of these parameters are expected to reach levels that would extirpate the sensitive fauna and possibly some of the more tolerant taxa, reducing species richness (Table 5-38). Those not affected by water quality changes would probably be affected by unstable substrate, decreased habitat suitability, increased turbidity, and decreases in macrophytes and algae. This would reduce the invertebrate species to those very tolerant of high chloride and sulfate and able to survive in unstable substrate. Of the species found in Reach 1, these may include Nematode and a few species of oligochaetes and chironomids. The loss of invertebrates would undoubtedly affect the fishes.

The high chloride levels that are predicted with WETOF overflow would probably extirpate most of the mollusks (unionids, sphaeriids, and prosobranchs).

Fish would also likely decline in abundance and diversity because of the decline in reproductive success of some species due to water quality and siltation of spawning habitat. Lack of macrophytes would also affect northern pike and brook stickleback. Species listed in Table 4-11 and not affected by the above factors would include fathead minnow, creek chub, black and brown bullhead, tadpole madtom, trout perch, white bass, smallmouth bass and white and black crappie. However, these species may be affected by lack of prey items.

After overflow stops, water quality may improve, and slower-flowing, fast-water habitat would decline. This upper reach would be less hydrologically stable. The channel would probably have changed, becoming wider and deeper, such that the reduced water levels would result in less available wetted habitat during low-flow conditions. Unionids, many invertebrate species, algal species and macrophyte species would probably not survive WETOF overflow. Only a few small permanent tributaries drain into Reach 1, and their suitability as unionid, fish, and invertebrate refugia is unlikely. Fish hosts are prevented from carrying glochidia upstream past Baldhill Dam. Unless unionid refugia occur in the small tributaries, this fauna is unlikely to recolonize. As conditions improve, the fish and invertebrate fauna would eventually invade from Lake Ashtabula. Recolonizing species would be dependent upon

species remaining in Lake Ashtabula and the habitat types that would form once pumping stops. The length of time required for recolonization would depend on the time required for the channel to stabilize, which is not known.

5.4.6.2 Sheyenne River Reach 2

Water quality and turbidity would be the most likely factors to change in Lake Ashtabula. Changes may be severe, as water quality standards would be exceeded both upstream and downstream of the lake. The increased TDS, sulfate, and chloride levels would be well below toxic levels for the fish species present. However, changes in water quality would likely affect the algal composition, macrophyte composition, and invertebrate composition (including mollusks). Sensitive invertebrates, mollusks, algae, and macrophytes would not likely survive water quality conditions in Reaches 1 and 3, and thus probably would not likely survive in Lake Ashtabula (Table 5-38). Water quality in Lake Ashtabula also may affect fish reproduction. The loss of macrophytes, change in algal composition, and loss of invertebrates would also likely affect fish abundance (Table 3-38).

Water quality should improve when overflow stops in the year 2025. However, the fauna remaining in Lake Ashtabula would be those species tolerant to the poorer water quality conditions.

5.4.6.3 Sheyenne River Reach 3

Changes in water quality, hydrology, geomorphology, and habitat in Reach 3 would be of a magnitude similar to or greater than Reach 1. Water quality degradation would be slightly less, but changes in habitat would be greater. Additionally, Reach 3 would support a more diverse fish and invertebrate community than Reach 1.

Increased flow would likely remove some of the macrophyte species through scouring or increased water depth. Turbidity may further limit macrophytes. Increased flow may allow expansion of existing vegetation into previously uncolonized areas. The effects of water quality changes are unknown, but those species intolerant of high sulfate and chloride would likely be extirpated. These changes may benefit aggressive species such as cattail and purple loosestrife.

Algal species would likely decline in abundance and diversity in Reach 3. Changes in water quality may shift the overall taxa to those more tolerant of the degraded conditions. Increased flow would favor phytoplankton species and may make conditions too deep for some periphytic species. Additionally, reduced abundance of macrophytes would reduce epiphyton.

The invertebrate community would probably be reduced to those species tolerant of water quality changes and unstable substrate. Water quality changes in this reach would only be slightly less than in Reach 1 (Table 5-30). The invertebrate community in Reach 3 currently consists of a fairly diverse mix of dipterans (several families rather than mainly chironomids), ephemeropteran (19 taxa), hemipterans (Corixidae), and tricopterans. Both tolerant and intolerant taxa occur in each of these groups (Table 4-7). Habitat for rheophilic invertebrates and overall invertebrate diversity should not change. However, scouring and deposition of substrate would tend to reduce the usefulness of these habitats. Between water quality degradation and unstable substrate, few invertebrate species may survive (Table 5-38).

Unionids, sphaeriids, and prosobranch gastropods would likely be extirpated from this reach due to increased sulfate and chloride concentrations.

Water quality changes would be expected to affect reproduction of sensitive fish species (northern pike, rosyface shiner, hornyhead chub, greater redhorse). Additionally, scouring and deposition, habitat changes, and possible declines in invertebrate abundance and macrophyte beds would negatively affect many of the fish species in this reach, including several North Dakota special concern species. Of the common species in this reach (common shiner, spotfin shiner, bluntnose minnow, shorthead redhorse, golden redhorse, smallmouth bass, blackside darter and Johnny darter), common shiner, both redhorses, and blackside darter are simple lithophils that would be negatively affected by depositional substrate in spawning areas. Of the North Dakota special concern species in this reach, hornyhead chub and rosyface shiner could be negatively affected by increased turbidity and water quality; pugnose shiner, blacknose shiner, and banded killifish could be negatively affected by the loss of weed beds and water quality; and silver redhorse, greater redhorse, and river darter (simple lithophils) would be affected by depositional substrate in spawning areas. Habitat changes would reduce the community further to species that live entirely in fast-water areas; however, if substrate is deposited in these areas or substrate is unstable, these habitats would be of little use, particularly if invertebrates are depleted.

When overflow stops, the channel would have changed somewhat in configuration due to erosion and deposition. If the fish fauna are depleted during overflow, species from downstream may recolonize according to available habitat. Thus, the fish fauna could change from the diverse fish fauna that now occur in this area to a less diverse fauna such as in Reach 5 (Table 3-11). Some of the North Dakota special concern species are primarily inhabitants of spring-fed tributary streams and may be able to reinvade after overflow stops if habitat is suitable. Invertebrates would likely drift in from Lake Ashtabula. However, only tolerant fauna is likely to survive the lowered water quality in the lake. Invertebrates should also be able to reinvade from tributary streams. Diversity should increase with time, as habitats re-stabilize and species invade from tributaries and downstream areas. Unionids would not likely survive overflow. Most of the unionid species found in Reach 3 prior to pumping may still occur in the Red River. Recolonization of unionids would follow recolonization of fishes. As with Reach 1, the time required for recolonization would be dependent on the time required for habitat to stabilize, which is currently unknown.

5.4.6.4 Sheyenne River Reaches 4 and 5

Impacts to Reaches 4 and 5 would also be due to changes in water quality, hydrology, scouring. deposition, turbidity, and habitat, which should be similar to or slightly less than in Reach 3. However, overall impacts to Reaches 4 and 5 should be less than Reach 3 due to the lower habitat variability and species richness in Reaches 4 and 5.

Macrophytes are sparse in this reach due to high turbidity, relatively deep water, and unstable substrate. Changes in habitat do not favor the establishment of macrophytes. Increased flow in the summer and fall may improve habitat for some fringe areas and help establish wetland and emergent vegetation, but this would be a long-term process. Existing macrophyte beds would likely be removed or buried due to scouring and deposition expected with the increased flow.

The algal community would be affected similarly to Reach 3. Attached algae and epiphytes would be depleted by increased scouring, turbidity, and substrate instability. Additionally, changes in water quality could be sufficient to reduce the abundance of intolerant taxa and shift the species composition toward tolerant taxa.

Differences in water quality may be less between WET baseline and WETOF overflow in these reaches than in upstream reaches, but increased chloride and sulfate would be sufficient to extirpate sensitive species and reduce the richness of tolerant taxa. Habitat diversity would also decline. Thus, invertebrate fauna remaining in these reaches would be those tolerant of high chloride and sulfate, shifting substrate, and fast water.

Water quality should not be sufficient to extirpate unionids, sphaeriids, and prosobranchs, but occasional levels above thresholds may affect reproduction and recruitment. Thus, abundance would likely decrease. Scouring and deposition would likely render habitat unsuitable for unionids. Sphaeriids and prosobranchs may also be reduced by habitat instability.

The fish community in Reach 5 is not particularly species rich compared to Reach 3, however, many of the species in this reach are simple lithophilic spawners (e.g., emerald shiner, sauger, and redhorse), and some need the shallow, medium, and deep pools as adults or juvenile (e.g., channel catfish, northern pike, sunfish, and minnows), which will be reduced in at least the Habitat Segment B area. In addition to reduced habitat availability, food sources such as algae and invertebrates would also be depleted. Water quality would also be degraded, which would reduce reproductive success. The cumulative effects of these factors could severely deplete the fish fauna in Reach 5.

When overflow stops, Reaches 4 and 5 should be the first to recolonize. Since habitat is similar to the Red River, Red River fish and invertebrate species would likely be those to recolonize. The Maple River may also serve as a refuge and source of recolonizing fish and invertebrates. As with other Sheyenne River reaches, the time for recolonization would be dependent on the time required for habitat stabilization. Since water quality would also affect the lower Red River, recolonization may take longer than under the 480 cfs unconstrained pumping conditions.

5.4.6.5 Red River

Water quality should be the only factor analyzed in this study that would be affected in the Red River. Impacts would be greatest in Red River Reach 1, but would extend to the Canadian border. Macrophytes and algae would probably not be affected in the Red River. However, changes in sulfate and chloride may be sufficient in Reach 1 to result in the occasional loss of recruitment in sensitive fish species, decrease in abundance of sensitive mollusks, and decrease in abundance and richness of invertebrates (Table 5-38). Sensitive invertebrates and mollusks may be affected throughout the Red River (Table 5-38). A shift to tolerant species and a decline in species richness would be expected.

Most of the species currently in the Red River would likely remain during overflow, at least in Reaches 2 and 3, although at a different frequency depending on their tolerance to water quality. As water quality returns to baseline conditions, the fauna should follow. None of the species should be extirpated, and many of the fish and probably invertebrate species occur in Red River tributaries. Unionids, however, are lacking in the lower end of most tributaries and may not be able to recolonize if decimated. Unionids

are not expected to be significantly affected by water quality, as chloride in Reach 1 is not expected to exceed 100 mg/l, and monthly averages would only exceed 50 mg/l in a few months (Table 5-30 and Appendix M-9).

5.5 COMPARISON OF ALTERNATIVES

5.5.1 300MOD50

All three alternatives would have a negative effect on the existing fauna. However, these effects would be least for 300MOD50 pumping. In this alternative, water quality degradation would likely decrease algal and invertebrate diversity throughout the Sheyenne River, but should not substantially affect fish and mollusks (Table 5-39). Changes in habitat may benefit rheophilic species in Sheyenne River Reach 3, but could be detrimental to many of the fish species in Reach 5, as spawning, nursery, and adult habitat would be affected. The Red River fauna should not be affected by this alternative. When pumping stops, the communities would probably shift again in response to the change in water quality and habitat.

5.5.2 Other Alternatives

The overall effects of 480MOD55 pumping and WETOF overflow are similar in magnitude. Hydrology, habitat, and geomorphology changes would be greater with 480MOD55 pumping and water quality changes would be greater with WETOF overflow.

5.5.2.1 480MOD55

With 480MOD55, macrophytes would be lost throughout most of the Sheyenne River because of scouring, deposition, and increased turbidity. Periphyton and epiphyton would also be lost because of scouring, deposition, increased turbidity, and increased water depth. The invertebrate community could be reduced to those species tolerant of sulfate, chloride, and unstable substrates. Unionids would probably be extirpated due to water quality. Other mollusks would be reduced by water quality and/or unstable substrate, reduced periphyton, and reduced macrophytes. Fish species richness and abundance in Reaches 1 to 4 would probably be reduced by water quality and changes in habitat. In Reach 5, fish may be limited to transient individuals. Habitat for rheophilic adults would be available, but most of these species are simple lithophils that require clean substrate for spawning. Additionally, nursery habitat for most of these species would be limited, weedy cover would be lost, and invertebrate abundance would be reduced (Table 5-39).

Recolonization potential of the Sheyenne River would be limited due to the lack of permanent tributaries, upstream migration blockage by Baldhill Dam, and the extent of habitat damage that may occur. Although water quality may recover to pre-pumping conditions, habitat throughout the river would have changed, and substrate may be left unstable. The lower Sheyenne River could recolonize from the Rush, Maple, and Red Rivers once habitat stabilizes. The upper reaches would require time to stabilize, however, fish and unionid species may not recolonize within the life of the project.

Red River Reach 1 could experience an increase in emergent and wetland fringe macrophytes as new shallow water zones are inundated with the higher flow. Increased depth would also favor phytoplankton over periphyton, but this is probably already the case. Fish should not be affected in the Red River.

However, a decline in abundance and richness of sensitive mollusk and invertebrate taxa could be expected throughout the Red River (Table 5-39). Unlike the Sheyenne River, the Red River has several large tributaries that harbor fish species similar to those in the Red River. Thus, as water quality improves, fish would probably recolonize within a few years. Invertebrates would also recolonize, as most species probably occur in tributaries and have short life spans and mobile adult stages. Unionids would probably recolonize Red River Reach 1 as fish recolonized from Reach 2 and 3. However, if unionids were decimated throughout the river, recolonization may not occur, as few unionids have been recently found in the lower reaches of tributaries due to high chloride levels and/or fluctuating water levels.

5.5.2.2 WETOF

Although flow increases that would affect hydrology, geomorphology, and habitat would occur with WETOF overflow, water quality would be degraded more than the other alternatives. Loss of macrophytes through burial and scouring is expected throughout most of the Sheyenne River. In Sheyenne River Reach 1, sensitive algae would likely be extirpated by high sulfate levels. Periphyton and epiphyton could be lost due to scouring and burial. Intolerant phytoplankton would also likely be affected through Sheyenne River Reach 3. These effects should dissipate some in Reaches 4 and 5, but without information on the tolerance of most species, these effects are difficult to estimate. A decrease in richness and abundance of invertebrates sensitive to chloride and sulfate is expected throughout the Sheyenne and Red Rivers. In Sheyenne River, even taxa tolerant to these variables may not tolerate the concentrations expected. Additionally, unstable habitat conditions in Reaches 1 and 3 would also negatively affect invertebrate survival. The extirpation of unionids, sphaeriids, and prosobranchs is expected in Sheyenne River Reaches 1 through 5 due to increased chloride levels and habitat instability. Fish species richness and abundance in Reaches 1 to 4 would be reduced by water quality and changes in habitat. In Reach 5, fish may be limited to transient individuals. Habitat for rheophilic adults would be available, but most of these species are simple lithophils that require clean substrate for spawning. Additionally, nursery habitat for most of these species would be limited, weedy cover would be lost, and invertebrate abundance would be reduced (Table 5-39).

Recolonization potential of the Sheyenne River would be limited due to the lack of permanent tributaries, upstream migration blockage by Baldhill Dam, and the extent of habitat damage that may occur. Although water quality may recover to pre-pumping conditions, habitat throughout the river would have changed, and substrate may be left unstable. The lower Sheyenne River could recolonize from the Rush, Maple, and Red Rivers once habitat stabilizes. The upper reaches would require time to stabilize, however, fish and unionid species may not recolonize within the life of the project.

Water quality effects from WETOF overflow would extend throughout the Red River. However, hydrology, geomorphology, and habitat in the Red River should not be affected by WETOF overflow. Water quality changes may not affect macrophytes and algae. Some decline in richness and abundance of sensitive invertebrate taxa is expected throughout the Red River due to high chloride and sulfate levels. Chloride levels may occasionally exceed levels thought to limit unionids (100 mg/l), but should be below this limit most of the year in Reach 1, and throughout the year in Reaches 2 and 3. However, chloride could reach as high as 90 mg/l in Red River Reach 3. Thus, some decline in unionids and other mollusks might occur in Reach 1, and mollusks may be affected in Reaches 2 and 3. Degraded water quality in Red River Reach 1 may also result in the loss of an occasional year class of sensitive fish

species, but should not affect recruitment in Reaches 2 and 3. As water quality improves, fish would probably recolonize within a few years. Invertebrates would also recolonize, as most species probably occur in tributaries, and have short life spans and mobile adult stages. Unionids, however, may not recover. The lower reaches of most Red River tributaries do not harbor unionids because of water quality problems. Unionids would probably recolonize Red River Reach 1 as fish recolonized from Reach 2 and 3.

6.0 MONITORING AND MITIGATION

6.1 PRE-OPERATION MONITORING - SHEYENNE RIVER

All of the above predictions are based on modeled hydrology and water quality, available geomorphology information, and habitat modeling. Hydrology and water quality model data should be compared to actual available data (2000-2002) to verify modeled values. Most of the biotic information is fairly recent, but was not collected at the same time and location as data for the models. For the purposes of this analysis, modeled conditions at one or two locations within a reach were assumed to occur throughout the reach. Additionally, aquatic communities and habitats naturally vary over time. Therefore, additional baseline data would be needed to define average conditions and natural variability, and to relate existing biota to available habitat.

Baseline monitoring should include resampling of habitat transects at flows that would best facilitate habitat modeling. The Sheyenne River habitat and vegetation communities should be mapped using LIDAR and infrared aerial photographs. Habitat types should be field verified and representative sections within each reach selected for sampling and long-term monitoring, so that data from habitat transects can be extrapolated to river-wide conclusions. Erosion and deposition rates need to be defined for existing conditions, and modeled and monitored for future conditions.

Once habitat transects are established, algae, macrophytes, mollusks, invertebrates, and fish should be sampled within those transects. Sampling should be seasonal, except for unionids that do not change on a seasonal basis, and take place over a period of at least three years to define trends. Habitat characteristics (depth, substrate, and flow at cells across the channel) should also be sampled seasonally for at least three years to determine habitat stability. Water quality (at least TDS, sulfate, and chloride) and productivity (chlorophyll a) should also be sampled at a minimum of three points along each habitat transect.

6.1.1 Phytoplankton and Periphyton

The periphyton and phytoplankton communities are very diverse and are often difficult to identify. Algae are the most basic biotic component in the river and may be the first group to respond to changes in water quality and hydrology. Changes in the algal community will also transfer up the trophic chain with consequences on the rest of the ecosystem. Algae are also primary producers and will affect nutrient transport and spiraling in the system. Many species can also form large floating mats and create aesthetic, odor, and taste problems. Some species of cyanobacteria also produce toxins when overly abundant.

Phytoplankton and periphyton have very different community compositions over a very small geographic scale. Compositions in pools, runs, riffles, and stable water (i.e. Lake Ashtabula) are often very different. For this reason, it is difficult to identify any one species that is a useful monitor for all locations. Furthermore, species composition can change seasonally, making the timing of monitoring potentially important. The following is a list of recommended monitoring parameters. These can be followed for both the phytoplanktonic and periphytic components of the algal community.

1. Chlorophyll a: Before looking at individual groups of species, a broad, comparable, quantifiable measurement should be considered as a surrogate for algal abundance. Chlorophyll a is a good way to compare algal response to nutrients, water chemistry, turbidity, and geomorphology.

2. Chlorophyta (green algae): This is a large group of algae with a wide range of habitats. Under eutrophic conditions, this group can reproduce rapidly and form large algal mats. Some of the species with the widest range include *Kirchneriella* sp., *Monoraphidium* sp., *Raphidonema* sp., and *Aestrococcus* sp.

3. Bacillariophyta (diatoms): This is also a very large group with a wide range of habitats. Diatoms are present in all reaches of the project, but have distinct community shifts in different flow and water quality conditions.

4. Cyanobacteria (blue-green algae): This group of algae is usually not common in undisturbed systems. It is generally considered a nuisance, as it can affect water quality and is not consumed by wildlife. When eutrophication occurs from increased nutrient inputs, this species can rapidly reproduce and dominate a system. This often leads to massive die-offs, which cause oxygen depletion, changes in water clarity, and potentially the production of toxins. Shifts in the abundance of cyanobacteria may be an early indication of deteriorating water quality.

5. Euglenophyta (euglenoids): The euglenoids are planktonic algae, which are present in all reaches of the Sheyenne River. This group has been singled out for monitoring because of the wide distribution, relative few species, and its tolerance to high concentrations of sulfate. Changes in this group may be indicative of changes in water quality.

6. Devils Lake Taxa: Several species of algae in Devils Lake are not present in the Sheyenne River. Monitoring for these taxa, or the occurrence of other "lake-like" taxa above Lake Ashtabula, should be conducted for assessment of how much foreign biota is entering the Sheyenne River. While many of the exotic taxa may not survive or coexist with the native taxa, shifts in overall community structure could indicate changes in water quality or hydrology.

The relative abundance of these groups should be enumerated and compared spatial and temporally.

6.1.2 Macrophytes

Specific information on aquatic vegetation abundance and distribution is lacking. Information on distribution and community composition could possibly be obtained from LIDAR and infrared aerial photographs. Distribution and abundance of macrophytes should be considered in habitat transect selection. The following is a list of suggested species to monitor:

1. Sago pondweed (*Potamogeton pectinatus*): This is one of few species confirmed to occur throughout the Sheyenne and Red Rivers. Sago is the most tolerant of the pondweeds (potamogetons) to high alkalinity, salinity, and turbidity. Found in most substrate types, sago pondweed provides food and cover to a wide variety of vertebrate and invertebrate species and

may be a key aquatic species in eutrophic systems. The potamogetons may also be studied as a group, as they best represent the submerged vegetation in the system. Curly-leaf pondweed (*Potamogeton crispus*) is a hardy but invasive species of pondweed that has been identified in the lower Sheyenne River. This species may be singled out for monitoring in the lower reaches and the Red River due to its aggressive nature.

2. Eurasian water milfoil (*Myriophyllum spicatum*): This exotic species was identified by Bonnie Alexander near Baldhill Dam in 1996, but subsequent draw downs may have frozen out the population, as no specimens have been observed since 1996. Changes in water levels may prevent the natural removal of this species and could lead to spreading. This species should be monitored as a representative of submerged habitat and to control the spread of an exotic species.

3. Cattail (*Typha latifolia* and/or *Typha glauca*): This emergent plant is believed to be present in shallow water areas throughout the study area. Cattails are useful for evaluating the effects of increased water elevations, as they can be drowned out by high water yet survive short periods of drying. In general, cattails are tolerant to a wide range of water quality conditions and are hardy enough to withstand scouring and flooding that many other plants cannot. Cattails also colonize recently disturbed areas and may monopolize any new habitat that develops. Monitoring the populations and distribution of cattail can serve as a measure of the amount of shallow water (marsh) habitat that changes in response to the hydrologic alterations.

4. Arrowhead (*Sagittaria* sp.): This is another emergent species that occupies the shallow water areas along the riverbanks and would be a good indicator of hydrologic changes. Arrowhead is more sensitive to changes in water quality, flooding, and scour than cattail, and may represent changes to the habitat and water quality not demonstrated by cattail.

5. Sedge, rush, willow communities: Many of the riverbanks are believed to be composed of a herbaceous community composed of various *Carex*, *Scirpus*, *Eleocharis*, and *Salix* species. Many of these species require spring inundation, but thrive in areas that are relatively dry for much of the growing season. Changes in hydrology will alter the available habitat for this group. Under the proposed changes, these areas may have flowing water during the season when no water would usually be present. The bank community is critical for wildlife habitat and bank stability.

6. Abundance of submerged, emergent, and bank communities: As a rough estimate of impacts, the relative abundance of submerged, emergent, and bank vegetation should also be monitored. Because of changes in hydrology under the proposed operating alternatives, the overall amount, or type, of habitat available may be altered. This information can be quantified from cross-sectional transects, but may be best estimated from aerial photographs. This would also allow for statistical analysis and comparisons to historical conditions.

Relative abundance of these species groups should be compared temporally and spatially throughout the Sheyenne River.

6.1.3 Invertebrates

Seasonal invertebrate data are currently being collected throughout the Sheyenne River at several habitat segments (Figure 3-16). This survey should continue to establish baseline invertebrate conditions in the Sheyenne River. Data should be analyzed by species sensitivity to chloride and sulfate, functional feeding group, habitat preferences (depth and flow), and substrate preferences. Invertebrate results could also be analyzed by ordination analysis similar to that conducted by Phillips *et al*. (2000) for algae and Koel (1997) for fish.

Other parameters that should be measured for spatial and temporal comparison include Rapid Bioassessment Metrics (RBP metrics-Barbour *et al*. 1999); richness measures, composition measures, tolerance/intolerance measures, feeding measures, and habit measures (Table 6-1).

6.1.4 Mollusks

Unionids were last sampled in the Sheyenne and Red River in early 1990. The distribution of unionids with respect to habitat transects should be established. Qualitative and quantitative samples should be collected in each bed. Metrics that are needed for spatial and temporal comparison include position of unionid beds, and density, species richness, recruitment and mortality within unionid beds (Dunn 2000).

6.1.5 Fish

Fish should also be sampled within each of the habitat transect areas. Metrics that might be used for spatial and temporal comparison could include those suggested by Goldstein *et al*. 1994: species richness and composition, trophic composition, reproductive guild, functional guild, and fish abundance and condition (Table 6-2).

6.2 PRE-OPERATION MONITORING—RED RIVER

Effects in the Red River are expected to be limited to water quality changes in Reaches 1 through 3 and hydrological changes in Reach 1. Benthic invertebrates are perhaps the best monitor for these changes, as species exhibit different responses to water quality and habitat change (Barbour *et al.* 1999). An RBP approach would most likely be adequate to establish a baseline for temporal and spatial comparison. The RBP approach includes collecting habitat, water quality, and land use variables at each site.

6.3 PRE-OPERATION AND POST-OPERATION MONITORING

Once an adequate baseline has been established, monitoring using the above methods should continue, but perhaps on a less frequent basis until pumping or overflow actually begins. Sampling should then be repeated on an annual basis (including a seasonal element) until biota stabilizes. Sampling frequency could then be reduced until pumping or overflow stopped. After pumping (300MOD50 or 480MOD55) or natural overflow (WETOF), monitoring should be reinitiated on a seasonal basis until biota again stabilizes.

6.4 MERCURY

No information was available on how methyl mercury availability would increase under the three alternatives. A relationship between the methyl mercury in surface water, sediment, and fish tissue should be established. A monitoring program should include the following elements:

- Monitor surface water, sediment, and fish tissue.
- Collect samples from every reach in habitat transect areas.
- Establish appropriate time(s) of year to collect samples and be consistent every year.
- Sample similar numbers of each species of fish within each reach; identify sex, as there is evidence that mercury may be more toxic to male fish.
- Establish most appropriate fish tissue to analyze (e.g., fillet vs. whole fish); may have to do both (fillet for human health; whole fish for fish toxicity, wildlife toxicity).
- Establish appropriate type and number of macroinvertebrates to collect and analyze.

Mercury levels in substrate subject to inundation during the alternatives need to be determined. A model should be developed to estimate the effects of this additional mercury release on fish and invertebrates.

6.5 POSSIBLE MITIGATION

6.5.1 All Alternatives

Increasing (or restoring) the storage capacity of the Devils Lake and Sheyenne River watersheds could perhaps help influence pumping levels and related impacts.

A healthy system can withstand more damage than an unhealthy system, whether it is an organism or an ecosystem. Enhancing the Sheyenne River watershed prior to pumping could potentially increase the river's ability to withstand impact and recover. Establishing riparian buffer throughout the river would be the first step in this process. This would decrease current erosion rates and reduce erosion due to alternatives. This buffer would also provide a sediment trap and nutrient/pesticide filter between the surrounding farms and the river. Other enhancement ideas could be developed with the assistance of North Dakota fish and wildlife agencies.

6.5.2 300MOD50 Pumping

Changes likely to occur with 300MOD50 pumping include increases in sulfate and chloride concentrations in Reaches 1 and 3 and habitat changes in Reaches 3 and 5 of the Sheyenne River. Reducing the concentration of chlorides so that levels do not exceed 50 mg/l and sulfates so that levels do not exceed 150 mg/l would probably protect all of the taxa in the Sheyenne River. However, this is not practical, as levels under MOD50 baseline are expected to exceed these criteria, at least in Sheyenne River Reach 1. Under 300MOD50 pumping, sulfate would be limited to 450 mg/l and chloride is not expected to exceed 80 mg/l. These levels should be sufficient to protect tolerant invertebrates and most mollusks, and not inhibit fish reproduction. However, effects of increased sulfate on algal species is

unknown. Perhaps toxicity testing of sensitive algal species in Reach 1 of the Sheyenne River could be conducted and water quality limits adjusted accordingly.

Increased depth and velocity would likely cause habitat changes that would not severely deplete any communities, but would alter the species composition. Habitat and species composition should be monitored as discussed above. The potential effects of scouring and deposition are not known, but are not expected to change by any order of magnitude. However, the magnitude of these effects could be underestimated, and scouring and deposition could have greater effects than the other parameters. These effects should be modeled. If they are believed to be significant, something as simple as a slow increase in the pumping of water to reduce scouring, and a slow decrease such that animals are not left stranded, may mitigate this affect. However, this mitigation would also need to be modeled to estimate its efficacy.

6.5.3 480MOD55 Pumping and Natural Overflow

The impacts of these alternatives could be dramatic, particularly in Reach 1 of the Sheyenne River, which is essentially isolated from recolonization sources. Under both alternatives, water quality, scouring, deposition, and turbidity could severely deplete much of the aquatic community in the Sheyenne River, except very tolerant species. Limiting pumping such that water quality parameters do not exceed levels lethal to algae, unionids, and invertebrates in the Sheyenne River would mitigate some effects; however, pumping may have to be reduced to 300MOD50 to accomplish this effect.

Changes in hydrology could be mitigated by modifying discharge such that biologically significant hydrological parameters fall within or near RVA limits most of the time (Appendix J).

The effects of erosion, deposition, and turbidity are also likely to substantially modify the Sheyenne River aquatic biota. Perhaps the potential for adverse effects is overestimated, but it needs to be determined before designing mitigation.

It is possible, given this analysis, that the non-tolerant aquatic biota of Sheyenne River Reach 1 may be extirpated, and the aquatic biota through Reach 5 may be depleted. If this were the case, stream rehabilitation measures that would assist with stabilizing substrates and habitats would be needed. Once habitats are stabilized, macrophytes could be reintroduced. Invertebrates should recolonize from downstream or nearby systems within time. Fish and unionids would probably need to be reintroduced.

Relocating existing unionid communities out of the Sheyenne River is not recommended for several reasons:

- Most of the species in the upper reaches (anodontines) have a short life span (less than 10 years)
- Those with a longer life span (amblemines and lampsilines) are not rare in the Mississippi River basin.
- Finding, and moving unionids from one system to another is labor intensive and very costly.

- Survival rate of unionids moved to ponds is low (Newton *et al.* 2001).

However, unionids should be sampled and tested for genetic stock differences from those in the Maple River, Red River and nearby Mississippi River Basin Rivers. If differences are detected, salvage efforts may be worthwhile. If genetic stocks are not different, several techniques most of which are experimental at this time, could be used to reestablish unionids in the Sheyenne River. Unionids have successfully been reintroduced into areas where water quality was the initial cause of extirpation and has been improved, however, habitat had not been disturbed in these areas. Habitat rehabilitation has been less successful. By the time pumping or overflow ceases, methods for habitat rehabilitation and reintroduction may be better defined, or this would be an ideal opportunity for research into this possibility.

Methods for restocking fish and restoring fish habitat are well established. Additionally, fish are more mobile and resilient to change. Recolonization would eventually occur if habitat and water quality improve sufficiently to support fish. Habitat could be enhanced and fish stocked, particularly in Reach 1. The monitoring program should provide sufficient data to determine where enhancement is needed and what species need assistance with recolonization.

TABLES

TABLE 2-1

SUMMARY OF BASELINE AND OPERATIONAL FUTURES
Final Aquatic Impact Analysis Report

Description	Abbreviation
Moderate future 1450 baseline conditions	MOD50
Moderate future 1455 baseline conditions	MOD55
Moderate future (1450) with 300cfs constrained pumping through Peterson Coulee	300MOD50
Moderate future (1455) with 480cfs unconstrained pumping through Peterson Coulee	480MOD55
Wet future without Devils Lake overflow	WET
Wet future with Devils Lake overflow through Tolna Coulee	WETOF

TABLE 3-1

WATER QUALITY STANDARDS FOR SHEYENNE AND RED RIVERS
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	USEPA[1]	IJC (1969)[1]	North Dakota[2]		Minnesota
			Sheyenne River	Red River	
TDS guideline (mg/l)	500	500	--	500	500
Sodium (mg/l)	20	--	60% of total cations	50% of total cations	--
Chloride (mg/l)	100	100	175	100	100
Sulfate (mg/l)	500max, 250 sec.	250	450	250	250
Dissolved oxygen (mg/l))	--	5	5	5	5
Fecal coliform (#/100ml)	--	200	200	200	200

[1]Stoner *et al* . 1998; USEPA=U.S. Environmental Protection Agency, IJC=International Joint Commission

[2]North Dakota standards of quality for waters of the state, ND Dept. of Health (Chapter 33-16-02)

TABLE 3-2

TIME PERIOD OF AVAILABLE WATER QUALITY DATA BY REACH[1]
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Reach	USGS Station	Flow	TDS	Calcium	Magnesium	Sodium	Potassium	Carbonate	Sulfate	Chloride
Devils Lake	Big Coulee		10-57 to 8-99	10-57 to 8-99	10-57 to 8-99	10-57 to 8-99	10-57 to 8-99	10-57 to 8-99	10-57 to 8-99	10-57 to 8-99
	Channel A		5-84 to 6-99	5-84 to 6-99	5-84 to 6-99	5-84 to 6-99	5-84 to 6-99	5-84 to 6-99	5-84 to 6-99	5-84 to 6-99
	Main Bay		10-59 to 8-79; 10-92 to 2-99	10-59 to 8-79; 10-92 to 2-99	10-59 to 8-79; 10-92 to 2-99	10-59 to 8-79; 10-92 to 2-99	10-59 to 8-79; 10-92 to 2-99	10-59 to 8-79; 10-92 to 2-99	10-59 to 8-79; 10-92 to 2-99	10-59 to 8-79; 10-92 to 2-99
	East Devils Lake		6-60 to 8-79; 10-92 to 2-99	6-60 to 8-79; 10-92 to 2-99	6-60 to 8-79; 10-92 to 2-99	6-60 to 8-79; 10-92 to 2-99	6-60 to 8-79; 10-92 to 2-99	6-60 to 8-79; 10-92 to 2-99	6-60 to 8-79; 10-92 to 2-99	6-60 to 8-79; 10-92 to 2-99
	Devils Lake (East Bay)		6-60 to 8-79; 10-92 to 2-99	6-60 to 8-79; 10-92 to 2-99	6-60 to 8-79; 10-92 to 2-99	6-60 to 8-79; 10-92 to 2-99	6-60 to 8-79; 10-92 to 2-99	6-60 to 8-79; 10-92 to 2-99	6-60 to 8-79; 10-92 to 2-99	6-60 to 8-79; 10-92 to 2-99
	Devils Lake (West Bay)									
Sheyenne 1	Highway 30									
Sheyenne 1	Warwick	10-71 to 10-99								
Sheyenne 1	Cooperstown	10-71 to 10-99	10-59 to 7-99	10-59 to 7-99	10-59 to 7-99	10-59 to 7-99	10-59 to 7-99	10-59 to 7-99	10-59 to 7-99	10-59 to 7-99
Sheyenne 2	Lake Ashtabula									
Sheyenne 3	Baldhill Dam	10-71 to 10-99								
Sheyenne 3	Lisbon	10-71 to 10-99								
Sheyenne 5	Kindred	10-71 to 10-99	5-72 to 9-99	5-72 to 9-99	5-72 to 9-99	5-72 to 9-99	5-72 to 9-99	5-72 to 9-99	5-72 to 9-99	5-72 to 9-99
Sheyenne 5	Horace	10-93 to 10-99								
Sheyenne 5	West Fargo	10-71 to 10-99								
Red 1	Fargo (at)		8-11-56 to 7-13-99	8-11-56 to 7-13-99	8-11-56 to 7-13-99	8-11-56 to 7-13-99	8-11-56 to 7-13-99	8-11-56 to 7-13-99	8-11-56 to 7-13-99	8-11-56 to 7-13-99
Red 1	Fargo (Dn of Fargo)	10-71 to 10-99	7-73 to 9-86	7-73 to 9-86	7-73 to 9-86	7-73 to 9-86	7-73 to 9-86	7-73 to 9-86	7-73 to 9-86	7-73 to 9-86
Red 1	Halstad									
Red 2	Grand Forks	10-71 to 10-99	10-71 to 10-99	10-71 to 10-99	10-71 to 10-99	10-71 to 10-99	10-71 to 10-99	10-71 to 10-99	6-49; 10-60 to 8-99	6-49; 10-60 to 8-99
Red 3	Drayton	10-71 to 10-99								
Red 3	Emerson	7-77 to 2-99	7-77 to 2-99	7-77 to 2-99	7-77 to 2-99	7-77 to 2-99	7-77 to 2-99	7-77 to 2-99	7-77 to 2-99	7-77 to 2-99

[1]Historical data from USGS gage stations provided by USACE in database format.

TABLE 3-3

BACKGROUND WATER QUALITY[1] (MEAN) IN DEVILS LAKE, SHEYENNE RIVER, AND RED RIVER[2]
Final Aquatic Impact Analysis Report

	USGS Station	TDS	CALCIUM	MAGNESIUM	SODIUM	POTASSIUM	CHLORIDE	SULFATE	CARBONATES
Devils Lake	Channel A	639.6	66.6	36.9	74.8	18.1	23.2	256.9	163.1
	Big Coulee	620.4	69.9	38.1	64.0	19.9	27.0	209.4	--
	Main Bay	5314.3	73.6	242.2	1203.8	140.3	565.9	2628.7	459.7
	East Bay	6138.9	78.4	284.9	1420.3	165.8	675.2	3079.3	447.1
Sheyenne River	Cooperstown	567.1	66.6	30.9	80.5	8.8	16.1	139.2	225.1
	Kindred	533.5	72.5	29.0	64.1	8.9	28.9	153.2	177.0
Red River	Fargo	325.6	46.4	31.1	15.6	5.8	8.4	70.7	148.7
	Dn of Fargo	371.6	50.5	33.8	23.3	7.0	14.8	84.8	157.4
	Grand Forks	332.1	54.6	25.0	16.8	5.3	10.0	70.0	152.6
	Emerson	459.8	63.5	30.2	46.3	6.8	54.5	94.1	164.4

[1]Water quality recorded as mg/l.

[2]See Table 3-2 for time period of data summarized; historical data from USGS gage stations provided by USACE in database format

TABLE 3-4

SUMMARY STATISTICS FOR TDS, SULFATE, AND CHLORIDE IN THE SHEYENNE AND RED RIVERS[1]
Final Aquatic Impact Analysis Report

	Summary statistics	Sheyenne River		Red River			
		Reach 1	Reach 5	Reach 1		Reach 2	Reach 3
		Cooperstown	Kindred	Fargo	Dn of Fargo	Grand Forks	Emerson
TDS (mg/l)	Min	143	200	134	183	158	251
	Max	1070	812	544	769	570	1100
	Ave	567.0	533.5	326.0	372.0	332.0	460.0
	Guideline[2]	500	500	500	500	500	500
	%>Guideline	74.8	68.2	1.4	7.9	4.5	26.0
Sulfate (mg/l)	Min	21	56	21	19	18	6
	Max	360	290	200	330	200	230
	Ave	139.0	153.2	71.0	85.0	70.0	94.0
	ND Standard	450	450	--	--	--	--
	%>Std	0	0	--	--	--	--
	MN Standard	250	250	250	250	250	250
	%>Std	1.2	1.5	0.0	0.9	0.0	0.0
Chloride (mg/l)	Min	0.1	6.0	0.4	4.0	2.0	10.0
	Max	39	74	39	65	34	240
	Ave	16.1	28.9	8.4	14.8	10.0	55.0
	Standard[3]	100	100	100	100	100	100
	%>Std	0.0	0.0	0.0	0.0	0.0	15.0

[1] See Table 3-2 for time period of data summarized; historical data from USGS gage stations provided by USACE in database format

[2] TDS level used is a USEPA guideline (Stoner *et al* . 1998)

[3] ND Sheyenne River standard is 175mg/l (Table 3-1), however >100mg/l is though to be restrictive to unionids (Cvancara, 1967) and was used for analysis

TABLE 3-5

SUMMARY HYDROLOGICAL STATISTICS FOR THE SHEYENNE AND RED RIVERS, 1971-1999
Final Aquatic Impact Analysis Report

	Sheyenne River					Red River		
	Reach 1 Warwick	Reach 1 Cooperstown	Reach 3 Baldhill Dam	Reach 3 Lisbon	Reach 5 Kindred	Reach 1 Halstad	Reach 2 Grand Forks	Reach 3 Emerson
Indicators of Hydrologic Alteration[1]								
Mean monthly flow (cfs)								
October	16.4	47.0	72.6	83.5	113.0	925.5	2130.6	2219.2
November	15.9	41.0	92.4	103.5	132.0	820.4	1766.5	1877.7
December	10.5	25.8	79.4	89.9	109.8	643.9	1475.4	1558.7
January	7.2	16.8	72.6	81.5	95.1	526.6	1218.4	1251.4
February	15.5	20.9	90.8	101.5	111.7	587.9	1277.6	1231.6
March	187.4	250.6	305.6	423.3	451.8	2874.7	4595.1	4504.7
April	382.3	742.3	784.9	943.7	1030.3	7955.2	14170.0	16966.8
May	136.7	286.7	350.1	469.3	621.4	4024.2	7428.4	9809.2
June	55.7	136.7	158.1	205.6	290.6	2478.1	4435.6	4961.7
July	52.6	124.1	157.4	201.3	277.8	3045.2	5159.8	5693.6
August	38.9	85.4	119.8	141.5	185.4	1267.0	2606.5	3015.8
September	16.6	48.7	77.9	86.8	121.9	961.3	2259.1	2454.3
Mean flow (cfs) of annual extremes								
1-day minimum	2.3	6.8	10.0	13.9	36.3	267.3	767.8	789.7
3-day minimum	2.5	7.3	12.4	15.3	38.4	277.1	805.4	805.7
7-day minimum	2.8	7.9	13.6	18.6	42.6	295.2	833.1	847.4
30-day minimum	3.9	10.5	17.9	26.6	53.8	365.7	950.1	959.2
90-day minimum	5.7	15.3	33.4	40.8	68.9	446.0	1068.0	1105.5
1-day maximum	1354.1	1898.4	1704.6	2083.1	1997.9	17088.3	30245.2	33288.6
3-day maximum	1286.2	1784.1	1659.6	1989.3	1946.9	16771.8	29439.2	32944.1
7-day maximum	1129.7	1599.1	1564.5	1804.5	1835.0	15887.8	27806.7	31495.9
30-day maximum	549.3	970.1	1063.4	1276.9	1375.2	10355.6	17656.8	21414.7
90-day maximum	256.8	474.7	546.1	686.8	790.8	5736.3	9947.2	11844.0
Number of zero days	0.1	0.4	0.0	0.0	0.0	0.0	0.0	0.0
Base flow	0.0	0.0	0.1	0.1	0.2	0.1	0.2	0.2
Mean date of annual extremes								
Date of minimum	220.0	214.9	234.8	254.8	247.9	221.0	242.7	245.3
Month	August	August	August	September	September	August	August	September
Date of maximum	102.6	103.2	117.7	110.5	111.0	116.4	115.1	115.8
Month	April	April	April	April	April	April	April	April
Mean duration (days) and frequency (count) of annual extremes								
Low pulse count	3.9	3.3	3.6	6.0	4.4	3.0	2.7	2.7
Low pulse duration	15.1	16.0	27.5	12.4	19.1	15.9	13.9	13.7
High pulse count	1.4	1.4	1.7	1.7	1.7	1.6	1.6	1.4
High pulse duration	12.6	14.5	10.4	11.5	13.2	11.8	13.9	19.3
Mean rise and fall rate (cfs)								
Rise rate	22.3	31.9	32.0	38.0	35.2	256.9	444.0	498.7
Fall rate	-12.9	-16.1	-27.9	-28.9	-24.8	-147.7	-277.4	-291.7
Number of reversals	70.7	63.2	80.4	87.0	72.3	57.0	63.3	45.6
Channel forming flows[2]								
1.5 yr flood level	520	760	880	980	920	--	--	--
2 yr flood level	890	1240	1360	1490	1370	--	--	--
Flow Duration (cfs)[3]								
90% exceedence	1.5	4	10	15	35	--	--	--
75% exceedence	3.5	10	15	25	50	--	--	--
50% exceedence	10	30	50	60	95	--	--	--
25% exceedence	35	80	150	175	200	--	--	--
10% exceedence	125	275	300	450	550	--	--	--
5% exceedence	250	500	600	850	1000	--	--	--
1% exceedence	1000	1750	2000	3000	3000	--	--	--

[1]Calculated using the IHA model

[2]From WEST 2001

[3]Estimated from historical duration flow (Appendix D) of West 2001

TABLE 3-6

SUMMARY OF HYDROLOGICAL VARIATION FOR THE SHEYENNE AND RED RIVERS, 1971-1999
Final Aquatic Impact Analysis Report

	Sheyenne River					Red River		
	Reach 1 Warwick	Reach 1 Cooperstown	Reach 3 Baldhill Dam	Reach 3 Lisbon	Reach 5 Kindred	Reach 1 Halstad	Reach 2 Grand Forks	Reach 3 Emerson
Indicators of Hydrologic Alteration[1]								
Coefficient of variation of monthly flow								
October	105.7	152.7	158.1	154.1	107.9	78.9	65.8	66.1
November	87.5	111.3	81.7	93.4	88.6	61.3	64.7	66.1
December	85.8	88.7	77.1	80.6	74.4	62.0	60.7	63.8
January	80.4	81.7	68.9	67.7	61.1	59.8	50.6	52.5
February	193.5	116.1	81.6	84.9	65.9	68.3	55.2	50.1
March	109.4	127.2	123.6	94.4	83.8	86.0	86.3	91.5
April	106.8	93.0	110.3	104.7	93.9	97.3	85.7	75.3
May	111.6	105.8	123.7	132.0	120.9	91.1	90.5	104.5
June	94.4	86.2	102.2	90.5	79.6	65.9	67.7	69.1
July	134.1	114.8	162.2	148.1	127.4	135.5	106.8	106.8
August	215.5	226.4	240.7	252.8	219.1	165.8	120.4	131.0
September	147.5	156.4	160.0	148.7	112.8	105.6	96.8	98.9
Coefficient of variation of annual extremes								
1-day minimum	119.9	119.7	96.1	155.4	79.5	86.2	66.6	65.5
3-day minimum	117.0	119.2	98.8	145.9	77.6	86.8	65.1	65.1
7-day minimum	108.7	114.7	107.1	141.2	78.1	84.1	64.5	64.3
30-day minimum	88.8	109.7	107.6	106.1	78.8	74.6	61.5	61.2
90-day minimum	84.6	86.4	92.0	86.2	69.0	67.5	62.1	63.7
1-day maximum	75.2	85.8	86.3	76.9	75.2	85.1	85.9	78.6
3-day maximum	74.7	82.2	87.6	80.1	77.3	85.7	83.0	78.8
7-day maximum	74.1	80.0	90.8	83.0	80.3	85.8	84.5	78.2
30-day maximum	76.5	79.4	98.2	92.9	87.4	85.9	79.1	74.7
90-day maximum	75.0	74.7	91.5	89.1	82.9	75.2	70.4	69.9
Number of zero days	550.0	426.7	--	--	--	--	--	--
Coefficient of variation on date of annual extremes								
Date of minimum	21.7	28.9	21.4	15.0	23.3	29.7	28.2	29.8
Date of maximum	9.4	7.9	15.5	9.9	10.2	10.5	9.9	9.1
Coefficient of variation on mean duration (days) and frequency (count) of annual extremes								
Low pulse count	69.0	73.1	68.2	70.2	92.9	76.8	88.5	98.9
Low pulse duration	92.0	79.5	213.4	68.7	107.4	89.1	132.2	122.3
High pulse count	71.6	81.6	97.0	77.5	89.0	92.6	79.9	76.6
High pulse duration	80.7	86.2	97.4	86.9	92.5	87.7	80.8	82.8
Coefficient of variation on rise and fall rate								
Rise rate	74.7	77.5	70.9	65.0	64.6	67.9	63.2	61.8
Fall rate	72.7	73.3	66.8	65.0	64.3	67.3	62.4	65.1
Number of reversals	26.7	21.5	29.1	15.3	22.6	20.5	24.9	30.8

[1]Calculated using the IHA model (CV=standard deviation *100/mean)

TABLE 3-7

HISTORICAL TRENDS IN SHEYENNE RIVER GEOMORPHOLOGY[1]
Final Aquatic Impact Analysis Report

Sheyenne River	USGS station	Erosion reach	Regime channel (cfs)		Top width (ft)		Stability	Predicted trend	Depth (ft)		Stability	Energy slope		Stability	Regime channel conditions[2]		
			1.5 yr flood	2 yr flood	1940	1998			1940	1998		1940	1998		Channel width	Meander length	Meander amplitude
Reach 1		K			87	87	stable	stable	5.2	5.2	stable	0.00005	0.00005	stable	90	1023	380
		J			160-190	155-215	variable to stable	stable	3.1	2.9-3.1	stable	0.0001-0.00012	0.0001-0.00012	stable	174	1993	786
	Warwick	I	520	890	60	70	stable	stable	4.2	3.8	?	0.00045	0.00045	stable	70	796	289
		H			90-100	85-85	narrowing	continued narrowing	4.5-4.7	4.3-4.7	stable	0.00018-0.0004	0.00018-0.0004	stable	94-135	1068-1541	398-594
		G															
	Cooperstown	F	760	1240	90	90	stable	stable	6.8	6.8	stable	0.00013	0.00013	stable	107	1223	461
Reach 2																	
Reach 3	Valley City	E	880	1360	105-195	90-110	stable to narrowing	stable to continued narrowing	7.8	5.9-8.9	deepen?	0.00014-0.00029	0.00014-0.00029	stable	101	1153	433
	Lisbon	D	980	1490	90-150	75-105	stable to narrowing	stable to continued narrowing	5.3-6.5	6.5-8.5	deepen?	0.00013-0.00029	0.00013-0.00029	stable	97	1106	414
Reach 4		C			80-95	85-165	widening	continue to widen	6.3-7.3	5.6-7.1	shallow?	0.00025-0.00029	0.00025-0.00029	stable	139	1587	613
Reach 5	Kindred	B	920	1370	60-70	75-80	widening	continue to widen	7.5-8.1	6.9-7.0	shallow?	0.00021-0.00023	0.00021-0.00023	stable	109	1246	471
	West Fargo	A	910	1350	75	90	widening	continue to widen	7.3	6.8	shallow?	0.00022	0.00022	stable	122	1396	533

[1]WEST 2001

[2]Conditions toward which the river is changing

TABLE 3-8

CONCENTRATIONS OF MERCURY CONSTITUENTS IN LAKE ASHTABULA
Final Aquatic Impact Analysis Report

Site Name	Date	Time	DOC, in mg/L		TOC, in mg/L		FMHg, in ng/L		FTHg, in ng/L		PTHg, in ng/L		UTHg, in ng/L	
			surface[1]	bottom[2]	surface[1]	bottom[2]	surface[1]	bottom[2]	surface[1]	bottom[2]	surface[1]	bottom[2]	surface[1]	bottom[2]
Lake Ashtabula nr Face of Baldhill Dam	03/13/01	11:20	17.971	18.072	17.836	18.859	LTD	0.218	0.631	0.876	LTD	LTD	0.631	0.876
	08/07/01	12:40	14.36	14.15	14.88	14.03	NYA	NYA	0.644	0.681	NYA	NYA	--	--
Lake Astabula nr North End	03/13/01	14:50	8.732	ND	8.49	ND	0.058	ND	0.532	ND	0.545	ND	1.077	ND
	08/07/01	11:05	18.56	ND	18.08	ND	NYA	ND	2.066	ND	NYA	ND	--	ND

[1]sample collected about 1 meter below water surface (USGS 2001)
[2]sample collected about 1 meter above lake bottom (USGS 2001)
DOC = dissolved organic carbon
TOC = total organic carbon
FMHg = filtered methylmercury
FTHg = filtered total mercury
PTHg = particulate total mercury
UTHg = unfiltered total mercury
LTD = less than detection level
ND = not determined
NYA = not yet analyzed

TABLE 3-9

CONCENTRATIONS AND LOADS OF MERCURY CONSTITUENTS IN THE SHEYENNE AND RED RIVER[1]
Final Aquatic Impact Analysis Report

Station Identification	Station Name	Date	Time	Discharge, in cfs	DOC, in mg/l	TOC, in mg/l	FMHg, in ng/l	FMHg load, in gm/d	FTHg in ng/l	FTHg load, in gm/d	PTHg in ng/l	UTHg in ng/l	UTHg load in ng/l
05056000 Reach 1	Sheyenne River near Warwick, ND	04/30/01	14:00	460	14.148	13.105	0.189	0.213	1.310	1.475	1.112	2.422	2.726
		07/24/01	10:20	380	21.289	20.943	NYA	--	2.322	2.158	NYA	--	--
05058000 Reach 3	Sheyenne River below Baldhill Dam, ND	05/01/01	8:30	720	11.154	10.802	0.088	0.155	1.589	2.799	0.973	2.562	4.513
		07/24/01	12:40	370	13.833	13.565	NYA	--	0.964	0.873	NYA	--	--
05059500 Reach 5	Sheyenne River at West Fargo, ND	05/01/01	10:30	1,650	8.693	8.783	0.078	0.315	1.596	6.441	16.249	17.844	72.029
		07/25/01	8:30	290	9.418	9.653	NYA	--	NYA	--	NYA	--	--
05054000 Reach 1	Red River of the North at Fargo, ND	05/01/01	12:00	7,700	7.949	7.593	0.059	1.111	1.394	26.251	6.415	7.808	147.089
		07/25/01	9:50	2,880	9.123	9.269	NYA	--	NYA	--	NYA	--	--
05064500 Reach 1	Red River of the North at Halstad, MN	05/01/01	13:45	23,500	8.441	8.096	0.077	4.427	1.543	88.722	11.494	13.037	749.524
		07/25/01	11:30	5,050	8.229	7.925	NYA	--	NYA	--	NYA	--	--
05082500 Reach 2	Red River of the North at Grand Forks, ND	05/01/01	15:15	26,400	11.553	11.19	0.114	7.363	1.316	84.990	4.415	5.731	370.129
		07/25/01	13:30	6,350	15.553	15.834	NYA	--	NYA	--	NYA	--	--
05102500 Reach 3	Red River of the North at Emerson, Man.	05/02/01	7:30	40,000	8.534	8.369	0.060	5.871	1.908	186.739	7.489	9.398	919.626
		07/26/01	7:15	6,100	9.437	9.415	NYA	--	NYA	--	NYA	--	--

[1]Data from USGS 2001
DOC = dissolved organic carbon
TOC = total organic carbon
FMHg = filtered methylmercury
FTHg = filtered total mercury
PTHg = particulate total mercury
UTHg = unfiltered total mercury

TABLE 3-10

BACKGROUND CONCENTRATIONS OF MERCURY IN FISH
RED RIVER OF THE NORTH BASIN
Final Aquatic Impact Analysis Report

Fish Species	Tissue	Upstream[1] (ppm fresh weight)			Downstream[1] (ppm fresh weight)		
		1984	1990	2000[2]	1984	1990	2000[2]
Carp	Whole fish	---	---	---	0.11[3]	---	---
	Fillet	---	---	0.36	---	---	---
	Plug	---	---	0.52	---	---	0.1 – 0.58
Sauger	Whole fish	---	---	---	0.26[3]	---	---
	Fillet	---	---	---	0.35[4]	---	---
Catfish	Fillet	---	0.32 – 1.3[5]	0.12 – 0.54	0.32[4]	---	---
	Plug	---	---	0.12 – 1.1	---	---	0.15 – 1.1
Walleye	Fillet	---	---	0.21	0.91[4]	---	0.52 – 1.8
	Plug	---	---	---	---	---	0.4 – 2.1
Crappie spp.	Plug	---	---	---	---	---	0.07 – 0.33
Northern Pike	Plug	---	---	0.13	---	---	0.25 – 1.3
	Fillet	---	---	0.12	---	---	0.52 – 1.0

NOTES:
--- = Not analyzed.
1 Upstream is Fargo/Moorhead and south; downstream is north of Fargo/Moorhead.
2 USGS 2001.
3 USFWS National Contaminant Biomonitoring Program; Schmitt and Brumbaugh (1990). Results of analysis on composite sample of three to five fish.
4 USEPA 1992.
5 MNDNR 1994.

TABLE 3-11

FISH SPECIES HISTORICALLY RECORDED IN THE SHEYENNE AND RED RIVERS
Final Aquatic Impact Analysis Report

Fish species	Common name	Status in ND[1]	Sheyenne River					Red River		
			Drift Plains	Lake Ashtablula	Drift Plains	Sand Delta	Lake Agassiz			
			Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	Reach 1	Reach 2	Reach 3
Petromyzontidae										
Ichthyomyzon castaneus	Chestnut lamprey	P/SC1			x			x	x	
Ichthyomyzon unicuspis	Silver lamprey	P/SC2						x		
Hiodontidae										
Hiodon alosoides	Goldeye				x		x	x	x	x
Hiodon tergisus	Mooneye					x		x	x	x
Salmonidae										
Onchorynchus mykiss	Rainbow trout	I	x							
Osmeridae										
Osmerus mordax	Rainbow smelt	I						?[2]	?	?
Esocidae										
Esox lucius	Northern pike		x	x	x	x	x	x	x	x
E.lucius x E.masquinongy	Tiger muskie	H/I								
Esox masquinongy	Muskellunge	I								
Cyprinidae										
Cyprinus carpio	Common carp	I			x	x	x	x	x	x
Cyprinella spiloptera	Spotfin shiner				x	x	x	x	x	x
Hybognathus hankinsoni	Brassy minnow				x	x	x			
Luxilus cornutus	Common shiner		x	x	x	x	x	x	x	x
Macrhybopsis storeriana	Silver chub	SC2					x	x	x	x
Nocomis biguttatus	Hornyhead chub	P/SC1			x					
Notemigonus chrysoleucas	Golden shiner		x		x	x		?	?	?
Notropis anogenus	Pugnose shiner	T			x					
Notropis atherinoides	Emerald shiner					x	x	x	x	x
Notropis blennius	River shiner		x		x	x		x	x	x
Notropis dorsalis	Bigmouth shiner			x	x	x	x	x	x	x
Notropis heterodon	Blackchin shiner					x				
Notropis heterolepis	Blacknose shiner	P/SC1			x	x				
Notropis hudsonius	Spottail shiner		x	x	x	x	x	x	x	x
Notropis rubellus	Rosyface shiner	P/SC1			x	x		x	x	
Notropis stramineus	Sand shiner		x		x	x	x	x	x	x
Notropis volucellus	Mimic shiner							x		
Phoxinus eos	Northern redbelly dace	SC1				x				
Pimephales notatus	Bluntnose minnow				x	x	x	?	?	?
Pimephales promelas	Fathead minnow		x	x	x	x	x	x	x	x
Platygobio gracilis	Flathead chub	SC1							x	
Rhinichthys atratulus	Blacknose dace		x	x	x	x				
Rhinichthys cataractae	Longnose dace		x	x	x	x		x	x	x
Semotilus atromaculatus	Creek chub		x	x	x	x		x	x	x
Catastomidae										
Carpiodes cyprinus	Quillback					x	x	x	x	x
Catostomus commersoni	White sucker		x	x	x	x	x	x	x	x
Ictiobus cyprinellus	Bigmouth buffalo						x		x	x
Moxostoma anisurum	Silver redhorse	P			x	x	x	x	x	x
Moxostoma erythrurum	Golden redhorse				x	x	x	x	x	x
Moxostoma macrolepidotum	Shorthead redhorse				x	x	x	x	x	x
Moxostoma valenciennesi	Greater redhorse	P			x	x		?	?	?
Ictaluridae										
Ameiurus melas	Black bullhead		x	x	x	x	x	x	x	x
Ameiurus nebulosus	Brown bullhead		x	x	x					x
Ictalurus punctatus	Channel catfish				x	x	x	x	x	x
Noturus flavus	Stonecat				x	x	x	x	x	x
Noturus gyrinus	Tadpole madtom		x	x	x	x	x	x	x	x

[1]P=peripheral, H=hybrid, I=introduced, T=threatened, SC-species whose status is questionable due to: SC1 suspected problems with abundance or distribution, or SC2 limited or inconclusive historical citations (NDFG 1994)

[2]Question marks indicate that the species was found in the river but specific site information was unknown.

TABLE 3-11 (Cont.)

FISH SPECIES HISTORICALLY RECORDED IN THE SHEYENNE AND RED RIVERS
Final Aquatic Impact Analysis Report

Fish species	Common name	Status in ND[2]	Sheyenne River					Red River		
			Drift Plains	Lake Ashtablula	Drift Plains	Sand Delta	Lake Agassiz			
			Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	Reach 1	Reach 2	Reach 3
Percopsidae										
Percopsis omiscomaycus	Trout perch	SC2	x	x	x	x	x	x	x	x
Gadidae										
Lota lota	Burbot							x	x	x
Cyprinodontidae										
Fundulus diaphanus	Banded killifish	P			x					
Gasterosteidae										
Culaea inconstans	Brook stickleback		x		x	x		x	x	x
Percichthyidae										
Morone chrysops	White bass	I	x	x	x			x		
Morone saxatilis	Striped bass	I								
Centrarchidae										
Ambloplites rupestris	Rock bass				x	x	x	x	x	x
Lepomis cyanellus	Green sunfish		x	x	x		x	?	?	?
Lepomis gibbosus	Pumpkinseed		x	x	x	x		?	?	?
Lepomis humilis	Orangespotted sunfish		x	x	x			?	?	?
Lepomis macrochirus	Bluegill		x	x	x			?	?	?
Micropteris dolomieui	Smallmouth bass	I	x	x	x					
Micropteris salmoides	Largemouth bass	I	x	x	x			?	?	?
Pomoxis annularis	White crappie		x	x	x		x			x
Pomoxis nigromaculatus	Black crappie		x	x	x		x	x	x	x
Percidae										
Etheostoma exile	Iowa darter		x	x	x	x		?[1]	?	?
Etheostoma nigrum	Johnny darter		x	x	x	x	x			x
Perca flavescens	Yellow perch		x	x	x	x			x	x
Percina caprodes	Logperch	P/SC2							x	x
Percina maculata	Blackside darter		x	x	x				x	x
Percina shumardi	River darter	SC2			x				x	x
Stizostedion canadense	Sauger						x	x	x	x
Stizostedion vitreum	Walleye		x	x	x	x	x	x	x	x
Sciaenidae										
Aplodinotus grunniens	Freshwater drum				x		x	x	x	x

[1]P=peripheral, H=hybrid, I=introduced, T=threatened, SC-species whose status is questionable due to: SC1 suspected problems with abundance or distribution, or SC2 limited or inconclusive historical citations (NDFG 1994)

[2]Question marks indicate that the species was found in the river but specific site information was unknown.

TABLE 3-12

TOLERANCE RATINGS[1] OF COMMON SHEYENNE AND RED RIVER FISHES
Final Aquatic Impact Analysis Report

Tolerant[2]	Intolerant[3]
Blacknose dace	Pugnose shiner
Bluntnose minnow	Blackchin shiner
Common carp	Blacknose shiner
Creek chub	Spottail shiner
Fathead minnow	Rosyface shiner
Golden shiner	Greater redhorse
Bigmouth buffalo	Rock bass
Quillback	Smallmouth bass
White sucker	Iowa darter
Black bullhead	
Channel catfish	
Green sunfish	
Freshwater drum	

[1]Tolerance to general habitat disturbance and organic pollution.
[2]Goldstein *et al*. 1996
[3]Lyons 1992

TABLE 3-13

FISH SPECIES HISTORICALLY RECORDED IN TRIBUTARIES TO THE SHEYENNE AND RED RIVERS[1]

Final Aquatic Impact Analysis Report

Fish species	Common name	Status in ND (NDFG 1994)	Sheyenne River Reach 5		up of Red River of the North Reach 1			Red River of the North Reach 1		Red River of the North Reach 2			Red River of the North Reach 3						
			Rush River, ND	Maple River, ND	Bois de Sioux, MN/ND	Wild Rice River, ND	Otter Tail River, MN	Buffalo River, MN	Elm River, ND	Goose River, ND	Sand Hill River, MN	Red Lake River, MN	Turtle River, ND	Forest River, ND	Snake River, MN	Park River, ND	Two Rivers, MN	Tongue River, ND	Pembina River, ND
Petromyzontidae																			
Ichthyomyzon castaneus	Chestnut lamprey	P/SC1				X				X		X							
Ichthyomyzon unicuspis	Silver lamprey	P/SC2										X							
Hiodontidae																			
Hiodon alosoides	Goldeye								X				X						
Hiodon tergisus	Mooneye											X							X
Osmeridae																			
Osmerus mordax	Rainbow smelt	I																	
Umbridae																			
Umbra limi	Central mudminnow	I				X					X	X			X				
Esocidae																			
Esox lucius	Northern pike		X	X		X	X	X	X	X		X	X	X		X		X	X
E.lucius X E.masquinongy	Tiger muskie	H/I																	
Esox masquinongy	Muskellunge	I																	
Cyprinidae																			
Campostoma oligolepis	Largescale stoneroller	P												X					
Cyprinus carpio	Common carp	I	X	X	X	X		X	X	X		X	X	X		X		X	X
Cyprinella spiloptera	Spotfin shiner		X		X			X		X									
Hybognathus hankinsoni	Brassy minnow			X															X
Luxilus cornutus	Common shiner		X	X		X	X	X		X	X	X	X	X		X	X	X	X
Macrhybopsis storeriana	Silver chub	SC2										X	X						X
Nocomis biguttatus	Hornyhead chub	P/SC1				X	X	X				X		X					
Notemigonus chrysoleucas	Golden shiner											X							
Notropis atherinoides	Emerald shiner		X		X							X							X
Notropis blennius	River shiner													X		X			X
Notropis dorsalis	Bigmouth shiner		X	X		X		X		X	X	X	X	X		X			X
Notropis heterodon	Blackchin shiner						X					X							
Notropis heterolepis	Blacknose shiner	P/SC1										X							
Notropis hudsonius	Spottail shiner						X					X				X			
Notropis rubellus	Rosyface shiner	P/SC1						X				X							
Notropis stramineus	Sand shiner			X	X	X		X		X		X	X	X					X
Phoxinus eos	Northern redbelly dace	SC1				X				X	X	X				X		X	X
Pimephales notatus	Bluntnose minnow		X	X						X		X		X		X			
Pimephales promelas	Fathead minnow		X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X
Platygobio gracilis	Flathead chub	SC1																	
Rhinichthys atratulus	Blacknose dace			X		X	X			X	X	X	X	X		X	X	X	X
Rhinichthys cataractae	Longnose dace			X		X		X			X	X	X	X		X		X	X
Semotilus atromaculatus	Creek chub			X		X		X	X	X	X	X	X	X	X	X	X	X	X

[1]Peterka and Koel 1996

TABLE 3-13 (Cont.)

FISH SPECIES HISTORICALLY RECORDED IN TRIBUTARIES TO THE SHEYENNE AND RED RIVERS[1]

Final Aquatic Impact Analysis Report

Fish species	Common name	Status in ND (NDFG 1994)	Sheyenne River Reach 5		up of Red River of the North Reach 1			Red River of the North Reach 1		Red River of the North Reach 2			Red River of the North Reach 3						
			Rush River, ND	Maple River, ND	Bois de Sioux, MN/ND	Wild Rice River, ND	Otter Tail River, MN	Buffalo River, MN	Elm River, ND	Goose River, ND	Sand Hill River, MN	Red Lake River, MN	Turtle River, ND	Forest River, ND	Snake River, MN	Park River, ND	Two Rivers, MN	Tongue River, ND	Pembina River, ND
Catastomidae																			
Carpiodes cyprinus	Quillback			X						X		X		X		X			X
Catostomus commersoni	White sucker		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Ictiobus cyprinellus	Bigmouth buffalo			X		X						X		X		X			X
Moxostoma anisurum	Silver redhorse	P			X			X		X		X							
Moxostoma erythrurum	Golden redhorse					X		X				X							
Moxostoma macrolepidotum	Shorthead redhorse					X	X	X	X	X		X				X	X		X
Moxostoma valenciennesi	Greater redhorse	P		X															
Ictaluridae																			
Ameiurus melas	Black bullhead		X	X	X	X	X	X	X	X		X	X	X		X		X	X
Ameiurus natalis	Yellow bullhead	P/SC2					X												
Ameiurus nebulosa	Brown bullhead			X					X	X		X	X	X		X			X
Ictalurus punctatus	Channel catfish		X	X						X		X	X	X		X			X
Noturus flavus	Stonecat							X	X			X							X
Noturus gyrinus	Tadpole madtom			X		X				X		X	X	X					X
Percopsidae																			
Percopsis omiscomaycus	Trout-perch	SC2				X				X		X		X		X		X	X
Gadidae																			
Lota lota	Burbot											X							
Gasterosteidae																			
Culaea inconstans	Brook stickleback			X		X			X	X	X	X	X	X	X	X		X	X
Percichthyidae																			
Morone chrysops	White bass	I																	
Morone saxatilis	Striped bass	I																	
Centrarchidae																			
Ambloplites rupestris	Rock bass			X		X		X				X	X	X			X		X
Lepomis cyanellus	Green sunfish			X															
Lepomis gibbosus	Pumpkinseed					X			X			X				X			
Lepomis humilis	Orangespotted sunfish																		
Lepomis macrochirus	Bluegill											X							
Micropteris dolomieui	Smallmouth bass	I										X							
Micropteris salmoides	Largemouth bass	I					X									X			
Pomoxis annularis	White crappie			X												X			
Pomoxis nigromaculatus	Black crappie			X	X	X	X		X	X		X		X		X		X	X
Percidae																			
Etheostoma exile	Iowa darter			X	X	X					X	X				X			
Etheostoma nigrum	Johnny darter			X	X	X	X	X	X	X		X	X	X	X	X	X	X	X
Perca flavescens	Yellow perch				X	X	X		X	X		X	X	X		X			X
Percina caprodes	Logperch	P/SC2								X									
Percina maculata	Blackside darter			X	X	X	X	X		X	X	X	X	X	X	X	X	X	X
Stizostedion canadense	Sauger		X							X		X	X	X		X			X
Stizostedion vitreum	Walleye		X			X			X	X		X	X	X		X			X
Sciaenidae																			
Aplodinotus grunniens	Freshwater drum		X	X	X	X			X	X		X	X	X					

[1]Peterka and Koel 1996

TABLE 3-14

FRESHWATER MOLLUSKS REPORTED FROM THE SHEYENNE AND RED RIVERS
Final Aquatic Impact Analysis Report

Species	Common name	Tolerance[1]	Feeding group[1]	General habitat[2]					Sheyenne River					Red River		
				1	2	3	4	5	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	Reach 1	Reach 2	Reach 3
UNIONIDAE		8	filterer/collector													
Ambleminae																
Amblema plicata	Three ridge							x	x	x	x	x	x	x	x	x
Fusconia flava	Wabash pigtoe							x	R	H	x	x	x	x	x	x
Quadrula quadrula	Maple leaf							x			?	?	H?	x	x	x
Anodontinae																
Anodontoides ferussacianus	Cylindrical papershell					x	x	x	R		x	x	x	x	x	x
Lasmigona complanata	White heel splitter					x	x	x	x	x	x	x	x	x	x	x
Lasmigona compressa	Creek heel splitter						x	x	R		x	x	?			
Pyganodon grandis	Floater	8	filterer/collector			x	x	x	R	x	R (juv)	x	x	x	x	x
Strophitus undulatus	Creeper						x	x	x	H	x	x	x	x		
Lampsilinae																
Lampsilis cardium	Pocketbook						x	x	H		x	x	x	x	x	x
Lampsilis siliquoidea	Fat mucket						x	x	R	x	x	x	x	x	x	x
Ligumia recta	Black sandshell							x		H	x	x	x	x	x	x
Potamilus alata	Pink heelsplitter							x			x	x	x	x	x	H
Potamilus ohiensis	Pink papershell						x?							x		
SPHAERIIDAE		8	filterer/collector						R							
Pisidium sp.		5-8	filterer/collector						R		R					
Pisidium casertanum		8	filterer/collector			x	x	x						H		
Pisidium compressum		8	filterer/collector	x		x	x	x	x	x	x				H	
Pisidium nitidum		4-8	filterer/collector	x		x	x		x	x	H					
Sphaerium sp.									R		R		R			
Sphaerium lacustre				x		x	x		x	x						
Sphaerium simile						x	x		x	x	H					
Sphaerium striatinum			filterer/collector			x	x	x	x		x	H	H	H	H	
Sphaerium transversum							x	x	x		x	x	x	x	x	

H=Shells only found; R=found in recent survey by Delorme and in field recon by Dunn
?=reported live by Kreil et al in lower Sheyenne, but no site specific data was available
[1] 0=intolerant of organic enrichment, habitat instability; 10=tolerant of organic enrichment, habitat instability (Barbour *et al.* 1999).
[2] Habitat 1=intermittent ponds, 2=permanent lakes, ponds, 3=intermittent streams, 4=small streams, 5=large streams (Cvancara 1983)
[3] Harman (in Hart and Fuller 1974)

TABLE 3-14 (Cont.)

FRESHWATER MOLLUSKS REPORTED FROM THE SHEYENNE AND RED RIVERS
Final Aquatic Impact Analysis Report

Species	Common name	Tolerance[1]	Feeding group[1]	General habitat[2]					Sheyenne River					Red River		
				1	2	3	4	5	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	Reach 1	Reach 2	Reach 3
GASTROPODA		7	scraper													
Prosobranchia																
Valvata tricarinata		8	scraper	x		x	x	x	R	x	x			H	H	
Campeloma decisum		6-7	scraper									H	H			
Hydrobiidae		7	scraper						R							
Probythinella lacustris							x		x		R		H	x	H	
Cincinnatia cincinnatiensis			scraper				x	x	R	x	R	H	H	x	H	
Amnicola limosa		8	scraper				x		R	x	R	H	H			
Pulmonata																
Lymnaeidae		6-7	scraper						R				R			
Fossaria sp.		2-8	scraper											?	?	?
Fossaria obrussa						x	x	x	H	H		x	x			
Pseudosuccinea columella		7.2	scraper											?	?	?
Stagnicola caperata		7-10	scraper	x	x				R			H	H			
Stagnicola elodes		7-10	scraper	x	x	x	x		R							
Physa sp.		8	scraper						R		R					
Physa gyrina		eurytopic[3]		x	x	x	x	x	R	x	x		R	x		
Physa integra		eurytopic[3]		x		x	x	x	x	x	x	x	x	x	x	
Aplexa hypnorum				x	x				H	H						
Planorbidae		7	scraper						R							
Gyraulus sp.		8	scraper										R			
Gyraulus parvus		5.5	scraper	x	x	x	x		R	x	R				H	
Armiger crista														?	?	?
Helisoma anceps		6-7	scraper	x		x	x		x	x	x	H	H			
Helisoma trivolvis		eurytopic[3]		x	x	x	x		x	x	x			x		
Planorbula armigera									H	H						
Promenetus exacuous			collector/gatherer	x	x	x			H	H						
Ferrissia sp.		5-7	scraper						R							
Ferrissia rivularis			scraper	x		x	x	x	x		x			H	x	

H=Shells only found; R=found in recent survey by Delorme and in field recon by Dunn

?=reported live by Kreil et al in lower Sheyenne, but no site specific data was available

[1] 0=intolerant of organic enrichment, habitat instability; 10=tolerant of organic enrichment, habitat instability (Barbour *et al.* 1999).

[2] Habitat 1=intermittent ponds, 2=permanent lakes, ponds, 3=intermittent streams, 4=small streams, 5=large streams (Cvancara 1983)

[3] Harman (in Hart and Fuller 1974)

TABLE 3-15

DISTRIBUTION OF MOLLUSKS IN TRIBUTARIES[1] TO THE SHEYENNE RIVER AND THE RED RIVER OF THE NORTH
Final Aquatic Impact Analysis Report

	Sheyenne River Reach 1	Sheyenne River Reach 5	Upstream of Red River Reach 1				Red River Reach 1			Red River Reach 2			Red River Reach 3								
	Sheyenne up of Hwy 30, ND	Maple River, ND	Bois de Sioux, MN/ND	Wild Rice River, ND	Otter Tail River, MN	Red River south of Fargo, MN/ND	Buffalo River, MN	Elm River, ND	Wild Rice River, MN	Goose River, ND	Sand Hill River, MN	Red Lake River, MN	Turtle River, ND	Forest River, ND	Snake River, MN	Middle River, MN	Park River, ND	Tamarac River, MN	Two Rivers, MN	Tongue River, ND	Pembina River, ND
UNIONIDAE																					
Ambleminae																					
Amblema plicata				x	x	x	x		x			x									
Fusconia flava		x			x	x	x		x		x	x	x						x		
Quadrula quadrula					x							x									
Anodontinae																					
Anodontoides ferussacianus		x			x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x
Lasmigona c. complanata		x	x	x	x		x		x	x	x	x	x	x				x	x	x	x
Lasmigona compressa					x				x		x	x	x	x					x		x
Lasmigona costata					x							x									
Pyganodon grandis	shells	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x
Strophitus undulatus					x		x		x		x	x	x	x					x		x
Lampsilinae																					
Actinonaias ligamentina					x																
Lampsilis cardium					x	x			x		x	x							x		
Lampsilis siliquoidea	x	x	x	x	x	x	x		x	x	x	x	x	x		x	x	x	x	x	x
Ligumia recta					x	x			x		x	x		x							
Potamilus alatus						x			x			x									
SPHAERIIDAE																					
Pisidium compressum									x	x			x	x						x	
Pisidium nitidum		x															x				x
Sphaerium lacustre		x		x						x				x			x			x	
Sphaerium simile		x												x						x	
Sphaerium striatinum				x						x			x	x			x				x
Sphaerium transversum		x		x						x										x	
GASTROPODA																					
Prosobranchia																					
Valvata tricarinata		x																			
Hydrobiidae																					
Probythinella lacustris				x						x				x							
Cincinnatia cincinnatiensis		x								x				x							
Amnicola integra														x							
Pulmonata																					
Lymnaeidae																					
Fossaria obrussa														x							
Stagnicola caperata						x															
Stagnicola elodes		x		x										x			x				
Stagnicola palustris														x							
Physa gyrina		x		x		x		x		x			x	x			x				
Physa integra		x		x		x							x	x						x	
Physa jennessi				x													x				
Aplexa hypnorum				x																	
Planorbidae																					
Gyraulus parvus		x		x		x								x						x	
Helisoma anceps														x							
Helisoma trivolvis				x				x						x			x				
Promenetus exacuous		x																			
Ferrissia rivularis		x		x						x			x	x			x				x

[1]Cvancara 1965, 1970, 1983; Cvancara *et al.* 1966, 1972, 1981; EarthTech, Inc and DeLorme; Hart 1995; Kreil *et al.* (unpublished manuscript)

TABLE 3-16

BENTHIC INVERTEBRATES (OTHER THAN MOLLUSKS) RECORDED FROM SHEYENNE RIVER, LAKE ASHTABULA, AND RED RIVER

Final Aquatic Impact Analysis Report

	Tolerance[1]	Habitat[2]	Feeding Guild[3]	Lake Ash[3]	Red River[3]	Sheyenne River[4]							
						Reach 1		Reach 3		Reach 4		Reach 5	
						No.	%	No.	%	No.	%	No.	%
Turbellaria					x								
Nematoda	5		parasite		x	6	0.09						
Annelida						6	0.09						
Oligochaeta					x	252	3.82	201	4.49	9	4.23	71	3.68
Naididae	7-10		collector/ gatherer			3	0.05						
Tubificidae	2-10		collector/ gatherer	x		1	0.02	1	0.02				
Branchiobdellida	6		collector/ gatherer		x	2	0.03	12	0.27				
Oligochaeta(total)						258	3.91	214	4.78	9	4.23	71	3.68
Oligochaeta(total taxa)						3		2		1		1	
Hirudinea				x	x								
Erpobdellidae	8		predator			5	0.08	2	0.04				
Erpobdella punctata						3	0.05						
Glossiphonidae	8		predator			7	0.11						
Helobdella stagnalis	6.7		predator			16	0.24						
Myzobdella sp.			predator	x									
Piscicolidae	10		predator	x									
Placobdella ornata	6		predator			2	0.03						
Hirudinea(total)						33	0.50	2	0.04	0	0.00	0	0.00
Hirudinea(total taxa)						5		1		0		0	
CRUSTACEA													
Amphipoda						1	0.02						
Hyallela azteca	8	macrophytes, debris	omnivore		x	745	11.30	69	1.54	1	0.47	12	0.62
Gammarus sp.	4		omnivore			3	0.05						
Gammarus pseudolimnaeus					x								
Decapoda					x	4	0.06	2	0.04				
Cambaridae	6		collector/ gatherer		x								
Orconectes sp.	2.7				x	18	0.27	32	0.72				
O. immunis					x								
O. rusticus					x								
O. virilis					x								
Ostracoda						11	0.17						
Crustacea(total)						782	11.86	103	2.30	1	0.47	12	0.62
Crustacea(total taxa)						4		2		1		1	
ARACHNIDA						12	0.18	3	0.07	2	0.94	3	0.16
Hydrocarina					x	23	0.35	17	0.38			2	0.10
Arachnida(total)						35	0.53	20	0.45	2	0.94	5	0.26
Arachnida(total taxa)						1		1		1		1	

[1] 0 = intolerant of organic enrichment, habitat instability; 10 = tolerant of organic enrichment, habitat instability (Barbour *et al.* 1999)

[2] Merritt and Cummins (1996); Thorp and Covich (1991), Barbour *et al.* (1999)

[3] Schmidt (1999)

[4] Earth Tech, Inc. and DeLorme

TABLE 3-16 (Cont.)

BENTHIC INVERTEBRATES (OTHER THAN MOLLUSKS) RECORDED FROM SHEYENNE RIVER, LAKE ASHTABULA, AND RED RIVER

Final Aquatic Impact Analysis Report

	Tolerance[1]	Habitat[2]	Feeding Guild[3]	Lake Ash[3]	Red River[3]	Sheyenne River[4]							
						Reach 1		Reach 3		Reach 4		Reach 5	
						No.	%	No.	%	No.	%	No.	%
INSECTA													
COLEOPTERA					x	1	0.02					3	0.16
Carabidae	4		predator			1	0.02						
Chrysomelidae			shredder		x								
Pyrrhalta sp.		on Nymphaeceae				1	0.02						
Curculionidae			shredder		x								
Stenopelmus sp.			shredder									1	0.05
Dryopidae													
Helichus lithophilus	3-5	erosional	shredder		x								
Dytiscidae	5		predator		x								
Hygrotus sp.		depositional, vascular hydrophytes	predator			1	0.02						
Laccophilus sp.	5-10	depositional	predator, piercer			2	0.03						
Liodessus sp.		erosional, depositional	predator		x	1	0.02	2	0.04			1	0.05
Nebrioporus sp.		erosional, depositional	predator		x								
Oreodytes sp.	5	erosional, depositional	predator		x								
Elmidae	4		collector/ gatherer		x								
Dubiraphia sp.	4-7	submerged macrophytes	collector/ gatherer		x	564	8.55	61	1.36			7	0.36
Dubiraphia vittata			omnivore		x								
Macronychus sp.		wood debris	collector/ gatherer, detritivore							5	2.35	7	0.36
Macronychus glabratus	2-5		omnivore		x								
Optioservus sp.	2-4	sediment, detritus	scraper, collector/ gatherer		x								
Optioservus fastiditus	2-4		scraper, collector/ gatherer		x								
Stenelmis sp.	3-7	coarse sediment, detritus	scraper, collector/ gatherer		x	9	0.14	76	1.70	1	0.47	16	0.83
Stenelmis crenata group			omnivore		x								
Gyrinidae	5		predator			1	0.02						
Gyrinus sp.	3-7		predator		x	1	0.02	1	0.02				
G. affinis					x								
G. confinis					x								
G. fraternus					x								
G. maculiventris					x								
Haliplidae	7%												
Haliplus sp.		vascular plants	piercer and shredder, herbivore			11	0.17	1	0.02				
H. immaculicollis					x								
Peltodytes sp.	5-9		shredder			8	0.12	2	0.04	1	0.47	1	0.05
P. duodecimpunctatus		vascular plants ?	piercer and shredder, herbivore, predator		x								
Helophoridae													
Helophorus sp.		erosional and margins	shredder, herbivore		x	2	0.03						
Heteroceridae								1	0.02			1	0.05
Hydraeniidae	5		predator										

[1] 0 = intolerant of organic enrichment, habitat instability; 10 = tolerant of organic enrichment, habitat instability (Barbour *et al.* 1999)

[2] Merritt and Cummins (1996); Thorp and Covich (1991), Barbour *et al.* (1999)

[3] Schmidt (1999)

[4] Earth Tech, Inc. and DeLorme

TABLE 3-16 (Cont.)

BENTHIC INVERTEBRATES (OTHER THAN MOLLUSKS) RECORDED FROM SHEYENNE RIVER, LAKE ASHTABULA, AND RED RIVER

Final Aquatic Impact Analysis Report

	Tolerance[1]	Habitat[2]	Feeding Guild[3]	Lake Ash[3]	Red River[3]	Sheyenne River[4]							
						Reach 1		Reach 3		Reach 4		Reach 5	
						No.	%	No.	%	No.	%	No.	%
Hydraena sp.	5	margins	predator		x								
Ochthebius sp.		erosional and margins				1	0.02						
Hydrochidae													
Hydrocus sp.		erosional and margins	shredder, herbivore									1	0.05
Hydrophilidae	5		predator										
Berosus sp.	5-9	depositional	piercer, herbivore, collector/ gatherer, shredder			6	0.09						
Enochrus sp.	5-9	littoral	collector/ gatherer, predator, herbivore		x			1	0.02				
Tropisternus sp.	5-10	depositional	collector/ gatherer, predator, herbivore		x								
Psephenidae	4		scraper										
Psephenus herricki	4	erosional	scraper		x								
Scirtidae													
Cyphon sp.	7	sediment, detritus	scraper					1	0.02				
Staphyliniidae	8		predator			1	0.02	1	0.02				
Stenus sp.		littoral surface			x							2	0.10
Coleoptera(total)						610	9.25	147	2.23	7	0.11	37	0.56
Coleoptera(total taxa)						14		10		3		9	
COLLEMBOLLA					x								
Isotomidae													
Folsomia sp.													
Onychiuridae		littoral fringe, intertidal?	collector/ gatherer									3	0.16
Sminthuridae					x								
Collembolla(total)						0	0.00	0	0.00	0	0.00	3	0.05
DIPTERA					x	5	0.08	8	0.18	1	0.47	6	0.31
Athericidae													
Atherix sp.	2	erosional, depositional	predator		x	1	0.02	5	0.11			6	0.31
Ceratopogonidae	6	margins, detritus	predator, collector/ gatherer		x	13	0.20	9	0.20			1	0.05
Bezzia sp.	6	lotic-hot springs?	predator, collector/ gatherer									1	0.05
Cerotopogon sp.	6		predator			1	0.02						
Probezzia sp.	6	lentic burrowers	predator			59	0.89	236	5.27				
Chaoboridae													
Chaoborus sp.		profundal, littoral	predator	x									
Chironomidae	6		collector/ gatherer		x	177	2.68	318	7.11			16	0.83
Chironominae	6		collector/ gatherer			25	0.38	19	0.42				
Chironomini	6	depositional	collector/ gatherer			1393	21.13	266	5.95	2	0.94	69	3.58
Chironomus sp.	8-10	lotic depositional	collector/ gatherer			15	0.23						
Chironomus (C.) plumosus (L.)		littoral and profundal	collector/ gatherer, shredder, herbivore	x									
Cryptochironomus sp. n.	4-8	littoral and profundal	predator	x									
Einfeldia sp. n.	8	littoral and profundal	collector/ gatherer	x									
Polypedilum sp.	6	vascular plants	shredder	x									

[1] 0 = intolerant of organic enrichment, habitat instability; 10 = tolerant of organic enrichment, habitat instability (Barbour *et al.* 1999)

[2] Merritt and Cummins (1996); Thorp and Covich (1991), Barbour *et al.* (1999)

[3] Schmidt (1999)

[4] Earth Tech, Inc. and DeLorme

TABLE 3-16 (Cont.)

BENTHIC INVERTEBRATES (OTHER THAN MOLLUSKS) RECORDED FROM SHEYENNE RIVER, LAKE ASHTABULA, AND RED RIVER

Final Aquatic Impact Analysis Report

	Tolerance[1]	Habitat[2]	Feeding Guild[3]	Lake Ash[3]	Red River[3]	Sheyenne River[4]							
						Reach 1		Reach 3		Reach 4		Reach 5	
						No.	%	No.	%	No.	%	No.	%
Tanytarsini	6	erosional, depositional	collector/ gatherer, filterer			472	7.16	28	0.63				
Tanytarsus sp.	3-6	vascular plants	collector/ gatherer, filterer	x									
Orthocladinae	5	lotic burrowers	collector/ gatherer			96	1.46	232	5.19	17	7.98	1	0.05
Cricotopus sp.	4-7	vascular plants	shredder	x									
Tanypodinae	7	sprawlers, swimmers	predator			39	0.59	136	3.04			48	2.49
Anatopynia sp.				x									
Procladius sp.	6-9	profundal	predator	x									
Culicidae	8		collector/ gatherer		x								
Culex sp.	8-10	limnetic	collector/ gatherer, filterer		x								
Dolichopodidae	4-10	margins	predator		x	1	0.02						
Hydroporini					x								
Hydroporus sp.		margins	predator		x	1	0.02					1	0.05
Empididae	3-8		predator		x	1	0.02	1	0.02				
Clinocera sp.	6	erosional	predator?		x								
Hemerodromia sp.	6	detritus	predator, collector/ gatherer		x	2	0.03	4	0.09				
Ephydridae	6		collector/ gatherer			1	0.02	3	0.07			1	0.05
Ephydra sp.		depositional	shredder, herbivore, collector/ gatherer		x	1	0.02						
Scatella sp.		vascular plants	collector/ gatherer, scraper			1	0.02						
Muscidae	6		predator		x								
Limnophora sp.	7	erosional (mosses)	predator		x								
Psychodidae	10	depositional	collector/ gatherer		x								
Simulidae						16	0.24	1	0.02				
Simulium sp.	4-6	erosional	collector/ gatherer, filterer		x	56	0.85	26	0.58	3	1.41	103	5.34
Stratiomyidae	8		collector/ gatherer			6	0.09						
Stratiomys sp.		margins	collector/ gatherer, filterer		x								
Nemotelus sp.		stream margins	collector/ gatherer					1	0.02				
Syrphidae	10		collector/ gatherer		x								
Tabanidae	8		predator										
Chrysops sp.	4-7	depositional	predator		x	1	0.02	10	0.22				
Tabanus sp.	5-10	erosional, depositional	predator		x								
Tipulidae	3		shredder			1	0.02						
Antocha sp.	2-5	erosional	collector/ gatherer		x								
Erioptera sp.	3	sand, detritus, margins	collector/ gatherer										
Hexatoma sp.	2-5	detritus	predator		x			1	0.02				
Ormosia sp.	3-7	detritus, organic matter	collector/ gatherer			2	0.03	4	0.09	2	0.94		
Tipula sp.	4-8	erosional, depositional	detritivore, herbivore, collector, shredder		x					2	0.94	1	0.05
Diptera(total)						2381	36.11	1300	29.06	26	12.21	248	12.85
Diptera(taxa)						16		14		5		9	

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[3] Schmidt (1999)

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TABLE 3-16 (Cont.)

BENTHIC INVERTEBRATES (OTHER THAN MOLLUSKS) RECORDED FROM SHEYENNE RIVER, LAKE ASHTABULA, AND RED RIVER

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	Tolerance[1]	Habitat[2]	Feeding Guild[3]	Lake Ash[3]	Red River[3]	Sheyenne River[4]							
						Reach 1		Reach 3		Reach 4		Reach 5	
						No.	%	No.	%	No.	%	No.	%
EPHEMEROPTERA					x	72	1.09	43	0.96				
Baetidae	4		collector/ gatherer		x	158	2.40	46	1.03	52	24.41	670	34.72
Acentrella sp.	4		collector/ gatherer			38	0.58	10	0.22	1	0.47		
Acentrella insignificans	4	erosional	collector/ gatherer		x								
Acerpenna sp.	4	erosional	collector/ gatherer, shredder		x								
Baetis sp.	3-6	erosional, depositional	collector/ gatherer (detritus, diatoms)		x	114	1.73	89	1.99			26	1.35
Centroptilum sp.	2	depositional	collector/ gatherer, scraper			4	0.06						
Labiobaetis sp.	6	depositional	collector/ gatherer		x	94	1.43	5	0.11	8	3.76	70	3.63
Paracloeodes minutes	9	depositional, sand	scraper		x								
Procloeon sp.		depositional	collector/ gatherer, scraper			3	0.05						
Baetiscidae													
Baetisca sp.	4	depositional (sand w detritus)	collector/ gatherer, scraper					1	0.02				
Caenidae	7		collector/ gatherer										
Branchycercus sp.	3.5	depositional	collector/ gatherer		x	2	0.03						
Caenis sp.	3-8	depositional	collector/ gatherer		x	812	12.32	53	1.18	8	3.76	63	3.26
C. anceps					x								
C. hilaris					x								
C. latipennis	7		collector/ gatherer		x								
C. tardata					x								
C. youngi					x								
Cercobranchys sp.		depositional	collector/ gatherer			1	0.02			4	1.88	4	0.21
Ephemeridae													
Hexagenia sp.	3-6	depositional	collector/ gatherer		x	99	1.50	15	0.34			3	0.16
H. bilineata		depositional			x								
H. limbata	3	depositional	collector/ gatherer		x	184	2.79	199	4.45	1	0.47	18	0.93
Pentagenia sp.		large river, hard clay banks	collector/ gatherer					23	0.51	9	4.23	23	1.19
Heptageniidae	4		scraper		x	18	0.27	26	0.58	1	0.47	19	0.98
Heptagenia sp.	2-4	erosional	scraper, collector/ gatherer		x	14	0.21	22	0.49	3	1.41	17	0.88
H. diabasia	2				x								
H. elegantula	4		scraper		x								
H. flavescens			omnivore		x								
Leucrocuta sp.	0-3	slow flowing warm water	scraper, collector/ gatherer		x	27	0.41	20	0.45				
L. maculipennis	2				x								
Rhithrogena sp.	0	erosional	collector/ gatherer, scraper (detritus, diatoms)		x								
Stenocron sp.	3-4	erosional	collector/ gatherer, scraper		x	185	2.81	21	0.47	2	0.94	6	0.31
S. interpunctatum	7		omnivore		x								
Stenonema sp.	2-4	depositional	scraper, collector/ gatherer		x	29	0.44	46	1.03	20	9.39	73	3.78
S. exiguum	2		omnivore		x								

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TABLE 3-16 (Cont.)

BENTHIC INVERTEBRATES (OTHER THAN MOLLUSKS) RECORDED FROM SHEYENNE RIVER, LAKE ASHTABULA, AND RED RIVER

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	Tolerance[1]	Habitat[2]	Feeding Guild[3]	Lake Ash[3]	Red River[3]	Sheyenne River[4]							
						Reach 1		Reach 3		Reach 4		Reach 5	
						No.	%	No.	%	No.	%	No.	%
S. mediopunctatum	1-3				x								
S. mexicanum					x								
S. pulchellum	2				x								
S. terminatum	2-5				x								
Isonychiidae						4	0.06						
Isonychia sp.	1-4	erosional, depositional	collector/ gatherer, filterer		x	5	0.08	9	0.20			12	0.62
I. bicolor					x								
I. rufa					x								
Leptophlebiidae	2	erosional	collector/ gatherer, scraper		x	1	0.02						
Polymitarcyidae													
Ephoron sp.	2	erosional, depositional	collector/ gatherer, filterer			1	0.02	128	2.86			26	1.35
E. album					x	36	0.55						
E. leukon	2				x								
Potamanthidae													
Anthopotamus sp.	3	depositional	collector/ gatherer, filterer		x	4	0.06	92	2.06				
A. myops					x	15	0.23						
Siphlonuridae	7												
Siphlonurus alternatus		depositional	collector/ gatherer, scraper		x								
Tricorythidae	4												
Leptohyphes sp.	2	depositional			x								
Trichorythodes sp.	2-5	depositional	collector/ gatherer			5	0.08	36	0.80	8	3.76	62	3.21
T. minutus	4		collector/ gatherer	x	x	4	0.06						
Ephemeroptera(total)						1929	29.26	884	19.76	117	54.93	1092	56.58
Ephemeroptera taxa(total)						18		15		10		12	
HEMIPTERA					x	2	0.03						
Belostomatidae		depositional, vascular plants	predator			1	0.02						
Belostoma flumineum	10					1	0.02						
Corixidae	5-9		predator		x	141	2.14	301	6.73	1	0.47	9	0.47
Callicorixa sp.		lentic	predator			4	0.06						
Cymatia americana	8		piercer					2	0.04				
Hesperocorixa sp.		depositional	piercer, herbivore			1	0.02	4	0.09				
Palmacorixa sp.	5		predator			7	0.11						
P. buenoi						2	0.03	1	0.02				
P. gillettei						2	0.03	13	0.29			2	0.10
Sigara sp.	9		predator			4	0.06	27	0.60	4	1.88		
S. lineata						1	0.02	639	14.28	5	2.35	33	1.71
Trichocorixa sp.	5	depositional	piercer, herbivore, collector/ gatherer			14	0.21	255	5.70	1	0.47	2	0.10
Gerridae	5		predator		x	2	0.03						

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TABLE 3-16 (Cont.)

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Final Aquatic Impact Analysis Report

	Tolerance[1]	Habitat[2]	Feeding Guild[3]	Lake Ash[3]	Red River[3]	Sheyenne River[4]							
						Reach 1		Reach 3		Reach 4		Reach 5	
						No.	%	No.	%	No.	%	No.	%
Gerris sp.		depositional, surface	predator		x								
Limnoporus sp.		limnetic	predator		x			3	0.07			1	0.05
Rheumatobates sp.		surfaces	predator			3	0.05	10	0.22				
Mesoveliidae													
Mesovelia sp.		vascular plants	predator		x								
Nepidae													
Ranatra fusca	7.5	depositional, vascular hydrophytes	predator			1	0.02						
Notonectidae													
Notonecta sp.		depositional	predator		x								
Pleidae													
Neoplea sp.		lentic vascular hydrophytes	predator, piercer			19	0.29	2	0.04			1	0.05
Veliidae													
Microvelia sp.	6	depositional, surface	predator		x								
Hemiptera(total)						205	3.11	1257	28.10	11	5.16	48	2.49
Hemiptera taxa(total)						10		9		2		5	
LEPIDOPTERA					x	1	0.02					1	0.05
Petrophila sp.	3-5	erosional	scraper, herbivore		x								
MEGALOPTERA													
Sialis sp.	4-7	erosional, depositional	predator		x	2	0.03	2	0.04			1	0.05
ODONATA													
Anisoptera													
Aeshnidae	3		predator										
Aeshna sp.	5					2	0.03						
A. verticalis		vascular plants	predator		x								
Boyeria sp.		detritus, vascular hydrophytes	predator		x								
Corduliidae	2-5	depositional	predator		x								
Somatochlora sp.	1-9	depositional (springs)	predator		x								
Gomphidae	1		predator		x	1	0.02					1	0.05
Dromogomphus sp.	6	detritus, larger rivers	predator		x								
D. spinosus			predator		x								
Gomphus sp.	5		predator			13	0.20	11	0.25	2	0.94		
Ophiogomphus sp.	1-6	sand	predator		x								
Stylurus sp.		depositional	predator					1	0.02	1	0.47	2	0.10
Zygoptera													
Calopterygidae	5		predator										
Calopteryx sp.	3-8	margins, detritus	predator		x	2	0.03	1	0.02				
C. maculata			predator		x								
Hetaerina sp.	3-6	margins, detritus	predator		x								
Coenagrionidae			predator		x	5	0.08	2	0.04			2	0.10

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TABLE 3-16 (Cont.)

BENTHIC INVERTEBRATES (OTHER THAN MOLLUSKS) RECORDED FROM SHEYENNE RIVER, LAKE ASHTABULA, AND RED RIVER

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	Tolerance[1]	Habitat[2]	Feeding Guild[3]	Lake Ash[3]	Red River[3]	Sheyenne River[4]							
						Reach 1		Reach 3		Reach 4		Reach 5	
						No.	%	No.	%	No.	%	No.	%
Enallagma sp.	8-9	vascular plants	predator		x, x	11	0.17						
Lestidae													
Lestes sp.	9	vascular plants	predator		x								
Odonata(total)						34	0.52	15	0.34	3	1.41	5	0.26
Odonata(total taxa)						4		4		2		2	
ORTHOPTERA		(semi-aquatic)											
Tridactylidae		lotic margins	shredder, herbivore										
Ellipes minuta										1	0.47		
PLECOPTERA												1	0.05
Perlidae	1		predator		x								
Acroneuria sp.	0	erosional	predator		x								
A. lycorias	1-3		predator		x								
Paragnetina sp.		erosional	predator		x								
P. media	2		predator		x								
Perlesta sp.	0-5	detritus	predator		x								
P. decipiens					x								
Perlodidae	2		predator									2	0.10
Isoperla sp.	2	erosional, depositional	predator							5	2.35	1	0.05
Pteronarcyidae					x								
Pteronarcys sp.	2	logs, leaf, litter	shredder, detritivore, herbivore		x								
P. dorsata	2		shredder										
Plecoptera(total)						0	0.00	0	0.00	5	2.35	4	0.21
Plecoptera(total taxa)						0		0		1		1	
TRICHOPTERA				x	x								
Brachycentridae	1		filterer					2	0.04	12	5.63	11	0.57
Brachycentrus sp.	1-2	erosional (debris, plants)	filterer		x								
B. numerousus	1-2				x								
Micrasema sp.	1-2	erosional (debris, plants)	shredder, herbivore, collector/ gatherer		x								
Glossosomatidae	0		scraper		x								
Protoptila sp.	1-3	erosional	scraper		x			1	0.02				
P. erotica					x								
Helicopsychidae	3		scraper										
Helicopsyche sp.	3	erosional	scraper		x								
H. borealis	0-3		scraper		x								

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TABLE 3-16 (Cont.)

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	Tolerance[1]	Habitat[2]	Feeding Guild[3]	Lake Ash[3]	Red River[3]	Sheyenne River[4]							
						Reach 1		Reach 3		Reach 4		Reach 5	
						No.	%	No.	%	No.	%	No.	%
Hydropsychidae	4		filterer		x	6	0.09	9	0.20			57	2.95
Ceratopsyche sp.		erosional	filterer		x	96	1.46	243	5.43	1	0.47	170	8.81
C. alhedra	0-3				x								
C. bifida	1				x								
C. bronta	3-5				x								
C. morosa	2-3				x								
Cheumatopsyche sp.	3-7	erosional	filterer		x	138	2.09	221	4.94	6	2.82	25	1.30
C. campyla	6		filterer		x								
Hydropsyche sp.	4	erosional	filterer		x	5	0.08	29	0.65	8	3.76	88	4.56
H. bidens	2-3				x								
H. confusa					x								
H. simulans	2-3				x								
Potamyia flava	2-3	erosional	filterer		x								
Hydroptilidae	4				x							2	0.10
Hydroptila sp.	3-6	erosional	piercer, herbivore, scraper		x	5	0.08	1	0.02				
H. grandiosa					x								
H. spatulata					x								
Mayatrichia sp.	6		scraper		x							11	0.57
Neotrichia sp.	3-4	erosional	scraper									10	0.52
Oxyethira sp.	5	vascular plants	piercer, herbivore, collector/ gatherer		x								
Lepidostomatidae	3		shredder										
Lepidostoma sp.		detritus	shredder		x								
Leptoceridae	4		collector/ gatherer		x	4	0.06	1	0.02				
Ceraclea sp.	2-5	lotic	collector/ gatherer, shredder, herbivore		x								
C. maculata	3-7				x								
Leptocerus americanus		vascular plants	shredder, herbivore		x								
Mystacides sepulchralis	3-4	depositional	collector/ gatherer, shredder, herbivore		x								
Nectopsyche sp.	2-3	erosional, depositional vascular hydrophytes	collector/ gatherer, shredder, herbivore		x	24	0.36	3	0.07	3	1.41	20	1.04
N. candida	4		omnivore		x								
N. diarna	3				x								
Oecetis sp.	3-8	erosional, depositional	predator, shredder, herbivore		x	11	0.17	3	0.07				

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TABLE 3-16 (Cont.)

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	Tolerance[1]	Habitat[2]	Feeding Guild[3]	Lake Ash[3]	Red River[3]	Sheyenne River[4]							
						Reach 1		Reach 3		Reach 4		Reach 5	
						No.	%	No.	%	No.	%	No.	%
O. avara					x								
O. cinerascens						4	0.06						
O. nocturna						2	0.03						
O. scala group					x								
Triaenodes sp.	6	vascular plants	shredder, herbivore		x								
Limnephilidae					x								
Anobolia sp.		depositional	shredder, detritivore		x								
A. bimaculata					x								
A. consocia					x	1	0.02						
Asynarchus sp.		depositional											
Limnephilus sp.	5		shredder										
Pycnopsyche sp.	2-4	erosional, depositional	shredder, detritivore		x	2	0.03	5	0.11				
Pycnopsyche lepida group	2-3				x								
Limnephiloidea													
Ptilostomis sp.		detritus, vascular hydrophytes	shredder, herbivore, detritivore, predator		x								
Molannidae													
Molanna sp.	6	depositional	scraper		x								
M. ulmerina					x								
Philopotamidae	3	erosional	filterer		x								
Chimarra sp.	2-4	erosional	filterer		x								
Polycentropodidae			filterer		x			1	0.02				
Cyrnellus fraternus	4-8	lotic, lentic	filterer		x								
Neureclipsis sp.	3-7	vascular plants	filterer		x								
N. bimaculata					x			2	0.04				
Paranyctiophylax sp.		erosional, depositional	predator, filterer, shredder		x								
Polycentropus sp.	3-6	erosional	filterer		x	4	0.06	1	0.02				
P. cinereus					x								
Psychomyiidae			scraper										
Psychomyia sp.	2	erosional	collector/ gatherer, scraper			3	0.05						

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	Tolerance[1]	Habitat[2]	Feeding Guild[3]	Lake Ash[3]	Red River[3]	Sheyenne River[4]							
						Reach 1		Reach 3		Reach 4		Reach 5	
						No.	%	No.	%	No.	%	No.	%
P. flavida	2-3	erosional	collector/ gatherer		x								
Tricoptera(total)						305	4.63	522	11.67	30	14.08	394	20.41
Tricoptera(total taxa)						11		11		5		6	
No. of sites						10		5		1		2	
Total ind.						6593		4474		213		1930	
Total taxa						89		70		32		52	
Invertebrate metrics													
No. EPT taxa						29		26		16		19	
Ephemeroptera taxa						18		15		10		12	
Tricoptera taxa						11		11		5		6	
%EPT taxa-% total taxa metric						32.6		37.1		50.0		36.5	
%EPT taxa-% total count metric						33.9		31.4		71.4		77.2	
%Ephemeroptera count						29.3		19.8		54.9		56.6	
%Tricoptera count						4.6		11.7		14.1		20.4	
No. EPT						2234		1406		152		1490	
No. E						1929		884		117		1092	
No. T						305		522		30		394	

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[4] Earth Tech, Inc. and DeLorme

TABLE 4-1

MODELED PARAMETERS OF HYDROLOGY AND WATER QUALITY AVAILABLE BY REACH[1]

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Reach		FLOW	TEMPERATURE	TDS	SULFATE	TOTAL HARDNESS	NON-CO_3 HARDNESS	CHLORIDE
Sheyenne 1	Highway 30	x		x	x			
	Cooperstown	x	x	x	x	x	x	x
Sheyenne 3	Baldhill Dam	x	x	x	x	x	x	x
	Lisbon	x	x	x	x			
Sheyenne 5	Kindred	x	x	x	x	x	x	x
	Horace	x	x	x	x			
Red 1	Halstad	x	x	x	x			x
Red 2	Grand Forks	x	x	x	x	x	x	x
Red 3	Emerson	x	x	x	x	x	x	x

[1] Data source USACE HEC5 data files Q5P50W48.dat (run April 26, 2001); Q5P55W48.dat (run April 25, 2001), Q5PWW48.dat (run April 9, 2001)

TABLE 4-2

LITERATURE SUMMARY OF CHRONIC EXPOSURE LEVELS OF TDS, SULFATE, AND CHLORIDE TO FRESHWATER FISH

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Parameter	Species group	Concentration and effect	Literature reference
TDS	Sensitive fish	-<1000 mg/l, no long term effects	Peterka 1972; Reed and Evans 1981; Peterka and Violett 1988; Hendrickson 1990; Koel 1992; AScI 1998
		-1000 to <1500 mg/l, Some reduction in hatching success or survival of fry is possible, but effects at the population level are unlikely	
		-1500 to <2500 mg/l, Same as above but with greater risk of year class failure	
		-2500 to 3500 mg/l, Effects are likely on some sensitive species, some of these effects may be severe (e.g., year class failure, reduced population levels)	
		-Severe effects (e.g., little or no reproduction) at long term exposures to concentrations >3500 mg/l	
	Tolerant fish	-No effect on growth or reproduction at concentrations <4800 mg/l	Peterka and Violett 1988
Sulfate		<500 mg/l adequate for the protection of aquatic life	Reed and Evans 1981; Koel 1993
		-<500 mg/l, long term exposure would not effect sensitive species	
		-500 to 1000, long term exposure presents a slight to moderate risk to sensitive fish	
		At concentrations of 1000 mg/l, long term exposure might affect sensitive species (e.g., northern pike) adversely, mainly through reducing reproductive success	
		Concentrations of 11,000 to 12,000 mg/l are toxic to 50% of test animals in 96 hr	
Chloride		No effects expected for chronic (>30 day) exposure to concentrations <600 mg/l	Reed and Evans 1981; Birge *et al.* 1985
		Concentrations of 5000-7000 mg/l are toxic to 50% of test animals in 96 hr.	EPA 1988

TABLE 4-3

CONCENTRATIONS OF WATER QUALITY PARAMETERS USED FOR ANALYSIS OF EFFECTS ON BIOTA

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	TDS	Sulfate	Chloride
Tolerant fish reproduction	4800	11,000	5000
Sensitive fish reproduction	>1000	>500	>600
Tolerant mollusk survival		3300	3500
Sensitive mollusk survival	1000	1300	100
Tolerant invertebrate survival		450	2000
Sensitive invertebrate survival		150	50

TABLE 4-4

SUMMARY OF FISH SPECIES TOLERANCE AND LIFE HISTORY CHARACTERISTICS

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Fish	Common name	Status in ND[1]	Host fish[2]	Tolerance[3]	Sensitivity to TDS, sulfate, chloride[4]	Spawning Guild[5]	Spawning time[6]	Turbidity tolerance[6]	Prefers weed beds[6]	Habitat Guild						
										Source[7]	Slow Riffle	Fast Riffle	Raceway	Shallow Pool	Medium Pool	Deep Pool
Petromyzontidae																
Ichthyomyzon castaneus	Chestnut lamprey	P/SC1		M			April/May									
Ichthyomyzon unicuspis	Silver lamprey	P/SC2		M	T	N	April/May									
Hiodontidae																
Hiodon alosoides	Goldeye			I	T	M	May/June	Tolerant								
Hiodon tergisus	Mooneye		x	I	T	M	April/May	Intolerant								
Salmonidae																
Onchorynchus mykiss	Rainbow trout	I		M		N	April/May									
Osmeridae																
Osmerus mordax	Rainbow smelt	I		M		M	March/May									
Esocidae																
Esox lucius	Northern pike		x	M		M	March/April		x	1					Adult	
E.lucius X E.masquinongy	Tiger muskie	H/I				M										
Esox masquinongy	Muskellunge	I		M		M	April/May									
Cyprinidae																
Cyprinus carpio	Common carp	I	x	T	T	M	April to	Tolerant								
Cyprinella spiloptera	Spotfin shiner		x	M		M	May to	Tolerant		2	Adult					
Hybognathus hankinsoni	Brassy minnow		x	M	M		May/June	Intolerant								
Luxilus cornutus	Common shiner		x	M		S	May to July			1	Spawner				Adult/Juv	Age-0
Macrhybopsis storeriana	Silver chub	SC2		M	T	M	June/July									
Nocomis biguttatus	Hornyhead chub	P/SC1	x	I	S	N	May to July	Intolerant		2	Adult			Juvenile	Adult	
Notemigonus chrysoleucas	Golden shiner		x	T	S	M	May to			2				Adult	Adult	Adult
Notropis anogenus	Pugnose shiner	T		I	S	M	May to July	Intolerant	x	2				Adult	Adult	Adult
Notropis atherinoides	Emerald shiner		x	M		S	May to	Intolerant								
Notropis blennius	River shiner		x	M	T	S	June to	high								
Notropis dorsalis	Bigmouth shiner			M	M	M	May to	Intolerant		2	Adult					
Notropis heterodon	Blackchin shiner		x	I	S	M	June to	Intolerant	x							
Notropis heterolepis	Blacknose shiner	P/SC1	x	I	S		June to	Intolerant	x					A	A	
Notropis hudsonius	Spottail shiner			M	S	M	May to June									
Notropis rubellus	Rosyface shiner	P/SC1	x	I	M	S	May/June	Intolerant		2		Adult/Spawner			Adult/Spawner	
Notropis stramineus	Sand shiner		x	M	M	M	May to			1	Spawner			Adult		
Notropis volucellus	Mimic shiner			I	S	M	May to August									
Phoxinus eos	Northern redbelly	SC1	x	M	S		May to									
Pimephales notatus	Bluntnose minnow		x	T		C	May to	moderate		1	Adult			Age-0		
Pimephales promelas	Fathead minnow			T		C	May/June			2				Adult	Adult	
Platygobio gracilis	Flathead chub	SC1			T			Tolerant								
Rhinichthys atratulus	Blacknose dace		x	T		S	May/June	moderate								
Rhinichthys cataractae	Longnose dace		x	I	M	S	April to June			1	Spawner	Adult		Age-0		
Semotilus atromaculatus	Creek chub		x	T		N	May to July	moderate		2	Spawner			Adult	Adult	
Catastomidae																
Carpiodes cyprinus	Quillback			M	M	M		no pref								
Catostomus commersoni	White sucker		x	T	M	S	April/May			1	Juvenile					Adult
Ictiobus cyprinellus	Bigmouth buffalo			M	M	M	April/May									
Moxostoma anisurum	Silver redhorse	P	x	M	M	S	April/May			1	Age-0	Spawner				Juvenile
Moxostoma erythrurum	Golden redhorse		x	M	S	S	May	Intolerant		1	Spawner		Adult	Juvenile	Age-0	
Moxostoma macrolepidotum	Shorthead redhorse		x	M	M	S	April/May	Intolerant		1		Spawner	Adult/Juv			
Moxostoma valenciennesi	Greater redhorse	P		I	S	S	May/June	Intolerant		1	Spawner		Adult/Juv			
Ictaluridae																
Ameiurus melas	Black bullhead		x	M	T	C	April to June	Tolerant		2				Age-0	Adult/Spawner	
Ameiurus nebulosus	Brown bullhead		x	T	M	C	June/July									
Ictalurus punctatus	Channel catfish		x	M	T	C	May to July	Tolerant		1	Age-0				Adult/Juv	
Noturus flavus	Stonecat		x	I	M	C	June to	Intolerant		1		Juv/Age-0	Adult			
Noturus gyrinus	Tadpole madtom		x	M	M	C	June/July			1					Age-0	
Percopsidae																
Percopsis omiscomaycus	Trout perch	SC2				M	April to June			2	Spawner			Adult	Adult	Adult
Gadidae																
Lota lota	Burbot			M		S	January to									
Cyprinodontidae																
Fundulus diaphanus	Banded killifish	P	x	T	S		June to		x	2					Adult	
Gasterosteidae																
Culaea inconstans	Brook stickleback		x	M		C	April to June		x	2				Adult	Adult	
Percichthyidae																
Morone chrysops	White bass	I	x	M	T	M	April to June	no pref		1					Juvenile	
Morone saxatilis	Striped bass	I		M		M										
Centrarchidae																
Ambloplites rupestris	Rock bass		x	M	M	C	May to	Intolerant	x							
Lepomis cyanellus	Green sunfish		x	T	S	C	May to	Tolerant		1				Adult/Age-0		
Lepomis gibbosus	Pumpkinseed		x	M	S	C	May to	moderate								
Lepomis humilis	Orangespotted sunfish		x	M	S	C	May to	Tolerant		1				Adult	Juvenile	
Lepomis macrochirus	Bluegill		x	M	S	C	May to	moderate		1				Juv/Age-0		
Micropteris dolomieui	Smallmouth bass	I	x	M	M	C	May/June	moderate		1			Adult/Juv	Age-0		
Micropteris salmoides	Largemouth bass	I	x	M	S	C	April to July	moderate	x	1					Juvenile	Age-0
Pomoxis annularis	White crappie		x	M	T	C	May/June	Tolerant		1					Adult/Juv	
Pomoxis nigromaculatus	Black crappie		x	M	M	C	May/June	moderate		1					Juvenile	Adult/Age-0
Percidae																
Etheostoma exile	Iowa darter		x	M	M	M	April/May	moderate								
Etheostoma nigrum	Johnny darter		x	M	M	C	April/May	Tolerant		2	Adult/Spawner			Adult		
Perca flavescens	Yellow perch		x	M		M	April/May		x	1	Adult				Juvenile	
Percina caprodes	Logperch	P/SC2	x	M	S	S	April to July	Intolerant		1		Adult/Age-0	Spawner			
Percina maculata	Blackside darter		x	M	M	S	April/June	moderate		2	Adult/Spawner					
Percina shumardi	River darter	SC2		M		S	April/June	Tolerant		2			Adult			
Stizostedion canadense	Sauger		x	M	T	S	April/May	Tolerant								
Stizostedion vitreum	Walleye		x	M		S	April/May	Tolerant		1					Juv/Age-0	
Sciaenidae																
Aplodinotus grunniens	Freshwater drum		x	M	T		May/June	Tolerant		2						Adult

[1] P=Peripheral, H=hybrid, I=introduced, T=threatened, SC-species wholse status is questionable due to SC1 suspected problems with abundance or distribution or SC2 limited or inconclusive historical citations (NDFG 1994)

[2] Appendix G

[3] I=Intolerant, M=moderately tolerant, T=tolerant to water quality and habitat degradation (Barbour *et al.* 1999)

[4] T=tolerant, M= moderately tolerant, S=sensitive, based on Koel (1997)

[5] Spawning guild; N=complex, no parental care; C=complex with parental care; M=simple, miscellaneous; S=simple lithophils (Ohio EPA1989)

[6] Becker (1983), Peterka and Koel (1996)

[7] Habitat guild-source

1 = Aadland

2 = Place in guild based on habitat preferences noted in Becker (1983), Pflieger (1975), and Peterka and Koel (1996)

TABLE 4-5

FISH AND MOLLUSK TOLERANCE[1] TO TDS, SULFATE, AND CHLORIDE USED FOR THIS ANALYSIS

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Sensitive	Intermediate	Tolerant
Fish		
N. pike	White bass	Fathead minnow
Walleye	Crappie	Brook stickleback
White sucker	Brassy minnow	Common carp
Hornyhead chub	Bigmouth shiner	Yellow perch
Golden shiner	Rosyface shiner	Silver lamprey
Pugnose minnow	Sand shiner	Goldeye
Blackchin shiner	Longnose dace	Mooneye
Blacknose shiner	Quillback	Silver chub
Spottail shiner	White sucker	River shiner
Mimic shiner	Bigmouth buffalo	Flathead chub
Northern redbelly dace	Silver redhorse	Black bullhead
Golden redhorse	Shorthead redhorse	Channel catfish
Greater redhorse	Brown bullhead	White crappie
Banded killifish	Stonecat	Sauger
Green sunfish	Tadpole madtom	Freshwater drum
Pumpkinseed	Rock bass	
Orangespotted sunfish	Smallmouth bass	
Bluegill	Black crappie	
Largemouth bass	Iowa darter	
Logperch	Johnny darter	
	Blackside darter	
Mollusks		
Unionidae		Gastropoda-Pulmonates
Sphaeriidae		
Gastropoda-Prosobranchs		

[1] See Tables 4-4 and 4-6

TABLE 4-6

LITERATURE SUMMARY OF MOLLUSK SENSITIVITY TO TDS, SULFATE, AND CHLORIDE

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Parameter	Biotic Group	General response of biotic group to changes in water quality	References
General			
Bivalves	Unionids	Valve closing behavior due to exposure to heavy metals, chlorine, and other biocides, and high levels of suspended solids.	McMahon (in Thorp and Covich 1991)
		No live unionids downstream of large cities in the Red River.	Cvancara 1970
	Sphaeriids	Overall tolerant to poor water quality conditions.	Fuller (in Fuller and Hart 1974)
Gastropoda	Pulmonates	Overall tolerant of poor water quality.	Fuller (in Fuller and Hart 1974)
	Prosobranchs	Less tolerant of poor water quality.	Fuller (in Fuller and Hart 1974)
Chlorides			
Bivalves	Unionids	Chloride levels of >100 mg/l may limit unionids.	Cvancara 1967, 1970, 1983
	Sphaeriids	Chloride levels of >100 mg/l may limit sphaeriids.	Cvancara 1983
Gastropoda	Pulmonates	*Physa jennessi* found in chloride of 3500 mg/l.	Cvancara 1983
	Prosobranchs	Chloride wastes eliminated *Io fluvialis* , *Oxytreme unicale* , *Leptoxis subglobsa* in Clinch River (Stansbery 1972, Goodrich 1940	Harman (in Fuller and Hart 1974)
Sulfates			
Bivalves	Unionids	No live unionids at sulfate >1300 mg/l.	Cvancara 1983
	Sphaeriids	No live sphaeriids at sulfate >1300 mg/l.	Cvancara 1983
Gastropoda	Pulmonates	*Stagnicola elodes* , *Physa gyrina* , *P. jennessi* in sulfate of 3300 mg/l.	Cvancara 1983

TABLE 4-7

INVERTEBRATE SENSITIVITY TO TDS, SULFATE, AND CHLORIDE
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Parameter	Order (Family)	Taxa[1]	Hart and Fuller (1974)[2]	Historic level in Sheyenne River[3]	Group
TDS	Coleoptera (Elmidae)	*Dubiraphia* sp.		Average 550, max 1000	Tolerant
		Macronychus sp.		Average 550, max 1000	Tolerant
		Stenelmis sp.		Average 550, max 1000	Tolerant
	Diptera	Chironiminae		Average 550, max 1000	Tolerant
		Orthocladinae		Average 550, max 1000	Tolerant
		Tanypodinae		Average 550, max 1000	Tolerant
	Ephemeroptera	*Baetis* sp.		Average 550, max 1000	Tolerant
		Labiobaetis sp., *Caenis* sp., *Stenonema* sp.	*Stenonema puchellum* (800 mg/l)	Average 550, max 1000	Tolerant
		Hexagenia sp., *Pentagenia* sp.		Average 550, max 1000	Tolerant
	Hemiptera (Corixidae)	*Sigara* sp., *Trichocorixa* sp.		Average 550, max 1000	Tolerant
	Tricoptera	*Ceratopsyche* sp., *Cheumatopsyche* sp., *Hydropsyche* sp.		Average 550, max 1000	Tolerant
Sulfate	Coleoptera (Elmidae)	*Dubiraphia* sp.	<1-450 mg/l	Average 150, max 360	Tolerant
		Macronychus sp.	<1-73 mg/l	Average 150, max 360	Sensitive
		Stenelmis sp.	2-450 mg/l	Average 150, max 360	Tolerant
	Diptera	Chironiminae	1-570 mg/l	Average 150, max 360	Tolerant
		Orthocladinae	25-135 mg/l (*Cricotopus*)	Average 150, max 360	Sensitive
		Tanypodinae	<1-480 mg/l (*Procladius*)	Average 150, max 360	Tolerant
	Ephemeroptera	*Baetis* sp.	<1-570 mg/l	Average 150, max 360	Tolerant
		Labiobaetis sp., *Caenis* sp., *Stenonema* sp.	<1-450 mg/l	Average 150, max 360	Tolerant
		Hexagenia sp., *Pentagenia* sp.	3-45 mg/l	Average 150, max 360	Sensitive
	Hemiptera (Corixidae)	*Sigara* sp., *Trichocorixa* sp.	2-450 mg/l	Average 150, max 360	Tolerant
	Tricoptera	*Ceratopsyche* sp., *Cheumatopsyche* sp., *Hydropsyche* sp	2-450 mg/l	Average 150, max 360	Tolerant
Chloride	Coleoptera (Elmidae)	*Dubiraphia* sp.	2-30 mg/l; sensitive to chlorides	Average 30, max 74	Sensitive
		Macronychus sp.	1-185 mg/l	Average 30, max 74	Sensitive
		Stenelmis sp.	1-845 mg/l; *S. crenata* tolerant to chlorides	Average 30, max 74	Tolerant
	Diptera	Chironiminae	1-2750 mg/l	Average 30, max 74	Tolerant
		Orthocladinae	7-5500 (Cricotopus)	Average 30, max 74	Tolerant
		Tanypodinae	7-2750 (Procladius)	Average 30, max 74	Tolerant
	Ephemeroptera	*Baetis* sp.	1-2750mg/l	Average 30, max 74	Tolerant
		Labiobaetis sp., *Caenis* sp., *Stenonema* sp.	Caenis -5-72mg/l ; *Stenonema* (1-845)	Average 30, max 74	Sensitive
		Hexagenia sp., *Pentagenia* sp.	1-72mg/l	Average 30, max 74	Sensitive
	Hemiptera (Corixidae)	*Sigara* sp., *Trichocorixa* sp.	1-56mg/l	Average 30, max 74	Sensitive
	Tricoptera	*Ceratopsyche* sp., *Cheumatopsyche* sp., *Hydropsyche* sp	1-2630 mg/l	Average 30, max 74	Tolerant

[1] Dominant Sheyenne River taxa from Table 3-16.

[2] Concentration in which taxon was reported.

[3] See Table 3-4.

TABLE 4-8

LITERATURE SUMMARY OF WATER QUALITY EFFECTS ON PERIPHYTON, PHYTOPLANKTON, AND MACROPHYTES

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Parameter	Biotic Group	General response of biotic group to parameter	References
Phytoplankton and Periphyton			
General			
Phytoplankton	All groups	Community structure shift at >0.020 mg/l phosphorus in flowing systems.	Traaen 1978, Craig and Day 1977
	Bacillariophyta	Water hardness is a significant indicator of species distributions.	Phillips *et al.* 2000
		Some species highly correlated with increased arsenic concentrations.	Phillips *et al.* 2000
Periphyton	All groups	Community structure shift at >0.020 mg/l phosphorus in flowing systems.	Traaen 1978, Craig and Day 1977
		Water hardness is a significant indicator of species distributions.	Phillips *et al.* 2000
		Low nitrate-nitrite levels preferred by some periphytic diatoms.	Phillips *et al.* 2000
		Some can produce toxins at high density.	Phillips *et al.* 2000
		Some species highly correlated with increased arsenic concentrations.	Phillips *et al.* 2000
TDS			
Phytoplankton	All groups	Most variance in distributions explained by orthophosphate, pH, arsenic, mitrate+nitrite, hardness, and sulfate.	Phillips *et al.* 2000
		Total dissolved solids was not a significant factor controlling phytoplankton communities.	Phillips *et al.* 2000
		Aluminum has some influence on phytoplankton distributions.	Phillips *et al.* 2000
Periphyton	All groups	Most variance in distribution explained by aluminum, pH, Arsenic, sulfate, hardness, and orthophosphate.	Phillips *et al.* 2000
		Total dissolved solids was not a significant factor controlling periphyton communities.	Phillips *et al.* 2000
Chlorides			
Phytoplankton	Chlorophyta	Generally sensitive to changes in salinity.	Leland 1995
	Bacillariophyta	Diatoms have been used to document historical salinity based on species remains.	Fritz et al 1993
	Cyanophyta	Generally sensitive to changes in salinity.	Leland 1995
	Euglenophyta	Generally sensitive to changes in salinity.	Leland 1995
Periphyton	Chlorophyta	Generally sensitive to changes in salinity.	Leland 1995
	Bacillariophyta	Diatoms have been used to document historical salinity based on species remains.	Fritz *et al.* 1993
	Cyanophyta	Generally sensitive to changes in salinity.	Leland 1995
	Euglenophyta	Generally sensitive to changes in salinity.	Leland 1995
Sulfates			
Phytoplankton	Chlorophyta	Some species found in higher sulfate concentrations, but prefers lower concentrations.	Phillips *et al.* 2000
	Bacillariophyta	Most species found at low sulfate concentrations.	Phillips *et al.* 2000
	Cyanophyta	No clear indicators of sulfate preference.	Phillips *et al.* 2000
	Euglenophyta	Species of *Euglena* found at sites with high sulfate concentrations.	Phillips *et al.* 2000
Periphyton	Chlorophyta	Some species found in higher sulfate concentrations, but prefers lower concentrations.	Phillips *et al.* 2000
	Bacillariophyta	Most species found at low sulfate concentrations.	Phillips *et al.* 2000
	Cyanophyta	No clear indicators of sulfate preference.	Phillips *et al.* 2000
	Euglenophyta	Species of *Euglena* found at sites with high sulfate concentrations.	Phillips *et al.* 2000
Macrophytes			
General	All groups	Generally generate dissolved oxygen, filter and trap suspended particles, take up nutrients.	Carpenter and Lodge1986
		May trap and collect nutrients, filter material during flooding events.	Rogers 1994
		Eutrification may occur with increased nutrient loading.	Dieck 1998
		Loss of diversity due to general degradation in water quality.	Fischer and Claflin 1995
Chlorides	Submerged	No specific tolerance limits identified, varies widely by species.	Adamus 1990
	Emergent	No specific tolerance limits identified, varies widely by species.	Adamus 1990
		Typha augustifolia more tolerant than *Typha latifolia* .	Adamus 1990
		Phragmites sp. adults more tolerant than seedlings to high chloride concentrations.	Adamus 1990
	Wetland fringe	No specific tolerance limits identified, varies widely by species.	Adamus 1990
Sulfates	Submerged	No specific tolerance limits identified, varies widely by species.	Adamus 1990
	Emergent	No specific tolerance limits identified, varies widely by species.	Adamus 1990
	Wetland fringe	No specific tolerance limits identified, varies widely by species.	Adamus 1990

TABLE 4-9

GENERAL TOLERANCE OF ALGAL GROUPS TO ENVIRONMENTAL CHANGE

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Group	Common Name	Tolerance to environmental change
Chlorophyta	green algae	Most species intolerant
Euglenophyta	euglenoids	Most species tolerant
Cyanophyta	blue-green bacteria	Most species tolerant
Cryptophyta	golden brown algae	Wide range of tolerance by species
Chrysophyta	golden brown algae	Wide range of tolerance by species
Xanthophyta	yellow green algae	Wide range of tolerance by species
Bacillariophyta	diatoms	Wide range of tolerance by species, habitat most critical
Rhodophyta*	red algae	Not enough information
Pyrrophyta	dinoflagellates	Not enough information
Phaeophyta*	brown algae	Not enough information

*Only found in Red River.

TABLE 4-10

SUMMARY OF HYDROLOGICAL PARAMETERS USED IN THE INDICATORS OF HYDROLOGIC ALTERATION AND THEIR CHARACTERISTICS (FROM RICHTER *et al*. 1996)
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IHA statistics group	Regime characteristics	Hydrological parameters
Group 1: Magnitude of monthly water conditions	Magnitude Timing	Mean value for each calendar month
Group 2: Magnitude and duration of annual extreme water conditions	Magnitude Duration	Annual minima 1-day means
		Annual maxima 1-day means
		Annual minima 3-day means
		Annual maxima 3-day means
		Annual minima 7-day means
		Annual maxima 7-day means
		Annual minima 30-day means
		Annual maxima 30-day means
		Annual minima 90-day means
		Annual maxima 90-day means
Group 3: Timing of annual extreme water conditions	Timing	Julian date of each annual 1 day maximum
		Julian date of each annual 1 day minimum
Group 4: Frequency and duration of high and low pulses	Magnitude Frequency Duration	No. of high pulses each year
		No. of low pulses each year
		Mean duration of high pulses within each year
		Mean duration of low pulses within each year
Group 5: Rate and frequency of water condition changes	Frequency rate of change	Means of all positive differences between consecutive daily means
		Means of all negative differences between consecutive daily means
		No. of rises
		No. of falls

TABLE 4-11

PREDICTED CHANGES IN SHEYENNE RIVER GEOMORPHOLOGY BETWEEN MOD50 AND 300MOD50 (2000-2050)[1]

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		Channel forming flows (predicted at gage stations)				Predicted channel geometry				Predicted channel planform			
		Mod50	300Mod50	Percent change from baseline	Trend	Mod50	300Mod50	Percent change from baseline	Trend	Mod50[2]	300Mod50	Percent change from baseline	Trend
		1.5 yr flood (cfs)				Width (ft)				Width (ft)			
Reach 1	K3-j	346	346	0.0	stable	87	87	0.0	stable	87	87	0.0	stable
	J1-e					155.4	155.4	0.0	stable				
	J1-a					175.7	177.2	0.9	stable	166	167	0.6	stable
	I4-a	397	408	2.8	stable	67.2	67.6	0.6	stable	67	68	1.5	stable
	H3-f					123.1	126	2.4	stable	123	126	2.4	stable
	H2-I					62.5	63	0.8	stable	88	89	1.1	stable
	F2-a	615	625	1.6	stable	100.7	101	0.3	stable	101	101	0.0	stable
Reach 3	E2-j					87.3	87.3	0.0	stable				
	E2-f					111.5	111.5	0.0	stable				
	E2-a	790	790	0.0	stable	95.1	95.1	0.0	stable	98	98	0.0	stable
	D3-l					80.8	80.8	0.0	stable				
	D3-k					93.6	93.6	0.0	stable				
	D3-h					91.2	91.2	0.0	stable				
	D3-f					134	134	0.0	stable				
	D3-d					82.6	82.6	0.0	stable				
	D3-a	842	842	0.0	stable	80.3	80.3	0.0	stable	94	94	0.0	stable
Reach 4	C3-j					131.8	131.8	0.0	stable				
	C2-d					142.1	142.1	0.0	stable	137	137	0.0	stable
Reach 5	B3-e					94.6	94.9	0.3	stable				
	B3-a	915	925	1.1	stable	123.5	123.5	0.0	stable	109	109	0.0	stable
	A2-f					123.5	125	1.2	stable	123	125	1.6	stable
		2 yr flood (cfs)				Depth (ft)				Meander Length (ft)			
Reach 1	K3-j	615	625	1.6	stable	5.2	5.2	0.0	stable	991	991	0.0	stable
	J1-e					3.2	3.2	0.0	stable				
	J1-a					3.2	3.3	3.1	stable	1899	1908	0.5	stable
	I4-a	708	728.0	2.8	stable	3.5	3.6	2.9	stable	765	769	0.5	stable
	H3-f					2.9	2.9	0.0	stable	1408	1441	2.3	stable
	H2-I					4.6	4.7	2.2	stable	999	1005	0.6	stable
	F2-a	1059	1080.0	2.0	stable	5.1	5.2	2.0	stable	1149	1153	0.3	stable
Reach 3	E2-j					7	7	0.0	stable				
	E2-f					7.4	7.4	0.0	stable				
	E2-a	1245	1245.0	0.0	stable	7.3	7.3	0.0	stable	1118	1118	0.0	stable
	D3-l					7.9	7.9	0.0	stable				
	D3-k					9.2	9.2	0.0	stable				
	D3-h					7.3	7.3	0.0	stable				
	D3-f					5.5	5.5	0.0	stable				
	D3-d					8.7	8.7	0.0	stable				
	D3-a	1318	1318.0	0.0	stable	9	9	0.0	stable	1069	1069	0.0	stable
Reach 4	C3-j					4.2	4.2	0.0	stable				
	C2-d					4.9	4.9	0.0	stable	1569	1569	0.0	stable
Reach 5	B3-e					5.8	5.9	1.7	stable				
	B3-a	1452	1463.0	0.8	stable	4.8	4.8	0.0	stable	1246	1248	0.2	stable
	A2-f					5.3	5.4	1.9	stable	1413	1430	1.2	stable
						Energy slope				Meander Amplitude (ft)			
Reach 1	K3-j					0.00003	0.00003	0.0	stable	380	380	0.0	stable
	J1-e					0.00007	0.00006	-14.3	slightly lower				
	J1-a					0.00005	0.00005	0.0	stable	746	749	0.4	stable
	I4-a					0.0003	0.0003	0.0	stable	277	278	0.4	stable
	H3-f					0.00016	0.00015	-6.3	slightly lower	538	552	2.6	stable
	H2-I					0.00038	0.00037	-2.6	stable	371	373	0.5	stable
	F2-a					0.0001	0.0001	0.0	stable	431	432	0.2	stable
Reach 3	E2-j					0.00013	0.00013	0.0	stable				
	E2-f					0.00007	0.00007	0.0	stable				
	E2-a					0.0001	0.0001	0.0	stable	419	419	0.0	stable
	D3-l					0.00013	0.00013	0.0	stable				
	D3-k					0.00005	0.00005	0.0	stable				
	D3-h					0.00012	0.00012	0.0	stable				
	D3-f					0.00013	0.00013	0.0	stable				
	D3-d					0.00009	0.00009	0.0	stable				
	D3-a					0.00008	0.00008	0.0	stable	399	399	0.0	stable
Reach 4	C3-j					0.00019	0.00019	0.0	stable				
	C2-d					0.00009	0.00009	0.0	stable	605	605	0.0	stable
Reach 5	B3-e					0.0002	0.0002	0.0	stable				
	B3-a					0.00022	0.00022	0.0	stable	471	472	0.2	stable
	A2-f					0.00024	0.00023	-4.2	stable	540	547	1.3	stable

[1] WEST (2001)

[2] Predicted at regime channel

TABLE 4-12

PREDICTED CHANGES IN SHEYENNE RIVER GEOMORPHOLOGY BETWEEN MOD55 AND 480MOD50 (2000-2050)[1]
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		Channel forming flows (predicted at gage stations)				Predicted channel geometry				Predicted channel planform				
		Mod50	480Mod50	Percent change from baseline	Trend	Mod50	480Mod50	Percent change from baseline	Trend	Mod50[2]	Trend	480Mod50	Percent change from baseline	Trend
		1.5 yr flood (cfs)				Width (ft)				Width (ft)				
Reach 1	K3-j	346	356	2.9	stable	87	88.4	1.6	stable	87	stable	89	2.3	stable
	J1-e					155.4	155.1	-0.2	stable					
	J1-a					175.7	176.7	0.6	stable	166	stable	166	0.0	stable
	I4-a	397	413	4.0	stable	67.2	68.6	2.1	stable	67	stable	69	3.0	stable
	H3-f					123.1	127	3.2	stable	123	stable	127	3.3	stable
	H2-l					62.5	63	0.8	stable	88	stable	89	1.1	stable
	F2-a	615	635	3.3	stable	100.7	102.4	1.7	stable	101	stable	102	1.0	stable
Reach 3	E2-j					87.3	87.5	0.2	stable					
	E2-f					111.5	112.5	0.9	stable					
	E2-a	790	801	1.4	stable	95.1	95.1	0.0	stable	98	stable	98	0.0	stable
	D3-l					80.8	82	1.5	stable					
	D3-k					93.6	94.8	1.3	stable					
	D3-h					91.2	92.5	1.4	stable					
	D3-f					134	135.7	1.3	stable					
	D3-d					82.6	82.8	0.2	stable					
	D3-a	842	852	1.2	stable	80.3	81.5	1.5	stable	94	stable	95	1.1	stable
Reach 4	C3-j					131.8	131.8	0.0	stable					
	C2-d					142.1	141.1	-0.7	stable	137	stable	137	0.0	stable
Reach 5	B3-e					94.6	95.9	1.4	stable					
	B3-a	915	946	3.4	stable	123.5	124.5	0.8	stable	109	stable	110	0.9	stable
	A2-f					123.5	126	2.0	stable	123	stable	126	2.4	stable
		2 yr flood (cfs)				Depth (ft)				Meander Length (ft)				
Reach 1	K3-j	615	635.0	3.3	stable	5.2	5.3	1.9	stable	991	stable	1007	1.6	stable
	J1-e					3.2	3.2	0.0	stable					
	J1-a					3.2	3.2	0.0	stable	1899	stable	1903	0.2	stable
	I4-a	708	749.0	5.8	slightly higher	3.5	3.6	2.9	stable	765	stable	780	2.0	stable
	H3-f					2.9	2.9	0.0	stable	1408	stable	1452	3.1	stable
	H2-l					4.6	4.7	2.2	stable	999	stable	1005	0.6	stable
	F2-a	1059	1111.0	4.9	stable	5.1	5.3	3.9	stable	1149	stable	1169	1.7	stable
Reach 3	E2-j					7	7.1	1.4	stable					
	E2-f					7.4	7.4	0.0	stable					
	E2-a	1245	1245.0	0.0	stable	7.3	7.3	0.0	stable	1118	stable	1123	0.4	stable
	D3-l					7.9	8	1.3	stable					
	D3-k					9.2	9.2	0.0	stable					
	D3-h					7.3	7.4	1.4	stable					
	D3-f					5.5	5.6	1.8	stable					
	D3-d					8.7	8.8	1.1	stable					
	D3-a	1318	1349.0	2.4	stable	9	9.1	1.1	stable	1069	stable	1083	1.3	stable
Reach 4	C3-j					4.2	4.2	0.0	stable					
	C2-d					4.9	4.9	0.0	stable	1569	stable	1563	-0.4	stable
Reach 5	B3-e					5.8	5.9	1.7	stable					
	B3-a	1452	1473.0	1.4	stable	4.8	4.8	0.0	stable	1246	stable	1259	1.0	stable
	A2-f					5.3	5.4	1.9	stable	1413	stable	1441	2.0	stable
						Energy slope				Meander Amplitude (ft)				
Reach 1	K3-j					0.00003	0.00003	0.0	stable	380	stable	387	1.8	stable
	J1-e					0.00007	0.00007	0.0	stable					
	J1-a					0.00005	0.00006	20.0	slightly higher	746	stable	748	0.3	stable
	I4-a					0.0003	0.00029	-3.3	stable	277	stable	283	2.2	stable
	H3-f					0.00016	0.00015	-6.3	slightly lower	538	stable	557	3.5	stable
	H2-l					0.00038	0.00037	-2.6	stable	371	stable	373	0.5	stable
	F2-a					0.0001	0.00009	-10.0	slightly lower	431	stable	439	1.9	stable
Reach 3	E2-j					0.00013	0.00013	0.0	stable					
	E2-f					0.00007	0.00006	-14.3	slightly lower					
	E2-a					0.0001	0.0001	0.0	stable	419	stable	421	0.5	stable
	D3-l					0.00013	0.00013	0.0	stable					
	D3-k					0.00005	0.00005	0.0	stable					
	D3-h					0.00012	0.00012	0.0	stable					
	D3-f					0.00013	0.00013	0.0	stable					
	D3-d					0.00009	0.00009	0.0	stable					
	D3-a					0.00008	0.00008	0.0	stable	399	stable	404	1.3	stable
Reach 4	C3-j					0.00019	0.0002	5.3	slightly higher					
	C2-d					0.00009	0.0001	11.1	slightly higher	605	stable	603	-0.3	stable
Reach 5	B3-e					0.0002	0.00019	-5.0	stable					
	B3-a					0.00022	0.00022	0.0	stable	471	stable	476	1.1	stable
	A2-f					0.00024	0.00023	-4.2	stable	540	stable	552	2.2	stable

[1] WEST (2001), MOD55 not modeled, so MOD50 used

[2] Predicted at regime channel

TABLE 4-13

RIVER SEGMENTS AND CORRESPONDING HABITAT REACHES USED IN THE HABITAT ANALYSIS
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River Reach	Habitat Segment	Number of Cross-sections [1]	Habitat Transect Naming Convention		USACE TABS2	Selected Habitat Segment
			From	To		
1	L	11/6	L1-H-1	L1-H-10	X	X
1	K	9/10	K3-H-0	K3-H-8	X	
1	J	4/5	J1-H-1	J1-H-4	X	
1	I	8/8	I4-H-1	I4-H-8	X	
1	H	9/9	H2-H-1	H2-H-9	X	X
1	G					
1	F	5/7	F2-H-1	F2-H-5		
2						
3	E	8/11	E2-H-1 HDSKL-1	E2-H-8 HDSKL-8	X	X
3	D	0/12				
4	C	5/10				
5	B	4/5	B3-H-1	B3-H-4	X	X
5	A	0/6				

[1] Number of habitat cross-sections/number of erosion cross-sections

TABLE 4-14

HABITAT OBSERVATIONS[1] FOR EACH HABITAT SEGMENT WITH TABS2 MODEL RESULTS IN RIVER REACH 1

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River Reach	Habitat Segment	Habitat
1	L	Pools, riffles, and raceways were all present. Some gravel riffles, some deep pools. Bottom substrates were diverse with gravel, sand, boulder and silt present. In-stream cover included boulders and vegetation (emergent and submergent aquatic). The narrow deep channel present in this site is representative of the habitat present in the stream reach.
1	K	Stream noticeably much smaller, fairly uniform depths and velocities. One riffle/raceway with some decent habitat diversity. Bottom substrates were primarily sand/silt with boulders and cobble present throughout the riffle transects.
1	J	No riffle or raceway areas were observed. Fairly uniform depths and velocities. Relatively wide and deep channel present, not particularly diverse in terms of aquatic habitat. Bottom substrates were sand/silt. Some in-stream cover in the form of emergent aquatic vegetation.
1	I	Mostly raceway and pool habitat, some small boulder substrates present. Some large woody debris and cover.
1	H	Pools, riffles, and raceways present. Gravel and cobble riffles present, some large woody debris and cover, extremely highly eroded bank, some small boulder substrates.

[1] Earth Tech (1998)

TABLE 4-15

HABITAT PREFERENCE GUILDS FOR FISH[1]
Final Aquatic Impact Analysis Report

Habitat Guild	Velocity (cm/s)	Depth (cm)
Shallow Pool	<30	<60
Slow Riffle	30-59	<60
Fast Riffle	>=60	<60
Raceway	>=30	60-149
Medium Pool	<30	60-149
Deep Pool	<30	>150

[1] Aadland (1993)

TABLE 4-16

HABITAT CLASSIFICATIONS FOR VARIOUS SHEYENNE AND RED RIVER FISHES
Final Aquatic Impact Analysis Report

Pool			Riffle		Raceway
Shallow	**Medium**	**Deep**	**Slow**	**Fast**	
Sand shiner (C4)– A[1,2]	Common shiner (C1, C3)– J	Common shiner (C1, C3)– Y	Longnose dace (W)– Sp	Longnose dace (W)– A	Golden redhorse (C3)– A
Bluntnose minnow (C3) - Y	Common shiner (C1, C3)– A	White sucker (C1,4) – A	Common shiner (C1, C3)– Sp	Silver redhorse (SC3, 4, 5)– Sp	Shorthead redhorse (C3, 4)– A
Longnose dace (W)– Y	Golden redhorse (C3)– J	Silver redhorse (SC3, 4, 5)–	Sand shiner (C4)– Sp	Shorthead redhorse (C3, 4)– Sp	Shorthead redhorse (C3, 4)– J
Golden redhorse (C3)– Y	Channel catfish (C5)– A	Largemouth bass (W)– Y	Bluntnose minnow (C3, 4) – A	Stonecat (W)– J	Greater redhorse (SC3, 4)– A
Green sunfish (W)– Y	Channel catfish (C5)– J	Black crappie (W)– A	White sucker (C1,4) – J	Stonecat (W)– Y	Greater redhorse (SC3, 4)– J
Green sunfish (W)– A	Tadpole madtom (W)– Y	Black crappie (W)– Y	Shorthead redhorse (C3, 4) – Y	Logperch (Red)– A	Stonecat (W)– A
Orangespotted sunfish (W) –A	Northern pike (W)– A		Golden redhorse (C3)– Sp	Logperch (Red)- Y	Smallmouth bass (C3)– A
Bluegill (W)– J	Orangespotted sunfish (W)- J		Greater redhorse (SC3, 4)– Sp		Smallmouth bass (C3)– J
Bluegill (W)– Y	Largemouth bass (W)– J		Channel catfish (C5)– Y		Logperch (Red)- Sp
Smallmouth bass (C3)- Y	Black crappie (W)- J		Yellow perch (W)- A		
	White crappie (W)– A		Silver redhorse (SC3, 4, 5)– Y		
	White crappie (W)– J				
	White bass (W)– J				
	Yellow perch (W)– J				
	Walleye (W)– J				
	Walleye (W)– Y				
Black bullhead (C1)-Y[3]	Black bullhead (C1)-Sp, A	Freshwater drum (C5)-A	Spotfin shiner (C3, 4)-A	Rosyface shiner (SC3, 4, 5)-A, Sp	River darter (SC3)-A
Brook stickleback (C1)	Brook stickleback (C1)		Bigmouth shiner (C4)-A		
Creek chub (C1)-A	Creek chub (C1)-A		Creek chub (C1)-Sp		
Fathead minnow (C1)	Trout-perch (C1, SC1, 2, 3)-A	Trout-perch (C1, SC1, 2, 3)-A	Trout-perch (C1, SC1, 2, 3)-Sp		
Trout-perch (C1, SC1, 2, 3)-A	Fathead minnow (C1)		Blackside darter (C3)		
Johnny darter (C3)-A	Rosyface shiner (C3, SC3,4,5)-A, Sp		Johnny darter (C3)-A, Sp		
Hornyhead chub (SC3)-J	Hornyhead chub (SC3)-A		Hornyhead chub (SC3)-A		
Pugnose shiner (SC3)	Pugnose shiner (SC3)	Pugnose shiner (SC3)			
Blacknose shiner (SC3)	Banded killifish (SC3)				
Banded killifish (SC3)	Blacknose shiner (SC3)				

[1] Species (distribution)-life stage
Distribution-W=widely distributed, C#=common in Sheyenne River Reach #, SC#=special concern in Reach #
Life stage- A=adult, Sp=spawner, J=juvenile, Y=young of year

[2] Upper portion of table from Aadland (1993)

[3] Guilds assigned from habitat information in Plieger (1975), Becker (1983), Peterka and Koel (1996)

TABLE 5-1

SUMMARY OF SELECTED LITERATURE ON THE POTENTIAL IMPACTS OF ALTERED FLOW ON AQUATIC BIOTA
Final Aquatic Impact Analysis Report

Group	Effect	Reference
General	Increased magnitude of variation-wash-out and/or stranding, loss of sensitive species, life cycle disruption, altered energy flow.	Poff *et al.* 1997
	Prolonged low flow-concentration of aquatic organisms.	
	Prolonged inundation-loss of riffle habitat.	
Fish	Alterations in natural flow regime, decreased richness, diversity, and abundance of fish species inhabiting shallow water areas, particularly fluvial specialists.	Travnichek and Maceina 1994
	Frequent and large fluctuations in river discharge below hydroelectric dams impairs the function of shallow, nearshore waters as fish habitat.	Bain *et al.* 1988
	Enhancements in the flow regime below a hydroelectric facility resulted in increased fish species richness and an increase in the relative abundance of fluvial specialists.	Travnichek *et al.* 1995
	Flow regulation reduced larval fish abundance in nursery habitat, altered taxonomic composition, and disrupted microhabitat relations.	Scheidegger and Bain 1995
	Documented macroinvertebrate and fish stranding resulting from operation of a hydropeaking facility. Predicted that stranding limited fish production.	Kroger 1973
	Increased ramping rates trapped increasing numbers of salmonids in off-channel pools. Stranding was influenced by seasonal (water temperature) and diurnal patterns.	Bradford 1997
	Increased ramping rates resulted in increased numbers of stranded salmonids. Addition of off-channel pools increased the stranding rate of rainbow trout.	Bradford *et al.* 1995
	Reduced ramping rates (70 m^3/sec – 30 m^3/sec over 2.5 hours) caused a decrease in the number of stranded salmonids. Incidence of stranding increased in winter and during daytime hours.	Saltviet *et al.* 2001
	Stranding rate of larval warmwater fishes was not related to drawdown rates, but bottom orientation and positive rheotaxis contributed to increased rates of stranding.	Adams *et al.* 1999
	Flow fluctuations caused by a hydropeaking facility resulted in large losses of 0+ salmon and trout.	Hvidsten 1985
	Pulsed, high water-velocities, similar to those that occur during hydropower generation, caused depressed growth and survival of larval suckers.	Weyers *et al.* 2001
	Reduced species richness in larval fish samples collected below a hydropeaking facility suggested that tailwater populations of adult fishes are maintained by immigration.	Farmer and Layzer 2001
	Discharges from a hydropeaking facility reduced YOY brown trout survival. Reduced peaking flows during the brown trout emergence period increased YOY density and persistence.	Leibig *et al.* 1999
Unionids	Decline of mussel species attributed to stream bed scour and dewatering caused by fluctuating flows below hydroelectric facilities.	Layzer *et al.* 1993
	Unnaturally high discharges in spring and summer caused by releases from hydroelectric facilities result in high shear forces on mussel beds when juvenile excystment is expected and may be a major factor limiting recruitment of some mussel species.	Hardison and Layzer 2001
	High shear stress limits mussel recruitment. Spates during or shortly after juvenile settlement may cause loss of juvenile mussels.	Layzer and Madison 1995
	Persistent mussel beds occur in flow refugia where shear stress is low, explaining the patchiness of unionid populations.	Strayer 1999; Vannote and Minshall 1982
	Increased flow reduces availability of stabilized sediments, sand bars, and low flow areas, all preferred unionid habitats.	McMahon (in Thorp and Covich 1991)
	Bivalve growth, reproduction and other important life history may be driven in part by seasonal water level variation.	McMahon (in Thorp and Covich 1991)
	Reduced flow may decrease fertilization success.	Fuller (in Fuller and Hart 1974)
	Prolonged aerial exposure during low flow.	Cvancara 1967, 1983; Layzer *et al.* 1993
Sphaeriids	Adapted to predictably unstable environments.	McMahon (in Thorp and Covich 1991)
	Tolerant, however, tendency to occupy shallow water, highly susceptible to declines in water level.	Fuller (in Fuller and Hart 1974)
	Prefer low flow areas with sediment and organic debris accumulation, increased flow may be detrimental.	McMahon (in Thorp and Covich 1991)
Gastropods	Flushing with ephemerally large flows.	Harman (in Fuller and Hart 1974)
Prosobranchs	Adapted to more stable environments, seldom in ephemeral environments.	McMahon (in Thorp and Covich 1991); Harman (in Fuller and Hart 1974)
	Winter kills have been observed in several species.	Harman (in Fuller and Hart 1974)
Pulmonates	Adapted to unstable environments.	McMahon (in Thorp and Covich 1991)
	Adapted to tolerate a wide range in temperature, resistant to desiccation.	Brown (in Thorp and Covich 1991)
	Stagnicola elodes move into shallower water in winter, could be stranded when flow reduced.	Brown (in Thorp and Covich 1991)
	Most move into deeper water in winter.	Brown (in Thorp and Covich 1991)
	May burrow into substratum in winter.	Brown (in Thorp and Covich 1991)
Invertebrates	Observed reduced diversity and abundance of swift water insects below a hydropeaking facility.	Trotzky and Gregory 1974
	Observed reduced macroinvertebrate diversity below a hydroelectric peaking facility relative to a non-impacted upstream site.	Valentin *et al.* 1995
	Increased flow variability from a hydroelectric facility, particularly the largest daily increase, was correlated with reduced macroinvertebrate species richness and abundance.	Englund and Malmqvist 1996
	Regulated but unreduced flow decreased abundances of predators and collectors.	Englund and Malmqvist 1996
	Increased flow decreases variability but also expands habitable area and thus production of invertebrates.	Englund and Malmqvist 1996
	No negative effect when flow increase is less than largest natural unregulated flow, single extreme events are critical.	Englund and Malmqvist 1996
	Shallow habitat benthic macroinvertebrate production was limited by flow fluctuations associated with a hydropeaking facility. The permanently submerged channel supported a four-fold higher macroinvertebrate density than the varial zone exposed to flow fluctuations.	Blinn *et al.* 1995
	High flow scoured bottom and dislodged biota.	Gislason 1985
	Observed increases in macroinvertebrate density following a switch from hydropeaking regulated flows to a natural flow regime.	Gislason 1985
	Reduction in the duration of low and high flow extremes from a hydropeaking facility resulted in a doubling of macroinvertebrate density and an improved biotic index.	Morgan *et al.* 1991
	Observed reduced macroinvertebrate biomass below a hydropeaking facility.	Moog 1993
	Observed flushing of animals not adapted to high current velocities below a hydropeaking facility.	Moog 1993
	Flow surge altered invertebrate behavior, invertebrates did not seek shelter, possibly due to lack of groundwater cues.	Moog 1993
	Flow surge increases invertebrate drift and erratic movement of invertebrates at the beginning and recession of flow.	Moog 1993
	Enhanced flow regime below a hydroelectric facility, including a reduced difference in base and peak flow, resulted in benthic macroinvertebrate recovery. Lack of recovery of effect on fish biomass was attributed to an unaltered ramping rate.	Parsiewicz *et al.* 1998
	Macroinvertebrate density declined three orders of magnitude following cessation of minimum flows. Dewatering was implicated as the primary mechanism.	Weisberg *et al.* 1990
	Discontinuities in flow disrupt natural cycles of drift and feeding.	Weisberg *et al.* 1990
	Gammarus fasciatus (Amphipoda) decreased in abundance with minimum flow maintainence.	Weisberg *et al.* 1990
	Chironomidae and Hydropsychidae increased in abundance with minimum flow requirements.	Weisberg *et al.* 1990
	Documented macroinvertebrate and fish stranding resulting from operation of a hydropeaking facility. Predicted that stranding limited fish production.	Kroger 1973
	Increases in flow rate caused increased macroinvertebrate drift, but the level of drift did not increase with higher flow rate increases as expected.	Irvine and Henriques 1984
	Initial increases in stream flow following a period of stable flows had a greater effect on macroinvertebrate drift than subsequent increases.	Irvine 1985
	Fluctuating flows associated with hydropeaking caused reductions in the number of benthic macroinvertebrate taxa, changes in the abundance of individual taxa, and reductions in the abundance of some specialized functional groups (i.e., scrapers and collector-filterers).	Troelstrup and Hergenrader 1990
	Benthic invertebrate communities in areas periodically exposed by flow fluctuations associated with hydroelectric generation were lower in density and diversity than communities in continuously flooded areas.	Risher and LaVoy 1972
	Sudden changes in current velocity increases invertebrate drift.	DeJalon *et al.* 1994
Algae	Increased algal scour and wash-out of organic matter with increased flow.	Poff *et al.* 1997
Periphyton	Regulated flow had no noticeable effect on periphyton diatoms.	Growns and Growns 2000
	Increased flow dilutes nutrients, reducing nitrogen mobilization via oxidation, and increasing competition with vascular plants.	Adamus 1990
Phytoplankton	Increased flow dilutes nutrients, reducing nitrogen mobilization via oxidation, and increasing competition with vascular plants.	Adamus 1990
Macrophytes	Growth, morphology, and reproduction all influenced by water level and flow variation.	Rogers and Theiling 1999; Merritt and Cooper 2000
	Regular flooding may increase overall plant diversity through competition.	Keddy *et al.* 1986
	Exposure of submerged beds, freezing and desiccation of exposed plants during reduced flow.	Rogers and Theiling 1999
	Physical removal due to scour, uprooting of mature plants during prolonged increase flow.	Rogers and Theiling 1999; Langrehr and Dukerschein 1994
	Decreased production of submerged macrophytes due to reduced light penetration at greater depth.	Rogers and Theiling 1999; Langrehr and Dukerschein 1994
	Loss of flood intolerant emergent and fringe species due to decreased light, oxygen, and toxic soil conditions.	Whitlow and Harris 1979
	Wetland fringe species may survive temporary flooding.	Whitlow and Harris 1979

TABLE 5-2

PREDICTED CHANGES IN HYDROLOGICAL PARAMETERS WITH PUMPING AND OVERFLOW
Final Aquatic Impact Analysis Report

Group	Parameter	Expected Change With Pumping And Overflow[1]
Magnitude	Mean monthly flow	Winter-No change (300MOD50) to double (WETOF)
		Spring-No change (300MOD50) to slight increase (WETOF)
		Summer-Increase
		Fall-Increase
	Variation in monthly flow	Winter-Slight (300MOD50) to high increase (WETOF)
		Spring-No change
		Summer-No change (300MOD50) to decrease (480MOD55 and WETOF)
		Fall-No change (300MOD50) to decrease (480MOD55 and WETOF)
	Mean low flow	Slight increase (300MOD50) to greater than double (WETOF)
	Mean high flow	No change (300MOD50) to slight change (WETOF)
	Variation in low flow	None (300MOD50) to slight increase (WETOF)
	Variation in high flow	None (300MOD50) to slight increase (WETOF)
Timing	Mean date of minimum	Decrease (300MOD50, 480MOD55), increase (WETOF)
	Mean date of maximum	No change
	Variation in date of minimum	None (300MOD50) to slight increase (WETOF)
	Variation in date of maximum	None
Frequency	Mean low pulse count	Decrease
	Mean low pulse duration	Slight increase (300MOD50, 480MOD55), to slight decrease (WETOF)
	Mean high pulse count	None to slight increase
	Mean high pulse duration	None to slight decrease
	Variation in low pulse count	Decrease
	Variation in low pulse duration	Increase (300MOD50, 480MOD55), decrease (WETOF)
	Variation in high pulse count	Increase
	Variation in high pulse duration	Increase (300MOD50, 480MOD55), no change (WETOF)
Rate of change	Mean rise rate	No change
	Mean fall rate	No change
	Mean number of reversals	Decrease
	Variation in rise rate	No change
	Variation in fall rate	No change
	Variation in number of reversals	No change to decrease

[1] Appendix I and J

TABLE 5-3

SUMMARY OF SELECTED LITERATURE ON THE POTENTIAL IMPACTS OF BIOTIC INTERACTION ON AQUATIC BIOTA
Final Aquatic Impact Analysis Report

Group	Effect on	Effect	Reference
Fish	Unionids	Species composition affects unionid community composition through host fish relationship.	Fuller (in Fuller and Hart 1974)
Invertebrates	Fish	Many of the Red River Basin fish are insectivores or omnivores, and changes in the abundance or composition of the macroinvertebrate community likely would affect various fish species.	Ohio EPA 1987; Lyons 1992
Algae	Invertebrates	Erosion of periphyton diminishes food source.	Moog 1993
Algae	Unionids	Decreased or increased food supply.	Fuller (in Fuller and Hart 1974)
Algae	Sphaeriids	Increased or decreased productivity which affects growth, affects maturation, and death which are size not age dependent.	McMahon (in Thorp and Covich 1991)
Algae	Gastropods	Types of available food may affect vigor.	Harman (in Fuller and Hart 1974)
		Green algae preferred, blue-green algae toxic.	Brown (in Thorp and Covich 1991)
		Many species are adapted to and prefer macrophyte or algae species-change would change species composition.	Brown (in Thorp and Covich 1991)
		Availability of micronutrients in periphyton effects population size.	Brown (in Thorp and Covich 1991)
Algae	Macrophytes	High algal abundance or blooms may limit light penetration and photosynthesis.	Rogers 1994
		Algae may shade out and outcompete macrophytes at high density.	Rogers and Theiling 1999
		Used for substrate for epiphytic algae.	Murkin *et al.* 1991
		Mediate the levels of nutrients, contaminants, and oxygen across benthic and plant surfaces.	Adamus 1996
		Can reduce dissolved oxygen levels through decomposition.	Adamus 1996
Phytoplankton	Invertebrates	Consumed by filter feeding invertebrates (Hydropsychidae, Simuliidae).	Pennak 1978; Merritt and Cummins 1994
		Consumed by many zooplankton species (Cladocera, Copepoda).	Leland and Berkus 1998
		Can reduce dissolved oxygen levels through decomposition.	Adamus 1996
Periphyton	Invertebrates	Consumed by grazing invertebrates (Baetidae, Glossosomatidae).	Pennak 1978; Merritt and Cummins 1994
		Can reduce dissolved oxygen levels through decomposition.	Adamus 1996
Chlorophyta	Fish	Consumed by young-of-year fish, and other small species.	Adamus 1996
		Can reduce dissolved oxygen levels through decomposition.	Adamus 1996
Phytoplankton	Mollusks	Filtered and used as a major food resource for Unionid and Sphaerid mussels.	Adamus 1996
		Many cyanophyta are toxic to mussels.	Adamus 1996
		Can reduce dissolved oxygen levels through decomposition.	Adamus 1996
Periphyton	Mollusks	Grazed by gastropods as a significant food resource.	Adamus 1996
		Periphytic species often use exposed shells and hard substrate for growth.	Adamus 1996
		Can reduce dissolved oxygen levels through decomposition.	Adamus 1996
Macrophytes	Fish	Emergent, submergent, and wetland fringe macrophytes provide shelter and cover for young and spawing fish.	Crowder and Cooper 1982; Junk *et al.* 1989; Holland and Huston 1984
		Submergent and emergent macrophytes provide food resource as leaves or fleshy tubers and roots for many species.	Raibley *et al.* 1995; Junk *et al.* 1989
		Wetland fringe vegetation provides spawning habitat during flooding.	Junk *et al* 1989; Johnson *et al.* 1995
		Provide refugia for invertebrates and forage fish.	Koel 1993
Macrophytes	Invertebrates	Submerged, emergent, and wetland fringe macrophytes provide substrate and food resources.	Pennak 1978; Merritt and Cummins 1994
		Erosion of macrophytes diminishes food source.	Moog 1993
		Reduction of biomass reduced relative abundance of scrappers.	DeJalon *et al.* 1994
Macrophytes	Gastropods	Macrophytes are used as substrate and forage for some gastropods.	Smith 2001, Pennak 1978, Fuller 1974
		Die offs in macrophytes due to disturbance, affects gastropod abundance and diversity.	Brown (in Thorp and Covich 1991)
Macrophytes	Algae	Submerged, emergent, and wetland fringe macrophytes provide substrate for epiphytic species.	Murkin *et al.* 1994, Cronk and Mitsch 1994
		Emergent and submergent macrophytes can collect and capture nutrients and limit algal abundance.	Mulholland *et al* 1991

TABLE 5-4

EXPECTED GEOMORPHOLOGY CHANGES AND POSSIBLE ENVIRONMENTAL RESPONSES
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Parameter	Expected change[1]	Possible environmental response
Channel forming flows		
1.5 yr flood level	Slight increase	increased erosion and deposition
2 yr flood level	Slight increase	increased erosion and deposition
% of events exceeding baseline channel forming flow	Increase	increased erosion and deposition
Channel geometry		
Change in width	No change to slight increase	increased erosion and deposition
Change in depth	No change to slight increase	increased erosion and deposition
Change in slope	Slight decrease in most areas	increased erosion and deposition
Channel planform		
Change in meander length	Slight increase	increased erosion and deposition
Change in meander amplitude	Slight increase	increased erosion and deposition

[1] See Tables 4-11 and 4-12

TABLE 5-5

SUMMARY OF SELECTED LITERATURE ON THE POTENTIAL IMPACTS OF EROSION AND DEPOSITION ON AQUATIC BIOTA
Final Aquatic Impacts Analysis Report

Group	Effect	Reference
Fish	Burying of clean, hard substrates will eliminate or greatly reduce the area available to species that need such areas for spawning (i.e., simple lithophiles). Likewise, species that feed in or over such substrates would likely be reduced.	Ohio EPA 1987; Lyons 1992
	Erosion and siltation would not likely effect species with feeding or reproductive strategies that allow them to prosper in all but the most severe cases of siltation (bluntnose minnow, fathead minnow, green sunfish).	Ohio EPA 1987; Lyons 1993
Unionids	Results in unstable substrate, not conducive to unionids.	Fuller (in Fuller and Hart 1974); McMahon (in Thorp and Covich 1991)
	Siltation can smother and starve (both food and oxygen).	McMahon (in Thorp and Covich 1991)
Sphaeriids	Prefer finer particles than unionids, prefers low flow habitat with silty sediment.	McMahon (in Thorp and Covich 1991)
Gastropods	Relationship between substrate and number of snail species.	Harman (in Fuller and Hart 1974)
	Egg development curtailed if covered in silt.	Harman (in Fuller and Hart 1974)
	Substrate availability, second only to dispersal ability in determining snail abundance, and diversity.	Brown (in Thorp and Covich 1991)
Invertebrates	Change in benthic composition due to redistribution of substrate.	Moog 1993
	Reduced heterogeneity of river bottom leads to decrease in invertebrate diversity.	DeJalon *et al.* 1994
	Increased sedimentation reduced density of two filter feeders and increased density of one filter feeder.	Kohlhepp and Hellenthal 1992
	Increased sedimentation increased density of five of six gatherer/collector species.	Kohlhepp and Hellenthal 1992
	Increased sedimentation reduced density of two shredders, and increased density of one shedder.	Kohlhepp and Hellenthal 1992
Phytoplankton	Less affected by turbidity than benthic species.	Adamus 2001
	Very little effect from sedimentation.	Adamus 2001
Periphyton	Affected greatly by increased turbidity.	Adamus 2001
	Can be greatly affected by sedimentation.	Adamus 2001
	Turbidity is habitat limiting.	Leland and Berkas 1998
Macrophytes	Loss or gain of suitable habitat for submerged, emergent, and wetland fringe.	Rogers and Theiling 1999; Fischer and Claflin 1995
	Siltation can cover leaves and reduce production of submergent macrophytes.	Rogers and Theiling 1999; Sparks *et al.*
	Suitable habitat for submergent and emergent macrophytes may be smothered, difficult to establish in shifting substrate.	Rogers and Theiling 1999
	Stands of submerged and emergent vegetation may trap and collect sediment, alter erosional patterns.	Rogers and Theiling 1999
	Less erosion control from wetland fringe macrophytes on vegetated banks.	Rogers and Theiling 1999
	Habitat limited by exposure of beds, erosion and removal of stable habitat.	Peck and Smart 1986; Rogers and Theiling 1999; Sparks *et al.* 1990
	Sensitive to sediment accumulation and resuspension.	Rogers and Theiling 1999
	Increased turbidity favors emergent vegetation over submerged.	Hough and Forwall 1988
	Agradation may create additional shallow water habitat for emergent macrophytes.	Eckbald 1977

TABLE 5-6

RED AND SHEYENNE RIVER BIOTA SENSITIVITY TO SCOURING AND EROSION
Final Aquatic Impact Analysis Report

	Minor scouring[2]	Major scouring[2]	Minor deposition[3]	Major deposition[3]
Fish[1]				
Sensitive (simple lithophils)	*	Decreased spawning success	Decreased spawning success	Decreased spawning success
Common shiner				
Emerald shiner				
River shiner				
Rosyface shiner (SC1)				
Blacknose dace				
Longnose dace				
White sucker				
Silver redhorse				
Golden redhorse				
Shorthead redhorse				
Greater redhorse				
Burbot				
Logperch				
Blackside darter				
River darter				
Sauger				
Walleye				
Obliquate riffle dwellers		Loss of food and cover		Loss of food and cover
Stonecat				
Longnose dace				
Turbidity intolerant		Untolerable turbidity levels		
Mooneye				
Brassy minnow				
Hornyhead chub				
Pugnose shiner				
Bigmouth shiner				
Blackchin shiner				
Blacknose shiner				
Rosyface shiner				
Golden redhorse				
Shorthead redhorse				
Greater redhorse				
Stonecat				
Rock bass				
Logperch				
Weed bed dwellers		Loss of spawning beds/cover		Loss of spawning beds/cover
Northern pike				
Pugnose shiner				
Blackchin shiner				
Blacknose shiner				
Banded killifish				
Brook stickleback				
Rock bass				
Mollusks				
Unionidae-Lampsilinae/Ambleminae	Increase available habitat	Decreased available habitat	No effect	Decreased available habitat
Unionidae-Anodontinae	Decrease available habitat	Decrease available habitat	Increase available habitat	Decreased available habitat
Sphaeriidae	Decrease available habitat	Decrease available habitat	Increase available habitat	Decreased available habitat
Prosobranchs	Increase available habitat	Decreased available habitat	No effect	Decreased available habitat
Pulmonates	Decreased available habitat	Decreased available habitat	Increase available habitat	No effect
Invertebrates				
Lotic or Erosional	Increase available habitat	Decrease available habitat/increase drift	Variable	Decrease available habitat
Stenelmis (Elmidae)				
Tanytarsini (Chironomidae)				
Stenacron (Ephemeroptera)				
Hydropsychidae (Tricoptera)				
Woody debris, macrophytes	No effect	Decrease available habitat/increase drift	No effect	Decrease available habitat
Hyllela azteca				
Dubiraphia (Elmidae)				
Macronychus (Elmidae)				
Nectopsyche (Tricoptera)				
Depositional	Decrease available habitat	Decrease available habitat	Increase available habitat	Increase available habitat (in some cases)
Chironomini (Chironomidae)				
Labiobaetis (Ephemeroptera)				
Caenis (Ephemeroptera)				
Stenonema (Ephemeroptera)				
Hexagenia (Ephemeroptera)				
Pentagenia (Ephemeroptera)				
Corixidae (Hemiptera)				
Periphyton	Increase benthic periphyton habitat	Loss of some attached algae and epiphytes	No effect	Algae buried
Macrophytes	No effect	Loss of macrophytes	No effect	Macrophytes buried

[1] see Table 4-4.
[2] Minor scouring would be scouring flows that reduced deposition of fine material.
Major scouring would be flows that depleted all fine material
[3] Fine material deposition that would not smother unionids, invertebrates, or fish eggs.
Deposition of coarser substrates that would result in unstable substrate, or would bury aquatic biota
* Blanks are left when insufficient information is available to determine effects

TABLE 5-7

SUMMARY OF SELECTED LITERATURE ON THE POTENTIAL IMPACTS OF HABITAT CHANGE ON AQUATIC BIOTA
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Group	Effect	Reference
Fish	Persistence of native fishes in flow regulated systems depends on the seasonal occurrence of stable habitat conditions that facilitate reproduction and YOY survival.	Freeman *et al.* 2001
	Juvenile fish abundances were strongly associated with flow and instream habitat variables. Juvenile abundances at the unregulated site were strongly correlated with average habitat availability and persistence, as well as peak flow. In contrast, the temporal sequence of flows appeared more important than habitat availability or flow extremes to YOY abundances in the hydropeaking regime.	Freeman *et al.* 2001
	Persistence of shallow water habitats was only compared to unregulated site conditions during summer. The fish assemblage at the flow regulated site was dominated numerically by species capable of spawning during the summer. All common spring spawning species were less abundant at the flow regulated site than at the unregulated site.	Freeman *et al.* 2001
	Increased abundance of percids, catostomids, and cyprinids was associated with persistence of shallow and slow-water habitats.	Bowen *et al.* 1998
	Hydropeaking dam operation reduced shallow-water habitat persistence and reduced year-to-year variation in the persistence of shallow water habitats.	Bowen *et al.* 1998
	The proportion of percids in collections was negatively correlated with the median availability of deep-fast habitat during spring and summer. The inverse relationship between relative abundance of percids and unit area of deep-fast habitat during spring and summer may represent habitat limitations for successful reproduction by percids.	Bowen *et al.* 1998
	Lower proportions of catostomids at regulated sites compared with the unregulated sites could also represent habitat limitations because of reduced short-term persistence of shallow-water habitats during spring and summer.	Bowen *et al.* 1998
	Alterations in natural flow regime decreased richness, diversity, and abundance of fish species inhabiting shallow water areas, particularly fluvial specialists.	Travnichek and Maceina 1994
	Species richness and diversity in shallow water habitats did not increase in a progressive manner as observed in deep-water collections or reported in other studies. The absence of a change was due to the lack of fluvial specialists at several of the regulated sites.	Travnichek and Maceina 1994
	Flow regulation affects species obligate to riverine environments more than species that can inhabit a wide range of environments.	Travnichek and Maceina 1994
	Relative abundance and catch rates of riverine habitat generalist species differed among the sites examined in relation to flow regulation and physiography. Centrarchids were present in a higher proportion for flow regulated streams. Catch rates for riverine catastomids classified as fluvial specialists was greater in unregulated streams than regulated streams.	Travnichek and Maceina 1994
	Balanced fish communities require a variety of substrates ranging from fine material to boulder size rock. Within this substrate continuum, there are generalists (e.g., creek chub and bluntnose minnow) that can utilize a wide variety of habitats and specialists (e.g., longnose dace and stonecat) that have very narrow substrate requirements.	Rankin 1989
Unionids	Most species require stable substrate and moderate current, shallow depths.	McMahon 1991, Johnson 1995
	Habitat limited by low discharge, low velocity, shallow depths, and loss of wetted area.	Johnson 1995
Sphaeriids	Prefer shallower depths.	McMahon (in Thorp and Covich 1991)
	Although most sphaeriids occur in unstable habitats, harsh conditions are predictable.	McMahon (in Thorp and Covich 1991)
	Increased homogeneity and stability of habitat may lead to reduced diversity.	Harman (in Fuller and Hart 1974)
Pulmonates	Slow silty habitats.	Harman (in Fuller and Hart 1974)
Prosobranchs	Fast currents dominated by limpets or prosobranch grazers.	Harman (in Fuller and Hart 1974)
	Slow silty habitats, prosobranch detrivores.	Harman (in Fuller and Hart 1974)
Phytoplankton	Taxa dramatically different in lentic and lotic systems.	
	Reservoirs influence species composition and can produce "lake-like" taxa in riverine systems.	Phillips *et al.* 2000
	Turbidity is habitat limiting.	Leland and Berkas 1998
Periphyton	Reservoirs influence species composition and can produce "lake-like" taxa in riverine systems.	Phillips *et al.* 2000
	Turbidity is habitat limiting.	Leland and Berkas 1998
Macrophytes	Most submergent species require stable substrate, moderate current, stable depth.	Peck and Smart 1986; Bhowmik and Adams 1989
	Most emergent species require stable substrate, moderate current, and shallow depths for most of growing season.	Peck and Smart 1986; Bhowmik and Adams 1989
	Wetland fringe species prefer shallow depths for only early part of season.	Whitlow and Harris 1979; Bhowmik and Adams 1989
	Habitat limited by exposure of beds, erosion and removal of stable habitat.	Peck and Smart 1986; Rogers and Theiling 1999; Sparks *et al.* 1990
	Wetland fringe species may survive temporary flooding.	Whitlow and Harris 1979

TABLE 5-8

FEEDING GUILDS, HABITAT PREFERENCES, AND GENERAL TOLERANCE TO DISTURBANCE FOR ABUNDANT SHEYENNE RIVER INVERTEBRATE TAXA
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Order (Family)	Representative Species/Group	Feeding Guild[1, 2]	Habit[1]	Habitat[1, 2]	General Tolerance[2]
Amphipoda	*Hyallela azteca*	Omnivores		Macrophytes, debris	Tolerant (8)
Coleoptera (Elmidae)	*Dubiraphia sp.*	Gatherer/collector	Clingers, climbers	Macrophytes	Intermediate (4-6)
	Macronychus sp.	Gatherer/detrivore	Clingers	Woody debris	Intolerant (3-5)
	Stenelmis sp.	Gatherer/collector/scraper	Clingers	Coarse sediment, detritus	Intermediate (3-7)
Diptera (Chironomidae)	*Chironomini*	Gatherer/collector	Burrowers	Depositional	Intermediate (6)
	Tanytarsini	Gatherer/collector/filterer	Burrowers or clingers	Erosional/depositional	Intermediate (6)
	Orthocladinae	Gatherer/collector/scraper	Burrowers	Lotic	Intermediate (5)
	Tanypodinae	Predator	Sprawlers, swimmers	All habitat types	Tolerant (7)
Ephemeroptera	*Baetis sp.*	Gatherer/collector/scraper	Swimmers, climbers, clingers	Erosional/depositional	Intermediate (3-6)
	Labiobaetis sp.	Gatherer/collector	Swimmers, clingers	Depositional	Intermediate (6)
	Caenis sp.	Gatherer/collector/scraper	Sprawlers, climbers	Depositional	Tolerant (7)
	Stenonema sp.	Gatherer/collector/scraper	Clingers (under loose stones)	Erosional/depositional	Intolerant (2-4)
	Stenacron sp.	Gatherer/collector/scraper	Clingers	Erosional	Intolerant (3-4)
	Hexagenia sp	Gatherer/collector	Burrowers	Depositional	Intolerant (3)
	Pentagenia sp.	Gatherer/collector	Burrowers	Depositional	
Hemiptera (Corixidae)	*Sigara sp.*	Predators/gatherer/collector	Swimmers, climbers	Depositional	Tolerant (9)
	Tricorixa sp.	Predators	Swimmers, climbers	Lentic	Intermediate (5)
Tricoptera (Hydropsychidae)	*Ceratopsyche sp.*	Collectors/filterers	Clingers (net spinners)	Erosional	Intolerant (1-5)
	Cheumatopsyche sp.	Collectors/filterers	Clingers (net spinners)	Erosional	Intermediate (3-7)
	Hydropsychyche sp.	Collectors/filterers	Clingers (net spinners)	Erosional	Various (2-8)

[1]Merritt and Cummins 1996

[2] Barbour *et al.* 1999

TABLE 5-9

PERCENT CHANGE[1] IN AVERAGE, MINIMUM, AND MAXIMUM TDS, SULFATE, AND CHLORIDE EXPECTED IN THE SHEYENNE AND RED RIVERS WITH 300MOD50 COMPARED TO MOD50

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	Sheyenne River				Red River		
	Reach 1	**Reach 3**	**Reach 3**	**Reach 5**	**Reach 1**	**Reach 2**	**Reach 3**
	Cooperstown	**Baldhill**	**Lisbon**	**Kindred**	**Halstad**	**Grand Forks**	**Emerson**
TDS (mg/l)							
Min	0.0	5.1	4.8	4.9	2.0	0.9	0.5
Max	26.0	36.6	12.2	9.0	14.4	2.1	3.7
Ave	29.7	32.4	20.6	16.0	5.0	2.8	2.0
% greater than guideline	5.2	128.0	44.8	31.4	410.3		4960.0
Sulfate (mg/l)							
Min	0.1	10.8	9.8	9.9	5.5	4.1	9.4
Max	96.4	80.8	41.1	27.3	16.5	18.9	2.2
Ave	68.9	63.4	45.3	32.1	12.1	7.4	5.2
% greater than guideline	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chloride (mg/l)							
Min	0.4	4.7		14.9	8.9	4.0	1.4
Max	200.4	174.7		46.0	1.5	7.4	0.7
Ave	140.9	134.9		64.2	11.6	8.8	4.1
% greater than guideline	0.0	0.0	0.0	0.0	0.0	0.0	0.0

[1] 300MOD50-MOD50/MOD50 *100 (see Table 5-10)

TABLE 5-10

AVERAGE, MINIMUM, AND MAXIMUM TDS, SULFATE, AND CHLORIDE EXPECTED[1] IN THE SHEYENNE AND RED RIVERS WITH 300MOD50 COMPARED TO MOD50

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MOD50

	Sheyenne River				Red River		
	Reach 1	**Reach 3**	**Reach 3**	**Reach 5**	**Reach 1**	**Reach 2**	**Reach 3**
	Cooperstown	**Baldhill**	**Lisbon**	**Kindred**	**Halstad**	**Grand Forks**	**Emerson**
TDS (mg/l)							
Min	211.4	256.4	254.8	258.3	305.3	266.6	290.2
Max	878.3	631.0	793.0	799.7	550.6	466.8	603.8
Ave	606.3	479.4	540.9	543.8	411.6	350.9	424.1
Guideline	500	500	500	500	500	500	500
% greater than guideline	83.2	40.3	63.3	67.2	1.9	0.0	0.3
Sulfate (mg/l)							
Min	35.4	70.1	73.0	74.0	63.9	41.1	45.7
Max	218.4	168.0	201.6	207.5	156.0	107.3	160.4
Ave	149.8	128.5	133.8	145.1	90.1	70.1	86.4
Standard	450	450	450	450	250	250	250
% greater than standard	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chloride (mg/l)							
Min	4.9	7.5		7.7	9.5	6.8	8.5
Max	26.5	18.0		29.0	39.5	25.9	58.1
Ave	16.5	13.2		16.0	18.9	12.1	21.1
Standard	100	100		100	100	100	100
% greater than standard	0	0.0		0.0	0.0	0.0	0.0

300MOD50

	Sheyenne River				Red River		
	Reach 1	**Reach 3**	**Reach 3**	**Reach 5**	**Reach 1**	**Reach 2**	**Reach 3**
	Cooperstown	**Baldhill**	**Lisbon**	**Kindred**	**Halstad**	**Grand Forks**	**Emerson**
TDS (mg/l)							
Min	211.4	269.5	266.9	270.9	311.5	269.0	291.6
Max	1106.5	862.0	890.0	871.9	629.6	476.6	626.0
Ave	786.3	634.6	652.5	630.6	432.2	360.9	432.4
Guideline	500	500	500	500	500	500	500
% greater than guideline	87.5	91.9	91.6	88.4	9.5	0.0	13.9
Sulfate (mg/l)							
Min	35.5	77.6	80.1	81.3	67.4	42.8	50.0
Max	429.0	303.7	284.4	264.2	181.7	127.7	163.9
Ave	253.0	209.9	194.4	191.7	101.0	75.3	90.9
Standard	450	450	450	450	250	250	250
% greater than standard	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chloride (mg/l)							
Min	4.9	7.8		8.9	10.4	7.1	8.6
Max	79.6	49.5		42.3	40.1	27.8	58.5
Ave	39.8	31.0		26.3	21.1	13.1	22.0
Standard	100	100		100	100	100	100
% greater than standard	0.0	0.0		0.0	0.0	0.0	0.0

[1] HEC-5 Data File: Moderate Future Max Elev 1450 Base Condition and 300 constrained cfs HEC-5Q Data File: Q5P50W48.DAT

TABLE 5-11

SUMMARY OF THE EFFECTS OF WATER QUALITY CHANGES EXPECTED WITH 300MOD50 COMPARED TO MOD50 ON AQUATIC BIOTA
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	TDS	Sulfate	Chloride	Total water quality
Sheyenne River Reach 1				
Sensitive fish	No effect[1]	No effect	No effect	No effect
Tolerant fish	No effect	No effect	No effect	No effect
Sensitive mollusks	No effect	No effect	No effect	No effect
Tolerant mollusks	No effect	No effect	No effect	No effect
Sensitive invertebrates	No effect	Some decrease in abundance/richness	Decrease in abundance/richness	Decrease in abundance/richness
Tolerant invertebrates	No effect	No effect	No effect	Increase in abundance/richness (?)
Sensitive algae/periphyton	No effect	Decrease in abundance	Decrease in abundance	Decrease in abundance/richness
Tolerant algae/periphyton	No effect	Increase in abundance	Increase in abundance	Increase in abundance/richness
Sensitive macrophytes	No effect	No effect	No effect	No effect
Tolerant macrophytes	No effect	No effect	No effect	No effect
Sheyenne River Reach 2				
Sensitive fish	No effect	No effect	No effect	No effect
Tolerant fish	No effect	No effect	No effect	No effect
Sensitive mollusks	No effect	No effect	No effect	No effect
Tolerant mollusks	No effect	No effect	No effect	No effect
Sensitive invertebrates	No effect	No effect	No effect	No effect
Tolerant invertebrates	No effect	No effect	No effect	No effect
Sensitive algae/periphyton	No effect	No effect	No effect	No effect
Tolerant algae/periphyton	No effect	No effect	No effect	No effect
Sensitive macrophytes	No effect	No effect	No effect	No effect
Tolerant macrophytes	No effect	No effect	No effect	No effect
Sheyenne River Reach 3				
Sensitive fish	No effect	No effect	No effect	No effect
Tolerant fish	No effect	No effect	No effect	No effect
Sensitive mollusks	No effect	No effect	No effect	No effect
Tolerant mollusks	No effect	No effect	No effect	No effect
Sensitive invertebrates	No effect	No effect	Some decrease in abundance/richness	Some decrease in abundance/richness
Tolerant invertebrates	No effect	No effect	No effect	No effect
Sensitive algae/periphyton	No effect	No effect	No effect	No effect
Tolerant algae/periphyton	No effect	No effect	No effect	No effect
Sensitive macrophytes	No effect	No effect	No effect	No effect
Tolerant macrophytes	No effect	No effect	No effect	No effect
Sheyenne River Reach 4				
Sensitive fish	No effect	No effect	No effect	No effect
Tolerant fish	No effect	No effect	No effect	No effect
Sensitive mollusks	No effect	No effect	No effect	No effect
Tolerant mollusks	No effect	No effect	No effect	No effect
Sensitive invertebrates	No effect	No effect	No effect	No effect
Tolerant invertebrates	No effect	No effect	No effect	No effect
Sensitive algae/periphyton	No effect	No effect	No effect	No effect
Tolerant algae/periphyton	No effect	No effect	No effect	No effect
Sensitive macrophytes	No effect	No effect	No effect	No effect
Tolerant macrophytes	No effect	No effect	No effect	No effect
Sheyenne River Reach 5				
Sensitive fish	No effect	No effect	No effect	No effect
Tolerant fish	No effect	No effect	No effect	No effect
Sensitive mollusks	No effect	No effect	No effect	No effect
Tolerant mollusks	No effect	No effect	No effect	No effect
Sensitive invertebrates	No effect	No effect	No effect	No effect
Tolerant invertebrates	No effect	No effect	No effect	No effect
Sensitive algae/periphyton	No effect	No effect	No effect	No effect
Tolerant algae/periphyton	No effect	No effect	No effect	No effect
Sensitive macrophytes	No effect	No effect	No effect	No effect
Tolerant macrophytes	No effect	No effect	No effect	No effect
Red River Reach 1				
Sensitive fish	No effect	No effect	No effect	No effect
Tolerant fish	No effect	No effect	No effect	No effect
Sensitive mollusks	No effect	No effect	No effect	No effect
Tolerant mollusks	No effect	No effect	No effect	No effect
Sensitive invertebrates	No effect	No effect	No effect	No effect
Tolerant invertebrates	No effect	No effect	No effect	No effect
Sensitive algae/periphyton	No effect	No effect	No effect	No effect
Tolerant algae/periphyton	No effect	No effect	No effect	No effect
Sensitive macrophytes	No effect	No effect	No effect	No effect
Tolerant macrophytes	No effect	No effect	No effect	No effect
Red River Reach 2				
Sensitive fish	No effect	No effect	No effect	No effect
Tolerant fish	No effect	No effect	No effect	No effect
Sensitive mollusks	No effect	No effect	No effect	No effect
Tolerant mollusks	No effect	No effect	No effect	No effect
Sensitive invertebrates	No effect	No effect	No effect	No effect
Tolerant invertebrates	No effect	No effect	No effect	No effect
Sensitive algae/periphyton	No effect	No effect	No effect	No effect
Tolerant algae/periphyton	No effect	No effect	No effect	No effect
Sensitive macrophytes	No effect	No effect	No effect	No effect
Tolerant macrophytes	No effect	No effect	No effect	No effect
Red River Reach 3				
Sensitive fish	No effect	No effect	No effect	No effect
Tolerant fish	No effect	No effect	No effect	No effect
Sensitive mollusks	No effect	No effect	No effect	No effect
Tolerant mollusks	No effect	No effect	No effect	No effect
Sensitive invertebrates	No effect	No effect	No effect	No effect
Tolerant invertebrates	No effect	No effect	No effect	No effect
Sensitive algae/periphyton[2]	No effect	No effect	No effect	No effect
Tolerant algae/periphyton[2]	No effect	No effect	No effect	No effect
Sensitive macrophytes[2]	No effect	No effect	No effect	No effect
Tolerant macrophytes[2]	No effect	No effect	No effect	No effect

[1] No effect-Maximum predicted levels of TDS, sulfate, and chloride do not exceed levels in Table 4-3.
Some effect-Maximum predicted levels of TDS, sulfate, or chloride exceed levels in Table 4-3.
Effect-Mean predicted levels of TDS, sulfate, or chloride exceed levels in Table 4-3 at least during part of the year.
May be extirpated-Mean TDS, sulfate, or chloride levels exceed values in Table 4-3 most of the time or during a critical life history period.

[2] No tolerance thresholds available, based on general tolerance of groups in literature.

TABLE 5-12

CHANGES IN BIOLOGICALLY RELAVENT HYDROLOGICAL PARAMETERS BETWEEN MOD50 AND 300MOD50 IN THE SHEYENNE AND RED RIVERS

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	Sheyenne River															Red River								
	Reach 1 (Hwy 30)			Reach 1 (Cooperstown)			Reach 3 (Baldhill)			Reach 3 (Lisbon)			Reach 5 (Kindred)			Reach 1 (Halstad)			Reach 2 (Grand Forks)			Reach 3 (Emerson)		
	MOD50	300MOD50		MOD50	300MOD50		MOD50	300MOD50		MOD50	300MOD50		MOD50	300MOD50		MOD50	300MOD50		MOD50	300MOD50		MOD50	300MOD50	
Indications of Hydro Alt[1]	Mean	Mean	H.A.[2]	Mean	Mean	H.A.[2]	Mean	Mean	H.A.[2]	Mean	Mean	H.A.[2]	Mean	Mean	H.A.[2]	Mean	Mean	H.A.[2]	Mean	Mean	H.A.[2]	Mean	Mean	H.A.[2]
Mean monthly flow (cfs)																								
October	13.1	13.1	0.00	47.2	58.2	0.14	179.4	190.6	0.14	172.4	184.5	0.00	200.7	213.6	0.13	973.2	986.9	0.00	2448.6	2462.8	0.14	2572.3	2587.3	0.00
November	14.6	14.6	0.00	47.9	60.7	0.13	171.4	184.2	-0.22	201.5	214.0	0.17	247.0	259.4	0.14	1114.6	1126.6	0.00	2633.5	2645.3	0.00	3029.8	3041.3	0.00
December	10.1	10.1	0.00	34.3	38.7	0.25	151.2	155.9	0.13	170.6	176.8	0.00	208.3	215.8	0.17	916.1	925.9	0.00	2266.9	2277.9	0.00	2480.6	2492.7	0.00
January	5.8	5.8	0.00	20.8	20.8	0.00	31.5	31.5	0.00	58.2	58.3	0.00	97.5	97.6	0.00	706.0	706.4	0.00	1737.6	1738.4	0.00	1902.9	1905.1	0.00
February	5.5	5.5	0.00	19.1	19.1	0.00	31.0	31.0	0.00	43.3	43.3	0.00	64.1	64.1	0.00	755.2	755.2	0.00	1689.1	1689.1	0.00	1807.3	1807.3	0.00
March	75.3	75.3	0.00	131.0	131.0	0.00	233.7	233.7	0.00	296.9	296.9	0.00	314.8	314.8	0.00	2617.5	2617.5	0.00	4159.6	4159.6	0.00	3359.0	3359.0	0.00
April	575.8	575.8	0.00	1199.5	1199.5	0.00	1270.4	1270.4	0.00	1543.2	1543.2	0.00	1631.2	1631.2	0.00	13865.3	13865.3	0.00	24195.1	24195.1	0.00	27057.0	27057.0	0.00
May	163.6	163.6	0.00	499.3	561.2	-0.14	688.7	747.8	0.00	923.5	974.9	0.00	1129.0	1173.2	0.00	6071.6	6101.2	0.00	10779.2	10800.6	0.00	19824.1	19831.9	0.00
June	62.7	62.7	0.00	184.4	250.8	0.00	240.4	308.1	0.00	340.9	411.3	-0.11	425.8	498.5	-0.22	2848.6	2924.5	0.00	5070.2	5147.5	-0.13	6536.5	6616.2	0.00
July	50.5	50.5	0.00	140.1	193.8	-0.25	165.5	219.4	0.00	263.6	317.6	0.00	390.7	444.9	-0.13	3781.0	3835.3	0.00	6919.1	6974.0	0.00	8960.7	9016.6	0.00
August	32.6	32.6	0.00	68.0	100.1	-0.13	97.6	129.8	0.00	109.4	142.4	-0.13	153.2	187.3	-0.13	1065.3	1103.8	0.00	2222.7	2264.1	0.00	2901.5	2948.1	0.00
September	30.6	30.6	0.00	66.2	98.6	0.00	89.4	122.2	0.14	122.4	155.9	0.14	169.7	203.5	-0.13	1111.8	1146.6	0.00	2694.0	2728.7	0.00	3110.0	3143.5	0.00
Mean flow (cfs) of annual extremes																								
1-day minimum	2.8	2.8	0.00	10.8	11.8	0.17	17.1	17.1	0.00	26.3	26.8	0.17	47.3	47.3	0.00	343.9	357.2	0.00	951.3	960.2	0.00	1138.5	1146.8	0.00
3-day minimum	2.8	2.8	0.00	11.1	12.1	0.00	17.3	17.5	0.00	27.3	27.6	0.14	49.6	49.6	0.00	358.3	371.0	0.00	1012.4	1019.7	0.00	1142.0	1150.4	0.00
7-day minimum	2.9	2.9	0.00	11.4	12.6	0.00	17.6	18.0	0.00	28.5	28.6	0.00	52.1	52.1	0.00	379.5	390.6	0.00	1036.1	1043.7	0.00	1178.7	1185.6	0.00
30-day minimum	3.8	3.8	-0.14	12.9	15.0	-0.25	23.1	23.2	0.00	32.4	32.6	0.00	58.3	58.3	0.00	439.4	448.0	0.00	1140.0	1145.7	0.00	1296.2	1304.0	0.00
90-day minimum	5.0	5.0	-0.13	17.5	18.4	0.00	42.8	43.4	-0.11	58.9	59.7	0.00	90.3	91.2	0.00	552.7	560.9	-0.14	1361.3	1369.5	0.14	1547.2	1553.8	0.00
1-day maximum	1533.2	1533.2	0.00	2365.7	2365.7	0.00	2368.1	2368.1	0.00	2800.5	2804.8	0.00	2918.7	2921.9	0.00	28978.0	28981.7	0.00	52872.5	52875.9	0.00	55636.8	55636.8	0.00
3-day maximum	1434.5	1434.5	0.00	2283.3	2283.3	0.00	2267.3	2267.3	0.00	2722.8	2726.9	0.00	2865.9	2869.5	0.00	28081.3	28085.2	0.00	49943.8	49947.2	0.00	55067.7	55067.7	0.00
7-day maximum	1242.3	1242.3	0.00	2076.4	2076.4	0.00	2101.6	2101.6	0.00	2467.2	2470.9	0.00	2709.5	2713.3	0.00	25898.9	25902.7	0.00	46879.8	46883.3	0.00	52708.9	52708.9	0.00
30-day maximum	640.9	640.9	0.00	1325.8	1330.2	0.00	1484.6	1491.7	0.00	1819.7	1823.2	0.00	1975.4	1979.4	0.00	16672.7	16676.1	0.00	27646.6	27646.6	0.00	35967.0	35967.0	0.00
90-day maximum	289.5	289.5	0.00	658.7	700.1	0.00	800.7	841.7	0.00	1026.6	1065.5	0.00	1162.2	1200.1	0.00	8561.5	8591.9	0.00	14596.8	14625.4	0.00	18963.1	18991.0	0.00
Number of zero days	0.5	0.5	0.00	0.0	0.0	0.00	0.0	0.0	0.00	0.0	0.0	0.00	0.0	0.0	0.00	0.0	0.0	0.00	0.0	0.0	0.00	0.0	0.0	0.00
Base flow	0.0	0.0	0.00	0.1	0.1	-0.17	0.1	0.1	-0.13	0.1	0.1	-0.17	0.2	0.2	0.00	0.2	0.2	-0.17	0.2	0.2	0.00	0.2	0.2	0.00
Mean date of annual extremes																								
Date of minimum	181.4	181.4	0.00	149.3	148.4	0.00	54.7	54.7	0.00	133.4	104.7	0.00	65.8	65.8	0.00	208.9	200.4	0.20	203.0	177.4	0.00	173.3	173.3	0.00
Month	July	July		May	May		February	February		May	April		March	March		July	July		July	June		June	June	
Date of maximum	97.4	97.4	0.00	104.1	104.1	0.00	101.8	101.8	0.00	104.5	104.5	0.00	109.3	109.3	0.00	105.5	105.5	0.00	110.2	110.2	0.00	110.3	110.3	0.00
Month	April	April		April	April		April	April		April	April		April	April		April	April		April	April		April	April	
Mean duration (days) and frequency (count) of annual extremes																								
Low pulse count	3.6	3.6	0.00	3.2	2.2	0.40	8.5	8.1	-0.13	4.3	3.5	0.25	3.4	3.1	0.00	3.9	3.8	-0.13	3.8	3.6	0.00	2.5	2.5	0.17
Low pulse duration	20.5	20.1	0.00	21.3	27.3	-0.33	11.8	11.9	0.00	22.5	24.8	0.00	30.8	30.4	0.14	19.8	18.8	0.14	17.5	17.5	0.00	24.6	23.6	0.17
High pulse count	1.0	1.0	0.00	1.2	1.4	0.00	1.5	1.4	0.17	1.5	1.5	-0.25	1.1	1.4	-0.11	1.4	1.4	0.00	1.7	1.7	0.00	1.4	1.4	0.00
High pulse duration	15.4	15.4	0.00	18.5	20.1	0.00	10.6	13.3	-0.20	8.2	8.6	-0.11	15.1	12.3	0.11	11.2	11.2	0.00	9.9	9.9	0.00	16.9	16.9	0.00
Mean rise and fall rate (cfs)																								
Rise rate	25.7	25.7	0.00	27.2	28.8	-0.13	47.2	48.2	0.00	42.8	43.9	0.00	37.9	38.8	0.00	300.9	301.2	0.00	551.9	558.5	0.00	493.1	494.4	0.00
Fall rate	-16.3	-16.3	0.00	-15.1	-15.2	0.00	-36.4	-36.0	0.00	-27.4	-27.6	0.00	-25.6	-25.8	0.00	-194.2	-194.3	0.00	-371.8	-369.1	-0.14	-348.3	-347.3	-0.14
Number of reversals	65.2	65.2	0.00	85.8	79.1	0.00	142.0	139.7	0.00	87.8	84.6	-0.14	81.8	79.2	-0.25	70.3	69.5	0.00	72.1	71.4	0.00	35.7	36.1	0.00
Flow Duration (CFS)[3]				**MOD50**	**300MOD50**	**% change**	**MOD50**	**300MOD50**	**% change**	**MOD50**	**300MOD50**	**% change**	**MOD50**	**300MOD50**	**% change**	**MOD50**	**300MOD50**	**% change**	**MOD50**	**300MOD50**	**% change**	**MOD50**	**300MOD50**	**% change**
99% exceedence				3.7	4.3	16	13.0	13.0	0	14.1	14.5	3	26.3	26.3	0	180.1	184.2	2	414.3	422.3	2	480.3	486.3	1
95% exceedence				6.7	7.1	6	13.0	13.0	0	16.9	17.5	3	36.8	38.6	5	243.5	249.9	3	757.2	763.8	1	860.0	871.0	1
90% exceedence				9.9	11.0	11	13.0	13.0	0	23.8	26.1	10	51.4	54.1	5	329.6	335.0	2	915.5	928.2	1	1019.4	1031.6	1
75% exceedence				21.4	25.0	17	36.5	41.3	13	59.2	64.0	8	93.9	99.3	6	594.2	607.0	2	1306.6	1319.3	1	1480.4	1492.5	1
50% exceedence				45.3	57.0	26	121.8	133.9	10	143.4	156.5	9	176.6	188.6	7	1055.5	1074.0	2	2222.0	2235.0	1	2542.3	2554.4	0
25% exceedence				140.8	177.0	26	212.1	244.8	15	255.3	284.5	11	317.4	342.1	8	2127.2	2144.1	1	4205.0	4238.6	1	4854.7	4869.5	0
10% exceedence				437.3	541.6	24	512.9	618.2	21	633.2	742.6	17	778.4	887.2	14	5619.2	5714.6	2	11558.4	11592.6	0	16593.8	16636.4	0
5% exceedence				888.8	962.6	8	962.6	1042.9	8	1220.3	1319.5	8	1438.4	1518.1	6	9618.4	9682.3	1	19814.8	19916.2	1	28043.4	28094.9	0
1% exceedence				3119.5	3119.5	0	3410.3	3410.3	0	4642.5	4642.5	0	5116.8	5116.8	0	41468.3	41468.3	0	55579.3	55579.3	0	73811.4	73811.4	0

[1] Calulations using the IHA model

[2] H.A.=Hydrological alteration

"+" value indicates values at 300MOD50 fell within the RVA (see Appendix J) more frequently than expected (less variability)

"-" value indicates values at 300MOD50 fell outside the RVA (see Appendix J) more frequently than expected (more variability, or different means)

0.0-0.33 little or no alteration

0.34-0.67 moderate alteration

0.68-1.00 high alteration

[3] Calculated from daily flows, 2005 to 2015; HEC-5 Data File: Moderate Future Max Elev 1450 Base Condition and 300 constrained cfs pumping, HEC-5Q Data File: Q5P50W48.DAT

Run date and time: 27APR01 - 09:17:08

TABLE 5-13

SUMMARY OF THE EFFECTS OF HYDROLOGICAL CHANGES EXPECTED WITH 300MOD50 COMPARED TO MOD50 ON AQUATIC BIOTA

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	Mean monthly flow				Variation in monthly flow				Low flow			Difference in Fall to Winter flow	Total Flow Effect
	Winter (no change)	Spring (no change)	Summer (slight increase)	Fall (slight increase)	Winter (no change)	Spring (no change)	Summer (no change)	Fall (no change)	Magnitude (no change)	Frequency (no change)	Duration (no change)	(slight increase)	
Sheyenne River Reach 1													
Fish	No effect[1]	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect
Mollusks	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect
Invertebrates	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect
Algae	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect
Macrophytes	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect
Sheyenne River Reach 2													
Fish	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect
Mollusks	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect
Invertebrates	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect
Algae	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect
Macrophytes	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect
Sheyenne River Reach 3													
Fish	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect
Mollusks	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect
Invertebrates	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect
Algae	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect
Macrophytes	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect
Sheyenne River Reach 4													
Fish	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect
Mollusks	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect
Invertebrates	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect
Algae	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect
Macrophytes	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect
Sheyenne River Reach 5													
Fish	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect
Mollusks	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect
Invertebrates	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect
Algae	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect
Macrophytes	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect
Red River Reach 1													
Fish	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect
Mollusks	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect
Invertebrates	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect
Algae	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect
Macrophytes	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect
Red River Reach 2													
Fish	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect
Mollusks	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect
Invertebrates	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect
Algae	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect
Macrophytes	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect
Red River Reach 3													
Fish	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect
Mollusks	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect
Invertebrates	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect
Algae	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect
Macrophytes	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect

[1]No effect= HA < 0.33 (see Table 5-12)

TABLE 5-14

PREDICTED CHANGES IN CHANNEL FORMING FLOW (1.5 YEAR FLOW, cfs) DURATION BETWEEN MODERATE MOD50 AND 300MOD50 (2005-2015)
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	Cooperstown	Baldhill	Lisbon	Kindred
MOD50				
Channel forming flow (c)[1]	615	790	842	915
no. of obs (n)[2]	3653	3653	3653	3653
(n) > c[2]	260	218	281	303
%c/(n)[3]	7.1	6.0	7.7	8.3
300MOD50				
Channel forming flow (c)[1]	615	790	842	915
no. of obs (n)[2]	3653	3653	3653	3652
(n) > c[2]	320	270	317	352
%c/(n)[3]	8.8	7.4	8.7	9.6
% Change	23	24	13	16

[1]WEST (2001)
[2]HEC-5 data file: Moderate future max elev 1450 base condition and 300 constrained cfs pumping, HEC-5Q data file Q5P50W48.dat; run date 27 April 01
[3] % of time exceeding channel forming flow

TABLE 5-15

AVERAGE[1] AND MAXIMUM PERCENT MAXIMUM WUA DURATION DIFFERENCE BETWEEN MOD50 AND 300MOD50

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		Segment H		Segment E		Segment B	
		AVE	**MAX**	**AVE**	**MAX**	**AVE**	**MAX**
SPRING							
	Shallow Pool	0.5	-3.2	3.9	15.4	6.9	10.9
	Slow Riffle	1.4	-4.1	4.9	-12.0	6.5	-15.9
	Fast Riffle	1.2	13.2	0.8	7.4	**47.5**	**-80.0**
	Raceway	2.4	9.4	3.1	10.4	**13.0**	**-27.9**
	Medium Pool	0.6	1.6	4.9	-12.7	4.7	10.1
	Deep Pool	0.0	0.0	4.1	12.7	**16.6**	**-46.5**
	Low Gradient	1.2	-4.2	2.7	-12.9	**18.8**	**52.1**
	Trichoptera	1.3	-4.2	3.3	-15.4	**19.9**	**42.0**
SUMMER							
	Shallow Pool	3.4	-10.1	8.8	**-28.0**	4.4	-13.4
	Slow Riffle	2.9	12.4	2.1	13.1	**30.3**	**-65.0**
	Fast Riffle	7.7	**32.2**	**10.5**	**69.0**	**31.9**	**-81.0**
	Raceway	6.0	**20.1**	**11.1**	**35.0**	**13.0**	**-24.5**
	Medium Pool	3.4	17.9	3.0	-16.4	5.6	-10.7
	Deep Pool	0.0	0.0	7.0	**31.8**	**11.9**	**-30.4**
	Low Gradient	3.1	11.7	2.5	**24.7**	7.7	**43.5**
	Trichoptera	2.0	11.0	6.4	**28.9**	7.1	**29.5**
FALL							
	Shallow Pool	6.6	-14.3	4.2	**-24.3**	2.4	-7.4
	Slow Riffle	3.4	**20.2**	2.2	8.0	3.2	7.1
	Fast Riffle	**11.0**	**28.3**	2.0	**22.6**	8.5	-16.1
	Raceway	2.4	18.2	5.5	15.3	4.2	7.3
	Medium Pool	7.6	**26.2**	2.5	-7.8	3.2	-7.1
	Deep Pool	0.0	0.0	5.4	10.0	2.7	7.3
	Low Gradient	2.6	8.2	2.0	-9.4	0.9	6.0
	Trichoptera	1.7	14.5	1.6	12.3	1.7	5.2

[1] - Average percent maximum WUA difference is calculated as the average absolute difference in percent maximum WUA between the base and alternative cases (see Appendix K and L)

Bold indicates difference could be sufficient to affect fauna

TABLE 5-16

80 % AND 20 % EXCEEDENCE VALUES FOR HABITAT GUILD %WUA'S FOR MOD50 COMPARED TO 300MOD50 IN HABITAT SEGMENTS MODELED FOR THE SHEYENNE RIVER
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			SEGMENT L		SEGMENT H		SEGMENT E		SEGMENT B	
SEASON	**GUILD**	**% exceedence[1]**	**50MOD**	**300MOD50**	**50MOD**	**300MOD50**	**50MOD**	**300MOD50**	**50MOD**	**300MOD50**
Fish										
Spring	Shallow pool	80	18.0	18.0	22.2	21.4	6.5	6.5	10.8	2.9
		20	86.8	86.8	55.2	55.1	78.1	81.0	57.0	65.5
	Slow riffle	80	33.8	33.8	31.7	31.4	19.1	19.6	21.9	15.9
		20	85.4	85.4	70.8	67.7	65.6	59.4	90.3	85.9
	Fast riffle	80	6.7	6.7	18.0	21.2	0.0	0.0	**11.9**	**0.6**
		20	65.3	65.3	80.2	81.4	76.6	75.1	**87.9**	**21.3**
	Raceway	80	0.4	0.4	1.5	1.8	3.2	3.6	**43.2**	**15.6**
		20	77.5	77.5	70.9	72.5	88.1	93.3	92.1	82.2
	Medium pool	80	13.1	13.1	58.4	59.3	15.3	14.6	7.0	1.4
		20	88.0	88.0	85.2	84.7	82.1	74.5	79.0	71.2
	Deep pool	80	0.0	0.0	0.0	0.0	0.0	0.0	6.4	0.8
		20	67.2	67.2	0.0	0.0	58.8	68.3	77.7	69.7
Summer	Shallow pool	80	33.2	33.2	21.7	21.7	**20.2**	**9.0**	**18.3**	**5.6**
		20	92.1	92.1	74.1	68.5	90.2	89.3	64.0	64.2
	Slow riffle	80	18.0	18.0	37.6	36.1	29.0	27.1	**69.5**	**6.6**
		20	81.5	81.5	80.8	77.3	70.0	69.8	90.6	85.0
	Fast riffle	80	1.7	1.7	1.6	3.0	0.0	0.0	**10.4**	**0.3**
		20	13.2	13.2	98.7	95.6	**5.9**	**34.5**	**87.2**	**6.2**
	Raceway	80	0.0	0.0	0.0	0.1	0.0	1.4	**24.5**	**5.5**
		20	33.8	33.8	**52.0**	**68.1**	**76.2**	**96.3**	**91.7**	**80.7**
	Medium pool	80	13.2	13.2	19.2	28.8	39.2	38.2	13.4	5.7
		20	83.3	83.3	85.1	85.1	83.9	86.3	95.3	89.9
	Deep pool	80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.8
		20	14.5	14.5	0.0	0.0	62.1	68.4	**73.3**	**62.2**
Fall	Shallow pool	80	72.0	72.0	30.6	26.5	18.7	14.9	26.9	24.3
		20	96.5	96.5	74.2	65.3	44.1	41.9	53.2	50.6
	Slow riffle	80	34.9	34.9	51.1	51.4	46.4	42.4	23.0	26.2
		20	69.6	69.6	90.0	87.3	66.3	65.8	75.5	78.8
	Fast riffle	80	28.7	28.7	1.9	7.1	5.8	5.9	14.3	5.8
		20	82.9	82.9	**82.4**	**97.1**	5.9	5.9	**20.4**	**8.7**
	Raceway	80	0.2	0.2	0.0	0.6	28.7	33.4	17.6	24.5
		20	6.5	6.5	18.3	18.2	81.7	89.7	74.3	77.9
	Medium pool	80	25.7	25.7	**22.6**	**38.6**	54.0	46.8	27.6	24.8
		20	60.9	60.9	87.9	86.6	90.1	87.6	81.9	77.2
	Deep pool	80	0.0	0.0	0.0	0.0	8.3	14.2	19.7	22.5
		20	0.0	0.0	0.0	0.0	73.4	79.1	80.3	80.3
Invertebrates										
Spring	Low gradient	80	61.8	61.8	41.8	41.7	60.2	57.8	**26.7**	**76.2**
		20	93.7	93.7	84.2	81.1	82.1	88.1	92.9	99.3
	Tricoptera	80	39.6	39.6	57.2	56.9	**54.2**	**42.5**	**23.6**	**65.6**
		20	90.0	90.0	90.4	89.4	93.9	95.3	89.4	99.1
Summer	Low gradient	80	60.2	60.2	49.9	45.8	72.9	70.3	**66.0**	**81.3**
		20	93.5	93.5	91.6	90.7	90.8	89.4	96.2	98.6
	Tricoptera	80	24.8	24.8	63.0	61.2	**44.8**	**56.4**	**56.9**	**72.9**
		20	90.0	90.0	95.6	93.4	94.5	95.1	95.7	98.9
Fall	Low gradient	80	91.0	91.0	66.4	61.7	74.4	72.7	90.0	91.3
		20	93.7	93.7	95.6	95.0	79.1	77.7	99.5	99.5
	Tricoptera	80	42.4	42.4	78.6	79.4	86.2	90.0	81.0	83.5
		20	67.0	67.0	98.1	98.1	96.7	97.2	99.1	99.3

[1]See Appendix K and L
Bold indicates greater than a 10% change in %WUA between baseline and pumping

TABLE 5-17

SUMMARY OF THE EFFECTS[1] OF HABITAT CHANGES EXPECTED WITH 300MOD50 COMPARED TO MOD50 ON FISH AND BENTHIC INVERTEBRATE GUILDS

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	Spring	Summer	Fall	Total potential effects of changes in habitat
Sheyenne River Reach 1				
Shallow pool	No change[2]	No change	No change	No change
Slow riffle	No change	No change	No effect[3]	
Fast riffle	No change	No effect	No effect	
Raceway	No change	No effect	No change	
Medium pool	No change	No change	No effect	
Deep pool	No change	No change	No change	
Invertebrate diversity	No change	No change	No change	No change
Tricopteran abundance	No change	No change	No change	
Sheyenne River Reach 2				
Shallow pool	No change	No change	No change	No change
Slow riffle	No change	No change	No change	
Fast riffle	No change	No change	No change	
Raceway	No change	No change	No change	
Medium pool	No change	No change	No change	
Deep pool	No change	No change	No change	
Invertebrate diversity	No change	No change	No change	No change
Tricopteran abundance	No change	No change	No change	
Sheyenne River Reach 3				
Shallow pool	No change	No change	Occassional decrease in shallow pool could reduce some year classes of common species	Increased fast water habitat could favor rheophilic species abundance; redhorse, smallmouth bass, longnose dace, rosyface shiner, stonecat
Slow riffle	No change	No change	No change	
Fast riffle	No change	Increased habitat availability for rheophilic species part of the time	Increased habitat availability for rheophilic species part of the time	
Raceway	No change	Increased habitat availability for rheophilic species part of the time	No change	
Medium pool	No change	No change	No change	
Deep pool	No change	No change	No change	
Invertebrate diversity	No change	No change	No change	No change
Tricopteran abundance	No change	No change	No change	
Sheyenne River Reach 5				
Shallow pool	No change	No change	No change	Reduced spawning, nursery, and adult habitat may reduce fish diversity and abundance
Slow riffle	No change	Substantial decline in nursery and adult habitat	No change	
Fast riffle	No change	Substantial decline in nursery and adult habitat	No change	
Raceway	Decreased spawning habitat	Moderate decline in habitat for adult redhorse	No change	
Medium pool	No change	No change	No change	
Deep pool	No change	Loss of habitat for some shiners, crappie	No change	
Invertebrate diversity	Increased habitat diversity	Periodic increase in diversity with increased flow	Slight increase in diversity with increased flow	Slight increase in diversity with increased flow
Tricopteran abundance	Increase in fast water habitat	Periodic increase in abundance of rheophilic taxa	Slight increase in abundance of rheophilic taxa	Slight increase in abundance of rheophilic taxa

[1] Effects are based on habitat alone, many other factors will contribute to community changes.

[2] No change = average % WUA changed less than 10%.

[3] No effect = % WUA change probably does not affect fish or invertebrates.

TABLE 5-18

SUMMARY OF EFFECTS OF 300MOD50 COMPARED TO MOD50 ON AQUATIC BIOTA IN THE SHEYENNE AND RED RIVERS

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	Sheyenne River					Red		
	Reach 1	**Reach 2**	**Reach 3**	**Reach 4**	**Reach 5**	**Reach 1**	**Reach 2**	**Reach 3**
Fish								
WQ	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect
Hydrology	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect
Geomorphology	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect
Habitat	No change	No effect	Increase in riffle/raceway species	Cannot be determined from this study	Loss of spawning, nursery, and adult habitat	No effect	No effect	No effect
Biotic interaction								
Overall expected effects	No change	No effect	Increase in riffle/raceway species; longnose dace, stonecat, rosyface shiner, smallmouth bass	Probably no effect	Loss of spawning, nursery, and adult habitat	No effect	No effect	No effect
Mollusks								
WQ	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect
Hydrology	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect
Geomorphology	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect
Habitat	Cannot be determined from this study	No effect	Cannot be determined from this study	Cannot be determined from this study	Cannot be determined from this study			
Biotic interaction								
Overall expected effects	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect
Invertebrates								
Water quality	Decrease in sensitive invertebrates such as Dubiraphia, Macronychus (Elmidae), Hexagenia, and Pentagenia (Ephemeroptera)	Decrease in sensitive invertebrates such as Dubiraphia, Macronychus (Elmidae), Hexagenia, and Pentagenia (Ephemeroptera)	Some decrease in sensitive invertebrates such as Dubiraphia, Macrohychus (Elmidae), Hexagenia and Pentagenia (Ephemeroptera)	Some decrease in sensitive invertebrates such as Dubiraphia, Macrohychus (Elmidae), Hexagenia and Pentagenia (Ephemeroptera)	Some decrease in sensitive invertebrates such as Dubiraphia, Macrohychus (Elmidae), Hexagenia and Pentagenia (Ephemeroptera)	No effect	No effect	No effect
Hydrology	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect
Geomorphology	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect
Habitat	No change	No effect	No effect	Cannot be determined from this study	Minor increase in overall diversity and rheophilic species abundance	No effect	No effect	No effect
Biotic interaction								
Overall expected effects	tolerant of sulfate and chloride particularly those that prefer erosional habitats (Hydropsychid caddisflies, Stenelmis)	Decrease in taxa sensitive to chloride and sulfate	tolerant of sulfate and chloride particularly those that prefer erosional habitats (Hydropsychid caddisflies, Stenelmis)	No effect	Minor increase in diversity and rheophilic species	No effect	No effect	No effect
Algae								
Water quality	Decrease in abundance/richness of sensitive taxa	Some decrease in abundance/richness of sensitive taxa	Some decrease in abundance/richness of sensitive taxa	No effect	No effect	No effect	No effect	No effect
Hydrology	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect
Geomorphology	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect
Habitat	Cannot be determined from this study	No effect	Cannot be determined from this study	Cannot be determined from this study	Cannot be determined from this study			
Biotic interaction								
Overall expected effects	Some decrease in abundance/richness of sensitive taxa	Some decrease in abundance/richness of sensitive taxa	Some decrease in abundance/richness of sensitive taxa	Some decrease in abundance/richness of sensitive taxa	Some decrease in abundance/richness of sensitive taxa	No effect	No effect	No effect
Macrophytes								
Water quality	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect
Hydrology	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect
Geomorphology	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect
Habitat	Cannot be determined from this study	No effect	Cannot be determined from this study	Cannot be determined from this study	Cannot be determined from this study			
Overall expected effects	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect

TABLE 5-19

PERCENT CHANGE[1] IN AVERAGE, MINIMUM, AND MAXIMUM TDS, SULFATE, AND CHLORIDE EXPECTED IN THE SHEYENNE AND RED RIVERS WITH 480MOD55 COMPARED TO MOD55
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	Sheyenne River				Red River		
	Reach 1	**Reach 3**	**Reach 3**	**Reach 5**	**Reach 1**	**Reach 2**	**Reach 3**
	Cooperstown	**Baldhill**	**Lisbon**	**Kindred**	**Halstad**	**Grand Forks**	**Emerson**
TDS (mg/l)							
Min	0.0	1.2	2.5	3.0	1.3	1.7	2.6
Max	62.7	115.3	67.3	58.2	60.7	77.7	66.2
Ave	52.8	109.3	73.6	63.0	34.7	25.2	17.4
% greater than guideline	6.5	62.6	30.6	22.1	58.7	17.6	27.7
Sulfate (mg/l)							
Min	0.0	8.4	8.4	8.5	28.8	12.6	10.1
Max	196.1	260.8	163.8	143.0	136.4	166.0	127.8
Ave	132.6	224.4	168.1	132.5	86.7	67.2	47.4
% greater than guideline	35.6	43.3	26.9	19.7	16.0	4.8	5.2
Chloride (mg/l)							
Min	0.1	5.5		8.4	4.4	9.0	16.1
Max	375.7	560.2		280.7	66.1	67.9	7.4
Ave	282.8	482.4		276.7	79.5	76.4	34.8
% greater than guideline	28.6	32.7	0.0	6.8	0.0	0.0	0.0

[1] 480MOD55-MOD55/MOD55 *100 (see Table 5-20)

TABLE 5-20

AVERAGE, MINIMUM, AND MAXIMUM TDS, SULFATE, AND CHLORIDE EXPECTED[1] IN THE SHEYENNE AND RED RIVERS WITH 480MOD55 COMPARED TO MOD55
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MOD55

	Sheyenne River				Red River		
	Reach 1	**Reach 3**	**Reach 3**	**Reach 5**	**Reach 1**	**Reach 2**	**Reach 3**
	Cooperstown	**Baldhill**	**Lisbon**	**Kindred**	**Halstad**	**Grand Forks**	**Emerson**
TDS (mg/l)							
Min	248.1	278.2	271.5	272.3	311.0	274.1	291.2
Max	889.4	665.2	808.6	826.1	663.1	492.3	592.8
Ave	596.9	474.4	535.9	542.2	414.8	350.7	420.4
Guideline	500	500	500	500	500	500	500
% greater than guideline	78.0	29.4	60.2	67.2	3.3	0.0	10.6
Sulfate (mg/l)							
Min	28.8	76.1	77.1	77.5	57.8	40.8	44.6
Max	217.8	173.7	224.5	233.1	188.2	128.9	149.3
Ave	147.4	125.7	134.8	145.9	91.2	70.0	87.7
Standard	450	450	450	450	250	250	250
% greater than standard	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chloride (mg/l)							
Min	5.5	8.1		8.1	10.1	6.7	8.1
Max	27.0	18.6		29.3	52.3	41.4	84.9
Ave	16.3	13.2		16.1	19.4	12.4	21.9
Standard	100	100		100	100	100	100
% greater than standard	0.0	0.0		0.0	0.0	0.0	0.0

480MOD55

	Sheyenne River				Red River		
	Reach 1	**Reach 3**	**Reach 3**	**Reach 5**	**Reach 1**	**Reach 2**	**Reach 3**
	Cooperstown	**Baldhill**	**Lisbon**	**Kindred**	**Halstad**	**Grand Forks**	**Emerson**
TDS (mg/l)							
Min	248.2	281.6	278.3	280.3	315.0	278.8	298.7
Max	1447.0	1431.9	1353.0	1306.9	1065.9	874.8	985.3
Ave	912.3	993.0	930.2	883.8	558.8	439.1	493.6
Guideline	500	500	500	500	500	500	500
% greater than guideline	84.5	92.0	90.8	89.3	62.1	17.6	38.4
Sulfate (mg/l)							
Min	28.8	82.5	83.5	84.1	74.5	46.0	49.1
Max	645.0	626.7	592.3	566.5	444.9	342.9	340.1
Ave	342.8	407.7	361.5	339.2	170.4	117.1	129.2
Standard	450	450	450	450	250	250	250
% greater than standard	35.6	43.3	26.9	19.7	16.0	4.8	5.2
Chloride (mg/l)							
Min	5.5	8.5		8.7	10.6	7.3	9.4
Max	128.4	122.8		111.6	86.8	69.6	91.2
Ave	62.4	76.9		60.6	34.8	21.9	29.6
Standard	100	100		100	100	100	100
% greater than standard	28.6	32.7		6.8	0	0	0

[1] HEC-5 Data File: Moderate Future Max Elev 1455 Base Condition and 480 unconstrained cfs HEC-5Q Data File: Q5P55W48.DAT
Run date and time: 24APR01 - 13:01:56

TABLE 5-21

SUMMARY OF THE EFFECTS OF WATER QUALITY CHANGES EXPECTED WITH 480MOD55 COMPARED TO MOD55 ON AQUATIC BIOTA

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	TDS[1]	Sulfate[1]	Chloride[1]	Total[1]
Sheyenne River Reach 1				
Sensitive fish	Some decline in reproduction of late spawners	No effect	No effect	Some decline in reproduction of late spawners
Tolerant fish	No effect	No effect	No effect	No effect
Sensitive mollusks	Some decrease in abundance/richness	No effect	May be extirpated	May be extirpated
Tolerant mollusks	No effect	No effect	No effect	No effect
Sensitive invertebrates	Some decrease in abundance/richness	Decrease in abundance/richness	May be extirpated	May be extirpated
Tolerant invertebrates	No effect	Some decrease in abundance/richness	No effect	Some decrease in abundance/richness
Sensitive algae/periphyton[2]	Some decrease in abundance/richness	Some decrease in abundance/richness, possible extirpation of some species	Some decrease in abundance/richness, possible extirpation of some species	Some decrease in abundance/richness, possible extirpation of some species
Tolerant algae/periphyton[2]	Some decrease in abundance/richness	Some decrease in abundance/richness	Some decrease in abundance/richness	Some decrease in abundance/richness
Sensitive macrophytes[2]	Some decrease in abundance/richness	Some decrease in abundance/richness	Some decrease in abundance/richness	Some decrease in abundance/richness
Tolerant macrophytes[2]	No effect	No effect	No effect	No effect
Sheyenne River Reach 2				
Sensitive fish	No effect	No effect	No effect	No effect
Tolerant fish	No effect	No effect	No effect	No effect
Sensitive mollusks	Some decrease in abundance/richness	No effect	May be extirpated	May be extirpated
Tolerant mollusks	No effect	No effect	No effect	No effect
Sensitive invertebrates	Some decrease in abundance/richness	Decrease in abundance/richness	May be extirpated	May be extirpated
Tolerant invertebrates	No effect	Some decrease in abundance/richness	No effect	Some decrease in abundance/richness
Sensitive algae/periphyton	Some decrease in abundance/richness	Some decrease in abundance/richness	Some decrease in abundance/richness	Some decrease in abundance/richness
Tolerant algae/periphyton				Some increase in abundance/richness
Sensitive macrophytes	Some decrease in abundance/richness	Some decrease in abundance/richness	Some decrease in abundance/richness	Some decrease in abundance/richness
Tolerant macrophytes				Some increase in abundance/richness
Sheyenne River Reach 3				
Sensitive fish	No effect	No effect	No effect	No effect
Tolerant fish	No effect	No effect	No effect	No effect
Sensitive mollusks	Some decrease in abundance/richness	No effect	May be extirpated	May be extirpated
Tolerant mollusks	No effect	No effect	No effect	No effect
Sensitive invertebrates	Some decrease in abundance/richness	Decrease in abundance/richness	May be extirpated	May be extirpated
Tolerant invertebrates	No effect	Some decrease in abundance/richness	No effect	Some decrease in abundance/richness
Sensitive algae/periphyton	Some decrease in abundance/richness	Some decrease in abundance/richness	Some decrease in abundance/richness	Some decrease in abundance/richness
Tolerant algae/periphyton				Some increase in abundance/richness
Sensitive macrophytes	Some decrease in abundance/richness	Some decrease in abundance/richness	Some decrease in abundance/richness	Some decrease in abundance/richness
Tolerant macrophytes				Some increase in abundance/richness
Sheyenne River Reach 4				
Sensitive fish	No effect	No effect	No effect	No effect
Tolerant fish	No effect	No effect	No effect	No effect
Sensitive mollusks	Some decrease in abundance/richness	No effect	Decrease in abundance/richness	Decrease in abundance/richness
Tolerant mollusks	No effect	No effect	No effect	No effect
Sensitive invertebrates	Some decrease in abundance/richness	Decrease in abundance/richness	Decrease in abundance/richness	Decrease in abundance/richness
Tolerant invertebrates	No effect	Some decrease in abundance/richness	No effect	Some decrease in abundance/richness
Sensitive algae/periphyton	Some decrease in abundance/richness	Some decrease in abundance/richness	Some decrease in abundance/richness	Some decrease in abundance/richness
Tolerant algae/periphyton	No effect	No effect	No effect	No effect
Sensitive macrophytes	No effect	No effect	No effect	No effect
Tolerant macrophytes	No effect	No effect	No effect	No effect
Sheyenne River Reach 5				
Sensitive fish	No effect	No effect	No effect	No effect
Tolerant fish	No effect	No effect	No effect	No effect
Sensitive mollusks	Some decrease in abundance/richness	No effect	Decrease in abundance/richness	Decrease in abundance/richness
Tolerant mollusks	No effect	No effect	No effect	No effect
Sensitive invertebrates	Some decrease in abundance/richness	Decrease in abundance/richness	Decrease in abundance/richness	Decrease in abundance/richness
Tolerant invertebrates	No effect	Some decrease in abundance/richness	No effect	Some decrease in abundance/richness
Sensitive algae/periphyton	No effect	No effect	No effect	No effect
Tolerant algae/periphyton	No effect	No effect	No effect	No effect
Sensitive macrophytes	No effect	No effect	No effect	No effect
Tolerant macrophytes	No effect	No effect	No effect	No effect
Red River Reach 1				
Sensitive fish	No effect	No effect	No effect	No effect
Tolerant fish	No effect	No effect	No effect	No effect
Sensitive mollusks	Some decrease in abundance/richness	No effect	Some decrease in abundance/richness	Some decrease in abundance/richness
Tolerant mollusks	No effect	No effect	No effect	No effect
Sensitive invertebrates	Some decrease in abundance/richness	Some decrease in abundance/richness	Some decrease in abundance/richness	Some decrease in abundance/richness
Tolerant invertebrates	No effect	Slight decrease in abundance/richness	No effect	Slight decrease in abundance/richness
Sensitive algae/periphyton	No effect	No effect	No effect	No effect
Tolerant algae/periphyton	No effect	No effect	No effect	No effect
Sensitive macrophytes	No effect	No effect	No effect	No effect
Tolerant macrophytes	No effect	No effect	No effect	No effect
Red River Reach 2				
Sensitive fish	No effect	No effect	No effect	No effect
Tolerant fish	No effect	No effect	No effect	No effect
Sensitive mollusks	Some decrease in abundance/richness	No effect	Some decrease in abundance/richness	Some decrease in abundance/richness
Tolerant mollusks	No effect	No effect	No effect	No effect
Sensitive invertebrates	Some decrease in abundance/richness	Some decrease in abundance/richness	Some decrease in abundance/richness	Some decrease in abundance/richness
Tolerant invertebrates	No effect	No effect	No effect	No effect
Sensitive algae/periphyton	No effect	No effect	No effect	No effect
Tolerant algae/periphyton	No effect	No effect	No effect	No effect
Sensitive macrophytes	No effect	No effect	No effect	No effect
Tolerant macrophytes	No effect	No effect	No effect	No effect
Red River Reach 3				
Sensitive fish	No effect	No effect	No effect	No effect
Tolerant fish	No effect	No effect	No effect	No effect
Sensitive mollusks	Some decrease in abundance/richness	No effect	Some decrease in abundance/richness	Some decrease in abundance/richness
Tolerant mollusks	No effect	No effect	No effect	No effect
Sensitive invertebrates	Some decrease in abundance/richness	Some decrease in abundance/richness	Some decrease in abundance/richness	Some decrease in abundance/richness
Tolerant invertebrates	No effect	No effect	No effect	No effect
Sensitive algae/periphyton	No effect	No effect	No effect	No effect
Tolerant algae/periphyton	No effect	No effect	No effect	No effect
Sensitive macrophytes	No effect	No effect	No effect	No effect
Tolerant macrophytes	No effect	No effect	No effect	No effect

[1] No effect-Maximum predicted levels of TDS, sulfate, and chloride do not exceed levels in Table 4-3.
Some effect-Maximum predicted levels of TDS, sulfate, or chloride exceed levels in Table 4-3.
effect-Mean predicted levels of TDS, sulfate, or chloride exceed levels in Table 4-3 at least during part of the year
May be extirpated-Mean TDS, sulfate, or chloride levels exceed values in Table 4-3 most of the time or during a critical life history period.

[2] No tolerance thresholds available, based on general tolerance of groups in literature

TABLE 5-22

CHANGES IN BIOLOGICALLY RELAVENT HYDROLOGICAL PARAMETERS BETWEEN MOD55 AND 480MOD55 IN THE SHEYENNE AND RED RIVERS

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	Sheyenne River															Red River								
	Reach 1 (Hwy 30)			Reach 1 (Cooperstown)			Reach 3 (Baldhill)			Reach 3 (Lisbon)			Reach 5 (Kindred)			Reach 1 (Halstad)			Reach 2 (Grand Forks)			Reach 3 (Emerson)		
	MOD55	480MOD55		Baseline	480MOD55		MOD55	480MOD55		MOD55	480MOD55		MOD55	480MOD55		MOD55	480MOD55		MOD55	480MOD55		MOD55	480MOD55	
Indications of Hydro Alt[1]	**Mean**	**Mean**	**H.A.[2]**	**Mean**	**Mean**	**H.A.[2]**	**Mean**	**Mean**	**H.A.[2]**	**Mean**	**Mean**	**H.A.[2]**	**Mean**	**Mean**	**H.A.[2]**	**Mean**	**Mean**	**H.A.[2]**	**Mean**	**Mean**	**H.A.[2]**	**Mean**	**Mean**	**H.A.[2]**
Mean monthly flow (cfs)																								
October	18.1	18.1	0.00	56.5	448.4	**-1.00**	193.6	586.5	**-0.75**	190.2	589.8	**-0.75**	219.0	623.0	**-0.71**	1164.3	1573.5	-0.13	2804.8	3220.4	-0.29	2987.0	3407.2	**-0.38**
November	15.6	15.6	0.00	50.2	442.6	**-0.75**	175.3	567.9	**-0.83**	204.9	595.7	**-0.86**	250.3	641.4	**-0.88**	1158.2	1548.4	0.00	2624.1	3012.7	0.00	3064.9	3451.7	0.00
December	10.5	10.5	0.00	36.7	129.3	**-0.75**	149.1	254.3	**-0.86**	168.3	309.9	**-0.86**	203.2	380.1	**-0.86**	926.2	1177.3	0.00	2334.7	2625.5	0.14	2541.4	2880.5	0.14
January	8.0	8.0	0.00	26.0	26.1	0.00	36.4	36.5	0.00	70.0	70.2	0.00	103.8	104.6	0.00	708.4	712.7	0.00	1904.2	1914.8	0.00	2032.8	2064.7	0.00
February	14.0	14.0	0.00	25.3	25.3	0.00	43.6	43.6	0.00	66.7	66.7	0.00	97.6	97.6	0.00	755.6	755.6	0.00	1890.2	1890.2	0.00	1970.8	1970.9	0.00
March	229.9	229.9	0.00	381.8	381.8	0.00	538.4	538.4	0.00	647.0	647.0	0.00	651.2	651.2	0.00	3445.9	3445.9	0.00	5662.0	5662.0	0.00	5321.4	5321.4	0.00
April	522.6	522.6	0.00	1244.0	1244.0	0.00	1327.2	1327.2	0.00	1589.4	1589.4	0.00	1721.8	1721.8	0.00	12518.0	12518.0	0.00	22434.3	22434.3	0.00	27496.9	27496.9	0.00
May	176.4	176.4	0.00	479.4	861.4	-0.13	642.0	1001.9	0.00	859.9	1176.9	0.13	1073.0	1348.0	0.13	5459.8	5643.7	0.00	10432.1	10564.1	0.13	18376.9	18434.0	0.00
June	52.7	52.7	0.00	181.4	653.6	**-1.00**	239.6	716.7	**-1.00**	336.2	811.5	**-0.75**	434.4	910.1	**-0.38**	3715.8	4197.1	0.14	7165.3	7648.5	0.25	8863.9	9326.4	0.14
July	36.2	36.2	0.00	144.1	621.4	**-1.00**	167.6	646.9	**-1.00**	262.2	738.1	**-1.00**	390.6	863.3	0.00	4170.0	4637.8	0.25	7302.0	7764.3	0.29	9417.6	9882.3	0.00
August	27.2	27.2	0.00	72.3	552.1	**-1.00**	96.5	575.4	**-1.00**	107.6	584.8	**-1.00**	152.7	625.4	**-1.00**	1192.7	1656.0	0.13	2629.9	3091.3	0.29	3187.2	3656.9	0.14
September	23.5	23.5	0.00	61.7	507.6	**-0.88**	84.3	531.3	**-1.00**	117.9	568.8	**-1.00**	169.4	625.2	**-1.00**	1173.1	1639.0	0.25	3105.2	3571.7	0.25	3638.4	4110.4	0.13
Mean flow (cfs) of annual extremes																								
1-day minimum	2.3	2.3	0.00	10.2	14.8	0.29	17.3	18.5	-0.10	25.8	36.3	-0.14	51.9	59.0	0.14	303.4	519.4	**-0.50**	1037.1	1273.8	-0.11	1161.4	1399.9	-0.13
3-day minimum	2.4	2.4	0.00	9.6	15.2	0.14	18.1	19.7	-0.10	26.8	37.5	-0.14	53.9	60.9	0.14	314.0	524.1	**-0.50**	1071.2	1310.4	0.00	1149.1	1413.2	-0.22
7-day minimum	2.7	2.7	0.00	10.3	16.1	0.00	18.5	20.5	-0.10	30.9	39.9	0.00	56.6	63.8	0.14	353.9	539.3	**-0.50**	1099.4	1358.7	0.00	1159.9	1445.8	0.00
30-day minimum	3.6	3.6	0.00	15.7	20.8	0.13	24.1	27.6	-0.22	39.6	49.7	0.17	65.1	75.1	0.14	464.6	613.5	-0.25	1319.0	1504.2	-0.11	1451.7	1631.1	-0.13
90-day minimum	4.7	4.7	0.00	24.9	38.1	-0.25	48.5	75.1	-0.14	72.7	104.6	**-0.38**	103.6	139.1	**-0.57**	590.1	781.8	0.00	1611.1	1812.7	0.00	1779.6	1994.2	0.00
1-day maximum	1659.8	1659.8	0.00	2867.5	2868.8	0.00	2935.6	2996.3	0.00	3291.9	3373.8	0.00	3360.9	3398.3	0.00	27289.9	27379.7	0.00	49143.5	49184.3	0.00	54230.0	54230.0	0.00
3-day maximum	1566.8	1566.8	0.00	2723.6	2724.2	0.00	2785.2	2834.0	0.00	3176.0	3263.0	0.00	3308.0	3349.5	0.00	26524.8	26616.8	0.00	47011.0	47051.8	0.00	53649.6	53649.6	0.00
7-day maximum	1391.2	1391.2	0.00	2481.1	2481.1	0.00	2520.0	2561.4	0.00	2929.1	3007.6	0.00	3187.1	3232.3	0.00	24705.7	24795.4	0.00	44053.2	44095.8	0.00	51255.4	51255.4	0.00
30-day maximum	705.7	705.7	-0.13	1525.4	1561.6	0.00	1823.6	1916.5	0.00	2162.5	2215.2	0.00	2322.7	2396.6	0.00	15558.1	15647.8	0.00	26535.4	26535.6	0.00	35254.1	35254.7	0.00
90-day maximum	323.1	323.1	-0.14	740.6	997.6	0.00	891.3	1178.2	0.13	1119.9	1366.7	0.25	1272.7	1505.0	0.25	8275.6	8494.7	0.13	14698.2	14839.7	0.00	19616.2	19752.2	0.25
Number of zero days	0.7	0.7	0.00	0.0	0.0	0.00	0.0	0.0	0.00	0.0	0.0	0.00	0.0	0.0	0.00	0.0	0.0	0.00	0.0	0.0	0.00	0.0	0.0	0.00
Base flow	0.0	0.0	0.00	0.0	0.0	0.29	0.1	0.0	**-0.67**	0.1	0.1	0.14	0.2	0.1	0.13	0.2	0.2	0.00	0.2	0.3	-0.25	0.2	0.2	-0.25
Mean date of annual extremes																								
Date of minimum	205.8	205.8	0.00	191.2	44.5	**-1.00**	114.2	60.9	**0.33**	218.0	48.8	**-1.00**	71.4	40.4	0.00	207.8	50.9	**-0.80**	231.1	104.7	**-0.38**	183.4	94.9	0.00
Month	July	July		July	February		April	March		August	February		March	February		July	February		August	April		July	April	
Date of maximum	90.4	90.4	0.00	96.5	97.6	0.00	94.4	117.9	0.00	98.8	128.5	0.00	105.0	105.0	0.00	110.1	110.1	0.00	103.5	103.5	0.00	106.8	106.8	0.00
Month	April	April		April	April		April	April		April	May		April	April		April	April		April	April		April	April	
Mean duration (days) and frequency (count) of annual extremes																								
Low pulse count	4.5	4.5	0.00	3.9	1.9	**-0.43**	10.0	5.5	-0.13	4.4	2.3	**-0.33**	4.2	1.8	0.25	3.5	1.3	**-0.57**	3.9	2.6	0.25	2.6	2.1	0.00
Low pulse duration	17.2	17.1	0.00	20.2	30.6	-0.25	8.3	10.5	-0.22	24.8	29.9	**-0.38**	24.2	31.1	-0.22	23.7	32.6	**-0.56**	18.7	24.2	-0.11	29.4	31.6	-0.13
High pulse count	1.5	1.5	0.00	1.5	2.5	-0.22	1.6	2.6	**-0.43**	1.5	1.9	-0.14	1.9	2.0	0.14	1.5	1.5	0.00	1.3	1.3	0.00	1.4	1.4	0.00
High pulse duration	14.7	14.7	0.00	19.3	17.8	-0.29	12.5	12.5	**0.33**	12.3	12.0	0.00	11.2	11.8	0.25	9.4	9.5	0.00	12.7	12.8	0.00	18.4	18.5	0.00
Mean rise and fall rate (cfs)																								
Rise rate	25.2	25.2	0.00	31.9	33.7	**0.33**	53.1	54.1	0.00	45.6	49.0	0.00	41.3	44.3	-0.13	327.3	333.8	-0.14	600.7	615.9	-0.13	556.2	566.0	0.25
Fall rate	-15.6	-15.6	0.00	-16.9	-18.8	0.17	-39.0	-39.1	**0.33**	-29.6	-32.1	0.25	-27.6	-29.7	0.25	-195.8	-195.1	0.00	-380.9	-377.2	-0.13	-354.3	-350.8	-0.25
Number of reversals	67.7	67.7	0.00	81.2	75.3	-0.25	133.3	137.4	0.14	91.0	86.2	0.00	81.0	71.9	**-0.57**	66.8	64.0	0.00	73.1	71.5	0.14	38.9	36.4	-0.13
Flow Duration (CFS)[3]				**MOD55**	**480MOD55**	**% change**	**MOD55**	**480MOD55**	**% change**	**MOD55**	**480MOD55**	**% change**	**MOD55**	**480MOD55**	**% change**	**MOD55**	**480MOD55**	**% change**	**MOD55**	**480MOD55**	**% change**	**MOD55**	**480MOD55**	**% change**
99% exceedence				2.2	11.8	**444**	13.0	13.0	0	14.8	20.4	**38**	28.1	35.1	25	96.9	357.4	**269**	566.2	634.4	12	656.0	711.1	8
95% exceedence				9.6	15.2	**59**	13.0	13.9	7	21.8	38.4	**76**	48.1	60.4	26	367.8	471.9	28	764.5	1075.0	**41**	887.0	1224.1	**38**
90% exceedence				13.6	21.9	**61**	13.0	26.8	**106**	33.3	58.5	**76**	60.8	92.1	**51**	434.5	602.9	**39**	999.4	1380.0	**38**	1241.7	1506.8	21
75% exceedence				24.0	69.5	**189**	38.8	147.5	**280**	69.3	182.3	**163**	108.9	227.7	**109**	680.9	966.8	**42**	1845.2	2023.8	10	2062.1	2258.9	10
50% exceedence				54.9	505.4	**820**	125.8	534.8	**325**	151.6	566.0	**273**	191.6	608.3	**218**	1126.3	1476.5	31	2732.5	3036.7	11	3202.6	3427.2	7
25% exceedence				167.4	581.8	**248**	237.7	671.3	**182**	279.2	711.3	**155**	373.3	777.9	**108**	2509.3	2816.7	12	4867.7	5207.9	7	6180.1	6566.1	6
10% exceedence				590.1	899.6	**52**	641.0	1001.5	**56**	889.7	1151.0	29	1087.4	1329.4	22	6321.5	6627.2	5	12165.7	12364.7	2	18932.7	19243.7	2
5% exceedence				1108.2	1305.3	18	1418.6	1596.4	13	1758.3	1845.9	5	1889.9	2020.8	7	12277.0	12407.8	1	25750.1	25942.9	1	33691.4	34035.9	1
1% exceedence				3514.3	3548.2	1	3389.4	3400.2	0	4564.1	4731.2	4	5079.6	5079.6	0	38564.1	38750.7	0	54088.6	54300.6	0	59409.5	59409.5	0

[1] Calulations using the IHA model

[2] H.A.=Hydrological alteration

"+" value indicates values at 480MOD55 fell within the RVA (see Appendix J) more frequently than expected (less variability)

"-" value indicates values at 480MOD55 fell outside the RVA (see Appendix J) more frequently than expected (more variability, or different means)

0.0-0.33 little or no alteration

0.34-0.67 moderate alteration

0.68-1.00 high alteration

[3] HEC-5 Data File: Moderate Future Max Elev 1455 Base Condition and 480 unconstrained cfs HEC-5Q Data File: Q5P55W48.DAT Run date and time: 24APR01 - 13:01:56

TABLE 5-23

SUMMARY OF THE EFFECTS OF HYDROLOGICAL CHANGES EXPECTED WITH 480MOD55 COMPARED TO MOD55 ON AQUATIC BIOTA
Final Aquatic Impact Analysis Report

	Mean monthly flow				Variation in monthly flow				Low flow				
	Winter (same)	Spring (same)	Summer (increase)	Fall (increase)	Winter (same)	Spring (same)	Summer (decrease)	Fall (decrease)	Magnitude (increase)	Frequency (decrease)	Duration (increase)	Difference in Fall to Winter flow (Decline 2 to 10 times greater)	Total Effect
Sheyenne River Reach 1													
Fish	Main effects are on habitat availability				No effect	No effect	Less stress due to less flow variability	Less stress due to less flow variability	Less stress to sensitive fish	Less stress to sensitive fish	No effect	May leave fish stranded	Less summer/fall stress but increased winter stress
Mollusks	No effect[1]	No effect	Improve conditions for mollusks	Improve conditions for mollusks	No effect	No effect	Less stress due to less flow variability	Less stress due to less flow variability	Less stress due to low flow events	Less stress due to low flow events	No effect	May leave mollusks stranded	Unionids will be limited by available winter habitat
Invertebrates	No effect	No effect	Improve habitat diversity	Improve habitat diversity	No effect	No effect	Decrease variability in habitat, fewer disturbance events	Decrease variability in habitat, fewer disturbance events	Less stress due to low flow events	Less stress due to low flow events	No effect	May leave invertebrates stranded	Less summer/fall stress but increased winter stress
Algae	No effect	No effect	Favor phytoplankton, possible loss of periphyton	Favor phytoplankton, possible loss of periphyton	No effect	No effect	Decrease variability in habitat, fewer disturbance events	Decrease variability in habitat, fewer disturbance events	Favor phytoplankton, possible loss of periphyton	Less stress due to low flow events	No effect	Favor species able to withstand exposure	diversity, possible loss of periphyton with loss of shallow water habitats
Macrophytes	No effect	No effect	Submergent species may expand, emergent and wetland species pushed up the banks, or removed if shallow water unavailable	Submergent species may expand, emergent and wetland species pushed up the banks	No effect	No effect	Less change in water levels in areas vegetated with macrophytes	Less change in water levels in areas vegetated with macrophytes	Emergent and wetland fringe vegetation should move up the banks into new shallow water zone	Less stress due to low flow events	No effect	Expanded macrophyte areas disturbed annually	Expanded macrophyte areas disturbed annually
Sheyenne River Reach 2													
Fish	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect
Mollusks	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	no effect	no effect	No effect	No effect	No effect
Invertebrates	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	no effect	no effect	No effect	No effect	No effect
Algae	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect
Macrophytes	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect
Sheyenne River Reach 3													
Fish	Main effects are on habitat availability				Main effects are on habitat availability		No effect	No effect	Less stress to sensitive fish	Less stress to sensitive fish	No effect	May leave fish stranded	Less summer/fall stress but increased winter stress
Mollusks	No effect	No effect	Improve conditions for mollusks	Improve conditions for mollusks	No effect	No effect	Less stress due to less flow variability	Less stress due to less flow variability	Less stress due to low flow events	Less stress due to low flow events	No effect	May leave mollusks stranded	Unionids will be limited by available winter habitat
Invertebrates	No effect	No effect	Improve habitat diversity	Improve habitat diversity	No effect	No effect	Decrease variability in habitat, fewer disturbance events	Decrease variability in habitat, fewer disturbance events	Less stress due to low flow events	Less stress due to low flow events	No effect	May leave invertebrates stranded	Less summer/fall stress but increased winter stress
Algae	No effect	No effect	Favor phytoplankton, possible loss of periphyton	Favor phytoplankton, possible loss of periphyton	No effect	No effect	Decrease variability in habitat, fewer disturbance events	Decrease variability in habitat, fewer disturbance events	Favor phytoplankton, possible loss of periphyton	Less stress due to low flow events	No effect	Favor species able to withstand exposure	diversity, possible loss of periphyton with loss of shallow water habitats
Macrophytes	No effect	No effect	Submergent species may expand, emergent and wetland species pushed up the banks, or removed if shallow water unavailable	Submergent species may expand, emergent and wetland species pushed up the banks	No effect	No effect	Less change in water levels in areas vegetated with macrophytes	Less change in water levels in areas vegetated with macrophytes	Emergent and wetland fringe vegetation should move up the banks into new shallow water zone	Less stress due to low flow events	No effect	Expanded macrophyte areas disturbed annually	Expanded macrophyte areas disturbed annually
Sheyenne River Reach 4													
Mollusks	No effect	No effect	Improve conditions for mollusks	Improve conditions for mollusks	No effect	No effect	Less stress due to less flow variability	Less stress due to less flow variability	Less stress due to low flow events	Less stress due to low flow events	No effect	May leave mollusks stranded	Unionids will be limited by available winter habitat
Invertebrates	No effect	No effect	Improve habitat diversity	Improve habitat diversity	No effect	No effect	Decrease variability in habitat, fewer disturbance events	Decrease variability in habitat, fewer disturbance events	Less stress due to low flow events	Less stress due to low flow events	No effect	May leave invertebrates stranded	Less summer/fall stress but increased winter stress
Algae	No effect	No effect	Favor phytoplankton, possible loss of periphyton	Favor phytoplankton, possible loss of periphyton	No effect	No effect	Decrease variability in habitat, fewer disturbance events	Decrease variability in habitat, fewer disturbance events	Favor phytoplankton, possible loss of periphyton	Less stress due to low flow events	No effect	Favor species able to withstand exposure	diversity, possible loss of periphyton with loss of shallow water habitats
Macrophytes	No effect	No effect	Submergent species may expand, emergent and wetland species pushed up the banks, or removed if shallow water unavailable	Submergent species may expand, emergent and wetland species pushed up the banks	No effect	No effect	Less change in water levels in areas vegetated with macrophytes	Less change in water levels in areas vegetated with macrophytes	Emergent and wetland fringe vegetation should move up the banks into new shallow water zone	Less stress due to low flow events	No effect	Expanded macrophyte areas disturbed annually	Expanded macrophyte areas disturbed annually
Sheyenne River Reach 5													
Fish	Main effects are on habitat availability				Main effects are on habitat availability		No effect	No effect	Less stress to sensitive fish	Less stress to sensitive fish	No effect	May leave fish stranded	Less summer/fall stress but increased winter stress
Mollusks	No effect	No effect	Improve conditions for mollusks	Improve conditions for mollusks	No effect	No effect	Less stress due to less flow variability	Less stress due to less flow variability	Less stress due to low flow events	Less stress due to low flow events	No effect	May leave mollusks stranded	Unionids will be limited by available winter habitat
Invertebrates	No effect	No effect	Improve habitat diversity	Improve habitat diversity	No effect	No effect	Decrease variability in habitat, fewer disturbance events	Decrease variability in habitat, fewer disturbance events	Less stress due to low flow events	Less stress due to low flow events	No effect	May leave invertebrates stranded	Less summer/fall stress but increased winter stress
Algae	No effect	No effect	Favor phytoplankton, possible loss of periphyton	Favor phytoplankton, possible loss of periphyton	No effect	No effect	Decrease variability in habitat, fewer disturbance events	Decrease variability in habitat, fewer disturbance events	Favor phytoplankton, possible loss of periphyton	Less stress due to low flow events	No effect	Favor species able to withstand exposure	diversity, possible loss of periphyton with loss of shallow water habitats
Macrophytes	No effect	No effect	Submergent species may expand, emergent and wetland species pushed up the banks, or removed if shallow water unavailable	Submergent species may expand, emergent and wetland species pushed up the banks	No effect	No effect	Less change in water levels in areas vegetated with macrophytes	Less change in water levels in areas vegetated with macrophytes	Emergent and wetland fringe vegetation should move up the banks into new shallow water zone	Less stress due to low flow events	No effect	Expanded macrophyte areas disturbed annually	Expanded macrophyte areas disturbed annually
Red River Reach 1													
Fish	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	Less stress to sensitive fish	Less stress to sensitive fish	No effect	No effect	Less stress to sensitive fish
Mollusks	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	Less stress due to low flow events	Less stress due to low flow events	No effect	No effect	Less stress due to low flow events
Invertebrates	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	Less stress due to low flow events	Less stress due to low flow events	No effect	No effect	Less stress due to low flow events
Algae	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	Favor phytoplankton, possible loss of periphyton	No effect	No effect	No effect	Favor phytoplankton, possible loss of periphyton
Macrophytes	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	vegetation should move up the banks into new shallow water zone	No effect	No effect	No effect	Emergent and wetland fringe vegetation should move up the banks into new shallow water zone
Red River Reach 2													
Fish	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect
Mollusks	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect
Invertebrates	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect
Algae	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect
Macrophytes	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect
Red River Reach 3													
Fish	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect
Mollusks	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect
Invertebrates	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect
Algae	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect
Macrophytes	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect

[1] No effect = HA < 0.33 (see Table 5-22).

TABLE 5-24

PREDICTED CHANGES IN CHANNEL FORMING FLOW (1.5 YEAR FLOW, cfs) DURATION BETWEEN MOD55 AND 480MOD55 (2005-2015)
Final Aquatic Impact Analysis Report

	Cooperstown	Baldhill	Lisbon	Kindred
MOD55				
Channel forming flow (c)[1]	615	790	842	915
no. of obs (n)[2]	3653	3653	3653	3653
(n) > c[2]	260	218	281	303
%c/(n)[3]	7.1	6.0	7.7	8.3
480MOD55				
Channel forming flow (c)[1]	615	790	842	915
no. of obs (n)[2]	3652	3652	3652	3652
(n) > c[2]	785	597	631	677
%c/(n)[3]	21.5	16.3	17.3	18.5
% change	202	174	125	123

[1]WEST (2001)

[2]HEC-5 data file: Moderate future max elev 1455 base condition and 480 unconstrained cfs pumping, HEC-5Q data file Q5P55W48.dat; run date 24 April 01

[3] % of time exceeding channel forming flow

TABLE 5-25

AVERAGE[1] AND MAXIMUM PERCENT MAXIMUM WUA DURATION DIFFERENCE BETWEEN MOD55 AND 480MOD55
Final Aquatic Impact Analysis Report

		Segment H		Segment E		Segment B	
		AVE	**MAX**	**AVE**	**MAX**	**AVE**	**MAX**
SPRING							
	Shallow Pool	1.1	-4.2	8.8	**-43.3**	6.7	**-26.2**
	Slow Riffle	6.8	-15.1	7.5	**-20.1**	5.5	10.1
	Fast Riffle	4.1	**36.4**	**18.4**	**57.7**	2.2	12.4
	Raceway	**13.1**	**41.7**	6.5	**21.5**	7.0	**23.0**
	Medium Pool	3.0	-7.2	**11.5**	**-32.6**	9.2	**-34.2**
	Deep Pool	0.1	4.7	6.5	**26.5**	7.2	**-27.2**
	Low Gradient	4.8	-11.1	4.8	-11.9	2.0	-11.0
	Trichoptera	6.6	-15.3	2.2	-4.8	1.7	-6.9
SUMMER							
	Shallow Pool	**26.3**	**43.6**	**40.7**	**-80.4**	**26.2**	**-65.8**
	Slow Riffle	**26.0**	**-62.7**	**21.2**	**-65.3**	**42.8**	**77.9**
	Fast Riffle	**42.4**	**88.5**	**80.7**	**99.0**	7.5	18.8
	Raceway	**63.3**	**86.0**	**48.3**	**84.5**	**42.1**	**70.6**
	Medium Pool	**20.2**	**59.1**	**39.6**	**-79.4**	**40.1**	**-82.6**
	Deep Pool	0.0	0.0	**31.2**	**48.8**	**27.5**	**-93.9**
	Low Gradient	**21.4**	**-48.9**	4.5	-12.7	3.6	-13.3
	Trichoptera	**23.8**	**-42.7**	**12.6**	**32.5**	7.8	17.6
FALL							
	Shallow Pool	**22.4**	**-58.8**	**27.3**	**-89.8**	**28.4**	**-54.6**
	Slow Riffle	**32.6**	**-56.0**	**23.3**	**-36.5**	**39.3**	**78.5**
	Fast Riffle	**49.9**	**94.6**	**80.7**	**96.6**	**21.5**	**61.2**
	Raceway	**72.1**	**92.1**	**27.2**	**69.8**	**37.7**	**71.9**
	Medium Pool	**22.1**	**59.5**	**45.6**	**-71.7**	**45.0**	**-87.9**
	Deep Pool	0.0	0.0	**21.8**	**40.1**	**46.2**	**-90.4**
	Low Gradient	**31.8**	**-54.2**	**13.0**	**-22.7**	3.5	13.3
	Trichoptera	**28.7**	**-41.6**	**10.1**	**35.2**	7.0	**35.4**

1 - Average percent maximum WUA difference is calculated as the average absolute difference in percent maximum WUA between the base and alternative cases (see Appendix K and L).
Bold indicates difference could be sufficient to affect fauna

TABLE 5-26

80 % AND 20 % EXCEEDENCE VALUES FOR HABITAT GUILD %WUA'S FOR MOD55 COMPARED TO 55MOD480 IN HABITAT SEGMENTS MODELED FOR THE SHEYENNE RIVER
Final Aquatic Impact Analysis Report

			SEGMENT L		SEGMENT H		SEGMENT E		SEGMENT B	
SEASON	**GUILD**	**% exceedence[1]**	**55MOD**	**55MOD480**	**55MOD**	**55MOD480**	**55MOD**	**55MOD480**	**55MOD**	**55MOD480**
Fish										
Spring	Shallow pool	80	14.7	14.7	25.3	28.1	6.4	5.3	2.3	2.0
		20	83.1	83.1	49.6	51.8	**89.4**	**48.7**	**62.9**	**50.3**
	Slow riffle	80	37.4	37.4	31.5	30.0	14.2	13.1	18.7	21.0
		20	86.7	86.7	63.0	53.1	**55.4**	**36.7**	85.1	92.9
	Fast riffle	80	9.0	9.0	**61.4**	**78.0**	0.0	0.0	0.6	0.7
		20	83.1	83.1	83.6	86.2	**85.3**	**98.7**	22.4	22.5
	Raceway	80	2.5	2.5	**8.9**	**26.3**	1.4	8.4	**25.4**	**48.5**
		20	88.8	88.8	74.6	76.0	92.2	92.5	80.4	88.8
	Medium pool	80	13.1	13.1	65.5	62.3	12.3	11.8	1.3	1.3
		20	87.4	87.4	85.6	85.2	**66.8**	**40.7**	**73.7**	**49.8**
	Deep pool	80	0.0	0.0	0.0	0.0	0.0	5.6	0.7	0.7
		20	68.9	68.9	0.0	0.0	59.7	50.0	**53.4**	**32.0**
Summer	Shallow pool	80	24.0	24.0	**22.1**	**62.9**	9.6	10.3	8.7	12.1
		20	90.6	90.6	68.5	64.0	**97.5**	**18.1**	**62.7**	**15.6**
	Slow riffle	80	7.8	7.8	36.0	32.2	25.7	23.8	**6.4**	**84.0**
		20	78.3	78.3	**82.3**	**35.3**	**68.5**	**30.8**	**87.7**	**98.1**
	Fast riffle	80	0.7	0.7	**1.7**	**88.5**	**0.0**	**96.8**	0.0	3.6
		20	12.7	12.7	98.5	91.9	**16.2**	**99.8**	**1.5**	**18.8**
	Raceway	80	0.0	0.0	**0.0**	**85.6**	**0.0**	**68.2**	**4.8**	**74.6**
		20	16.1	16.1	**53.8**	**91.3**	90.2	99.8	**83.9**	**96.9**
	Medium pool	80	5.7	5.7	**19.3**	**59.6**	**40.3**	**15.1**	9.3	6.3
		20	76.8	76.8	**85.4**	**74.7**	**84.8**	**17.6**	**89.1**	**15.0**
	Deep pool	80	0.0	0.0	0.0	0.0	**0.0**	**39.8**	2.9	1.2
		20	0.0	0.0	0.0	0.0	61.4	53.4	**64.7**	**3.4**
Fall	Shallow pool	80	34.6	34.6	29.3	24.7	**16.3**	**5.7**	**26.5**	**5.6**
		20	60.7	60.7	**66.8**	**24.8**	**45.5**	**7.7**	**52.2**	**6.3**
	Slow riffle	80	54.2	54.2	**50.2**	**31.8**	**41.3**	**25.6**	**15.0**	**88.7**
		20	97.1	97.1	**82.9**	**33.2**	**65.6**	**29.9**	**75.2**	**96.0**
	Fast riffle	80	18.5	18.5	**2.3**	**95.3**	**3.1**	**97.9**	13.7	19.3
		20	85.3	85.3	88.2	96.5	**5.9**	**99.3**	**19.4**	**54.3**
	Raceway	80	0.0	0.0	**0.0**	**92.0**	**18.3**	**74.9**	**14.5**	**82.2**
		20	4.8	4.8	**20.2**	**94.7**	86.6	90.7	**73.2**	**93.5**
	Medium pool	80	20.1	20.1	**27.0**	**59.9**	**44.5**	**16.2**	**28.2**	**2.8**
		20	58.6	58.6	**85.8**	**65.7**	**89.0**	**18.0**	**84.6**	**4.0**
	Deep pool	80	0.0	0.0	0.0	0.0	**6.1**	**42.0**	**17.3**	**1.8**
		20	0.0	0.0	0.0	0.0	**79.8**	**49.5**	**88.9**	**2.7**
Invertebrates										
Spring	Low gradient	80	64.0	64.0	39.9	37.2	49.3	45.0	72.1	62.7
		20	93.5	93.5	75.8	68.4	**89.6**	**77.9**	98.1	97.0
	Tricoptera	80	40.3	40.3	55.3	53.4	42.5	42.6	61.4	57.0
		20	90.4	90.4	89.0	82.1	93.9	89.1	98.1	97.2
Summer	Low gradient	80	26.2	26.2	46.0	45.7	71.2	75.4	**80.4**	**90.7**
		20	93.3	93.3	**92.4**	**50.1**	89.4	85.6	98.8	97.8
	Tricoptera	80	37.8	37.8	61.6	54.3	**45.3**	**77.7**	**71.5**	**88.8**
		20	66.0	66.0	**94.8**	**56.7**	94.2	91.1	98.9	98.6
Fall	Low gradient	80	88.0	88.0	**61.5**	**42.1**	**74.1**	**61.9**	89.4	93.4
		20	93.3	93.3	**96.4**	**43.5**	**79.1**	**67.4**	99.7	96.8
	Tricoptera	80	77.9	77.9	**77.9**	**55.4**	84.1	80.4	**79.9**	**92.8**
		20	96.9	96.9	**96.9**	**56.4**	97.5	88.4	99.0	97.5

[1]See Appendix K and L

Bold indicates greater than a 10% change in %WUA between baseline and pumping

TABLE 5-27

SUMMARY OF EFFECTS[1] OF HABITAT CHANGES WITH 480MOD55 COMPARED TO MOD55 ON FISH AND INVERTEBRATES

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	Spring	Summer	Fall	Total
Sheyenne Reach 1				
Shallow pool	No change[2]	Increased nursery habitat, increased spawning habitat for centrarchids	Decreased survival of YOY and juveniles	Most species in this reach can use either slow riffle or shallow pool for nursery habitat, thus recruitment should not be affected,sunfish and minnows should have additional habitat; however, species composition may shift toward more rheophilic taxa
Slow riffle	No change	Decreased nursery habitat for common Reach 1 species	Decreased nursery habitat for common Reach 1 species	
Fast riffle	Increased spawning habitat, but for species not typical of Reach 1	Increase in summer habitat for rheophilic species (currently not abundant in Reach 1)	Increase in fall habitat for rheophilic species (currently not abundant in Reach 1)	
Raceway	Increased spawning habitat, but for species not typical of Reach 1	Increase in summer habitat for rheophilic species (currently not abundant in Reach 1)	Increase in fall habitat for rheophilic species (currently not abundant in Reach 1)	
Medium pool	No change	Increased nursery habitat, increased spawning habitat for centrarchids	Increase habitat for minnows, sunfish	
Deep pool	No change	No change	No change	
Invertebrate diversity	No change	Decline in habitat availability	Decline in habitat availability	Invertebrate diversity and abundance may decline
Tricopteran abundance	No change	Decline in habitat availability	Decline in habitat availability	
Sheyenne Reach 2				
Shallow pool	No change	No change	No change	No change
Slow riffle	No change	No change	No change	
Fast riffle	No change	No change	No change	
Raceway	No change	No change	No change	
Medium pool	No change	No change	No change	
Deep pool	No change	No change	No change	
Invertebrate diversity	No change	No change	No change	No change
Tricopteran abundance	No change	No change	No change	
Sheyenne Reach 3				
Shallow pool	Reduced spawning habitat for sunfish, catfish, minnows	Decline in abundance of many ND special concern species, reduced nursery habitat for rheophilic species, reduced spawning habitat for centrarchids	Decline in abundance of many ND special concern species, reduced nursery habitat for rheophilic species	Reduction of fish community to those species that use primarily fast riffle and run habitat throughout their life cycle.
Slow riffle	No effect	Reduced nursery habitat for rheophilic species	Reduced nursery habitat for rheophilic species	
Fast riffle	Occasional increase in spawning area for redhorse, rosyface shiner	Increased habitat for rheophilic species	Increased habitat for rheophilic species	
Raceway	Occasional increase in spawning area for redhorse, rosyface shiner	Increased habitat for rheophilic species	Increased habitat for rheophilic species	
Medium pool	No effect[3]	Decline in abundance of many ND special concern species, reduced nursery habitat for rheophilic species, reduced spawning habitat for centrarchids, reduced habitat for adult centrarchids	Decline in abundance of many ND special concern species, reduced nursery habitat for rheophilic species	
Deep pool	No effect	Increased habitat for adult centrarchids	Increased habitat for pool species (minnows,	
Invertebrate diversity	No change	No change	Decline in overall invertebrate diversity	Decline in overall diversity, but increased abundance of hydropsychid caddisflies, and rheophilic diptera and ephemeroptera
Tricopteran abundance	No change	Increased habitat for rheophilic invertebrates	Increase in abundance of rheophilic invertebrates	
Sheyenne Reach 5				
Shallow pool	Reduced spawning habitat for sunfish, catfish, minnows	Decline in nursery area for many species, spawning habitat for sunfish	Decline in nursery area for many species	Decline in minnows, sunfish, and other pool species; reduced recruitment of rheophilic species, however increased habitat for adult rheophilic species
Slow riffle	No change	Increased nursery area for channel catfish and redhorse	Increased nursery area for channel catfish and redhorse	
Fast riffle	No change	No change	Increased habitat for rheophilic species	
Raceway	Occassional increased spawning habitat for catastomids	Increased habitat for rheophilic species	Increased habitat for rheophilic species	
Medium pool	No effect	Decreased habitat for pool species (minnows, sunfish)	Decreased habitat for pool species (minnows, sunfish)	
Deep pool	No effect	Decreased habitat for pool species (minnows, sunfish)	Decreased habitat for pool species (minnows, sunfish)	
Invertebrate diversity	No change	No change	No change	Slight increase in hydropychid caddisflies, and rheophilic diptera and ephemeroptera
Tricopteran abundance	No change	No change	Increase in abundance of rheophilic invertebrates	

[1]Effects are based on habitat alone, many other factors will contribute to community changes

[2]No change=average %WUA changed less than 10%

[3]No effect=%WUA changed but change probably does not effect fish or invertebrates

TABLE 5-28

SUMMARY OF EFFECTS OF 480MOD55 COMPARED TO MOD55 ON AQUATIC BIOTA IN THE SHEYENNE AND RED RIVERS

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	Sheyenne River					Red River		
	Reach 1	**Reach 2**	**Reach 3**	**Reach 4**	**Reach 5**	**Reach 1**	**Reach 2**	**Reach 3**
Fish								
WQ	Some decline in reproduction of late spawning sensitive fish species	No effect	No effect	No effect	No effect	No effect	No effect	No effect
Hydrology	Less summer/fall stress but increased winter stress	No effect	Less summer/fall stress but increased winter stress	Less summer/fall stress but increased winter stress	Less summer/fall stress but increased winter stress	Less stress to sensitive fish	No effect	No effect
Geomorphology	Loss of simple lithophils, obligate riffle species	No effect	Loss of simple lithophils, obligate riffle species, loss of turbidity intolerant taxa	Loss of simple lithophils, obligate riffle species, loss of turbidity intolerant taxa	Loss of simple lithophils, obligate riffle species, loss of turbidity intolerant taxa	No effect	No effect	No effect
Habitat	Increased fish abundance, shift in species composition toward rheophilic taxa	No effect	Reduction of fish community to those species that use primarily fast riffle and run habitat throughout their life cycle	Cannot predict from this study	Decline in minnows, sunfish, and other pool species, reduced recruitment of rheophilic species, however increased habitat for adult rheophilic species	No effect	No effect	No effect
Biotic interaction	Decrease in invertebrates will effect survival of insectivore species; loss of macrophytes will reduce cover		Decrease in invertebrates will effect survival of insectivore species, loss of macrophytes will affect species prefering weed beds	Decrease in invertebrates will effect survival of insectivore species, loss of macrophytes will affect species prefering weed beds	Decrease in invertebrates will effect survival of insectivore species, loss of macrophytes will affect species prefering weed beds			
Overall expected effects	Decline in abundance and diversity of fish community	No effect	Decline in abundance and diversity of fish community, possible loss of special concern species	Decline in abundance and diversity of fish community	Potential severe decline or loss of fish in this reach	No effect	No effect	No effect
Mollusks								
WQ	Unionids, sphaeriids, and prosobranchs may be extirpated	Unionids, sphaeriids, and prosobranchs may be extirpated	Unionids, sphaeriids, and prosobranchs may be extirpated	Decrease in abundance of sensitive mollusks	Decrease in abundance of sensitive mollusks	Some decline in abundance of sensitive mollusks	Some decline in abundance of sensitive mollusks	Some decline in abundance of sensitive mollusks
Hydrology	Unionids will be limited by available winter habitat	No effect	Unionids will be limited by available winter habitat	Unionids will be limited by available winter habitat	Unionids will be limited by available winter habitat	Less stress due to low flow events	No effect	No effect
Geomorphology	Scouring and deposition could extirpate unionids, displace other mollusks	No effect	Scouring and deposition could extirpate unionids, displace other mollusks	Scouring and deposition could extirpate unionids, displace other mollusks	Scouring and deposition could extirpate unionids, displace other mollusks	No effect	No effect	No effect
Habitat	Cannot predict from this study	Cannot predict from this study	Cannot predict from this study	Cannot predict from this study	Cannot predict from this study		No effect	No effect
Biotic interaction	Decline in fish hosts		Decline in fish hosts	Decline in fish hosts	Decline in fish hosts			
Overall expected effects	Unionids, sphaeriids, and prosobranchs may be extirpated	Unionids, sphaeriids, and prosobranchs may be extirpated	Unionids, sphaeriids, and prosobranchs may be extirpated	Unionids may be extirpated, sphaeriids and prosobranchs may be reduced in abundance	Unionids may be extirpated, sphaeriids and prosobranchs may be reduced in abundance	Some decline in abundance of sensitive mollusks	Some decline in abundance of sensitive mollusks	Some decline in abundance of sensitive mollusks
Invertebrates								
Water quality	Sensitive invertebrates may be extirpated, reduced abundance of tolerant taxa	Sensitive invertebrates may be extirpated, reduced abundance of tolerant taxa	Sensitive invertebrates may be extirpated, reduced abundance of tolerant taxa	Decrease in abundance and species richness	Decrease in abundance and species richness	Decrease in abundance of sensitive and tolerant taxa	Decrease in abundance of sensitive taxa	Some decrease in abundance of sensitive taxa
Hydrology	Less summer/fall stress but increased winter stress	No effect	Less summer/fall stress but increased winter stress	Less summer/fall stress but increased winter stress	Less summer/fall stress but increased winter stress	Less stress due to low flow events	No effect	No effect
Geomorphology	Unstable substrate will lead to less diversity and abundance	No effect	Unstable substrate will lead to less diversity and abundance	Unstable substrate will lead to less diversity and abundance	Unstable substrate will lead to less diversity and abundance	No effect	No effect	No effect
Habitat	Invertebrate diversity and abundance may decline	No effect	Decline in overall diversity, but increased abundance of hydropsychid caddisflies, rheophilic diptera, and rheophilic ephemeroptera	Cannot predict from this study	Slight increase in hydropsychid caddisflies, rheophilic diptera and ephemeroptera	No effect	No effect	No effect
Biotic interaction	Decrease in macrophytes (food and cover)		Decrease in macrophytes (food and cover)	Decrease in macrophytes (food and cover)	Decrease in macrophytes (food and cover)			
Overall expected effects	Reduced invertebrate community to only species tolerant of water quality changes, and unstable substrate	Sensitive invertebrates may be extirpated, reduced abundance of tolerant taxa	Reduced invertebrate community to only species tolerant of water quality changes, and unstable substrate	Reduced invertebrate community to only species tolerant of water quality changes, and unstable substrate	Reduced invertebrate community to only species tolerant of water quality changes, and unstable substrate	Decrease in abundance of sensitive taxa	Decrease in abundance of sensitive taxa	Some decrease in abundance of sensitive taxa
Algae								
Water quality	Possible extirpation of some sensitive species, decrease in abundance/richness of sensitive and tolerant species	Some decrease in richness and abundance of sensitive taxa/increase of tolerant taxa	Some decrease in richness and abundance of sensitive taxa/increase of tolerant taxa	Some decrease in richness and abundance of sensitive taxa	No effect	No effect	No effect	No effect
Hydrology	Decline in algal abundance and diversity, possible loss of periphyton with loss of shallow water habitats	No effect	Decline in algal abundance and diversity, possible loss of periphyton with loss of shallow water habitats	Decline in algal abundance and diversity, possible loss of periphyton with loss of shallow water habitats	Decline in algal abundance and diversity, possible loss of periphyton with loss of shallow water habitats	Favor phytoplankton, possible loss of periphyton	No effect	No effect
Geomorphology	Loss of some attached algae and epiphytes through scouring or burial, decreased production due to turbidity	Decreased production due to increase in turbidity	Loss of some attached algae and epiphytes through scouring or burial, decreased production due to turbidity	Loss of some attached algae and epiphytes through scouring or burial, decreased production due to turbidity	Loss of some attached algae and epiphytes through scouring or burial, decreased production due to turbidity	No effect	No effect	No effect
Habitat								
Biotic interaction	Loss of macrophytes will affect epiphyton							
Overall expected effects	Loss of some attached algae and epiphytes through scouring or burial, decreased production due to turbidity	Some decline in abundance and species richness	Loss of some attached algae and epiphytes through scouring or burial, decreased production due to turbidity	Loss of some attached algae and epiphytes through scouring or burial, decreased production due to turbidity	Loss of some attached algae and epiphytes through scouring or burial, decreased production due to turbidity	Favor phytoplankton, possible loss of periphyton	No effect	No effect
Macrophytes								
Water quality	Some decrease in abundance/richness of sensitive taxa	Some decrease in richness and abundance of sensitive taxa/increase of tolerant taxa	Some decrease in richness and abundance of sensitive taxa/increase of tolerant taxa	No effect	No effect	No effect	No effect	No effect
Hydrology	Expanded macrophyte areas disturbed annually	No effect	Expanded macrophyte areas disturbed annually	Expanded macrophyte areas disturbed annually	Expanded macrophyte areas disturbed annually	Emergent and wetland fringe vegetation should move up the banks into new shallow water zone	No effect	No effect
Geomorphology	Loss of macrophytes through scouring and burial, decreased production due to turbidity	Decreased production due to increase in turbidity	Loss of macrophytes through scouring and burial, decreased production due to turbidity	Loss of macrophytes through scouring and burial, decreased production due to turbidity	Loss of macrophytes through scouring and burial, decreased production due to turbidity	No effect	No effect	No effect
Habitat								
Overall expected effects	Loss of macrophytes through scouring and burial, decreased production due to turbidity	Some decline in abundance and species richness	Loss of macrophytes through scouring and burial, decreased production due to turbidity	Loss of macrophytes through scouring and burial, decreased production due to turbidity	Loss of macrophytes through scouring and burial, decreased production due to turbidity	Emergent and wetland fringe vegetation should move up the banks into new shallow water zone	No effect	No effect

TABLE 5-29

PERCENT CHANGE[1] IN AVERAGE, MINIMUM, AND MAXIMUM TDS, SULFATE, AND CHLORIDE EXPECTED IN THE SHEYENNE AND RED RIVERS WITH WETOF COMPARED TO WET

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	Sheyenne River				Red River		
	Reach 1	Reach 3	Reach 3	Reach 5	Reach 1	Reach 2	Reach 3
	Cooperstown	Baldhill	Lisbon	Kindred	Halstad	Grand Forks	Emerson
TDS (mg/l)							
Min	49.5	68.0	54.5	53.9	7.4	3.0	7.0
Max	282.7	269.2	195.9	173.6	76.7	103.0	56.4
Ave	170.6	175.6	133.9	116.0	45.0	29.8	20.6
% greater than guideline	18.6	57.7	38.3	33.1	60.1	24.1	37.4
Sulfate (mg/l)							
Min	118.3	110.1	82.0	76.9	29.1	16.6	12.1
Max	633.9	533.4	389.6	345.4	155.6	211.0	118.8
Ave	381.2	351.0	286.0	232.1	107.3	76.8	52.8
% greater than guideline	72.2	64.2	60.6	54.1	18.4	5.3	4.1
Chloride (mg/l)							
Min	93.9	132.6		119.9	15.8	15.1	15.9
Max	1148.4	1187.1		575.4	77.6	85.3	19.9
Ave	747.6	717.1		456.8	102.7	89.3	41.7
% greater than guideline	66.4	59.0		38.9	0.3	0.0	0.0

[1] WETOF-WET/WET *100 (see Table 5-30)

TABLE 5-30

AVERAGE, MINIMUM, AND MAXIMUM TDS, SULFATE, AND CHLORIDE EXPECTED[1] IN THE SHEYENNE AND RED RIVERS WITH WETOF COMPARED TO WET
Final Aquatic Impact Analysis Report

WET

	Sheyenne River				Red River		
	Reach 1	**Reach 3**	**Reach 3**	**Reach 5**	**Reach 1**	**Reach 2**	**Reach 3**
	Cooperstown	**Baldhill**	**Lisbon**	**Kindred**	**Halstad**	**Grand Forks**	**Emerson**
TDS (mg/l)							
Min	222.2	266.1	259.2	262.8	325.4	285.8	301.5
Max	880.6	746.5	819.1	819.1	659.6	474.5	729.5
Ave	600.5	489.3	537.2	542.2	417.7	356.4	426.7
Guideline	500	500	500	500	500	500	500
% greater than guideline	77.7	41.9	60.6	65.3	5.5	0	8.0
Sulfate (mg/l)							
Min	38.7	73.0	74.5	75.4	57.2	40.6	44.2
Max	220.9	203.7	229.1	228.9	186.8	117.9	173.1
Ave	147.8	128.9	135.4	144.7	92.2	72.0	89.1
Standard	450	450	450	450	250	250	250
% greater than standard	0	0	0	0	0	0	0
Chloride (mg/l)							
Min	5.6	7.8		7.9	10.3	6.7	8.3
Max	26.7	20.2		29.8	60.2	40.6	73.4
Ave	16.4	13.6		16.0	19.7	12.8	22.6
Standard	100	100		100	100	100	100
% greater than standard	0	0		0	0	0	0

WETOF

	Sheyenne River				Red River		
	Reach 1	**Reach 3**	**Reach 3**	**Reach 5**	**Reach 1**	**Reach 2**	**Reach 3**
	Cooperstown	**Baldhill**	**Lisbon**	**Kindred**	**Halstad**	**Grand Forks**	**Emerson**
TDS (mg/l)							
Min	332.1	447.2	400.5	404.3	349.4	294.3	322.7
Max	3369.5	2756.4	2423.4	2240.6	1165.7	963.4	1140.7
Ave	1624.7	1348.7	1256.8	1171.3	605.8	462.5	514.4
Guideline	500	500	500	500	500	500	500
% greater than guideline	96.3	99.6	98.9	98.5	65.6	24.1	45.5
Sulfate (mg/l)							
Min	84.5	153.3	135.5	133.4	73.8	47.4	49.6
Max	1621.2	1290.3	1121.8	1019.8	477.5	366.8	378.6
Ave	711.5	581.3	522.5	480.4	191.1	127.3	136.2
Standard	450	450	450	450	250	250	250
% greater than standard	72.2	64.2	60.6	54.1	18.4	5.3	4.1
Chloride (mg/l)							
Min	10.8	18.3		17.4	11.9	7.8	9.7
Max	333.4	260.4		201.2	106.9	75.2	88.0
Ave	138.7	111.1		88.8	39.9	24.2	32.0
Standard	100	100		100	100	100	100
% greater than standard	66.4	59.0		38.9	0.3	0.0	0.0

[1] HEC-5 Data File: Wet Future Base Condition vs. Wet Future with Overflow HEC-5Q Data File: Q5PWW48.DAT
Run date and time: 09APR01 - 16:36:37

TABLE 5-31

SUMMARY OF THE EFFECTS OF WATER QUALITY CHANGES EXPECTED WITH WETOF COMPARED TO WET ON AQUATIC BIOTA

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	TDS[1]	Sulfate[1]	Chloride[1]	Total[1]
Sheyenne Reach 1				
Sensitive fish	Decline in reproductive success	Decline in reproductive success	No effect	Decline in reproductive success
Tolerant fish	No effect	No effect	No effect	No effect
Sensitive mollusks	Some decrease in abundance/richness	Some decrease in abundance/richness	May be extirpated	May be extirpated
Tolerant mollusks	No effect	No effect	No effect	No effect
Sensitive invertebrates	Decrease in abundance/richness	May be extirpated	May be extirpated	May be extirpated
Tolerant invertebrates	Some decrease in abundance/richness	Decrease in abundance/richness	No effect	Decrease in abundance/richness
Sensitive algae/periphyton[2]	Some decrease in abundance/richness, possible extirpation of the most sensitive species	Some decrease in abundance/richness	Some decrease in abundance/richness	Some decrease in abundance/richness, possible extirpation of the most sensitive species
Tolerant algae/periphyton[2]				Some increase in abundance/richness
Sensitive macrophytes[2]	Some decrease in abundance/richness	Some decrease in abundance/richness	Some decrease in abundance/richness	Some decrease in abundance/richness
Tolerant macrophytes[2]				Some increase in abundance/richness
Sheyenne Reach 2				
Sensitive fish	Decline in reproductive success	Decline in reproductive success	No effect	Decline in reproductive success
Tolerant fish	No effect	No effect	No effect	No effect
Sensitive mollusks	Some decrease in abundance/richness	Some decrease in abundance/richness	May be extirpated	May be extirpated
Tolerant mollusks	No effect	No effect	No effect	No effect
Sensitive invertebrates	Decrease in abundance/richness	May be extirpated	May be extirpated	May be extirpated
Tolerant invertebrates	Some decrease in abundance/richness	Decrease in abundance/richness	No effect	Decrease in abundance/richness
Sensitive algae/periphyton	Some decrease in abundance/richness, possible extirpation of the most sensitive species	Some decrease in abundance/richness	Some decrease in abundance/richness	Some decrease in abundance/richness, possible extirpation of the most sensitive species
Tolerant algae/periphyton				Some increase in abundance/richness
Sensitive macrophytes	Some decrease in abundance/richness	Some decrease in abundance/richness	Some decrease in abundance/richness	Some decrease in abundance/richness
Tolerant macrophytes				Some increase in abundance/richness
Sheyenne Reach 3				
Sensitive fish	Decline in reproductive success	Decline in reproductive success	No effect	Decline in reproductive success
Tolerant fish	No effect	No effect	No effect	No effect
Sensitive mollusks	Some decrease in abundance/richness	Some decrease in abundance/richness	May be extirpated	May be extirpated
Tolerant mollusks	No effect	No effect	No effect	No effect
Sensitive invertebrates	Decrease in abundance/richness	May be extirpated	May be extirpated	May be extirpated
Tolerant invertebrates	Some decrease in abundance/richness	Decrease in abundance/richness	No effect	Decrease in abundance/richness
Sensitive algae/periphyton	Some decrease in abundance/richness	Some decrease in abundance/richness	Some decrease in abundance/richness	Some decrease in abundance/richness
Tolerant algae/periphyton				Some increase in abundance/richness
Sensitive macrophytes	Some decrease in abundance/richness	Some decrease in abundance/richness	Some decrease in abundance/richness	Some decrease in abundance/richness
Tolerant macrophytes				Some increase in abundance/richness
Sheyenne Reach 4				
Sensitive fish	Decline in reproductive success	Decline in reproductive success	No effect	Decline in reproductive success
Tolerant fish	No effect	No effect	No effect	No effect
Sensitive mollusks	Some decrease in abundance/richness	No effect	Decrease in abundance/richness	Decrease in abundance/richness
Tolerant mollusks	No effect	No effect	No effect	No effect
Sensitive invertebrates	Decrease in abundance/richness	May be extirpated	May be extirpated	May be extirpated
Tolerant invertebrates	Some decrease in abundance/richness	Decrease in abundance/richness	No effect	Decrease in abundance/richness
Sensitive algae/periphyton	No effect	Some decrease in abundance/richness	Some decrease in abundance/richness	Some decrease in abundance/richness
Tolerant algae/periphyton				Some increase in abundance/richness
Sensitive macrophytes	No effect	No effect	No effect	No effect
Tolerant macrophytes				No effect
Sheyenne Reach 5				
Sensitive fish	Decline in reproductive success	Decline in reproductive success	No effect	Decline in reproductive success
Tolerant fish	No effect	No effect	No effect	No effect
Sensitive mollusks	Some decrease in abundance/richness	No effect	Decrease in abundance/richness	Decrease in abundance/richness
Tolerant mollusks	No effect	No effect	No effect	No effect
Sensitive invertebrates	Decrease in abundance/richness	May be extirpated	May be extirpated	May be extirpated
Tolerant invertebrates	Some decrease in abundance/richness	Decrease in abundance/richness	No effect	Decrease in abundance/richness
Sensitive algae/periphyton	No effect	No effect	No effect	No effect
Tolerant algae/periphyton	No effect	No effect	No effect	No effect
Sensitive macrophytes	No effect	No effect	No effect	No effect
Tolerant macrophytes	No effect	No effect	No effect	No effect
Red River Reach 1				
Sensitive fish	Potential loss of occasional year class	No effect	No effect	Potential loss of occasional year class
Tolerant fish	No effect	No effect	No effect	No effect
Sensitive mollusks	No effect	No effect	Some decrease in abundance/richness	Some decrease in abundance/richness
Tolerant mollusks	No effect	No effect	No effect	No effect
Sensitive invertebrates	No effect	Some decrease in abundance/richness	Some decrease in abundance/richness	Some decrease in abundance/richness
Tolerant invertebrates	No effect	No effect	No effect	No effect
Sensitive algae/periphyton	No effect	No effect	No effect	No effect
Tolerant algae/periphyton	No effect	No effect	No effect	No effect
Sensitive macrophytes	No effect	No effect	No effect	No effect
Tolerant macrophytes	No effect	No effect	No effect	No effect
Red River Reach 2				
Sensitive fish	No effect	No effect	No effect	No effect
Tolerant fish	No effect	No effect	No effect	No effect
Sensitive mollusks	No effect	No effect	No effect	No effect
Tolerant mollusks	No effect	No effect	No effect	No effect
Sensitive invertebrates	No effect	Some decrease in abundance/richness	Some decrease in abundance/richness	Some decrease in abundance/richness
Tolerant invertebrates	No effect	No effect	No effect	No effect
Sensitive algae/periphyton	No effect	No effect	No effect	No effect
Tolerant algae/periphyton	No effect	No effect	No effect	No effect
Sensitive macrophytes	No effect	No effect	No effect	No effect
Tolerant macrophytes	No effect	No effect	No effect	No effect
Red River Reach 3				
Sensitive fish	No effect	No effect	No effect	No effect
Tolerant fish	No effect	No effect	No effect	No effect
Sensitive mollusks	No effect	No effect	No effect	No effect
Tolerant mollusks	No effect	No effect	No effect	No effect
Sensitive invertebrates	No effect	Some decrease in abundance/richness	Some decrease in abundance/richness	Some decrease in abundance/richness
Tolerant invertebrates	No effect	No effect	No effect	No effect
Sensitive algae/periphyton	No effect	No effect	No effect	No effect
Tolerant algae/periphyton	No effect	No effect	No effect	No effect
Sensitive macrophytes	No effect	No effect	No effect	No effect
Tolerant macrophytes	No effect	No effect	No effect	No effect

[1] No effect-Maximum predicted levels of TDS, sulfate, and chloride do not exceed levels in Table 4-3.
Some effect-Maximum predicted levels of TDS, sulfate, or chloride exceed levels in Table 4-3.
effect-Mean predicted levels of TDS, sulfate, or chloride exceed levels in Table 4-3 at least during part of the year
May be extirpated-Mean TDS, sulfate, or chloride levels exceed values in Table 4-3 most of the time or during a critical life history period.

[2] No tolerance thresholds available, based on general tolerance of groups in literature

TABLE 5-32

CHANGES IN BIOLOGICALLY RELAVENT HYDROLOGICAL PARAMETERS BETWEEN WET AND WETOF IN THE SHEYENNE AND RED RIVERS

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	Sheyenne River															Red River								
	Reach 1 (Hwy 30)			Reach 1 (Cooperstown)			Reach 3 (Baldhill)			Reach 3 (Lisbon)			Reach 5 (Kindred)			Reach 1 (Halstad)			Reach 2 (Grand Forks)			Reach 3 (Emerson)		
	WET	WETOF		WET	WETOF		WET	WETOF		WET	WETOF		WET	WETOF		WET	WETOF		WET	WETOF		WET	WETOF	
Indications of Hydro Alt[1]	**Mean**	**Mean**	**H.A.[2]**	**Mean**	**Mean**	**H.A.[2]**	**Mean**	**Mean**	**H.A.[2]**	**Mean**	**Mean**	**H.A.[2]**	**Mean**	**Mean**	**H.A.[2]**	**Mean**	**Mean**	**H.A.[2]**	**Mean**	**Mean**	**H.A.[2]**	**Mean**	**Mean**	**H.A.[2]**
Mean monthly flow (cfs)																								
October	21.5	21.5	0.00	91.8	164.7	-0.25	236.3	309.5	0.00	254.0	329.9	-0.13	279.1	357.8	-0.13	1377.6	1459.9	0.29	2901.8	2986.4	0.00	3318.0	3406.9	0.13
November	19.3	19.3	0.00	68.3	138.1	-0.25	198.8	268.6	**-0.38**	231.7	301.2	-0.25	272.6	342.2	-0.13	1130.9	1200.7	-0.14	2260.0	2330.1	0.00	2766.9	2837.4	0.00
December	13.8	13.8	0.00	43.8	115.3	**-0.78**	158.1	229.5	**-0.78**	182.9	253.3	**-0.56**	214.0	283.6	**-0.38**	906.3	975.5	-0.11	2016.8	2085.5	0.00	2279.6	2348.3	0.00
January	9.5	9.5	0.00	29.1	107.7	**-0.75**	39.0	117.3	**-0.71**	71.6	146.5	**-0.50**	103.1	175.0	**-0.63**	642.0	712.1	-0.25	1512.8	1581.4	-0.13	1665.4	1732.4	-0.13
February	26.9	26.9	0.00	43.2	135.6	**-0.63**	62.9	154.4	**-0.38**	84.2	175.1	-0.29	92.3	181.6	**-0.43**	784.0	868.9	0.11	1672.0	1754.9	0.00	1633.7	1712.6	0.00
March	233.3	233.3	0.00	402.5	515.0	0.14	587.1	688.4	0.00	666.3	771.7	0.00	666.3	775.1	0.14	4089.2	4199.6	0.00	6596.4	6708.6	0.00	6509.0	6615.6	0.00
April	454.0	454.0	0.00	1159.9	1298.9	0.00	1216.3	1350.1	-0.13	1510.7	1640.8	-0.13	1658.2	1786.5	-0.25	10746.9	10867.4	0.00	18420.6	18537.9	0.00	23469.7	23581.6	0.00
May	155.0	155.0	0.00	411.8	615.4	-0.14	597.0	807.3	0.14	782.3	983.5	-0.14	991.8	1183.0	0.00	5605.7	5783.9	0.11	9989.5	10159.7	0.00	16015.2	16166.7	0.00
June	70.4	70.4	0.00	211.3	442.9	**-0.56**	267.0	504.4	**-0.50**	337.2	574.2	**-0.44**	438.3	675.9	-0.25	3389.6	3620.5	0.00	6511.4	6738.3	-0.13	8331.6	8564.1	0.00
July	72.8	72.8	0.00	228.6	444.2	**-0.50**	317.3	532.4	**-0.38**	386.8	604.0	**-0.38**	465.5	685.0	**-0.44**	4171.3	4399.7	0.00	7575.2	7807.4	0.00	9131.0	9370.1	0.00
August	58.9	58.9	0.00	185.7	355.1	-0.13	263.7	436.7	0.13	314.5	491.1	0.13	375.8	555.4	0.13	2188.7	2373.9	0.25	4097.6	4283.0	0.00	5492.4	5681.9	0.00
September	20.3	20.3	0.00	98.7	206.0	0.00	131.4	240.4	0.00	159.9	273.8	0.00	212.5	330.7	0.00	1400.9	1531.9	0.14	3299.0	3439.5	-0.13	4069.7	4221.8	0.00
Mean flow (cfs) of annual extremes																								
1-day minimum	4.4	4.4	0.00	15.4	53.6	**-0.71**	17.6	60.5	**-0.44**	31.4	76.6	-0.29	54.0	103.7	**-0.57**	396.1	456.2	0.17	1128.4	1195.8	0.00	1322.4	1393.5	-0.13
3-day minimum	4.6	4.6	0.00	16.1	54.7	**-0.71**	20.2	63.0	**-0.50**	32.7	77.7	**-0.38**	56.0	105.0	**-0.50**	406.4	464.8	0.17	1152.4	1219.8	0.00	1330.8	1401.3	0.00
7-day minimum	4.8	4.8	0.00	17.0	57.0	**-0.75**	22.7	67.4	**-0.50**	34.6	80.2	**-0.33**	60.1	109.3	**-0.40**	432.3	490.8	0.17	1192.4	1259.7	-0.11	1359.8	1425.8	0.00
30-day minimum	5.9	5.9	0.00	21.4	65.0	**-0.75**	29.7	83.2	**-0.60**	43.4	102.0	**-0.33**	69.8	128.5	**-0.50**	507.1	593.3	0.00	1274.4	1356.1	-0.11	1447.5	1511.7	0.00
90-day minimum	7.9	7.9	0.00	28.8	68.1	**-0.71**	56.6	119.8	**-0.86**	81.3	143.0	**-0.63**	109.8	173.9	**-0.40**	617.5	706.2	0.14	1463.3	1551.5	0.13	1615.3	1700.5	0.00
1-day maximum	1469.4	1469.4	0.00	2707.0	2841.0	0.00	2600.2	2721.2	0.00	2910.2	3044.1	0.00	3023.0	3160.3	0.00	21507.1	21644.7	0.00	38660.6	38817.0	0.00	41578.3	41700.6	0.00
3-day maximum	1395.0	1395.0	0.00	2555.3	2689.9	0.00	2535.3	2660.3	0.00	2841.5	2970.9	0.00	2986.3	3124.9	0.00	21176.4	21313.5	0.00	37128.1	37283.3	0.00	41274.4	41395.9	0.00
7-day maximum	1242.4	1242.4	0.00	2305.7	2444.3	0.00	2396.6	2520.2	0.14	2728.1	2852.0	0.00	2867.6	3007.2	0.00	20045.3	20178.1	0.00	35058.9	35211.0	0.00	39936.1	40057.0	0.00
30-day maximum	648.7	648.7	0.00	1490.1	1636.0	-0.13	1829.8	1961.4	-0.13	2148.0	2268.6	0.00	2266.6	2391.3	0.00	13848.5	13974.4	0.00	23122.5	23254.8	0.00	30591.9	30710.7	0.00
90-day maximum	308.3	308.3	0.00	741.4	933.1	0.00	927.3	1111.6	-0.14	1134.7	1314.3	**-0.33**	1269.4	1446.0	-0.25	7756.6	7925.2	0.00	13266.2	13428.0	0.00	17786.9	17948.4	0.00
Number of zero days	0.0	0.0	0.00	0.0	0.0	0.00	0.0	0.0	0.00	0.0	0.0	0.00	0.0	0.0	0.00	0.0	0.0	0.00	0.0	0.0	0.00	0.0	0.0	0.00
Base flow	0.1	0.1	0.00	0.1	0.1	**-0.75**	0.1	0.1	**-0.63**	0.1	0.1	**-0.63**	0.1	0.2	-0.14	0.2	0.2	0.00	0.2	0.2	-0.13	0.2	0.2	0.00
Mean date of annual extremes																								
Date of minimum	177.4	177.4	0.00	119.2	264.8	0.00	99.3	112.5	**-0.75**	158.5	141.1	0.00	110.1	119.4	0.00	212.0	213.7	0.00	215.9	215.7	0.00	189.7	189.5	0.00
Month	June	June		May	Sept		April	April		June	May		April	May		August	August		August	August		July	July	
Date of maximum	99.2	99.2	0.00	104.0	104.0	0.00	102.7	106.9	0.17	100.9	100.8	0.00	110.0	109.9	0.00	125.1	125.0	0.00	130.4	130.4	0.00	128.6	128.6	0.00
Month	April	April		April	April		April	April		April	April		April	April		May	May		May	May		May	May	
Mean duration (days) and frequency (count) of annual extremes																								
Low pulse count	4.6	4.7	0.17	3.7	0.6	**-0.57**	5.8	1.5	**-0.71**	3.1	1.5	**-0.50**	2.9	1.6	**-0.38**	2.9	2.6	0.17	4.1	3.4	0.00	2.5	2.5	-0.11
Low pulse duration	23.2	16.0	0.13	37.0	23.5	**-0.75**	19.5	9.8	**-0.43**	32.3	15.4	**-0.71**	35.2	17.8	**-0.43**	24.1	23.3	0.00	33.0	30.9	0.00	38.5	35.3	-0.25
High pulse count	1.5	1.5	0.00	1.5	2.2	-0.13	2.5	2.6	0.13	1.9	2.3	-0.11	2.0	2.0	0.13	2.0	2.1	-0.13	2.2	2.1	0.00	1.7	1.7	0.00
High pulse duration	17.2	17.2	0.00	20.0	21.1	0.00	12.1	16.3	0.00	15.5	16.6	0.14	17.9	20.4	0.00	14.6	14.7	0.00	13.8	14.6	-0.14	22.5	22.8	0.00
Mean rise and fall rate (cfs)																								
Rise rate	23.6	23.6	0.00	33.3	30.4	0.00	51.2	50.0	-0.13	45.7	45.8	0.00	42.0	42.2	-0.13	309.9	309.8	0.00	556.8	554.4	0.00	535.5	530.1	-0.11
Fall rate	-13.7	-13.7	-0.14	-17.8	-19.7	-0.14	-39.6	-39.6	0.00	-31.9	-33.0	-0.13	-28.5	-29.6	0.00	-172.8	-174.1	0.13	-331.0	-332.4	0.00	-300.9	-302.5	0.00
Number of reversals	66.6	66.6	0.00	77.0	66.8	**-0.33**	130.6	129.3	0.17	83.5	82.6	-0.22	81.7	76.8	0.00	63.5	62.9	0.00	70.7	71.1	0.14	34.5	34.5	0.00
Flow Duration (CFS)[3]				WET	WETOF	% Change	WET	WETOF	% Change	WET	WETOF	% Change	WET	WETOF	% Change	WET	WETOF	% Change	WET	WETOF	% Change	WET	WETOF	% Change
99% exceedence				4.6	5.8	26	13.0	13.0	0	15.5	15.8	2	30.8	36.7	19	180.0	278.1	**54**	375.3	494.3	32	406.0	532.3	31
95% exceedence				15.3	32.9	**114**	13.0	35.5	**173**	22.2	44.4	**100**	44.4	67.2	**51**	331.4	385.4	16	785.0	899.7	15	1010.0	1028.0	2
90% exceedence				22.3	49.6	**123**	24.7	77.0	**212**	39.3	88.9	**126**	58.4	105.8	**81**	408.6	480.6	18	1247.2	1295.2	4	1350.9	1432.0	6
75% exceedence				35.6	91.9	**158**	54.5	151.1	**178**	86.3	170.9	**98**	120.6	204.8	**70**	745.8	802.3	8	1742.3	1819.0	4	1956.3	2014.3	3
50% exceedence				70.8	214.2	**202**	160.6	267.4	**66**	190.4	295.6	**55**	224.9	345.4	**54**	1162.8	1308.9	13	2574.9	2692.7	5	3009.5	3171.4	5
25% exceedence				226.4	479.3	**112**	292.1	540.8	**85**	363.3	611.3	**68**	457.7	683.8	**49**	2924.3	3154.1	8	5402.7	5669.1	5	6797.3	7000.5	3
10% exceedence				549.3	857.8	**56**	703.0	991.1	**41**	941.2	1194.1	27	1131.9	1417.8	25	7126.3	7436.4	4	13134.0	13383.3	2	18934.2	19165.4	1
5% exceedence				1098.7	1293.0	18	1393.0	1608.6	15	1719.2	1858.4	8	1879.2	2042.8	9	12271.3	12371.0	1	21363.7	21454.5	0	27171.5	27404.3	1
1% exceedence				2760.5	2967.7	8	3367.4	3378.4	0	4105.5	4105.5	0	4334.0	4376.8	1	23228.0	23363.0	1	40482.0	40599.0	0	53868.6	53943.8	0

[1] Calulations using the IHA model

[2] H.A.=Hydrological alteration

"+" value indicates values at 480MOD55 fell within the RVA (see Appendix J) more frequently than expected (less variability)

"-" value indicates values at 480MOD55 fell outside the RVA (see Appendix J) more frequently than expected (more variability, or different means)

0.0-0.33 little or no alteration

0.34-0.67 moderate alteration

0.68-1.00 high alteration

[3] HEC-5 Data File: Wet Future Base Condition vs. Base Condition with Overflow HEC-5Q Data File: Q5PWW48.DAT

Run date and time: 09APR01 - 16:36:37

TABLE 5-33

SUMMARY OF THE EFFECTS OF HYDROLOGICAL CHANGES EXPECTED WITH WETOF COMPARED TO WET ON AQUATIC BIOTA
Final Aquatic Impact Analysis Report

	Mean seasonal flow				Variation in monthly flow				Low flow			Fall to winter	
	Winter (increase)	Spring (no change)	Summer (increase)	Fall (increase)	Winter (slight increase)	Spring (decrease)	Summer (decrease)	Fall (decrease)	Magnitude (increase)	Frequency (decrease)	Duration (decrease)	(same to increased flow)	Total flow effect
Sheyenne River Reach 1													
Fish	Main effects are on habitat availability				Main effects are on habitat availability				Less stress to sensitive fish	Less stress to sensitive fish	Less stress to sensitive fish	Less stress to sensitive fish	Less summer, fall and winter stress due to low flow
Mollusks	Improve conditions for mollusks	No effect[1]	Improve conditions for mollusks	Improve conditions for mollusks	No effect	No effect	Improve conditions for mollusks	Improve conditions for mollusks	Improve conditions for mollusks	Improve conditions for mollusks	Improve conditions for mollusks	No effect	Less summer, fall and winter stress due to low flow
Invertebrates	Improve habitat diversity	No effect	Improve habitat diversity	Improve habitat diversity	No effect	No effect	Improve conditions for invertebrates	Improve conditions for invertebrates	Less stress to sensitive invertebrates	Less stress to sensitive invertebrates	Less stress to sensitive invertebrates	No effect	Less summer, fall and winter stress due to low flow
Algae	Favor phytoplankton, possible loss of periphyton	No effect	Favor phytoplankton, possible loss of periphyton	Favor phytoplankton, possible loss of periphyton	No effect	Decrease variability in habitat, fewer disturbance events	Decrease variability in habitat, fewer disturbance events	Decrease variability in habitat, fewer disturbance events	Favor phytoplankton, possible loss of periphyton	Less stress due to low flow events	Less stress due to low flow events	No effect	Favor phytoplankton, possible loss of periphyton
Macrophytes	Submergent species may expand, emergent and wetland species pushed up the banks, or removed if shallow water unavailable	No effect	Submergent species may expand, emergent and wetland species pushed up the banks, or removed if shallow water unavailable	Submergent species may expand, emergent and wetland species pushed up the banks, or removed if shallow water unavailable	No effect	Less change in water levels in areas vegetated with macrophytes	Less change in water levels in areas vegetated with macrophytes	Less change in water levels in areas vegetated with macrophytes	Emergent and wetland fringe vegetation should move up the banks into new shallow water zone	Less stress due to low flow events	Less stress due to low flow events	No effect	Submergent species may expand, emergent and wetland species pushed up the banks, or removed if shallow water unavailable
Sheyenne River Reach 2													
Fish	No effect	No effect	No effect		No effect	No effect	No effect		No effect	No effect	No effect	No effect	No effect
Mollusks	No effect	No effect	No effect		No effect	No effect	No effect		No effect	No effect	No effect	No effect	No effect
Invertebrates	No effect	No effect	No effect		No effect	No effect	No effect		No effect	No effect	No effect	No effect	No effect
Algae	No effect	No effect	No effect		No effect	No effect	No effect		No effect	No effect	No effect	No effect	No effect
Macrophytes	No effect	No effect	No effect		No effect	No effect	No effect		No effect	No effect	No effect	No effect	No effect
Sheyenne River Reach 3													
Fish	Main effects are on habitat availability				Main effects are on habitat availability				Less stress to sensitive fish	Less stress to sensitive fish	Less stress to sensitive fish	No effect	Less summer, fall and winter stress due to low flow
Mollusks	Improve conditions for mollusks	No effect	Improve conditions for mollusks	Improve conditions for mollusks	No effect	No effect	Improve conditions for mollusks	Improve conditions for mollusks	Improve conditions for mollusks	Improve conditions for mollusks	Improve conditions for mollusks	No effect	Less summer, fall and winter stress due to low flow
Invertebrates	Improve habitat diversity	No effect	Improve habitat diversity	Improve habitat diversity	No effect	No effect	Decrease variability in habitat, fewer disturbance events	Decrease variability in habitat, fewer disturbance events	Less stress to sensitive invertebrates	Less stress to sensitive invertebrates	Less stress to sensitive invertebrates	No effect	Less summer, fall and winter stress due to low flow
Algae	Favor phytoplankton, possible loss of periphyton	No effect	Favor phytoplankton, possible loss of periphyton	Favor phytoplankton, possible loss of periphyton	No effect	No effect	Decrease variability in habitat, fewer disturbance events	Decrease variability in habitat, fewer disturbance events	Favor phytoplankton, possible loss of periphyton	Less stress due to low flow events	Less stress due to low flow events	No effect	Favor phytoplankton, possible loss of periphyton
Macrophytes	Submergent species may expand, emergent and wetland species pushed up the banks, or removed if shallow water unavailable	No effect	Submergent species may expand, emergent and wetland species pushed up the banks, or removed if shallow water unavailable	Submergent species may expand, emergent and wetland species pushed up the banks, or removed if shallow water unavailable	No effect	No effect	Less change in water levels in areas vegetated with macrophytes	Less change in water levels in areas vegetated with macrophytes	Emergent and wetland fringe vegetation should move up the banks into new shallow water zone	Less stress due to low flow events	Less stress due to low flow events	No effect	Submergent species may expand, emergent and wetland species pushed up the banks, or removed if shallow water unavailable
Sheyenne River Reach 4													
Fish	Main effects are on habitat availability				Main effects are on habitat availability				Less stress to sensitive fish	Less stress to sensitive fish	Less stress to sensitive fish	No effect	Less summer, fall and winter stress due to low flow
Mollusks	Improve conditions for mollusks	No effect	Improve conditions for mollusks	Improve conditions for mollusks	No effect	No effect	No effect	No effect	Improve conditions for mollusks	Improve conditions for mollusks	Improve conditions for mollusks	No effect	Less summer, fall and winter stress due to low flow
Invertebrates	Improve habitat diversity	No effect	Improve habitat diversity	Improve habitat diversity	No effect	No effect	No effect	No effect	Less stress to sensitive invertebrates	Less stress to sensitive invertebrates	Less stress to sensitive invertebrates	No effect	Less summer, fall and winter stress due to low flow
Algae	Favor phytoplankton, possible loss of periphyton	No effect	Favor phytoplankton, possible loss of periphyton	Favor phytoplankton, possible loss of periphyton	No effect	No effect	Decrease variability in habitat, fewer disturbance events	Decrease variability in habitat, fewer disturbance events	Favor phytoplankton, possible loss of periphyton	Less stress due to low flow events	Less stress due to low flow events	No effect	Favor phytoplankton, possible loss of periphyton
Macrophytes	Submergent species may expand, emergent and wetland species pushed up the banks, or removed if shallow water unavailable	No effect	Submergent species may expand, emergent and wetland species pushed up the banks, or removed if shallow water unavailable	Submergent species may expand, emergent and wetland species pushed up the banks, or removed if shallow water unavailable	No effect	No effect	Less change in water levels in areas vegetated with macrophytes	Less change in water levels in areas vegetated with macrophytes	Emergent and wetland fringe vegetation should move up the banks into new shallow water zone	Less stress due to low flow events	Less stress due to low flow events	No effect	Submergent species may expand, emergent and wetland species pushed up the banks, or removed if shallow water unavailable
Sheyenne River Reach 5													
Fish	Main effects are on habitat availability				Main effects are on habitat availability				Less stress to sensitive fish	Less stress to sensitive fish	Less stress to sensitive fish	No effect	Less summer, fall and winter stress due to low flow
Mollusks	Improve conditions for mollusks	No effect	Improve conditions for mollusks	Improve conditions for mollusks	No effect	No effect	No effect	No effect	Improve conditions for mollusks	Improve conditions for mollusks	Improve conditions for mollusks	No effect	Less summer, fall and winter stress due to low flow
Invertebrates	Improve habitat diversity	No effect	Improve habitat diversity	Improve habitat diversity	No effect	No effect	No effect	No effect	Less stress to sensitive invertebrates	Less stress to sensitive invertebrates	Less stress to sensitive invertebrates	No effect	Less summer, fall and winter stress due to low flow
Algae	Favor phytoplankton, possible loss of periphyton	No effect	Favor phytoplankton, possible loss of periphyton	Favor phytoplankton, possible loss of periphyton	No effect	No effect	Decrease variability in habitat, fewer disturbance events	Decrease variability in habitat, fewer disturbance events	Favor phytoplankton, possible loss of periphyton	Less stress due to low flow events	Less stress due to low flow events	No effect	Favor phytoplankton, possible loss of periphyton
Macrophytes	Submergent species may expand, emergent and wetland species pushed up the banks, or removed if shallow water unavailable	No effect	Submergent species may expand, emergent and wetland species pushed up the banks, or removed if shallow water unavailable	Submergent species may expand, emergent and wetland species pushed up the banks, or removed if shallow water unavailable	No effect	No effect	Less change in water levels in areas vegetated with macrophytes	Less change in water levels in areas vegetated with macrophytes	Emergent and wetland fringe vegetation should move up the banks into new shallow water zone	Less stress due to low flow events	Less stress due to low flow events	No effect	Submergent species may expand, emergent and wetland species pushed up the banks, or removed if shallow water unavailable
Red River Reach 1													
Fish	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect
Mollusks	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect
Invertebrates	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect
Algae	No effect	No effect	No effect	No effect	No effect	No effect		No effect	No effect	No effect	No effect	No effect	No effect
Macrophytes	No effect	No effect	No effect	No effect	No effect	No effect		No effect	No effect	No effect	No effect	No effect	No effect
Red River Reach 2													
Fish	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect
Mollusks	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect
Invertebrates	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect
Algae	No effect	No effect	No effect	No effect	No effect	No effect		No effect	No effect	No effect	No effect	No effect	No effect
Macrophytes	No effect	No effect	No effect	No effect	No effect	No effect		No effect	No effect	No effect	No effect	No effect	No effect
Red River Reach 3													
Fish	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect
Mollusks	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect
Invertebrates	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect
Algae	No effect	No effect	No effect	No effect	No effect	No effect		No effect	No effect	No effect	No effect	No effect	No effect
Macrophytes	No effect	No effect	No effect	No effect	No effect	No effect		No effect	No effect	No effect	No effect	No effect	No effect

[1] No effect = NA < 0.33 (see Table 5-32).

TABLE 5-34

PREDICTED CHANGES IN CHANNEL FORMING FLOW (1.5 YEAR FLOW, cfs) DURATION BETWEEN WET AND WETOF (2015-2025)[1]
Final Aquatic Impact Analysis Report

	Cooperstown	Baldhill	Lisbon	Kindred
WET				
Channel forming flow (c)[2]	615	790	842	915
no. of obs (n)	3653	3653	3653	3653
(n) > c	329	308	406	568
%c/(n)[3]	9.0	8.4	11.1	15.5
WETOF				
Channel forming flow (c)[3]	615	790	842	915
no. of obs (n)	3653	3653	3653	3653
(n) > c	663	511	602	656
%c/(n)[3]	18.1	14.0	16.5	18.0
% change	101	67	49	16

[1]HEC-5 Data File: Wet Future Base Condition vs. Base Condition with Overflow HEC-5Q Data File: Q5PWW48.DAT

[2]Channel forming flow not calculated for wet future without overflow, moderate future channel forming flow used for comparison

[3]% of time exceeding channel forming flow

TABLE 5-35

AVERAGE[1] AND MAXIMUM PERCENT MAXIMUM WUA DURATION DIFFERENCE BETWEEN WET AND WETOF
Final Aquatic Impact Analysis Report

		Segment H		Segment E		Segment B	
		AVE	**MAX**	**AVE**	**MAX**	**AVE**	**MAX**
SPRING							
	Shallow Pool	**10.6**	**24.5**	**10.7**	**-56.9**	2.9	-12.9
	Slow Riffle	6.4	**-23.9**	3.9	-7.8	2.7	11.4
	Fast Riffle	7.9	**67.3**	**12.7**	**38.8**	2.5	9.8
	Raceway	**12.0**	**30.5**	5.8	**25.2**	7.0	**41.2**
	Medium Pool	3.5	**45.0**	6.7	**-21.6**	9.2	**-36.7**
	Deep Pool	0.3	6.6	3.9	**27.5**	2.1	-10.4
	Low Gradient	6.4	-17.4	5.5	-13.2	2.5	-11.1
	Trichoptera	5.8	-12.4	1.7	7.4	1.4	-4.8
SUMMER							
	Shallow Pool	6.8	**-26.2**	**18.3**	**-41.9**	**12.4**	**-23.9**
	Slow Riffle	**14.8**	**-30.8**	**12.6**	-18.7	**13.8**	**35.6**
	Fast Riffle	**17.7**	**70.6**	**30.2**	**92.1**	**16.5**	**61.4**
	Raceway	**26.9**	**48.6**	**18.9**	**45.5**	**12.9**	**39.4**
	Medium Pool	5.1	**27.3**	**18.3**	**-30.5**	**17.5**	**-38.7**
	Deep Pool	0.0	0.0	**10.7**	**34.7**	**12.3**	**-30.2**
	Low Gradient	**14.6**	**-31.3**	7.4	-13.4	1.1	**-22.6**
	Trichoptera	**13.1**	**-23.5**	2.6	13.7	1.7	11.0
FALL							
	Shallow Pool	**10.1**	-19.5	**11.5**	**-44.0**	9.6	-18.9
	Slow Riffle	**15.7**	**-32.8**	7.1	-13.7	**13.1**	**23.2**
	Fast Riffle	**25.6**	**58.9**	**13.7**	**60.4**	3.0	**25.0**
	Raceway	**18.2**	**51.9**	**15.7**	**31.8**	**13.0**	**22.5**
	Medium Pool	4.8	**39.5**	**11.5**	**-22.2**	**13.1**	**-24.6**
	Deep Pool	0.0	0.0	**12.0**	**23.3**	7.5	-15.2
	Low Gradient	**15.2**	**-27.4**	2.1	-10.1	1.5	-5.5
	Trichoptera	9.6	**-23.3**	3.2	18.5	3.0	8.4

[1] - Average percent maximum WUA difference is calculated as the average absolute difference in percent maximum WUA between the base and alternative cases (see Appendix K and L).
Bold indicates difference could be sufficient to affect fauna

TABLE 5-36

80 % AND 20 % EXCEEDENCE VALUES FOR HABITAT GUILD %WUA'S FOR WET COMPARED TO WETOF IN HABITAT SEGMENTS MODELED FOR THE SHEYENNE RIVER
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			SEGMENT L		SEGMENT H		SEGMENT E		SEGMENT B	
SEASON	**GUILD**	**% exceedence[1]**	**WET**	**WETOF**	**WET**	**WETOF**	**WET**	**WETOF**	**WET**	**WETOF**
Fish										
Spring	Shallow pool	80	15.8	15.8	21.9	31.6	5.8	5.6	2.2	2.6
		20	63.0	63.0	40.2	47.6	**41.0**	**15.3**	59.5	57.7
	Slow riffle	80	46.4	46.4	32.0	29.7	14.2	12.8	20.3	28.6
		20	88.7	88.7	55.6	49.8	52.5	44.7	87.7	89.9
	Fast riffle	80	9.4	9.4	78.0	78.3	5.9	5.9	0.7	0.9
		20	82.4	82.4	83.3	86.0	94.3	97.8	22.2	23.0
	Raceway	80	10.6	10.6	**14.2**	**44.7**	25.4	33.7	**45.4**	**55.8**
		20	88.2	88.2	74.7	77.6	99.5	99.5	83.9	87.1
	Medium pool	80	14.5	14.5	62.4	65.4	12.2	11.5	1.3	1.3
		20	92.8	92.8	84.7	85.7	**62.7**	**49.0**	**45.4**	**29.1**
	Deep pool	80	0.0	0.0	0.0	0.0	**16.7**	**29.0**	0.7	0.7
		20	70.2	70.2	0.0	0.0	71.1	70.0	54.8	52.7
Summer	Shallow pool	80	44.0	44.0	21.0	20.4	9.1	6.3	7.4	3.3
		20	93.0	93.0	**51.9**	**25.7**	**82.9**	**42.3**	**52.2**	**40.9**
	Slow riffle	80	35.0	35.0	**44.2**	**30.9**	**35.5**	**23.2**	**18.6**	**48.4**
		20	83.4	83.4	**81.0**	**52.5**	68.5	59.7	90.9	93.1
	Fast riffle	80	5.1	5.1	**20.2**	**90.8**	0.0	5.9	2.7	2.9
		20	13.5	13.5	98.8	93.4	**25.3**	**98.5**	**6.1**	**61.8**
	Raceway	80	0.2	0.2	**1.8**	**15.7**	**3.2**	**32.6**	**13.2**	**41.3**
		20	28.1	28.1	**61.0**	**89.0**	98.7	99.6	87.9	90.7
	Medium pool	80	25.5	25.5	63.6	64.0	**40.3**	**16.1**	8.0	2.3
		20	90.1	90.1	85.8	84.3	**86.9**	**76.8**	**78.5**	**50.2**
	Deep pool	80	0.0	0.0	0.0	0.0	**0.0**	**13.2**	2.9	1.4
		20	0.0	0.0	0.0	0.0	71.9	76.6	**75.5**	**59.7**
Fall	Shallow pool	80	70.9	70.9	34.6	26.2	12.1	7.5	**25.9**	**8.0**
		20	96.3	96.3	60.7	51.1	40.0	32.6	54.0	45.0
	Slow riffle	80	40.2	40.2	52.3	42.8	41.2	32.5	**23.9**	**41.9**
		20	75.0	75.0	**93.6**	**83.6**	62.9	60.2	**77.1**	**90.1**
	Fast riffle	80	43.3	43.3	**19.3**	**39.4**	5.9	5.9	2.8	3.0
		20	89.3	89.3	80.7	90.3	**5.9**	**61.7**	4.1	6.0
	Raceway	80	0.5	0.5	1.7	4.8	**37.3**	**50.9**	**20.8**	**41.1**
		20	15.5	15.5	**12.7**	**64.7**	**88.8**	**99.6**	**74.8**	**88.8**
	Medium pool	80	30.7	30.7	67.4	75.0	**43.2**	**29.5**	**25.5**	**7.9**
		20	69.9	69.9	92.2	86.6	80.2	78.6	**76.6**	**61.1**
	Deep pool	80	0.0	0.0	0.0	0.0	**19.2**	**36.0**	11.5	3.3
		20	0.0	0.0	0.0	0.0	**72.5**	**87.5**	85.6	77.5
Invertebrates										
Spring	Low gradient	80	71.0	71.0	41.1	37.0	48.7	43.8	66.2	57.4
		20	94.9	94.9	**68.4**	**57.9**	77.5	73.1	99.0	98.9
	Tricoptera	80	43.0	43.0	56.0	53.3	42.8	50.2	58.0	54.7
		20	93.7	93.7	87.5	78.9	95.3	95.0	99.1	99.0
Summer	Low gradient	80	88.8	88.8	46.8	40.8	70.9	62.8	88.6	88.5
		20	93.5	93.5	**91.0**	**59.8**	**89.6**	**77.2**	99.3	99.1
	Tricoptera	80	43.9	43.9	63.3	54.9	**66.0**	**76.8**	79.1	81.8
		20	89.2	89.2	**94.4**	**82.6**	96.0	96.0	99.2	99.3
Fall	Low gradient	80	91.0	91.0	**60.1**	**46.0**	72.4	70.9	90.0	93.7
		20	93.2	93.2	92.5	84.0	77.3	78.1	99.7	99.4
	Tricoptera	80	46.3	46.3	**80.7**	**62.2**	83.2	88.7	81.4	88.2
		20	71.5	71.5	98.8	97.1	96.5	98.0	99.0	99.4

[1] - Average percent maximum WUA difference is calculated as the average absolute difference in percent maximum WUA between the base and alternative cases (see Appendix K and L)

Bold indicates difference could be sufficient to affect fauna

TABLE 5-37

SUMMARY OF EFFECTS[1] OF HABITAT CHANGES WITH WETOF COMPARED TO WET ON FISH AND INVERTEBRATES
Final Aqutic Impact Analysis Report

	Spring	Summer	Fall	Total
Sheyenne Reach 1				
Shallow pool	No effect[3]	Decreased recruitment in some years, decreased sunfish spawning	Decreased recruitment in some years	Habitat availability for adult sunfish, shiners, and rheophilic species increases, but these species may be limited by the lack of nursery habitat in some years
Slow riffle	No effect	Decreased recruitment in some years, decreased sunfish spawning	Decreased recruitment in some years	
Fast riffle	Increased spawning habitat, but for species not typical of Reach 1	Increase in summer habitat for rheophilic species (currently not abundant in Reach 1)	Increase in summer habitat for rheophilic species (currently not abundant in Reach 1)	
Raceway	Increased spawning habitat, but for species not typical of Reach 1	Increase in summer habitat for rheophilic species (currently not abundant in Reach 1)	Increase in summer habitat for rheophilic species (currently not abundant in Reach 1)	
Medium pool	No effect	Increased habitat for shiners and sunfish	Occassional increased habitat for shiners and sunfish	
Deep pool	No effect	No change	No change	
Invertebrate diversity	No change[2]	Decline in habitat availability	Decline in habitat availability	Decline in overall invertebrate abundance and diversity
Tricopteran abundance	No change	Decline in habitat availability	Decline in habitat availability	
Sheyenne Reach 2				
Shallow pool	No change	No change	No change	No change
Slow riffle	No change	No change	No change	
Fast riffle	No change	No change	No change	
Raceway	No change	No change	No change	
Medium pool	No change	No change	No change	
Deep pool	No change	No change	No change	
Invertebrate diversity	No change	No change	No change	No change
Tricopteran abundance	No change	No change	No change	
Sheyenne Reach 3				
Shallow pool	No effect	Slight decline in abundance of many ND special concern species, reduced nursery habitat for rheophilic species	Slight decline in abundance of many ND special concern species, reduced nursery habitat for rheophilic species	Shift in community composition from mix of slow and fast water species to mainly rheophilic species, however, nursery habitat for rheophilic species in some years may limit the abundance of this group. Loss of shallow and medium pool habitat may affect abundance of ND special concern species
Slow riffle	No change	Reduced nursery habitat for rheophilic species	No change	
Fast riffle	Occasional increase in spawning area for redhorse, rosyface shiner	Increased habitat for rheophilic species	Increased habitat for rheophilic species	
Raceway	Occasional increase in spawning area for redhorse, rosyface shiner	Increased habitat for rheophilic species	Increased habitat for rheophilic species	
Medium pool	No effect	Slight decline in abundance of many ND special concern species, reduced nursery habitat for rheophilic species	Slight decline in abundance of many ND special concern species, reduced nursery habitat for rheophilic species	
Deep pool	No effect	No effect	No effect	
Invertebrate diversity	No change	No change	No change	No change
Tricopteran abundance	No change	No change	No change	
Sheyenne Reach 5				
Shallow pool	No change	Slight decline in nursery area for sunfish and minnows	No change	Fish community composition will probably shift from pool species to rheophilic species. Reduced pool habitat may affect abundance of channel catfish.
Slow riffle	No change	Increased nursery area for channel catfish and redhorse	Increased nursery area for channel catfish and redhorse	
Fast riffle	No change	Increased habitat for rheophilic species	Increased habitat for rheophilic species	
Raceway	Increase in spawning area for redhorse, rosyface shiner	Increased habitat for rheophilic species	Increased habitat for rheophilic species	
Medium pool	No effect	Slight decrease in habitat for pool species (minnows, sunfish)	Slight decrease in habitat for pool species (minnows, sunfish)	
Deep pool	No change	Slight decrease in habitat for pool species (minnows, sunfish)	No change	
Invertebrate diversity	No change	Decline in habitat diversity and invertebrate diversity	No change	Decline in habitat diversity and invertebrate diversity
Tricopteran abundance	No change	No change	No change	

[1]Effects are based on habitat alone, many other factors will contribute to community changes

[2]No change=average %WUA changed less than 10%

[3]No effect=%WUA changed but change probably does not effect fish or invertebrates

TABLE 5-38

SUMMARY OF EFFECTS OF WETOF COMPARED TO WET ON AQUATIC BIOTA IN THE SHEYENNE AND RED RIVERS.

Final Aquatic Impact Anlaysis Report

	Sheyenne River					Red River		
	Reach 1	**Reach 2**	**Reach 3**	**Reach 4**	**Reach 5**	**Reach 1**	**Reach 2**	**Reach 3**
Fish								
WQ	Decline in reproductive success	Decline in reproductive success	Decline in reproductive success of sensitive taxa	Decline in reproductive success of sensitive taxa	Decline in reproductive success of sensitive taxa	Potential loss of occasional year class of sensitive taxa	No effect	No effect
Hydrology	Less summer, fall and winter stress due to low flow	No effect	Less summer, fall and winter stress due to low flow	Less summer, fall and winter stress due to low flow	Less summer, fall and winter stress due to low flow	No effect	No effect	No effect
Geomorphology	Loss of simple lithophils, obligate riffle species	No effect	Decline of simple lithophils, obligate riffle species	Decline of simple lithophils, obligate riffle species	Decline of simple lithophils, obligate riffle species	No effect	No effect	No effect
Habitat	Habitat availability for adult sunfish, shiners, and rheophilic species increases, but these species may be limited by the lack of nursery habitat in some years	No change	Shift in community composition from mix of slow and fast water species to mainly rheophilic species, however, nursery habitat for rheophilic species in some years may limit the abundance of this group. Loss of shallow and medium pool habitat may affect abundance of ND special concern species	Cannot be determined from this study	Shift in community composition from mix of slow and fast water species to mainly rheophilic species, however, nursery habitat for rheophilic species in some years may limit the abundance of this group. Loss of shallow and medium pool habitat may affect abundance of ND special concern species	No effect	No effect	No effect
Biotic interaction	Loss of food source and cover in invertebrates, periphyton, and macrophytes	Decrease in food for insectivores	Loss of invertebrate food source, loss of weedy cover	Loss of invertebrate food source, loss of weedy cover	Loss of invertebrate food source, loss of weedy cover			
Overall expected effects	Decline abundance and diversity of fish	Possible decline in some fish species	Decline in most of the fish species that occur in this reach now, including most ND special concern species, fish community will probably be limited to very tolerant taxa (carp, green sunfish, fathead minnows)	Loss of sensitive species such as blacknose shiner, rosyface shiner, silver redhorse; abundance species in this reach (spotfin shiner, sand shiner, bluntnose minnow) probably not affected. Loss of species restricted to this reach (blacknose dace, blacknose shiner, blackchin shiner)	Fish may be limited to transient individuals. Habitat for rheophilic adults is present, but most of these are simple lithophils, and nursery habitat will be limited. Weedy cover and invertebrate productivity also lost.	Potential loss of occasional year class of sensitive taxa	No effect	No effect
Mollusks								
WQ	Unionids, sphaeriids, and prosobranchs may be extirpated	Unionids, sphaeriids, and prosobranchs may be extirpated	Unionids, sphaeriids, and prosobranchs may be extirpated	Decrease in richness and abundance of sensitive taxa	Decrease in richness and abundance of sensitive taxa	Some decrease in richness and abundance of sensitive taxa	Some decrease in richness and abundance of sensitive taxa	Some decrease in richness and abundance of sensitive taxa
Hydrology	Less summer, fall and winter stress due to low flow	No effect	Less summer, fall and winter stress due to low flow	Less summer, fall and winter stress due to low flow	Less summer, fall and winter stress due to low flow	No effect	No effect	No effect
Geomorphology	Scouring and deposition could extirpate unionids, displace other mollusks	No effect	Scouring and deposition could reduce unionid habitat, displace other mollusks	Scouring and deposition could reduce unionid habitat, displace other mollusks	Scouring and deposition could reduce unionid habitat, displace other mollusks	No effect	No effect	No effect
Habitat	Cannot be determined from this study	Cannot be determined from this study	Cannot be determined from this study	Cannot be determined from this study	Cannot be determined from this study	No effect	No effect	No effect
Biotic interaction	Possible loss or decline in algal food source, loss or decline of fish hosts		Loss of food source as less palatable algal species dominate	Loss of food source as less palatable algal species dominate				
Overall expected effects	Unionids, sphaeriids, and prosobranchs may be extirpated	Unionids, sphaeriids, and prosobranchs may be extirpated	Unionids, sphaeriids, and prosobranchs may be extirpated	Decrease in unionid and prosobranch abundance	Scouring and deposition could reduce unionid habitat, displace other mollusks	Some decrease in richness and abundance of sensitive taxa	Some decrease in richness and abundance of sensitive taxa	Some decrease in richness and abundance of sensitive taxa
Invertebrates								
Water quality	Sensitive invertebrates may be extirpated, tolerant taxa may decrease in abundance or richness	Sensitive invertebrates may be extirpated, tolerant taxa may decrease in abundance or richness	Sensitive invertebrates may be extirpated, tolerant taxa may decrease in abundance or richness	Sensitive invertebrates may be extirpated, tolerant taxa may decrease in abundance or richness	Sensitive invertebrates may be extirpated, tolerant taxa may decrease in abundance or richness	Some decrease in richness and abundance of sensitive taxa	Some decrease in richness and abundance of sensitive taxa	Some decrease in richness and abundance of sensitive taxa
Hydrology	Less summer, fall and winter stress due to low flow	No effect	Less summer, fall and winter stress due to low flow	Less summer, fall and winter stress due to low flow	Less summer, fall and winter stress due to low flow	No effect	No effect	No effect
Geomorphology	Unstable substrate will lead to less diversity and abundance	No effect	Unstable substrate will lead to less diversity and abundance	Unstable substrate will lead to less diversity and abundance	Unstable substrate will lead to less diversity and abundance	No effect	No effect	No effect
Habitat	Decline in overall invertebrate abundance and diversity	No change	No change	Cannot be determined from this study	Decline in habitat diversity and invertebrate diversity	No effect	No effect	No effect
Biotic interaction	Loss of periphyton (food source) and macrophytes (cover and food)		Loss of food source as less palatable algal species dominate	Loss of food source as less palatable algal species dominate				
Overall expected effects	Decline of species intolerant of water quality and unstable substrate	Sensitive invertebrates may be extirpated, tolerant taxa may decrease in abundance or richness	Sensitive invertebrates may be extirpated, tolerant taxa may decrease in abundance or richness	Sensitive invertebrates may be extirpated, tolerant taxa may decrease in abundance or richness	Sensitive invertebrates may be extirpated, tolerant taxa may decrease in abundance or richness	Some decrease in richness and abundance of sensitive taxa	Some decrease in richness and abundance of sensitive taxa	Some decrease in richness and abundance of sensitive taxa
Algae								
Water quality	Possible extirpation of most sensitve taxa, decrease in richness and abundance of most sensitive taxa, increase in abundance of tolerant taxa	Some decrease in richness and abundance of sensitive taxa, increase in tolerant taxa	Some decrease in richness and abundance of sensitive taxa, increase in tolerant taxa	Some decrease in richness and abundance of sensitive taxa, increase in tolerant taxa	No effect	No effect	No effect	No effect
Hydrology	Favor phytoplankton, possible loss of periphyton	No effect	Favor phytoplankton, possible loss of periphyton	Favor phytoplankton, possible loss of periphyton	Favor phytoplankton, possible loss of periphyton	No effect	No effect	No effect
Geomorphology	Loss of some attached algae and epiphytes through scouring or burial, decreased production due to turbidity	Possible decreased production due to increase in turbidity	Some decline of some attached algae and epiphytes through scouring or burial, possible decreased production due to turbidity	Some decline of some attached algae and epiphytes through scouring or burial, possible decreased production due to turbidity	Some decline of some attached algae and epiphytes through scouring or burial, possible decreased production due to turbidity	No effect	No effect	No effect
Habitat	Cannot be determined from this study	Cannot be determined from this study	Cannot be determined from this study	Cannot be determined from this study	Cannot be determined from this study	No effect	No effect	No effect
Biotic interaction	Loss of macrophytes which serve as surface for epiphytes		Loss of macrophytes which serve as surface for epiphytes	Loss of macrophytes which serve as surface for epiphytes				
Overall expected effects	Possible extirpation of sensitive species, loss of periphyton and epiphytes, possible increase in phytoplankton	Decreased production, decline in water quality sensitive taxa, possible increase in tolerant taxa	Decrease in periphyton and epiphyton, decrease in intolerant phytoplankton	Possible loss of periphyton, epiphyton, increase in tolerant phytoplankton	Favor phytoplankton, possible loss of periphyton	No effect	No effect	No effect
Macrophytes								
Water quality	Some decrease in richness and abundance of sensitive taxa, increase in tolerant taxa	Some decrease in richness and abundance of sensitive taxa, increase in tolerant taxa	Some decrease in richness and abundance of sensitive taxa, increase in tolerant taxa	No effect	No effect	No effect	No effect	No effect
Hydrology	Submergent species may expand, emergent and wetland species pushed up the banks, or removed if shallow water unavailable	No effect	Submergent species may expand, emergent and wetland species pushed up the banks, or removed if shallow water unavailable	Submergent species may expand, emergent and wetland species pushed up the banks, or removed if shallow water unavailable	Submergent species may expand, emergent and wetland species pushed up the banks, or removed if shallow water unavailable	No effect	No effect	No effect
Geomorphology	Loss of macrophytes through scouring and burial, decreased production due to turbidity	Possible decreased production due to increase in turbidity	Some loss of macrophytes through scouring and burial, some decreased production due to turbidity	Some loss of macrophytes through scouring and burial, some decreased production due to turbidity	Some loss of macrophytes through scouring and burial, some decreased production due to turbidity	No effect	No effect	No effect
Habitat	Cannot be determined from this study	Cannot be determined from this study	Cannot be determined from this study	Cannot be determined from this study	Cannot be determined from this study	No effect	No effect	No effect
Overall expected effects	Loss of macrophytes through scouring and burial, decreased production due to turbidity	Some decrease in richness and abundance of sensitive taxa, increase in tolerant taxa	Decrease in production, richness, and abundance of macrophytes	Some loss of macrophytes through scouring and burial, some decreased production due to turbidity	Some loss of macrophytes through scouring and burial, some decreased production due to turbidity	No effect	No effect	No effect

TABLE 5-39

COMPARISON BETWEEN EFFECTS OF 300MOD50, 480MOD55, AND OVERFLOW ON THE AQUATIC BIOTA OF THE SHEYENNE AND RED RIVERS.

Final Aquatic Impact Analysis Report

	Sheyenne River					Red River		
	Reach 1	**Reach 2**	**Reach 3**	**Reach 4**	**Reach 5**	**Reach 1**	**Reach 2**	**Reach 3**
Fish								
300MOD50 vs MOD50	No effect	No effect	Increase in rheophilic species	Probably no effect	Loss of spawning, nursery and adult habitat	No effect	No effect	No effect
480MOD 55 vs MOD55	Decline in abundance and diversity of fish community	No change	Decline in abundance and diversity of fish community, possible loss of special concern species	Decline in abundance and diversity of fish community	Fish may be limited to transient individuals. Habitat for rheophilic adults is present, but most of these are simple lithophils, and nursery habitat will be limited. Weedy cover and invertebrate productivity also lost.	No effect	No effect	No effect
WETOF vs WET	Decline abundance and diversity of fish	Possible decline in some fish species	Decline in most of the fish species that occur in this reach now, including most ND special concern species, fish community will probably be limited to very tolerant taxa (carp, green sunfish, fathead minnows)	Loss of sensitive species such as blacknose shiner, rosyface shiner, silver redhorse; abundance species in this reach (spotfin shiner, sand shiner, bluntnose minnow) probably not affected. Loss of species restricted to this reach (blacknose dace, blacknose shiner, blackchin shiner)	Fish may be limited to transient individuals. Habitat for rheophilic adults is present, but most of these are simple lithophils, and nursery habitat will be limited. Weedy cover and invertebrate productivity also lost.	Potential loss of occasional year class of sensitive taxa	No effect	No effect
Mollusks								
300MOD50 vs MOD50	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect
480MOD 55 vs MOD55	Unionids, sphaeriids, and prosobranchs may be extirpated	Unionids, sphaeriids, and prosobranchs may be extirpated	Unionids, sphaeriids, and prosobranchs may be extirpated	Unionids may be extirpated, sphaeriids and prosobranchs may be reduced in abundance	Unionids may be extirpated, sphaeriids and prosobranchs may be reduced in abundance	Some decline in abundance of sensitive mollusks	Some decline in abundance of sensitive mollusks	Some decline in abundance of sensitive mollusks
WETOF vs WET	Unionids, sphaeriids, and prosobranchs may be extirpated	Unionids, sphaeriids, and prosobranchs may be extirpated	Unionids, sphaeriids, and prosobranchs may be extirpated	Unionids, sphaeriids, and prosobranchs may be extirpated	Unionids, sphaeriids, and prosobranchs may be extirpated	Some decrease in richness and abundance of sensitive taxa	Some decline in abundance of sensitive mollusks	Some decline in abundance of sensitive mollusks
Invertebrates								
300MOD50 vs MOD50	Decrease in diversity, increase in taxa tolerant of sulfate and chloride particularly those that prefer erosional habitats (Hydropsychid caddisflies, Stenelmis)	Decrease in taxa sensitive to chloride and sulfate	Decrease in diversity, increase in taxa tolerant of sulfate and chloride particularly those that prefer erosional habitats (Hydropsychid caddisflies, Stenelmis)	No effect	Minor increase in diversity and rheophilic species	No effect	No effect	No effect
480MOD 55 vs MOD55	Reduced invertebrate community to only species tolerant of water quality changes, and unstable substrate	Sensitive invertebrates may be extirpated, reduced abundance of tolerant taxa	Reduced invertebrate community to only species tolerant of water quality changes, and unstable substrate	Reduced invertebrate community to only species tolerant of water quality changes, and unstable substrate	Reduced invertebrate community to only species tolerant of water quality changes, and unstable substrate	Decrease in abundance of sensitive taxa	Decrease in abundance of sensitive taxa	Some decrease in abundance of sensitive taxa
WETOF vs WET	Decline in overall invertebrate abundance and diversity	Sensitive invertebrates may be extirpated, tolerant taxa may decrease in abundance or richness	Sensitive invertebrates may be extirpated, tolerant taxa may decrease in abundance or richness	Sensitive invertebrates may be extirpated, tolerant taxa may decrease in abundance or richness	Sensitive invertebrates may be extirpated, tolerant taxa may decrease in abundance or richness	Some decrease in richness and abundance of sensitive taxa	Some decrease in richness and abundance of sensitive taxa	Some decrease in richness and abundance of sensitive taxa
Algae								
300MOD50 vs MOD50	Decline in diversity	Decline in diversity	Decline in diversity	Decline in diversity	Decline in diversity	No effect	No effect	No effect
480MOD 55 vs MOD55	Loss of some attached algae and epiphytes through scouring or burial, decreased production due to turbidity	Some decline in abundance and species richness	Loss of some attached algae and epiphytes through scouring or burial, decreased production due to turbidity	Loss of some attached algae and epiphytes through scouring or burial, decreased production due to turbidity	Loss of some attached algae and epiphytes through scouring or burial, decreased production due to turbidity	Favor phytoplankton, possible loss of periphyton	No effect	No effect
WETOF vs WET	Possible extirpation of sensitive species, loss of periphyton and epiphytes, possible increase in phytoplankton	Decreased production, decline in water quality sensitive taxa, possible increase in tolerant taxa	Decrease in periphyton and epiphyton, decrease in intolerant phytoplankton	Possible loss of periphyton, epiphyton, increase in tolerant phytoplankton	Favor phytoplankton, possible loss of periphyton	No effect	No effect	No effect
Macrophytes								
300MOD50 vs MOD50	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect
480MOD 55 vs MOD55	Loss of macrophytes through scouring and burial, decreased production due to turbidity	Some decline in abundance and species richness	Loss of macrophytes through scouring and burial, decreased production due to turbidity	Loss of macrophytes through scouring and burial, decreased production due to turbidity	Loss of macrophytes through scouring and burial, decreased production due to turbidity	Emergent and wetland fringe vegetation should move up the banks into new shallow water zone	No effect	No effect
WETOF vs WET	Loss of macrophytes through scouring and burial, decreased production due to turbidity	Some decrease in richness and abundance of sensitive taxa, increase in tolerant taxa	Decrease in production, richness, and abundance of macrophytes	Some loss of macrophytes through scouring and burial, some decreased production due to turbidity	Some loss of macrophytes through scouring and burial, some decreased production due to turbidity	No effect	No effect	No effect

TABLE 6-1

DEFINITIONS OF BEST CANDIDATE BENTHIC METRICS AND PREDICTED DIRECTION OF METRIC RESPONSE TO INCREASING PERTURBATION (COMPILED FROM DESHON 1995, BARBOUR *et al.* 1996B, FORE *et al.* 1996, SMITH AND VOSHELL 1997) IN BARBOUR *et al.* 1999

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Category	Metric	Definition	Predicted Response to Increasing Perturbation
Richness Measures	Total No. taxa	Measures the overall variety of the macroinvertebrate assemblage	Decrease
	No. Ephemeroptera, Plecoptera, and Trichoptera (EPT) taxa	Number of taxa in the insect orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies)	Decrease
	No. Ephemeroptera taxa (mayflies)	Number of mayfly taxa (usually genus or species level)	Decrease
	No. Plecoptera taxa (stoneflies)	Number of stonefly taxa (usually genus or species level)	Decrease
	No. Trichoptera taxa (caddisflies)	Number of caddisfly taxa (usually genus or species level)	Decrease
Composition Measures	% EPT	Percent of the composite of mayfly, stonefly, and caddisfly larvae	Decrease
	% Ephemeroptera	Percent of mayfly nymphs	Decrease
Tolerance/Intolerance Measures	No. of Intolerant taxa	Taxa richness of those organisms considered to be sensitive to perturbation	Decrease
	% Tolerant Organisms	Percent of macrobenthos considered to be tolerant of various types of perturbation	Increase
	% Dominant taxon	Measures the dominance of the single most abundant taxon. Can be calculated as dominant 2, 3, 4, or 5 taxa.	Increase
Feeding Measures	% Filterers	Percent of the macrobenthos that filter FPOM from either the water column or sediment	Variable
	% Grazers and Scrapers	Percent of the macrobenthos that scrape or graze upon periphyton	Decrease
Habit Measures	Number of Clinger taxa	Number of taxa of insects	Decrease
	% Clingers	Percent of insects having fixed retreats or adaptations for attachment to surfaces in flowing water	Decrease

FPOM - fine particulate organic matter.

TABLE 6-2

NEW AND MODIFIED METRICS FOR THE RED RIVER OF THE NORTH BASIN
METRICS ARE GROUPED BY CATEGORY AND STREAM SIZE CLASS (FROM GOLDSTEIN *et al.* 1994)
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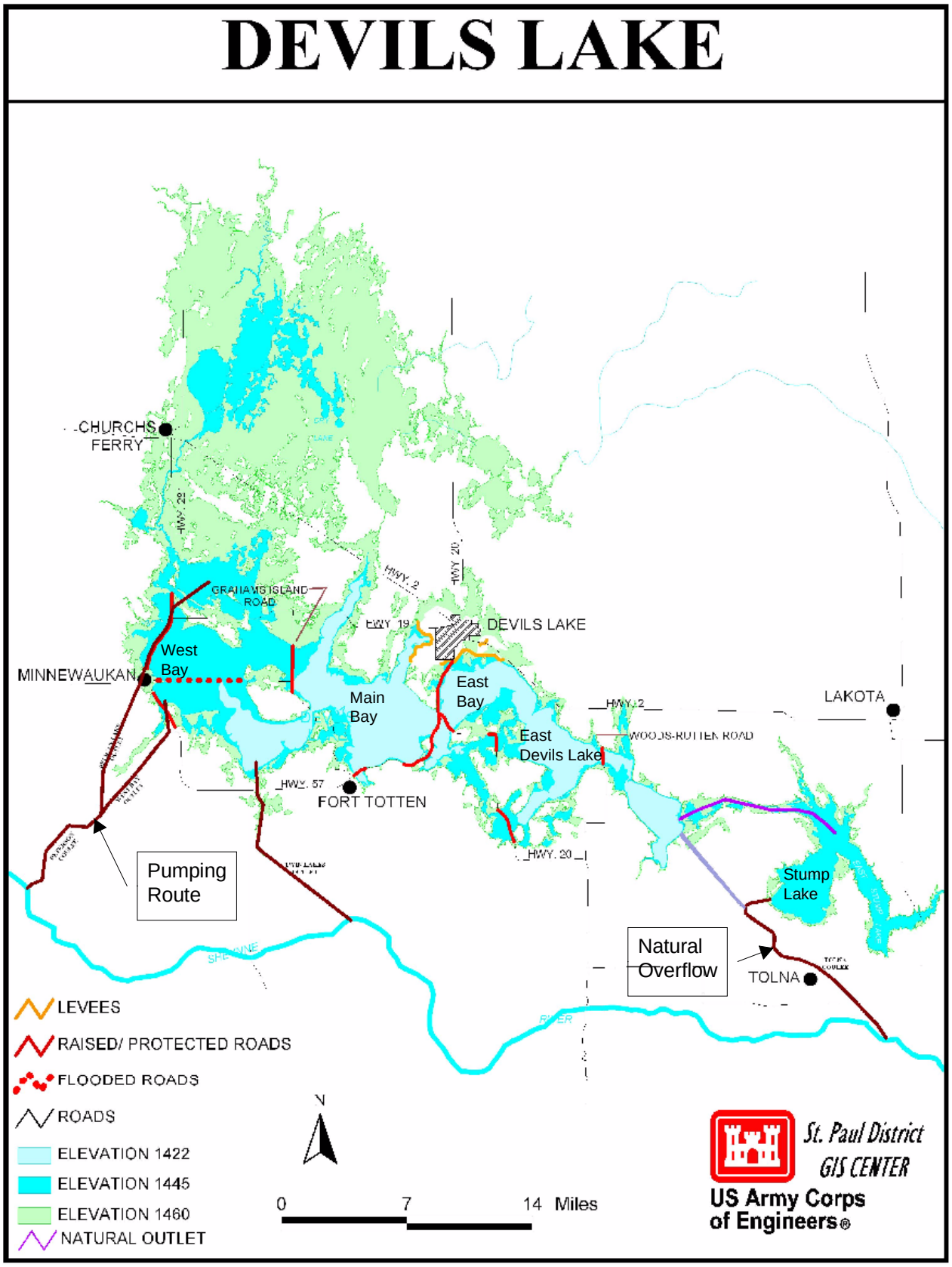
Category	Stream Size Class[1]	Metric
Species richness and composition	H, M, L	Total number of species including exotic species
	H, M	Number of benthic insectivore species
	H	Proportion or number of headwater species
	H, M	Number of minnow species
	H, M, L	Evenness
	M, L	Number of bass and sunfish species
	L	Proportion of large river species
Trophic composition	H, M, L	Biomass of omnivores
	H, M, L	Total biomass
Reproductive guild	H, M	Ratio of nest building to broadcast spawning minnows
	H, M, L	Proportion of simple lithophils
Functional guild	H, M, L	Proportion of minnows with subtenminal mouths
	H, M, L	Proportion of intolerant species
		Proportion of tolerant species
Fish abundance and condition	H, M	Proportion of pioneer species
	H, M, L	Total individuals in sample based on CPUE[2]
	H, M, L	Proportion with disease, tumors, fin damage, parasites (excluding black spot), and skeletal anomalies

[1] H = headwaters; M = mid-sized streams and rivers; L = large rivers

[2] CPUE = catch per unit effort

FIGURES



Source: Map adapted from the U.S. Army Corps of Engineers, St. Paul District.

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FIGURE 1-1
Devils Lake Map Showing Peterson Coulee Outlet Route and Stump Lake
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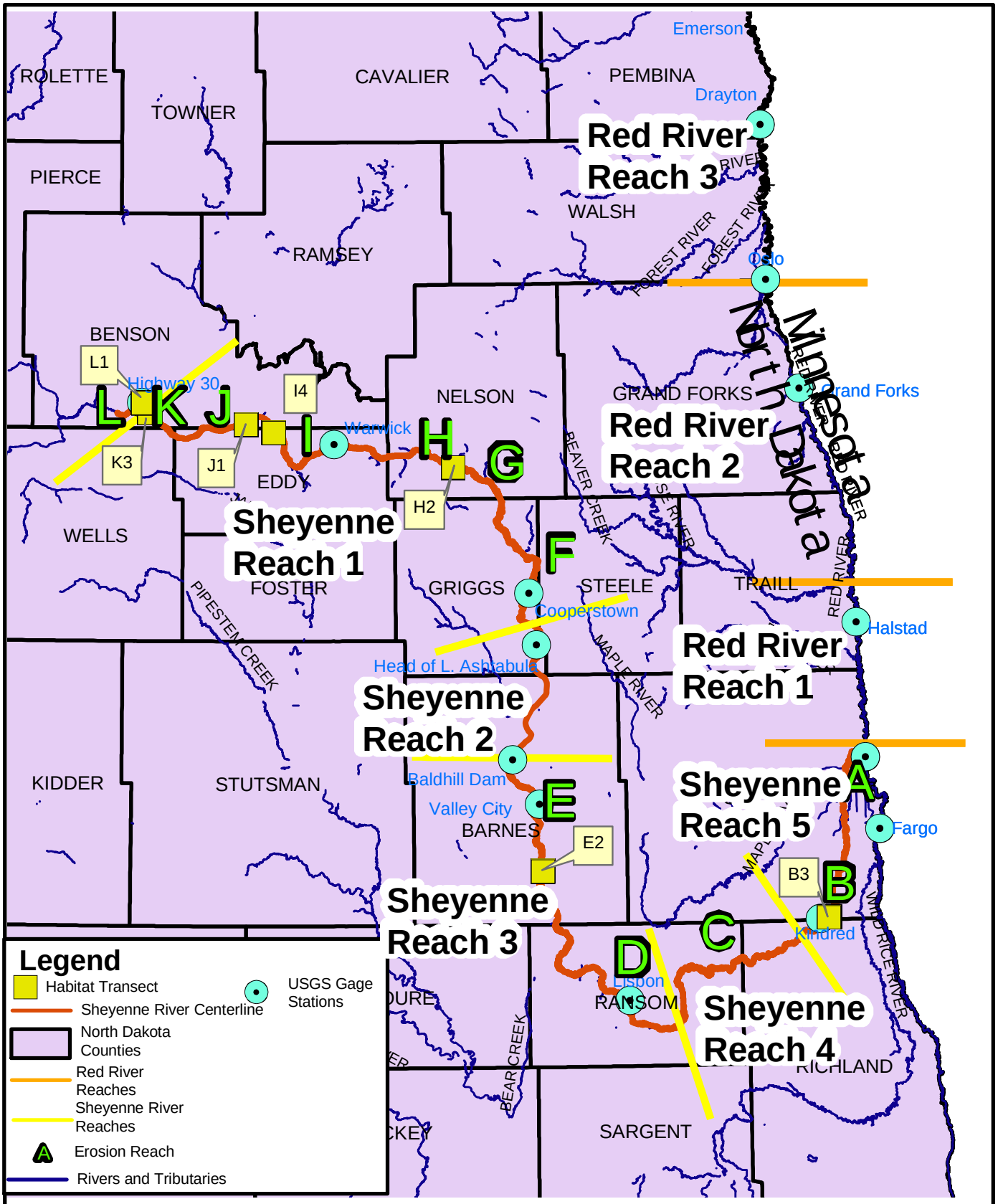

Map Source: U.S. Army Corps of Engineers Habitat Cross-Section Data, 2001.

0 5 10 20 Miles

Figure 3-1
Location of Erosion and Aquatic Reaches on the Sheyenne and Red Rivers, North Dakota
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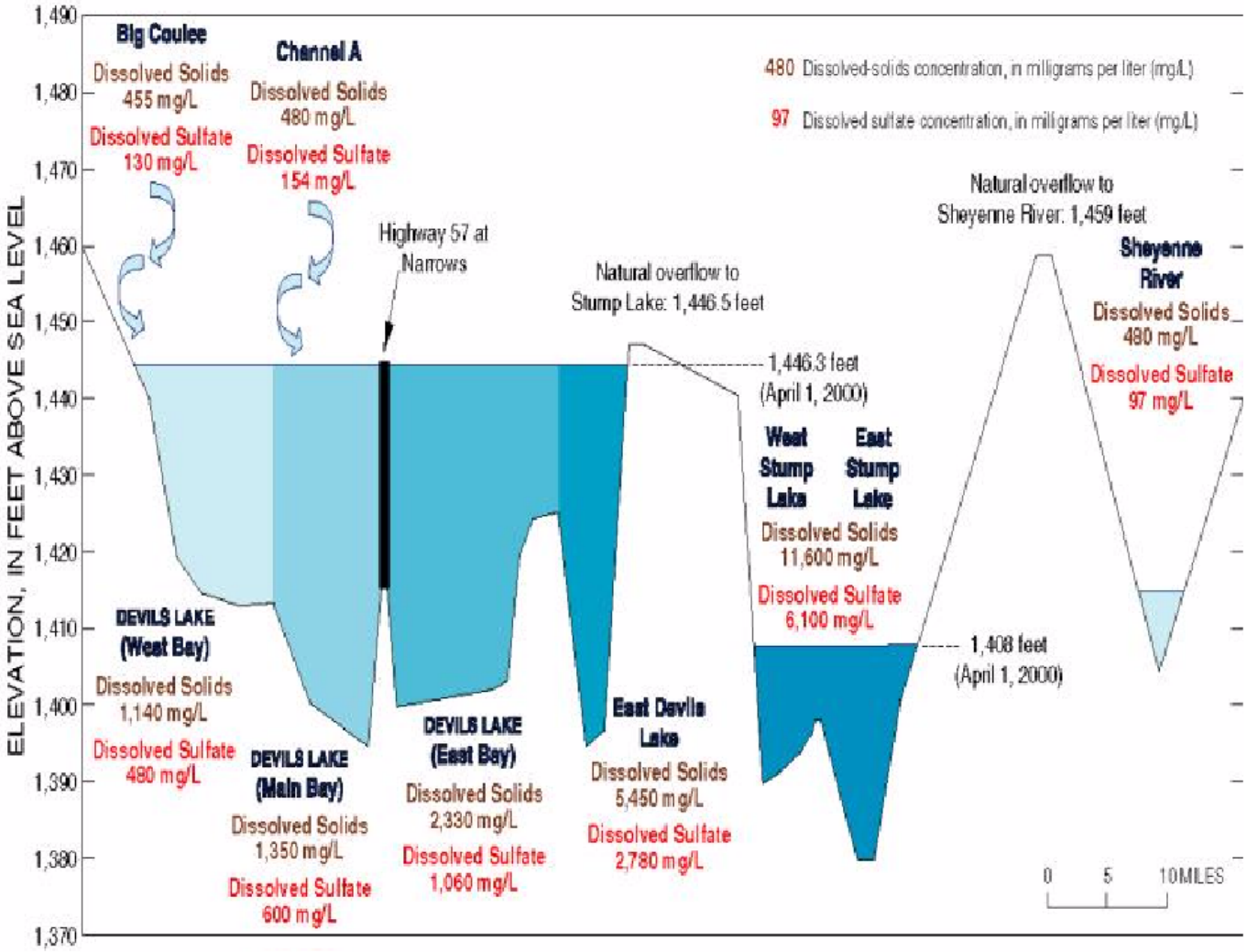

Source: Map adapted from the U.S. Army Corps of Engineers, St. Paul District.

EARTH TECH

FIGURE 3-2
Devils Lake Map Showing
West-to-East Cross Section
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FIGURE 3-3
HISTORICAL DISCHARGE (CFS) IN THE SHEYENNE RIVER NEAR WARWICK, ND (1945-2000)
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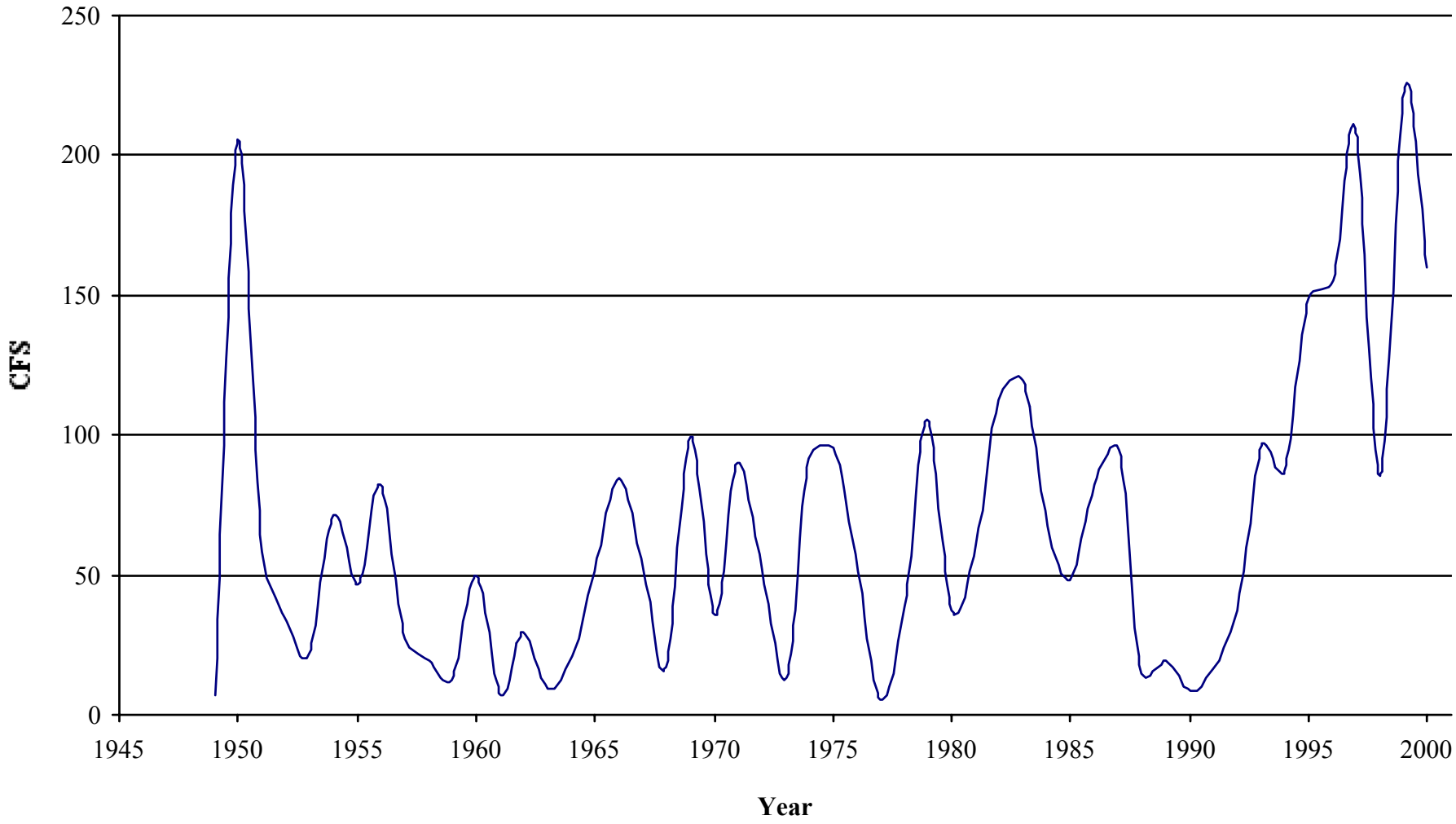

FIGURE 3-4
HISTORICAL DISCHARGE (CFS) IN THE RED RIVER NEAR EMERSON, ND (1945-2000)
Final Aquatic Impact Analysis Report

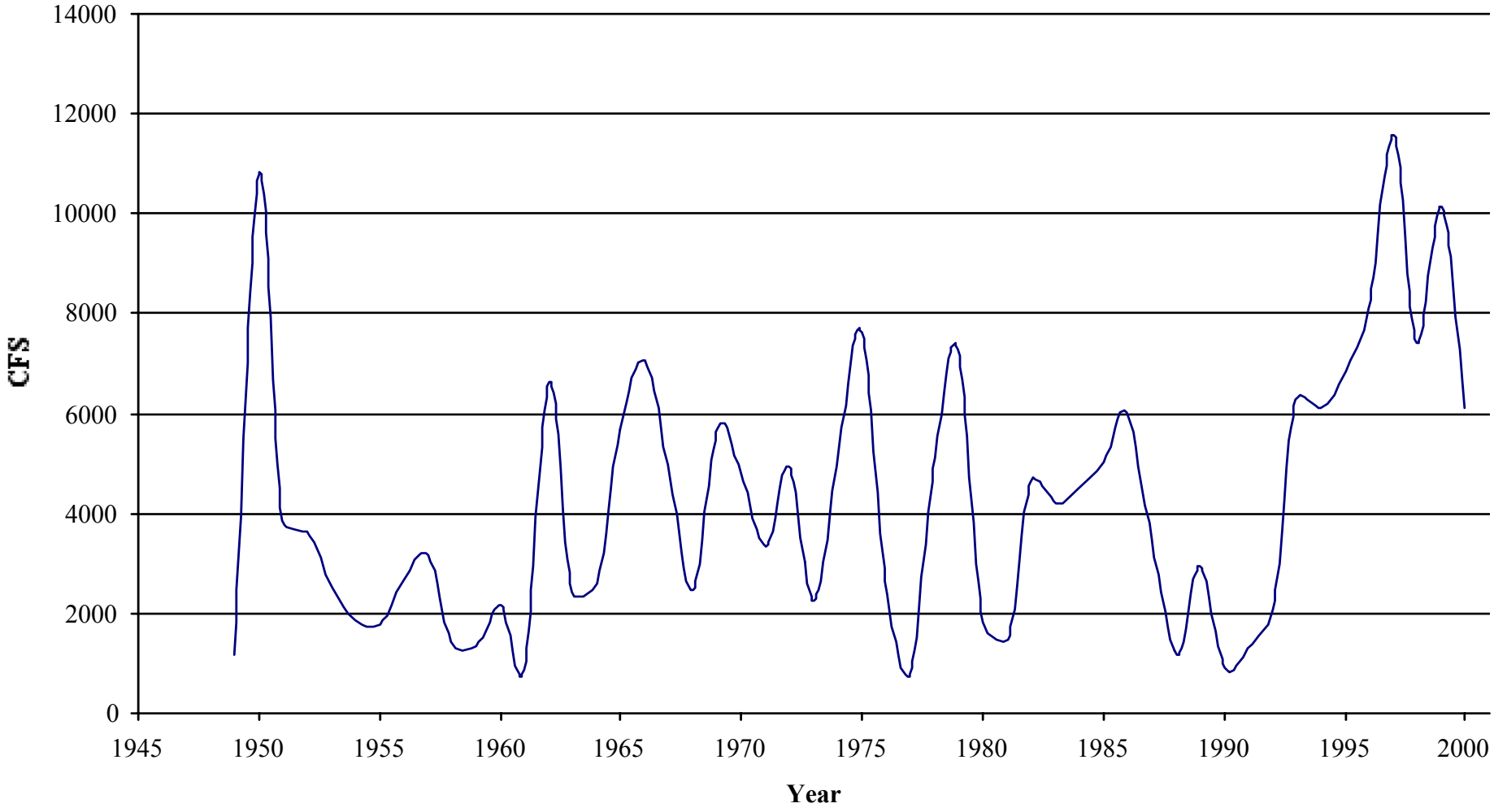

FIGURE 3-5

AVAILABLE HABITITAT OVER A RANGE OF DISCHARGE, HABITAT SEGEMENT L1[1]

SHOWING A RANGE OF HISTORIC MEAN (±1SD) MONTHLY DISCHARGE[2]

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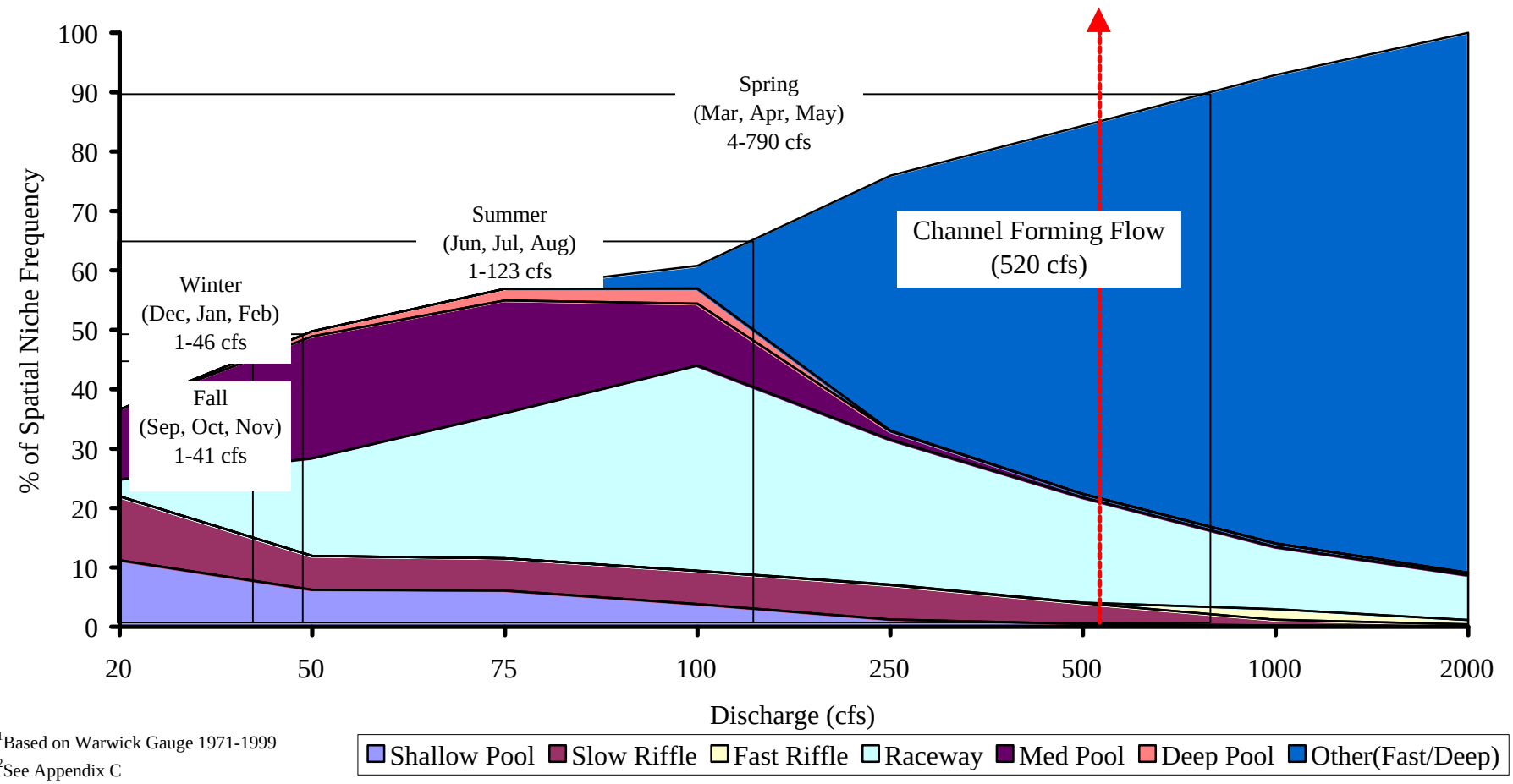

[1]Based on Warwick Gauge 1971-1999

[2]See Appendix C

FIGURE 3-6
SUBSTRATE COMPOSITION AT HABITAT SEGMENT L1
Final Aquatic Impact Analysis Report

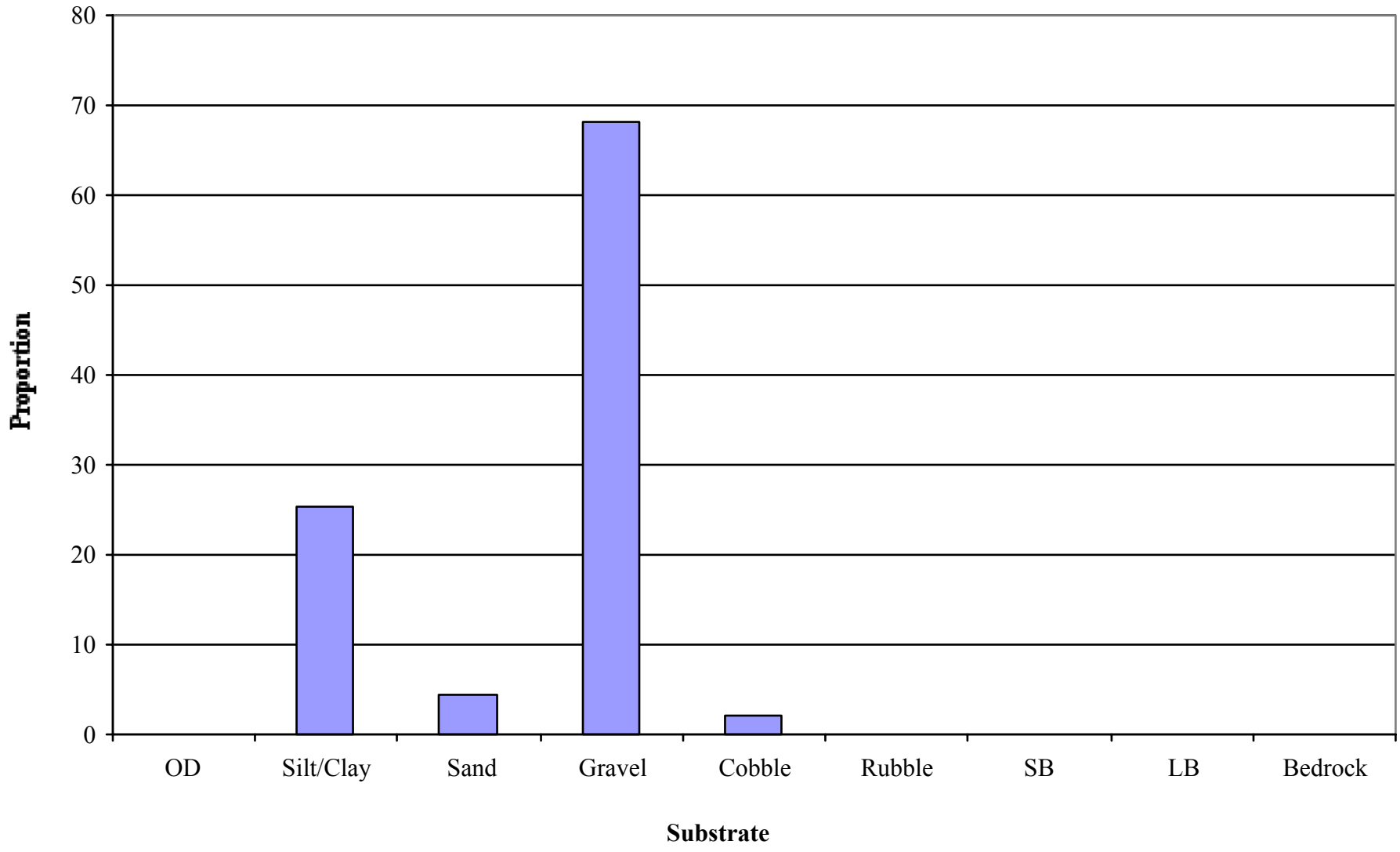

FIGURE 3-7
SUBSTRATE COMPOSTION AT HABITAT SEGMENT K3
Final Aquatic Impact Analysis Report

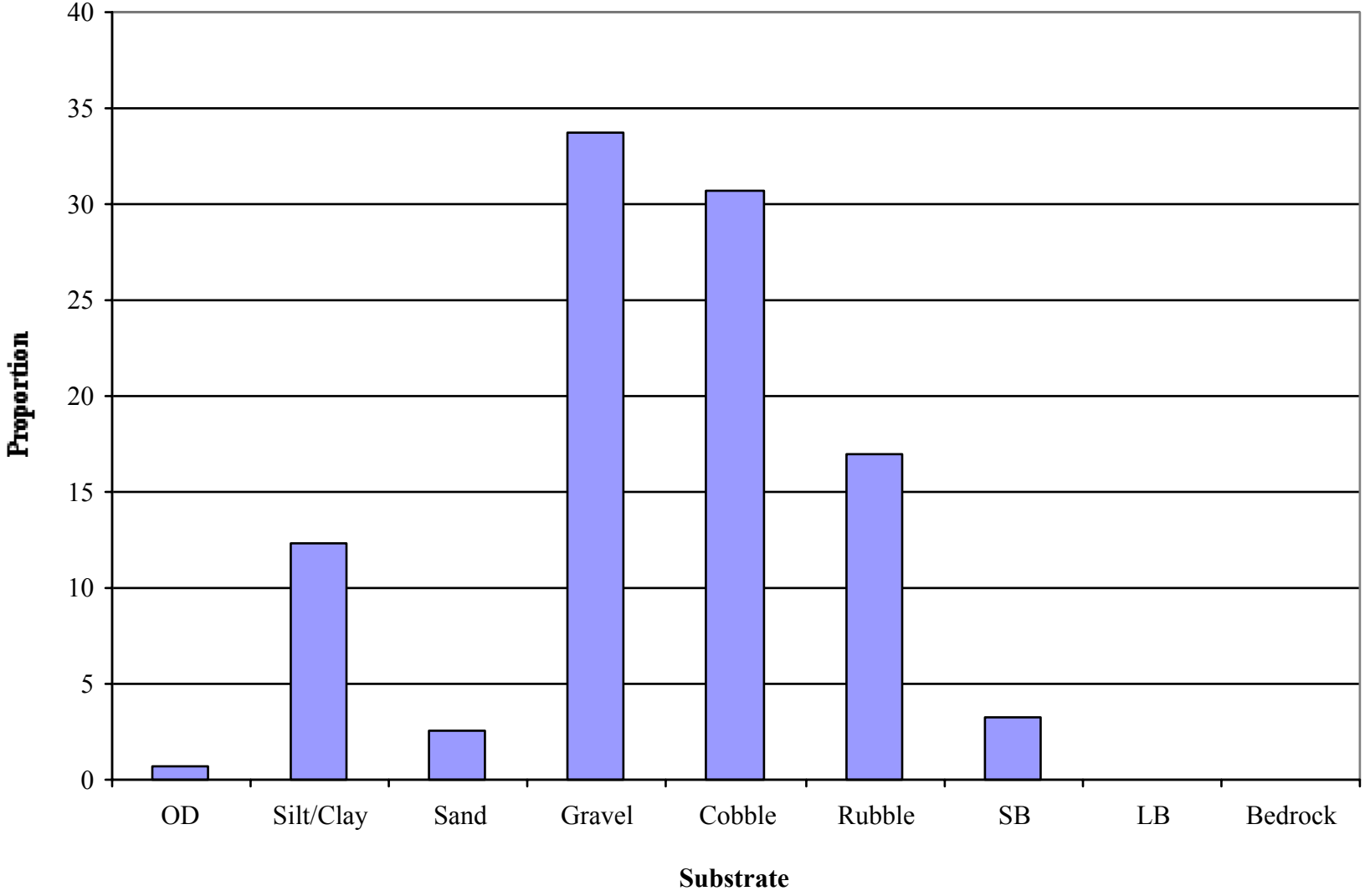

FIGURE 3-8
SUBSTRATE COMPOSTION AT HABITAT SEGMENT I4
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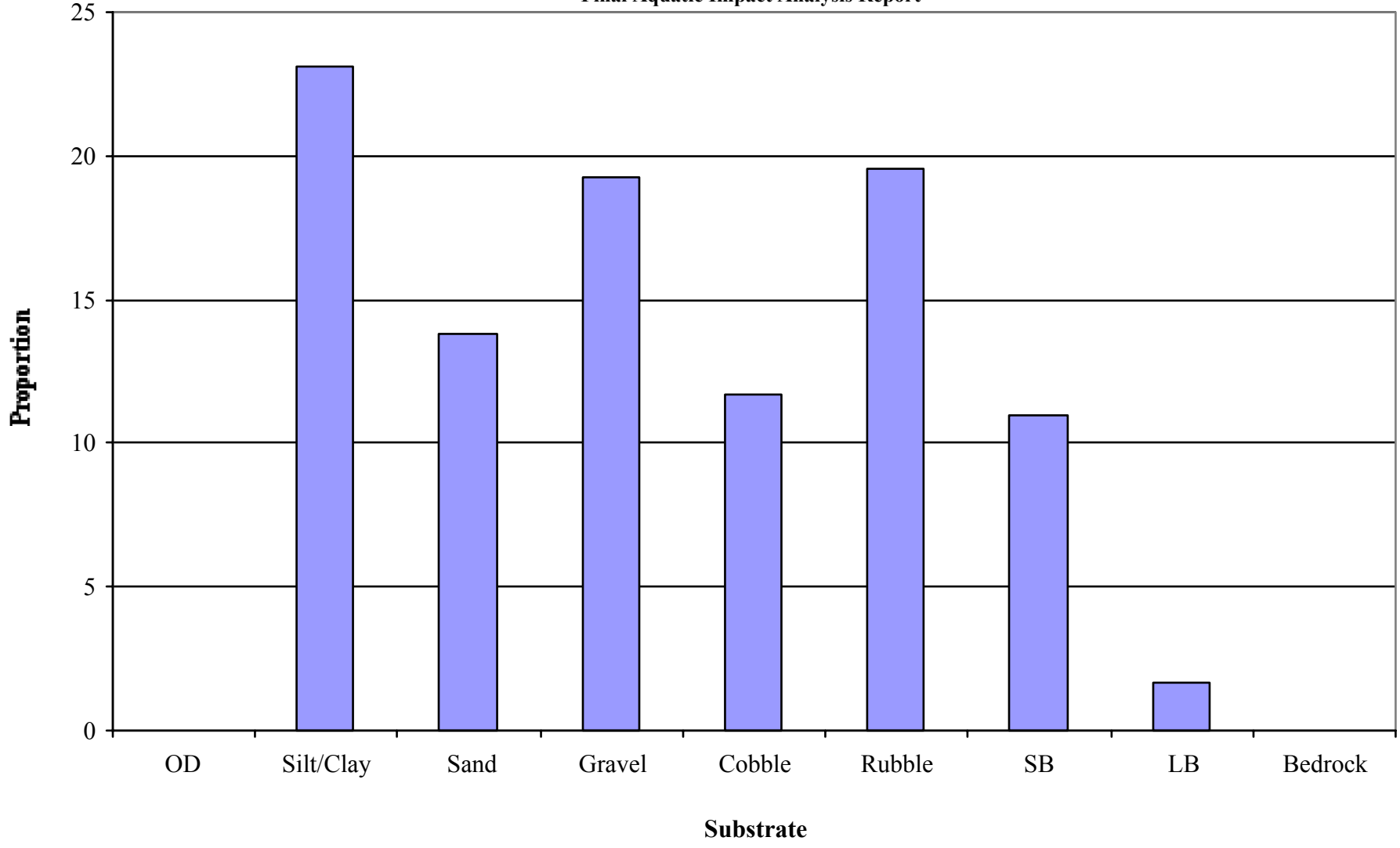

FIGURE 3-9

AVAILABLE HABITAT OVER A RANGE OF DISCHARGE, HABITAT SEGMENT H2[1]

SHOWING A RANGE OF HISTORIC MEAN (±1SD) MONTHLY DISCHARGE[2]

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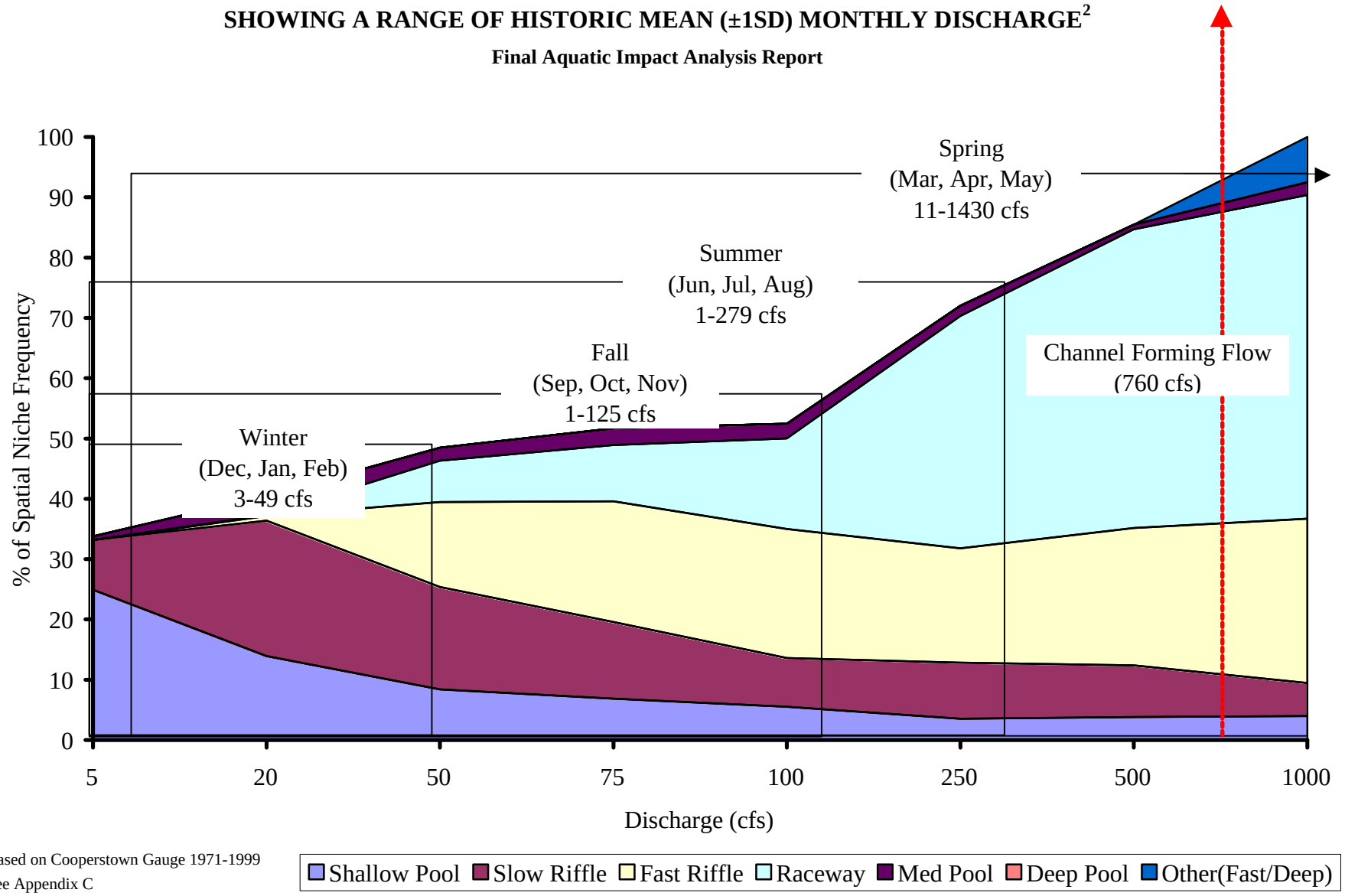

[1]Based on Cooperstown Gauge 1971-1999

[2]See Appendix C

FIGURE 3-10
SUBSTRATE COMPOSITION AT HABITAT SEGMENT H2
Final Aquatic Impact Analysis

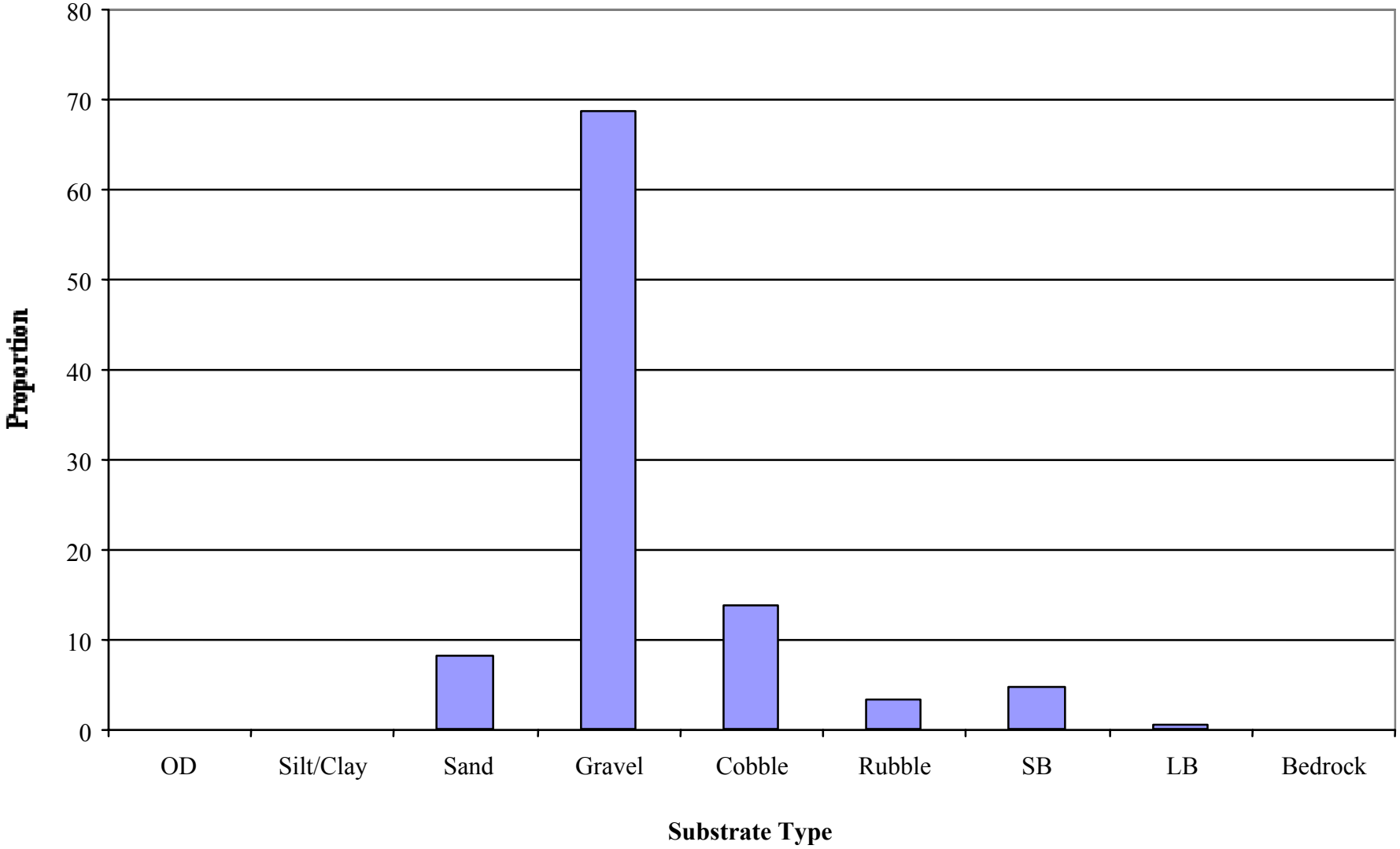

FIGURE 3-11

AVAILABLE HABITAT OVER A RANGE OF DISCHARGE, HABITAT SEGMENT E2[1]

SHOWING A RANGE OF HISTORIC MEAN (±1SD) MONTHLY DISCHARGE[2]

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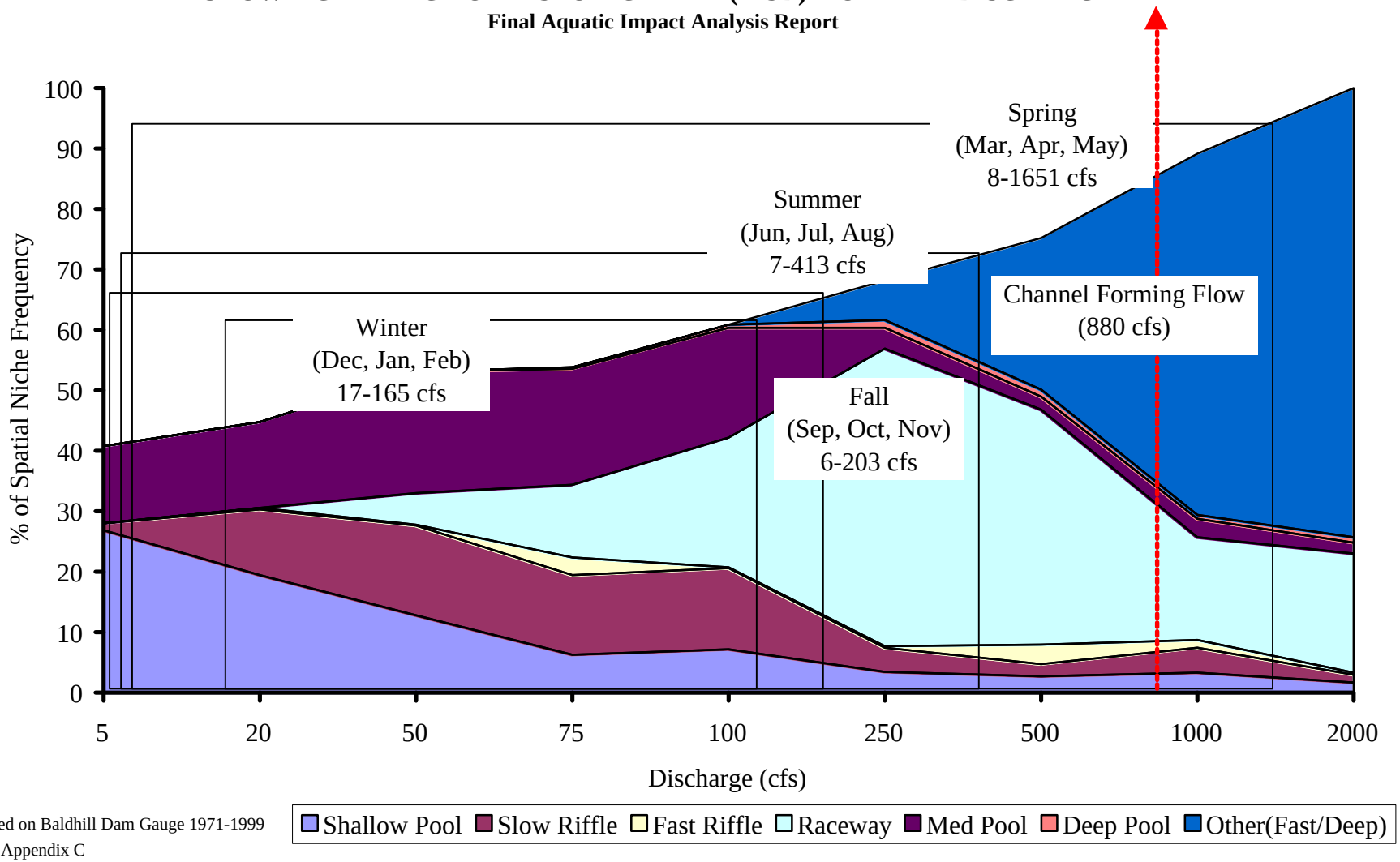

[1]Based on Baldhill Dam Gauge 1971-1999

[2]See Appendix C

FIGURE 3-12

AVAILABLE HABITAT OVER A RANGE OF DISCHARGE, HABITAT SEGMENT B3[1]

SHOWING A RANGE OF HISTORIC MEANS (±1SD) MONTHLY DISCHARGE[2]

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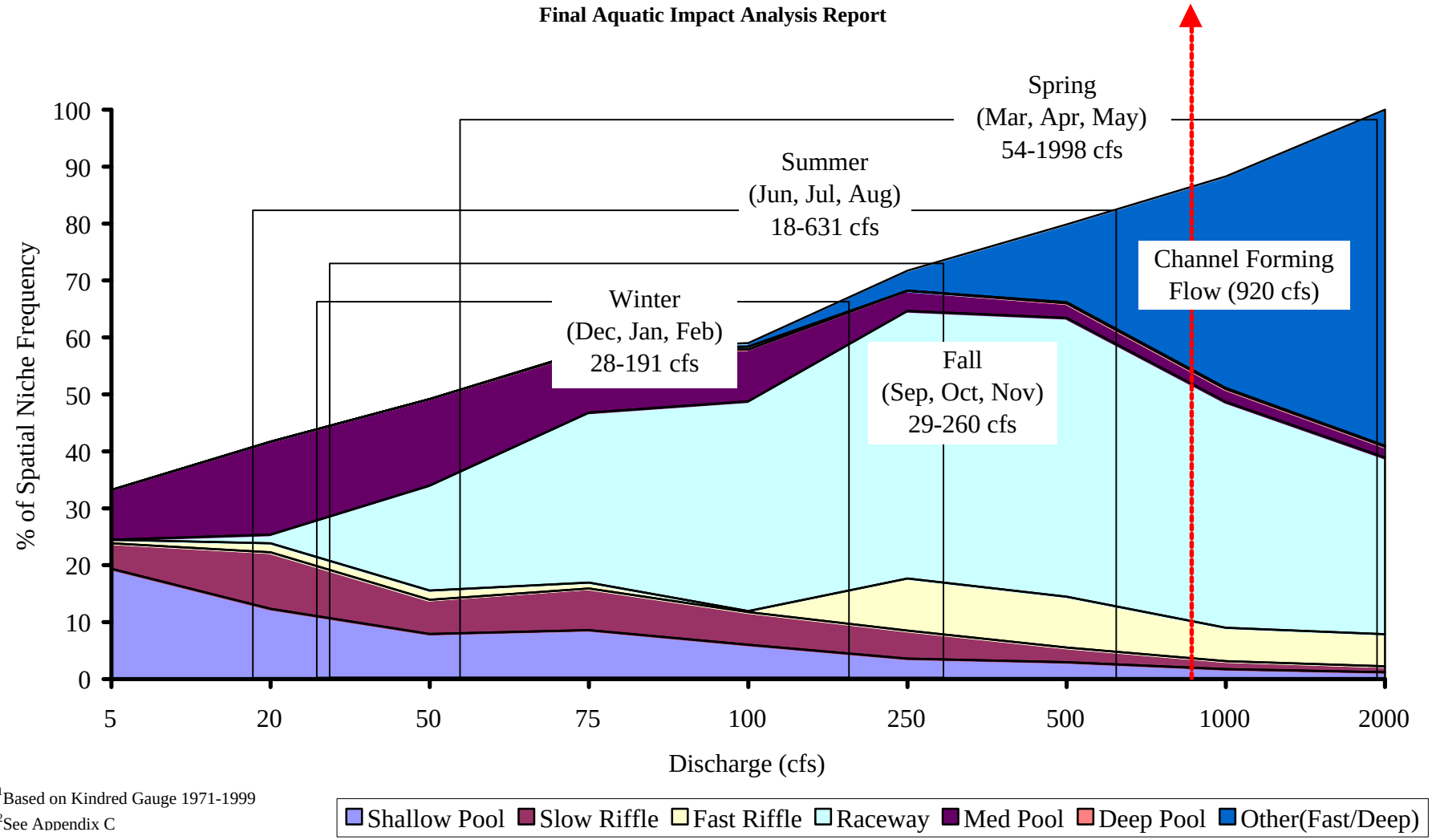
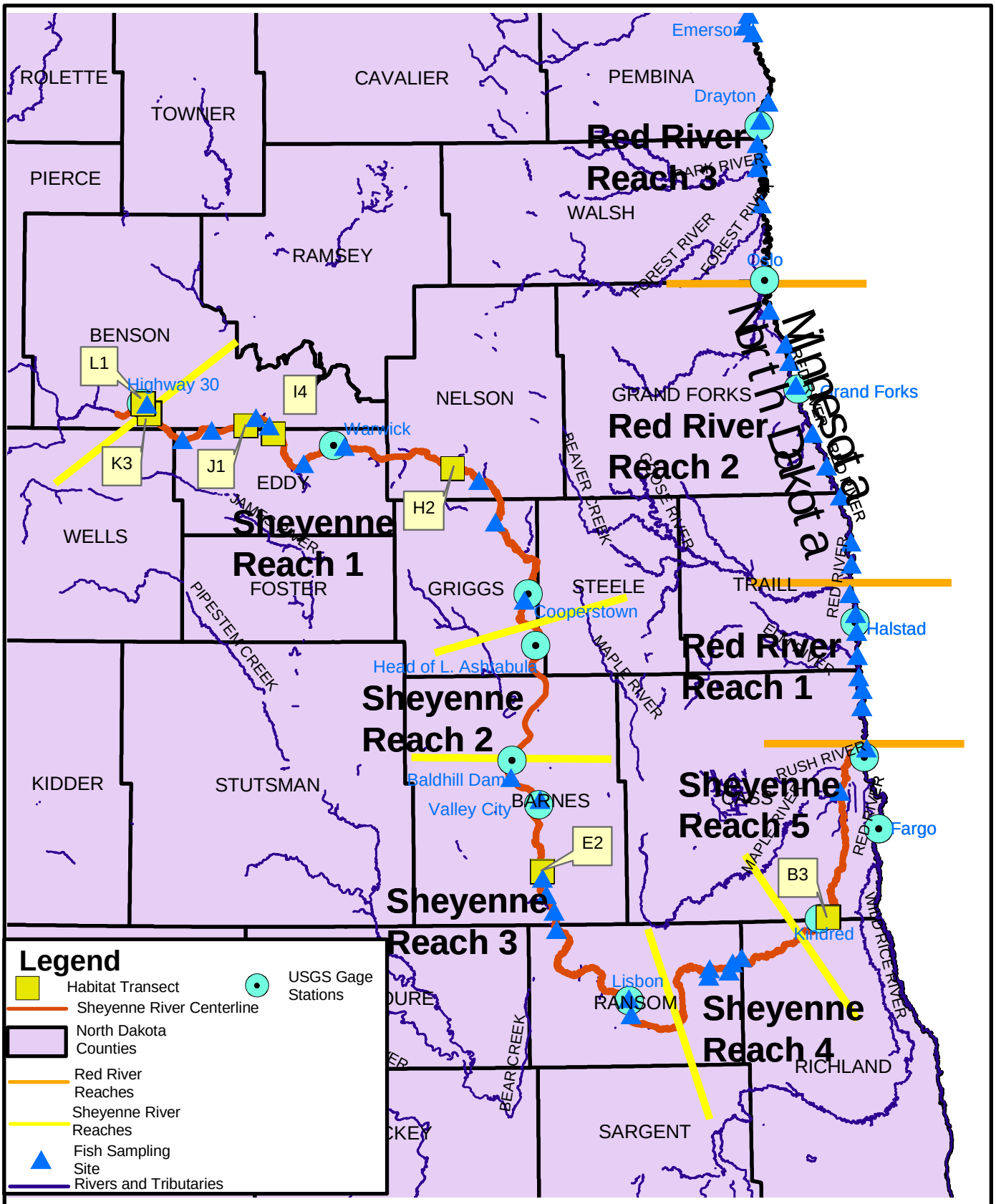


[1]Based on Kindred Gauge 1971-1999

[2]See Appendix C



Map Source: U.S. Army Corps of Engineers Habitat Cross-Section Data, 2001.

0 5 10 20 Miles

Figure 3-13
Location of Fish Sampling Sites on the Sheyenne and Red Rivers, North Dakota
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FIGURE 3-14
RED RIVER BASIN FISH SPECIES IN RELATION TO ENVIRONMENTAL GRADIENTS
(ADAPTED FROM GOLDSTEIN ET AL. 1996)
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(Small)	(Intermediate Small)	(Intermediate Large)	(Large)
		Spottail shiner	
		Spotfin shiner	
Longnose dace		Burbot	
Blacknose dace		Black crappie	
Johnny darter	Blackside darter	Walleye	
Iowa darter	Black bullhead	Yellow perch	
Common shiner	White sucker	Northern pike	
Bigmouth shiner	Fathead minnow	Golden redhorse	Sauger
Brook stickleback	Stonecat	Silver redhorse	Quillback
Tadpole madtom	Rockbass	Shorthead redhorse	Mooneye
Creek chub	Hornyhead chub	Smallmouth bass	Goldeye
Northern redbelly dace	Bluntnose minnow	Common carp	Silver chub
Central mudminnow	Sand shiner	Chestnut lamprey	Emerald shiner

Stream Size →

Habitat Volume →

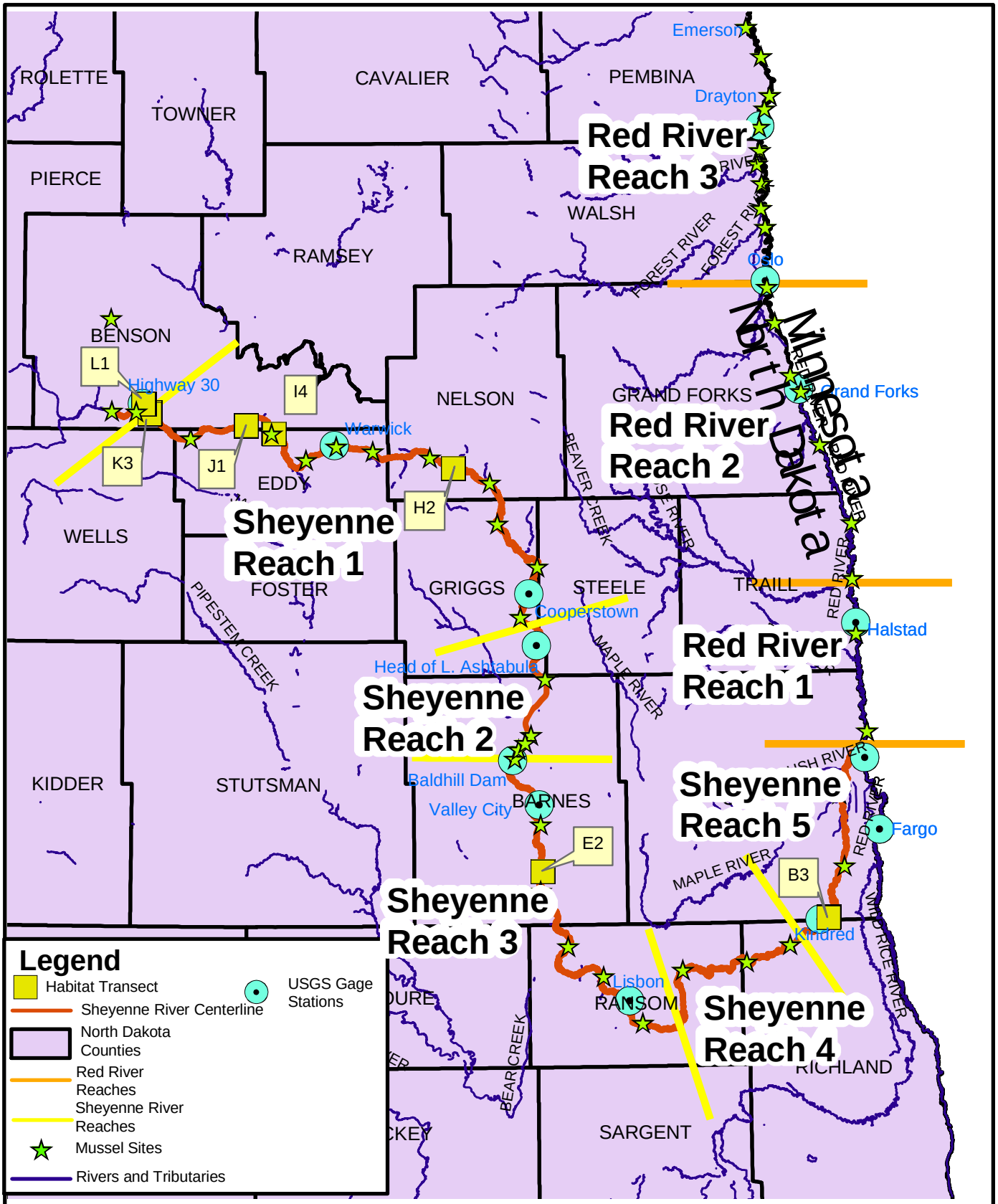
Discharge Variability →

Instream Habitat Diversity →

← **Forest** ← **NonAgricultural** → **Wetlands** →

Turbidity →

← **Lowest Dissolved Oxygen**



Map Source: U.S. Army Corps of Engineers Habitat Cross-Section Data, 2001.

0 5 10 20 Miles

Figure 3-15
Location of Mussel Sampling Sites on the Sheyenne and Red Rivers, North Dakota
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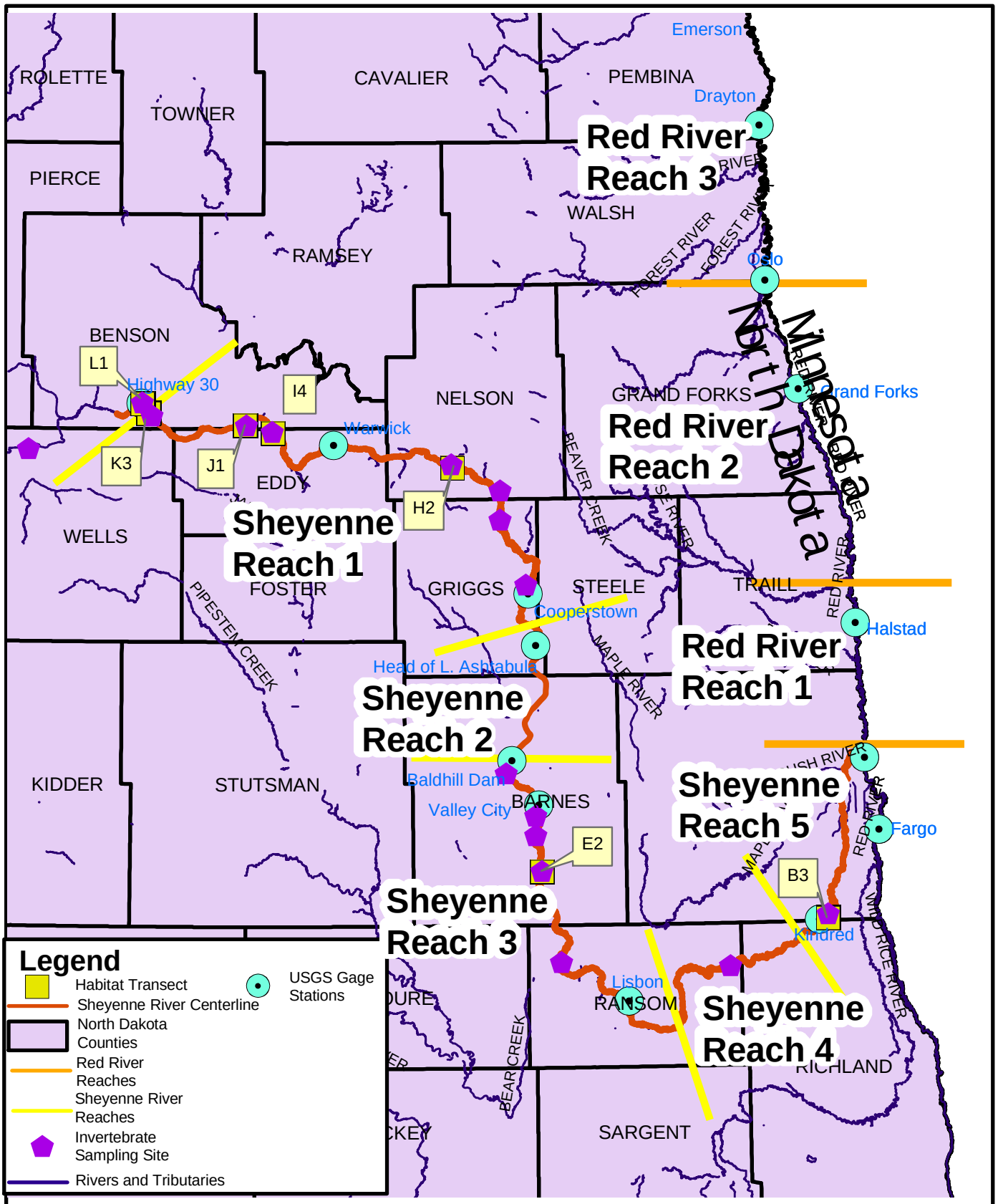

Map Source: U.S. Army Corps of Engineers Habitat Cross-Section Data, 2001.

0 5 10 20 Miles

Figure 3-16
Location of Invertebrate Sampling Sites on the Sheyenne and Red Rivers, North Dakota
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FIGURE 4-1
IMPACT ANALYSIS FRAMEWORK
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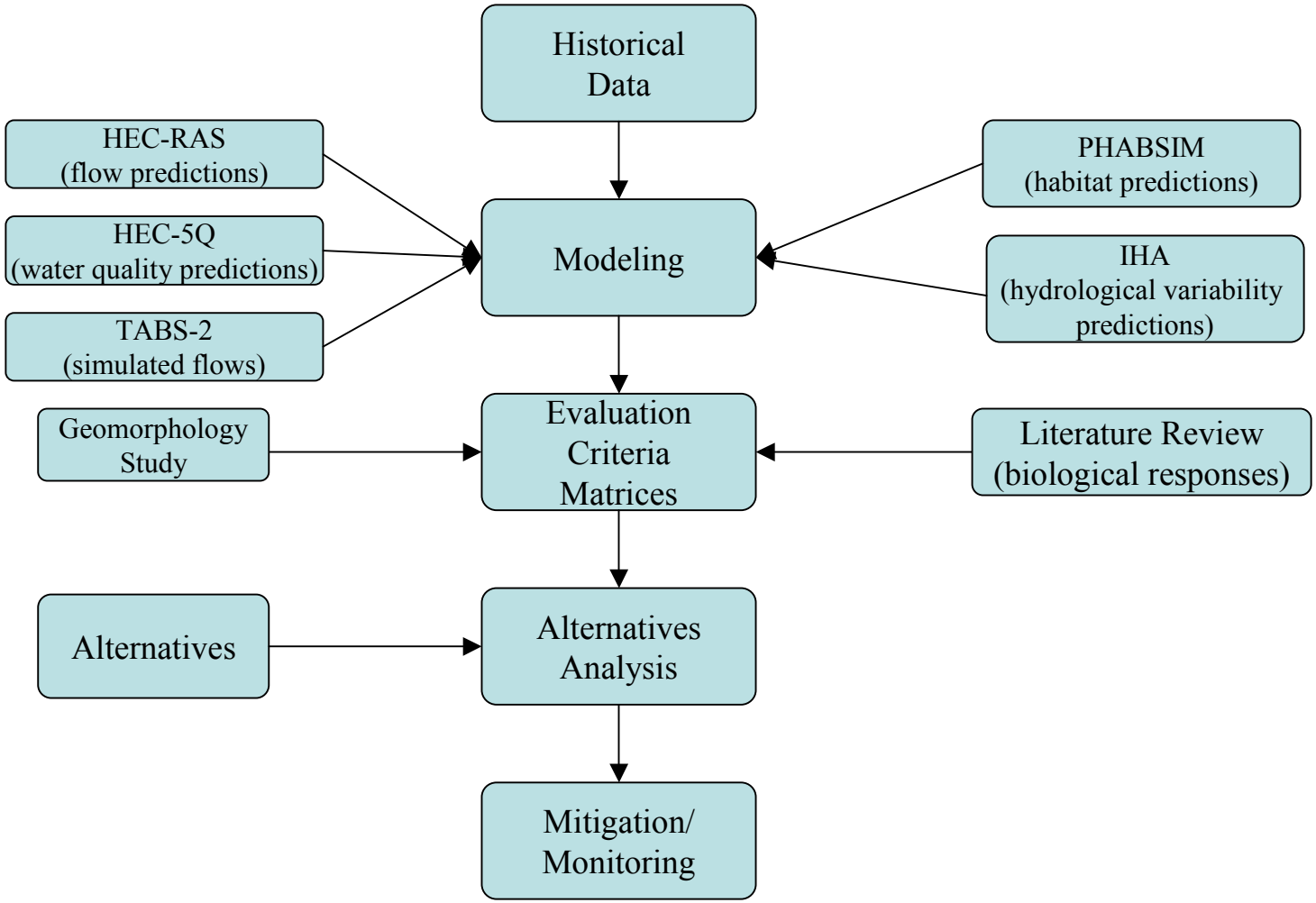

FIGURE 4-2

DIFFERENCE IN DISCHARGE BETWEEN 300MOD50 AND MOD50 AT COOPERSTOWN, ND USGS GAGE

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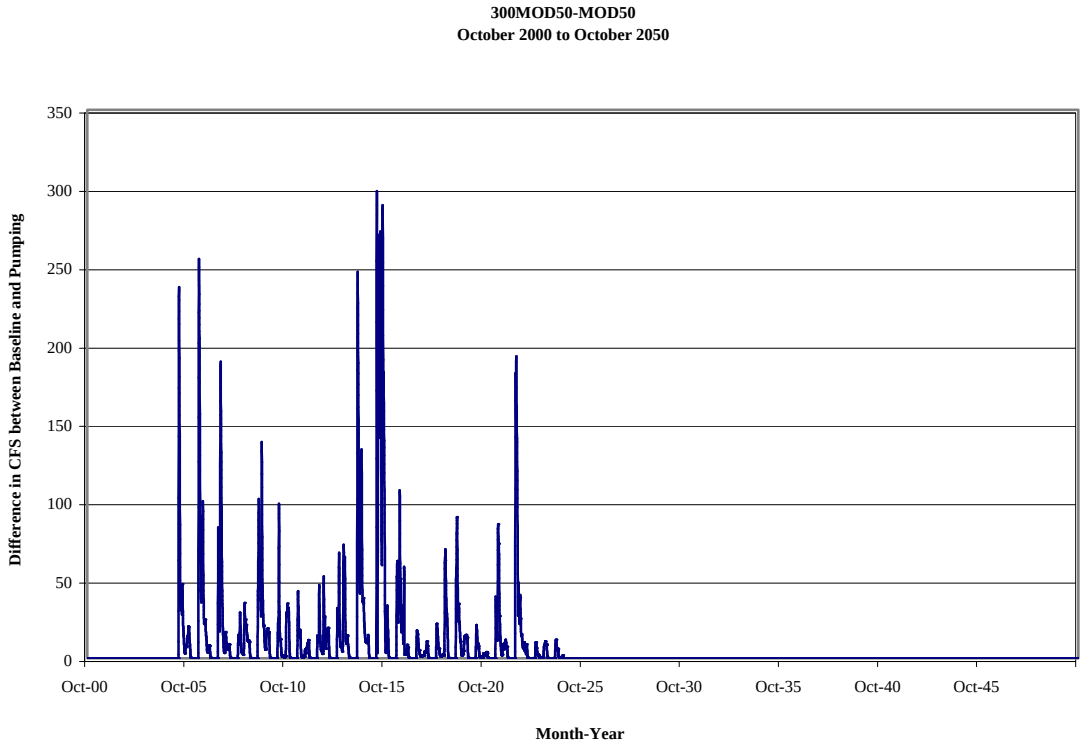


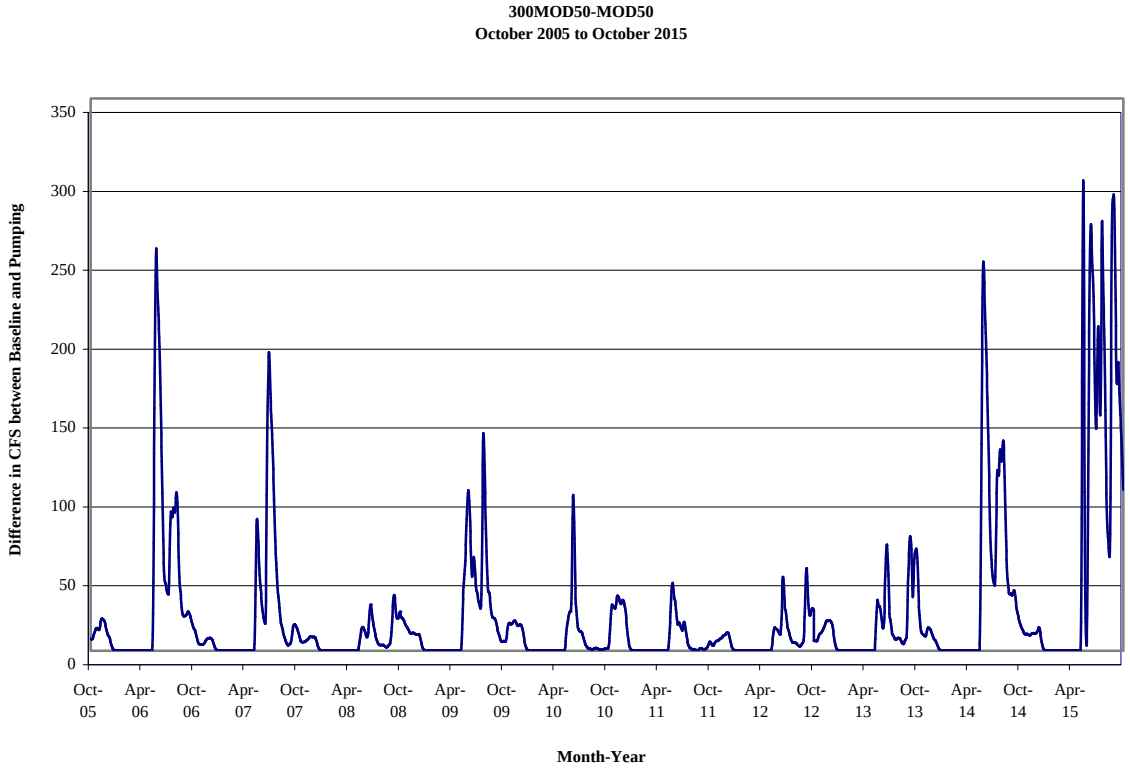
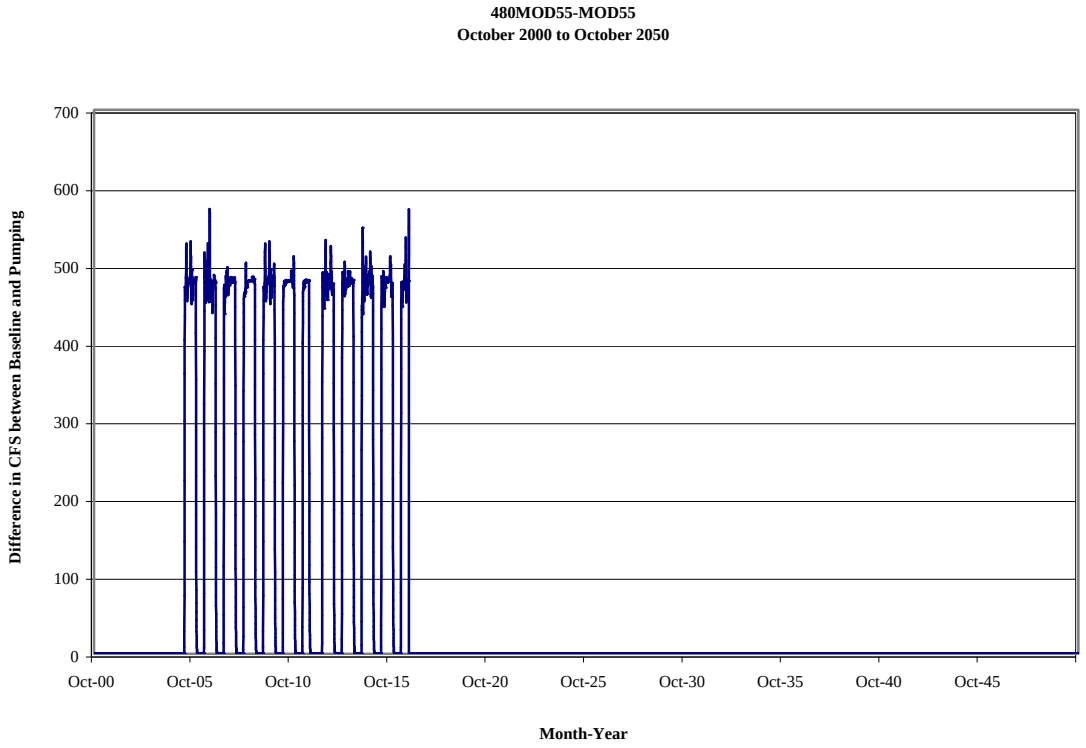


FIGURE 4-3

DIFFERENCE IN DISCHARGE BETWEEN 480MOD55 AND MOD55 AT COPPERSTOWN, ND USGS GAGE

Final Aquatic Impact Analysis Report



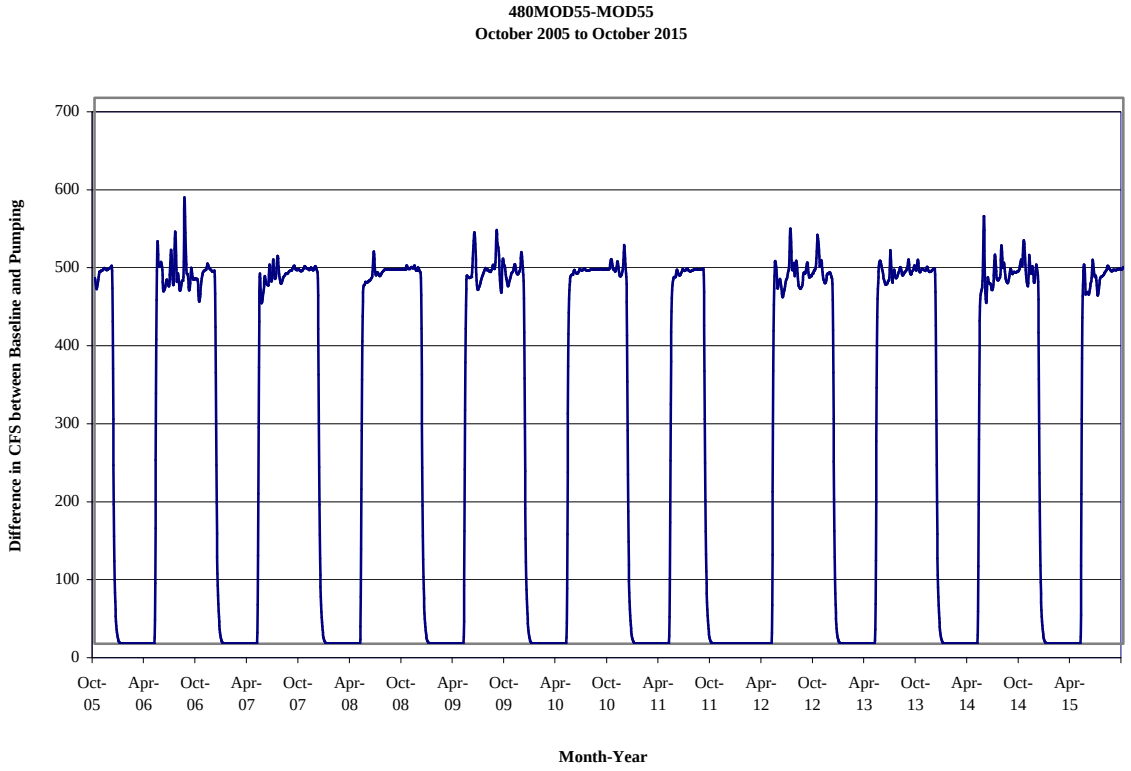
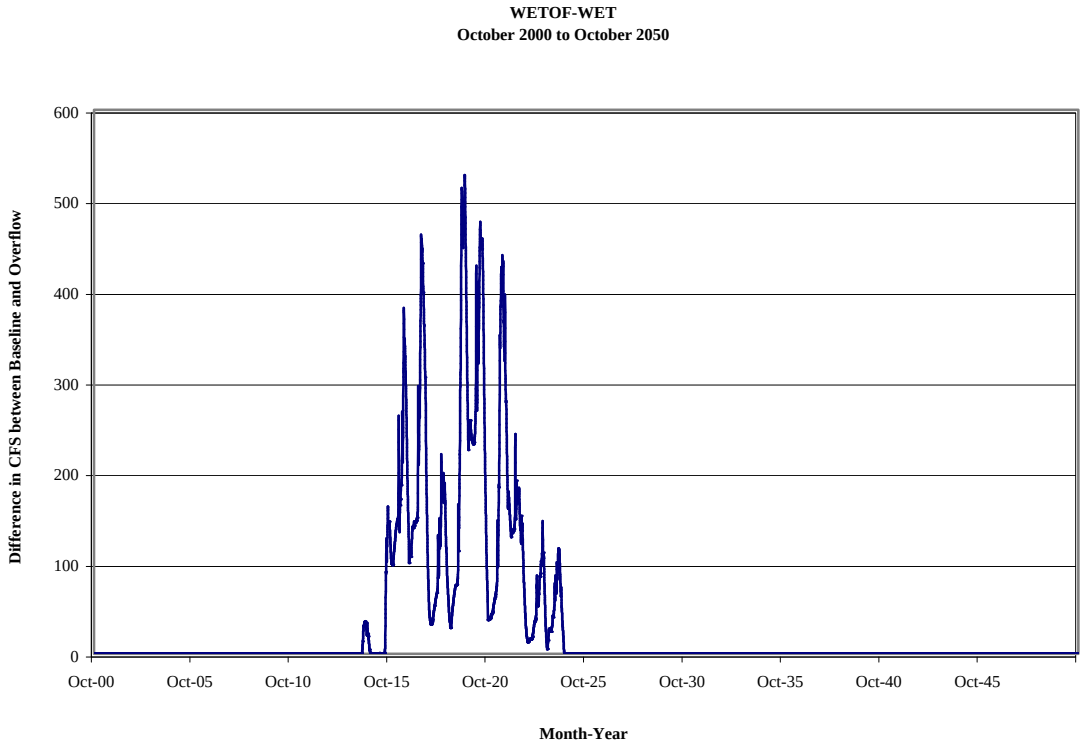


FIGURE 4-4

DIFFERENCE IN DISCHARGE BETWEEN WETOF AND WET AT COOPERSTOWN, ND USGS GAGE

Final Aquatic Impact Analysis Report



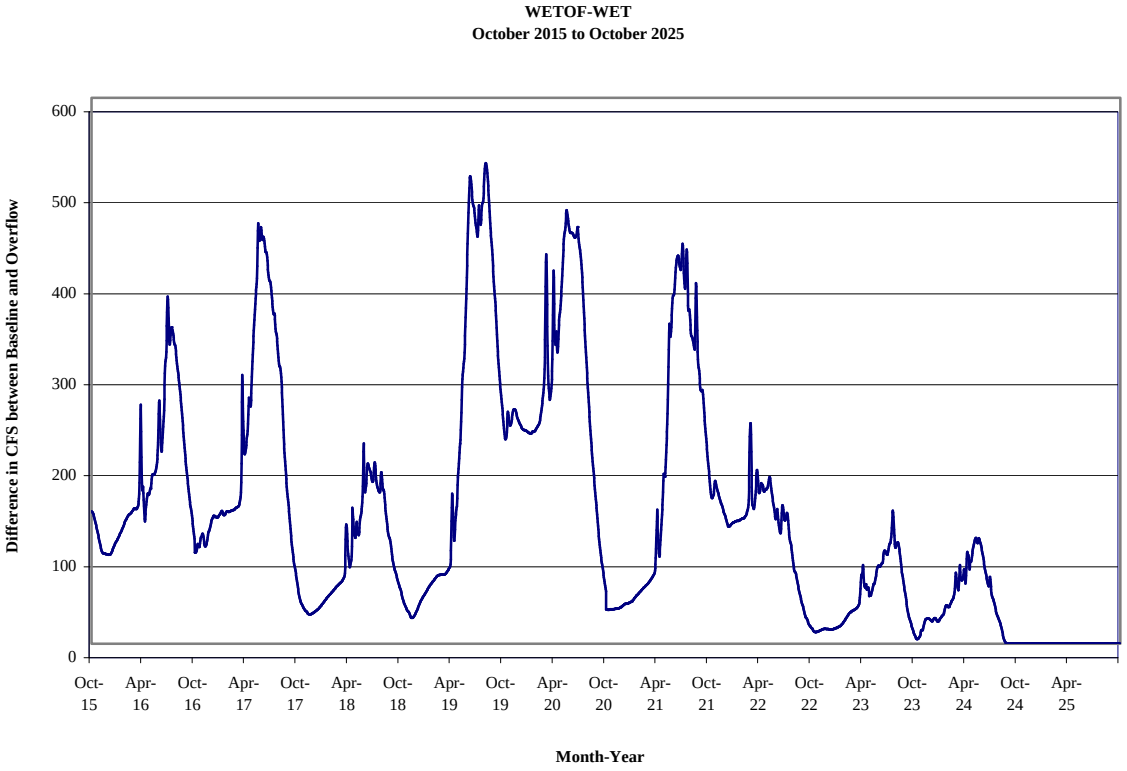


FIGURE 4-5
CONCEPTUAL APPROACH TO THE HABITAT TIME SERIES ANALYSIS
Final Aquatic Impact Analysis Report

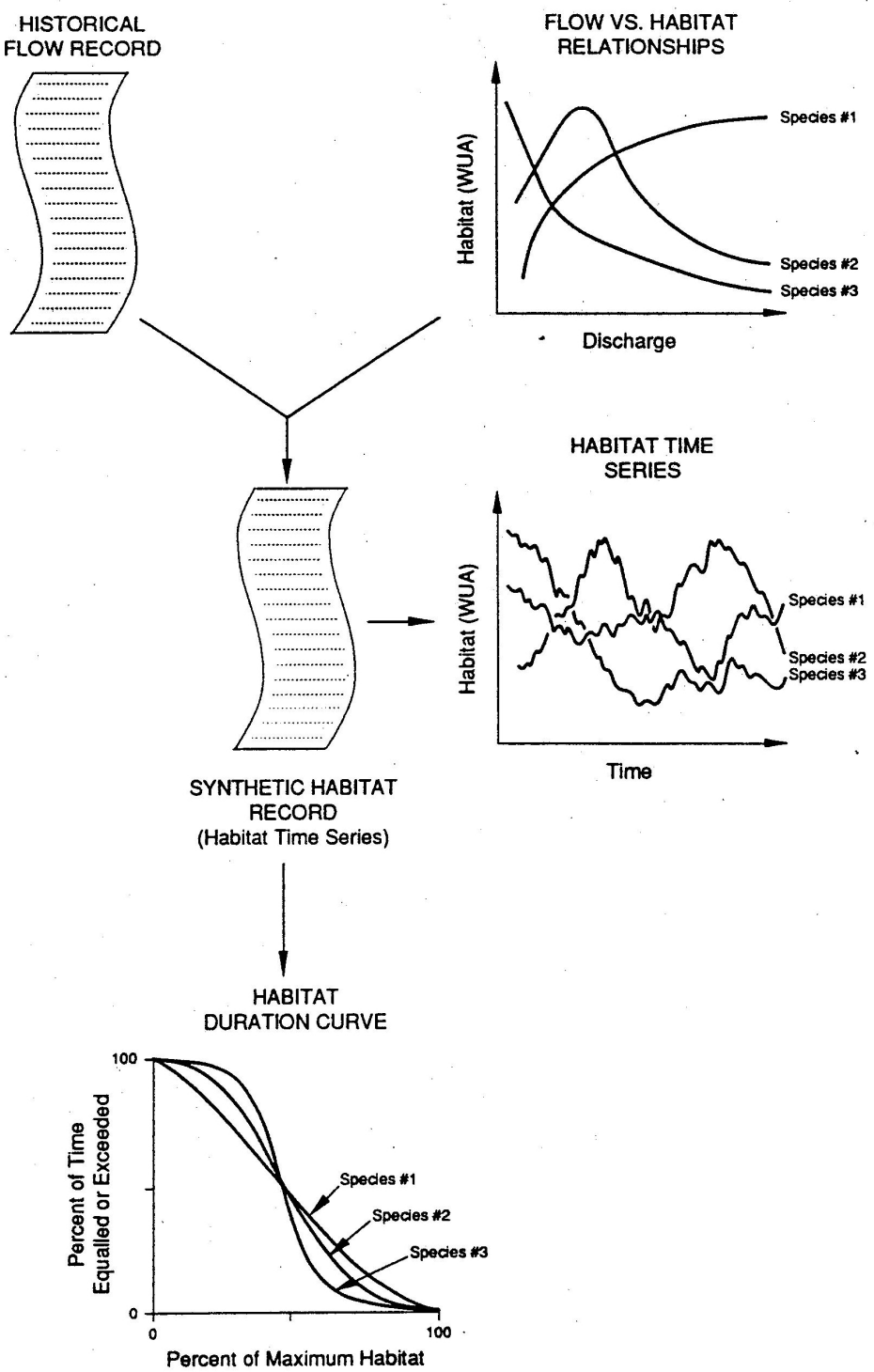


FIGURE 5-1
COMPARISON OF TDS, SULFATE AND CHLORIDE AVERAGES AND RANGES BETWEEN MOD50 AND 300MOD50, 2005-2015
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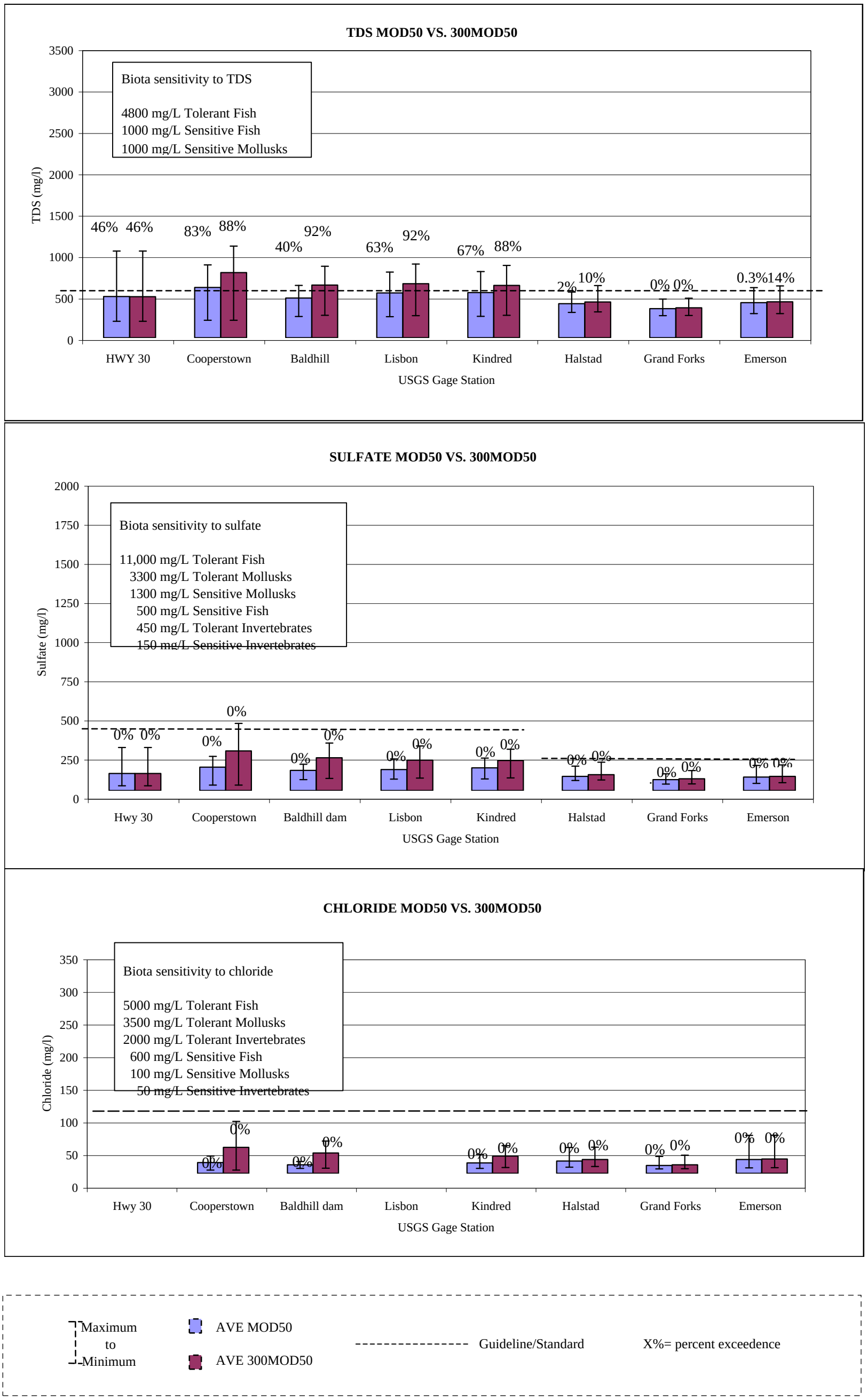
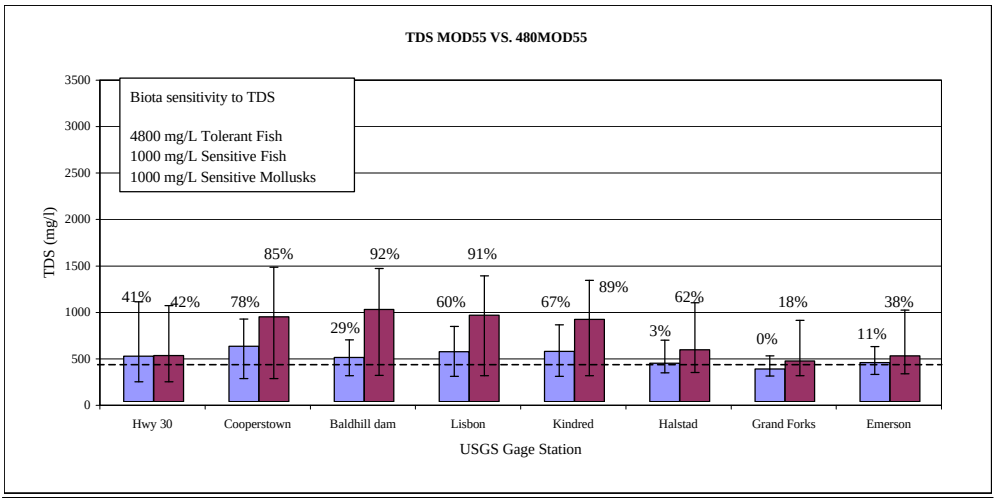
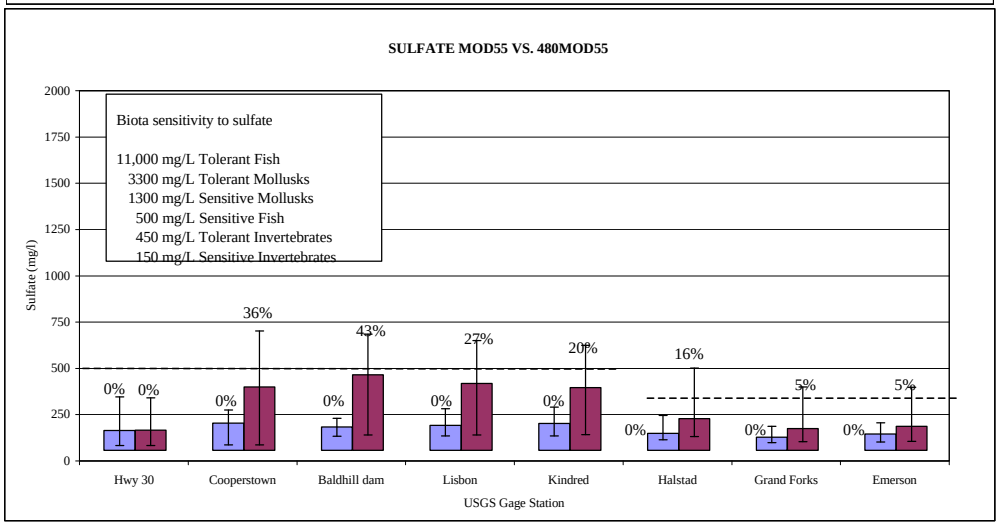
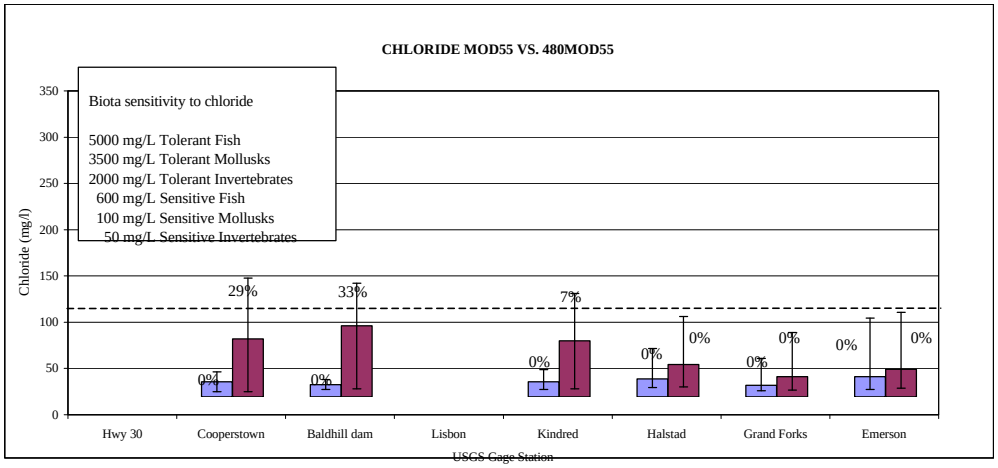


FIGURE 5-2
COMPARISON OF TDS, SULFATE AND CHLORIDE AVERAGES AND RANGES BETWEEN MOD55 AND 480MOD55, 2005-2015
Final Aquatic Impact Analysis Report







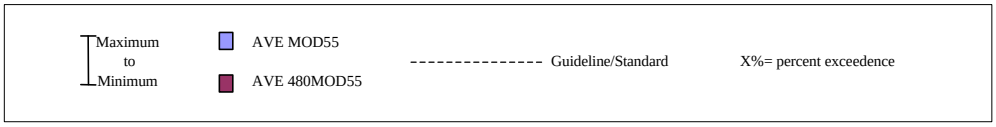
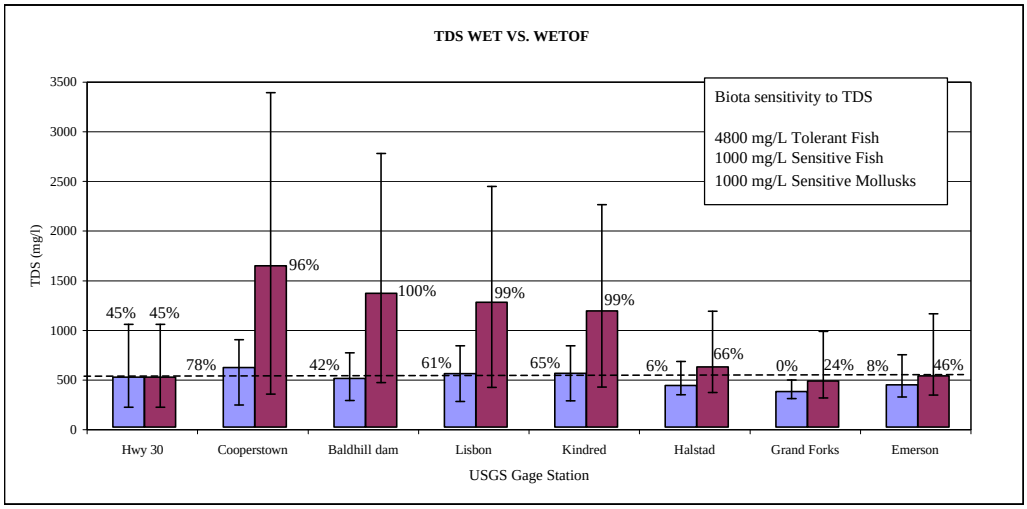
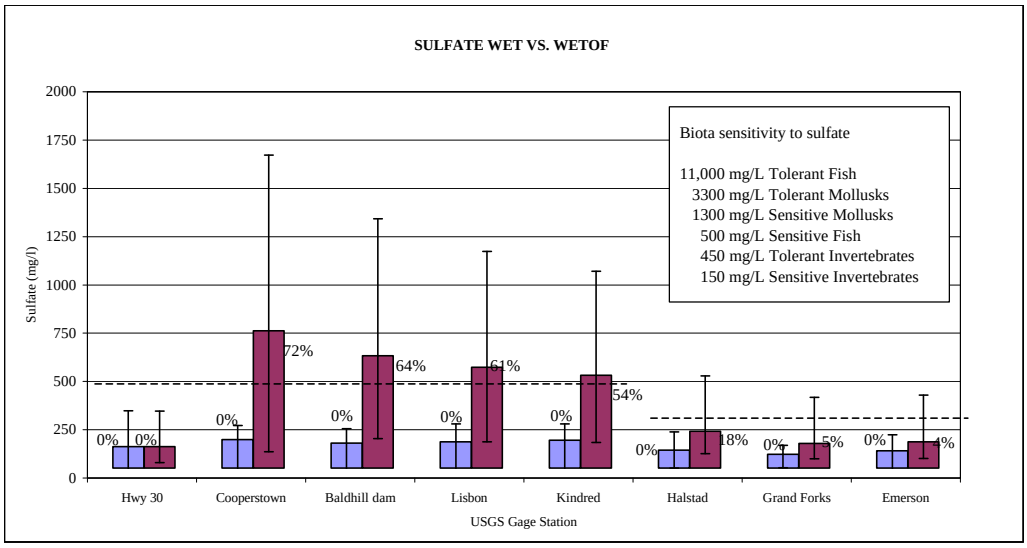
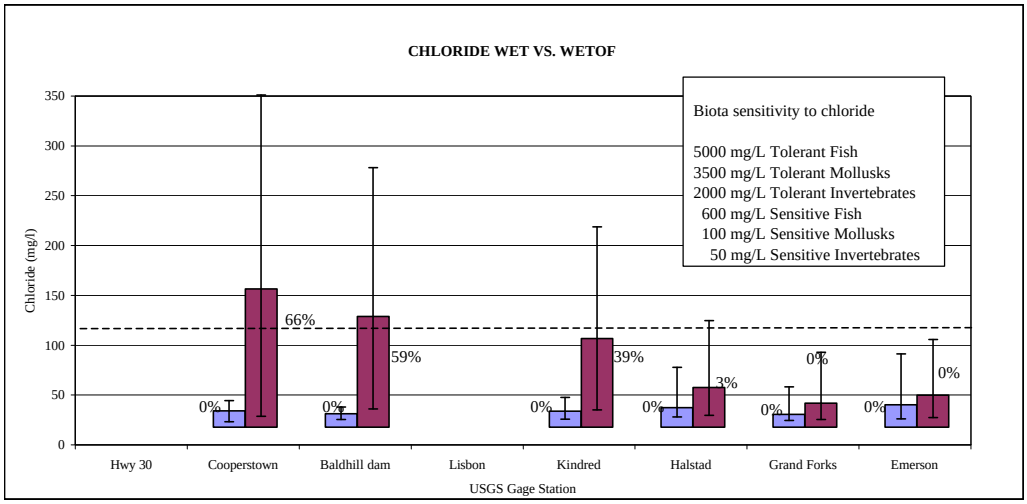


FIGURE 5-3
COMPARISON OF TDS, SULFATE, AND CHLORIDE AVERAGES AND RANGES BETWEEN WET AND WETOF, 2015-2025
Final Aquatic Impact Analysis Report







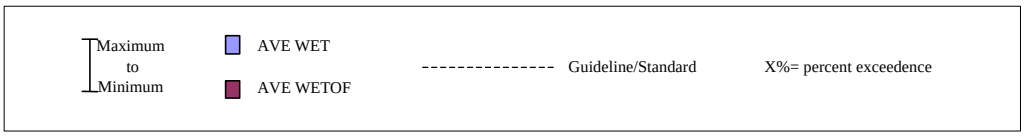


FIGURE 5-4
SPATIAL NICHE AND % MAXIMUM WUA VERSUS DISCHARGE AT HABITAT SEGMENT H
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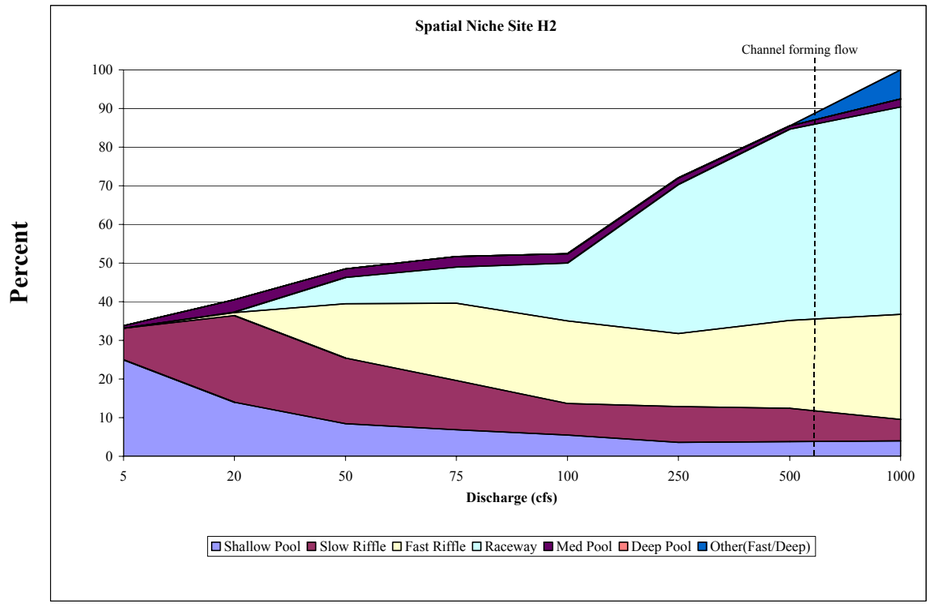


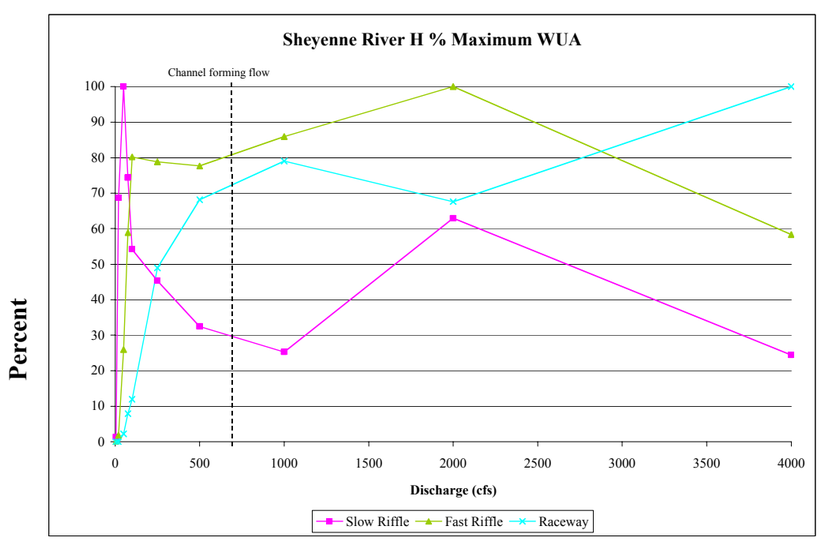
Discharge Comparison Between Baseline and Operation/Overflow at Cooperstown

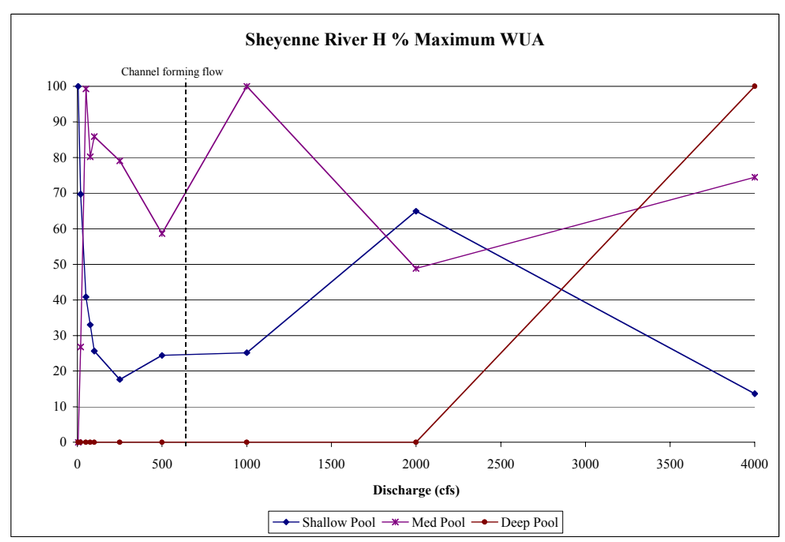
	MOD50	300MOD50
Winter	7-60*	7-67
Spring	34-2254	34-2254
Summer	10-325	14-447
Fall	6-144	7-221

	MOD55	480MOD55
Winter	13-57	13-178
Spring	51-2465	51-2465
Summer	4-330	462-797
Fall	2-137	249-650

	WET	WETOF
Winter	7-79	20-251
Spring	41-2015	41-2169
Summer	10-485	23-708
Fall	3-208	26-385

*Values are -1 Standard Deviation to +1 Standard Deviation around the mean discharge (cfs).





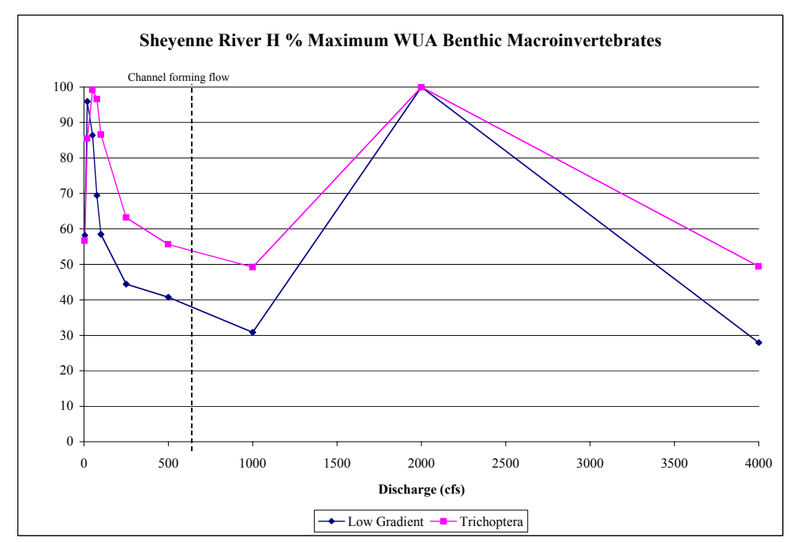
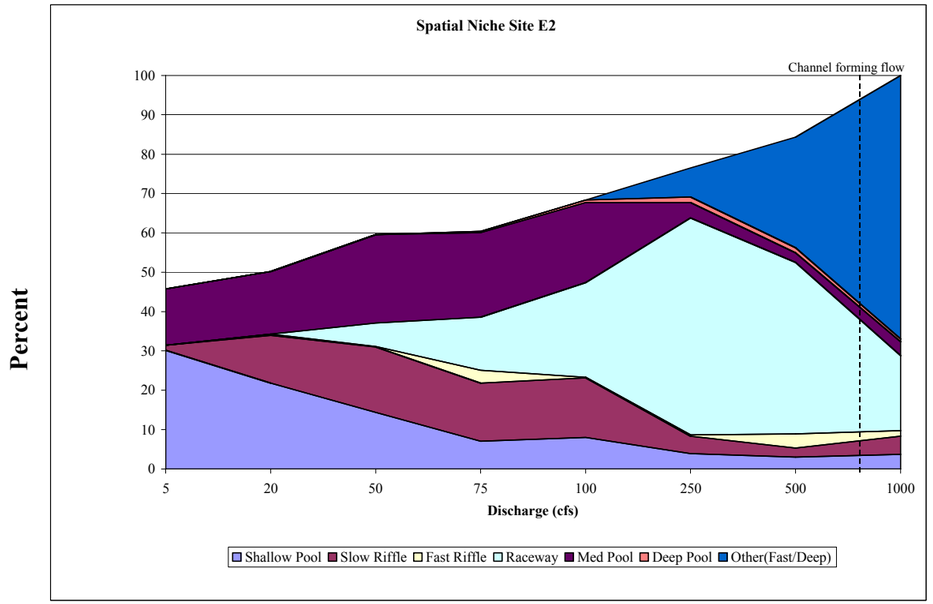


FIGURE 5-5
SPATIAL NICHE AND % MAXIMUM WUA VERSUS DISCHARGE AT HABITAT SEGMENT E
Final Aquatic Impact Analysis Report



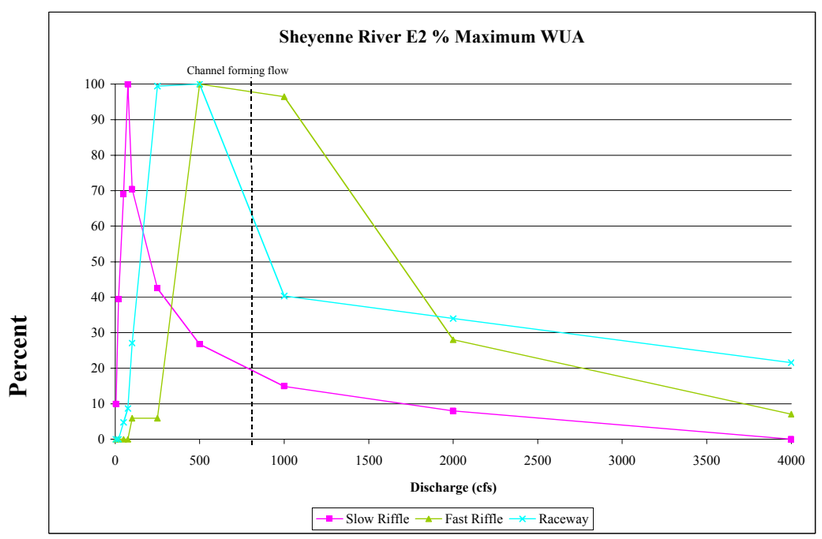
Discharge Comparison Between Baseline and Operation/Overflow at Baldhill Dam

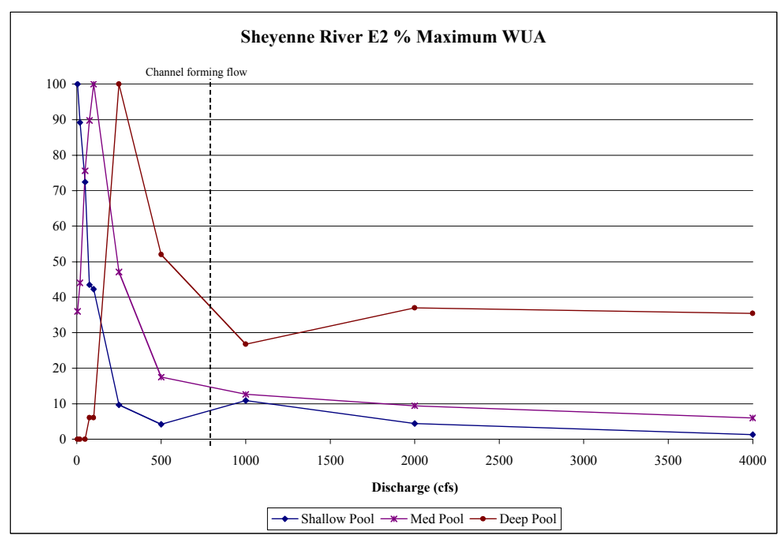
	MOD50	300MOD50
Winter	13-192	13-198
Spring	13-2791	13-2791
Summer	16-219	17-260
Fall	18-445	23-567

	MOD55	480MOD55
Winter	21-177	21-307
Spring	13-3010	13-3010
Summer	13-454	466-920
Fall	13-238	376-780

	WET	WETOF
Winter	13-193	17-319
Spring	13-2343	140-2517
Summer	18-593	18-926
Fall	13-270	35-482

*Values are -1 Standard Deviation to +1 Standard Deviation around the mean discharge (cfs).





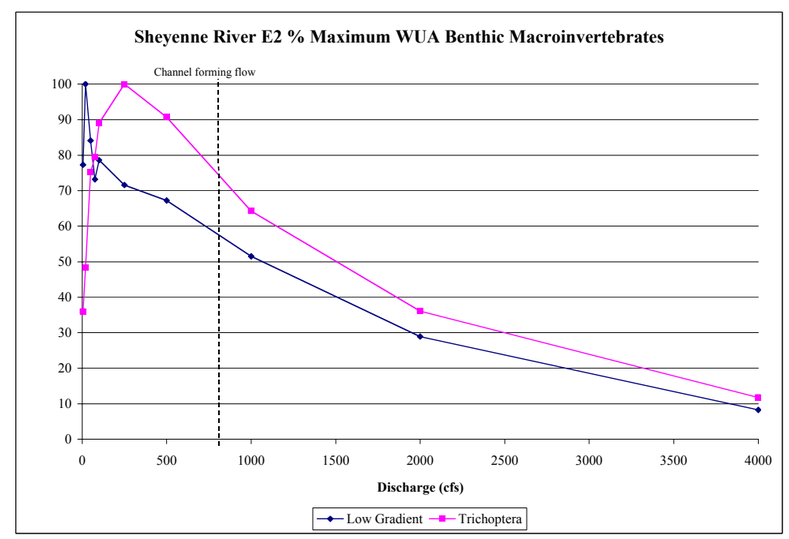
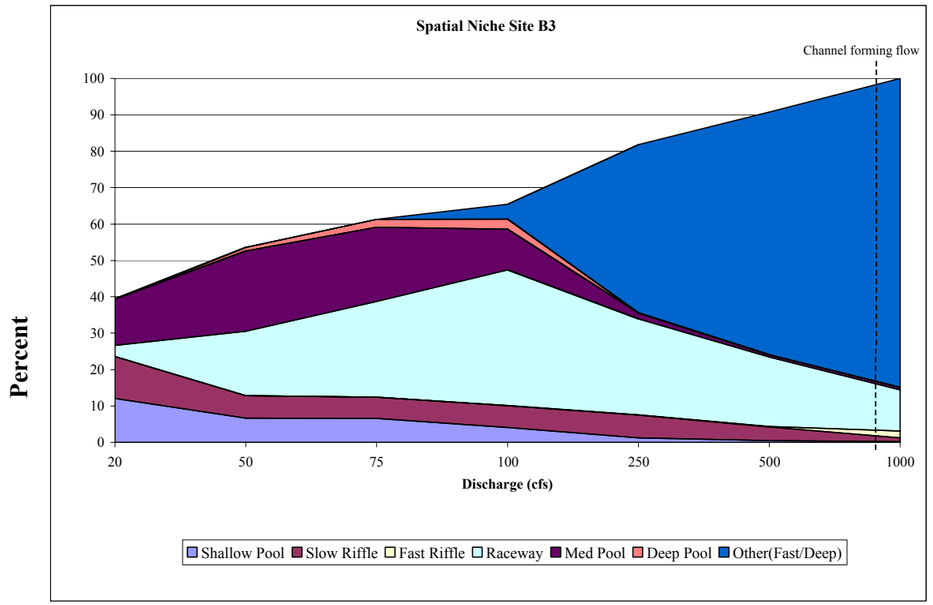


FIGURE 5-6
SPATIAL NICHE AND % MAXIMUM WUA VERSUS DISCHARGE AT HABITAT SEGMENT B
Final Aquatic Impact Analysis Report



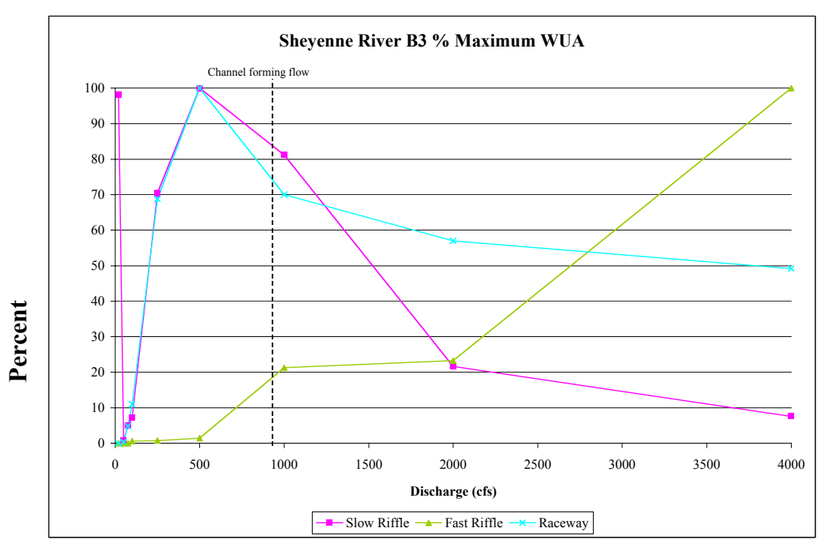
Discharge Comparison Between Baseline and Operation/Overflow at Kindred

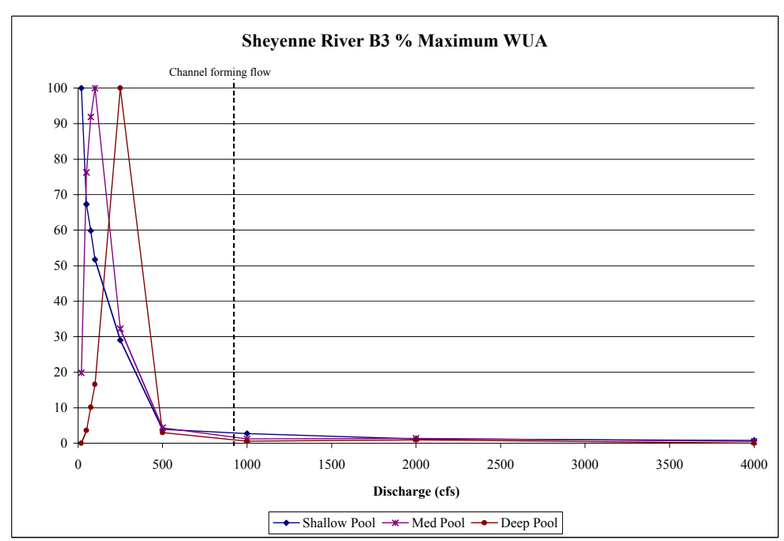
	MOD50	300MOD50
Winter	28-280*	28-290
Spring	50-3430	48-3430
Summer	38-813	41-892
Fall	6-334	47-419

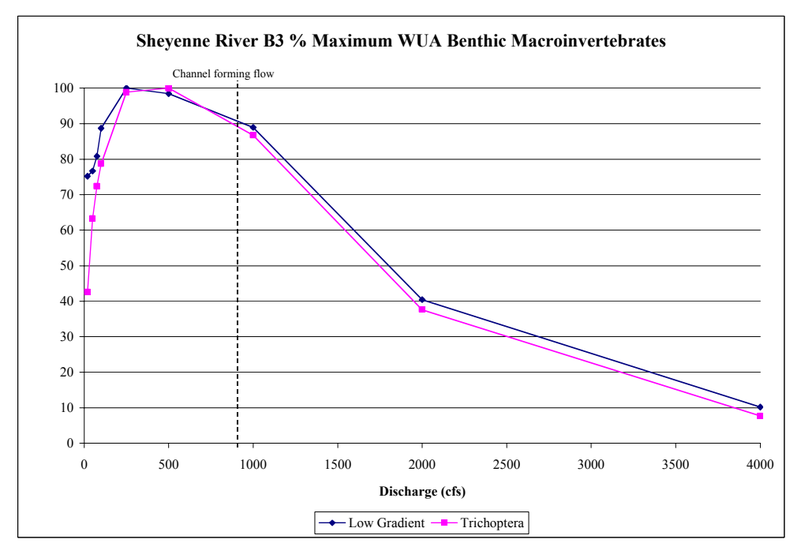
	MOD55	480MOD55
Winter	48-264	47-467
Spring	53-3720	89-3720
Summer	44-794	460-1267
Fall	15-324	409-838

	WET	WETOF
Winter	33-282	45-400
Spring	46-2903	154-3037
Summer	40-1009	39-1201
Fall	35-448	74-587

*Values are -1 Standard Deviation to +1 Standard Deviation around the mean discharge (cfs).







APPENDIX A

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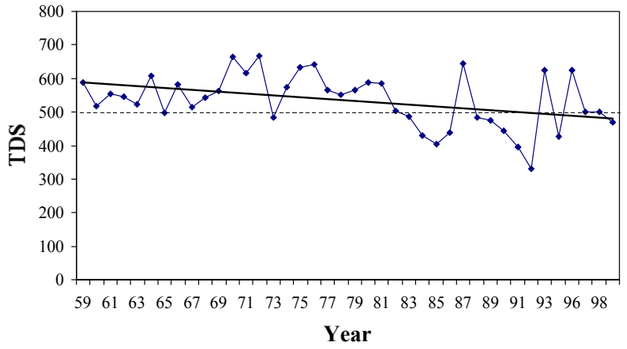
APPENDIX B

HISTORIC WATER QUALITY TRENDS

APPENDIX B-1
HISTORIC WATER QUALITY NEAR COOPERSTOWN
Final Aquatic Impact Analysis Report

Sheyenne River near Cooperstown



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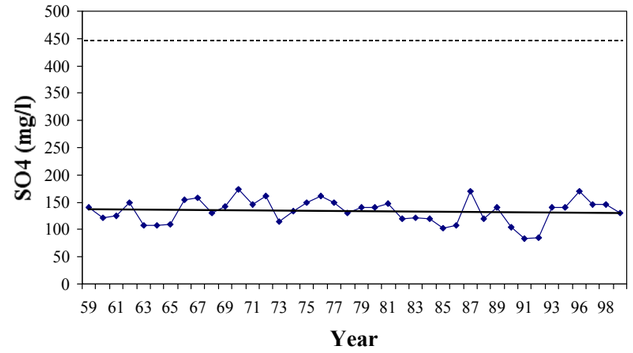

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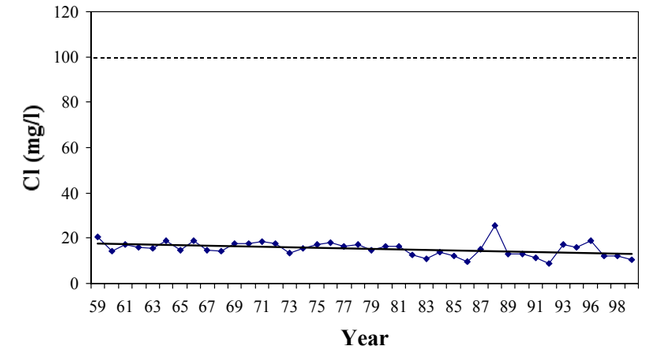

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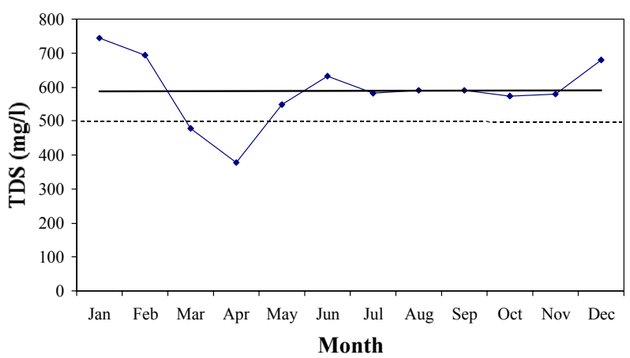

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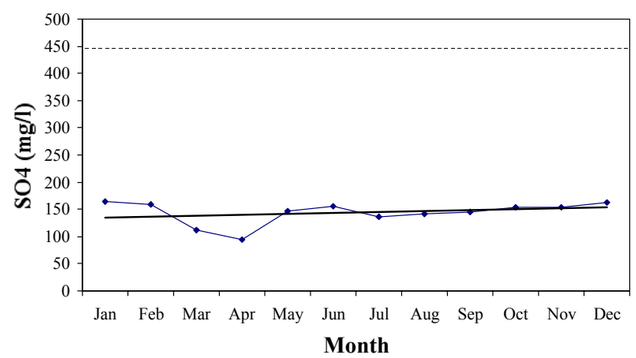

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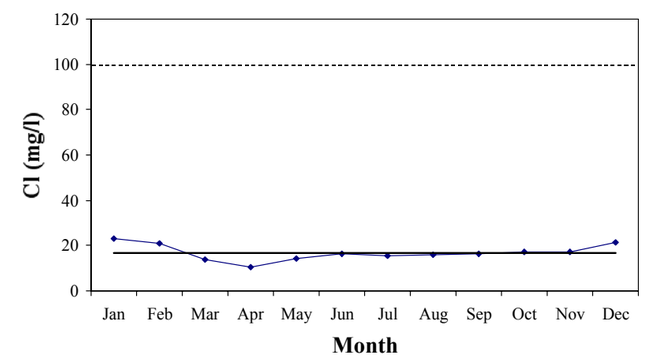
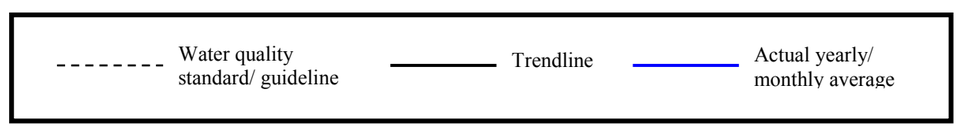
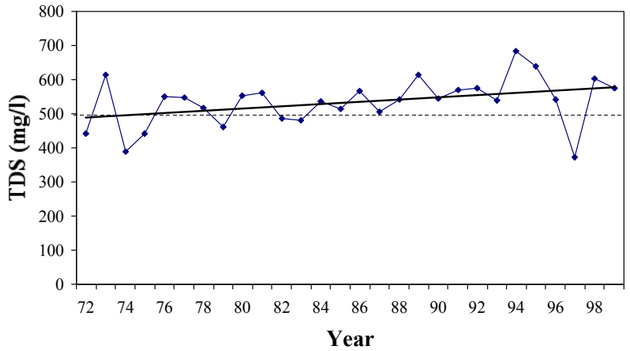


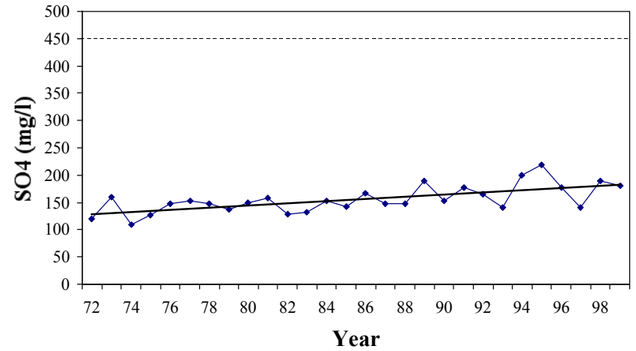


APPENDIX B-2
HISTORIC WATER QUALITY AT KINDRED
Final Aquatic Impact Analysis Report

Sheyenne River at Kindred



Sheyenne River at Kindred



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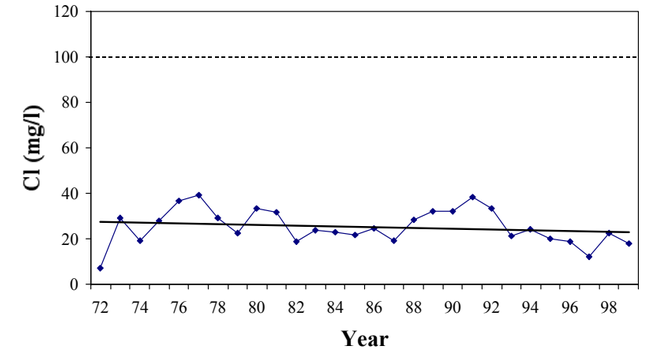

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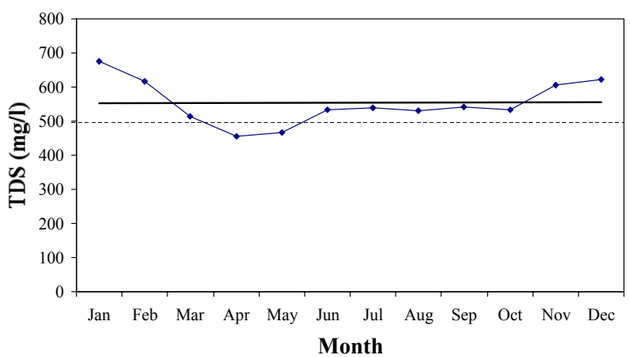

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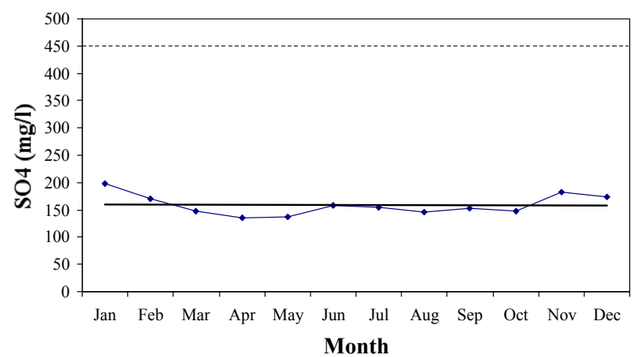
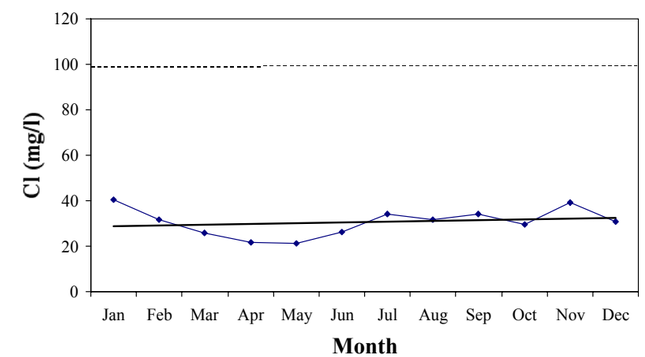
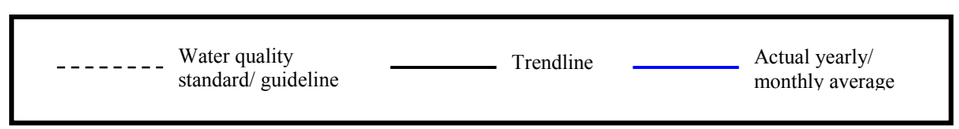


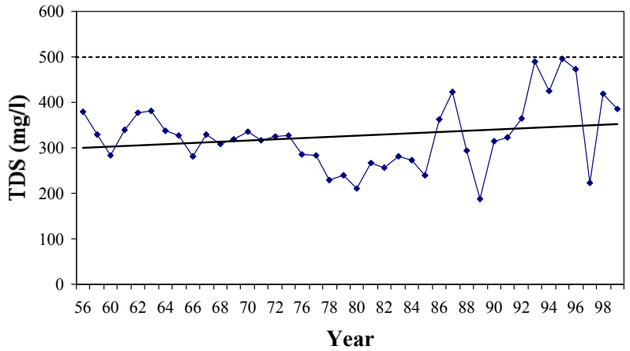
Sheyenne River at Kindred



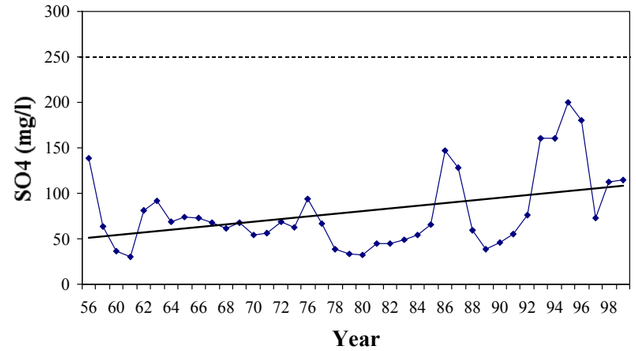


APPENDIX B-3
HISTORIC WATER QUALITY AT FARGO
Final Aquatic Impact Analysis Report

Red River of the North at Fargo



Red River of the North at Fargo



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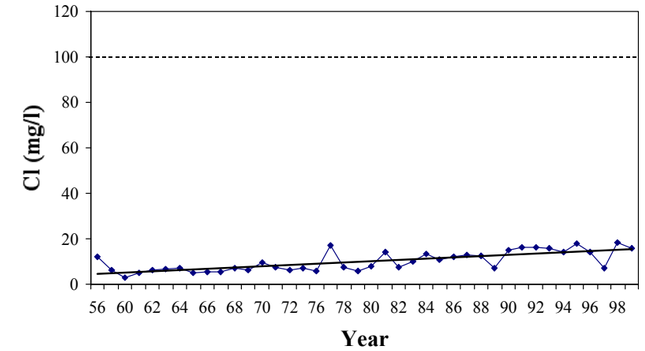

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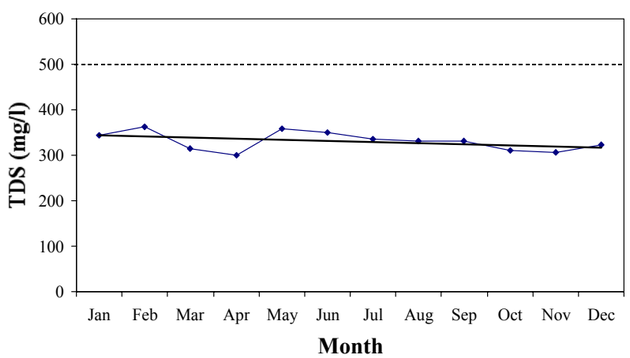
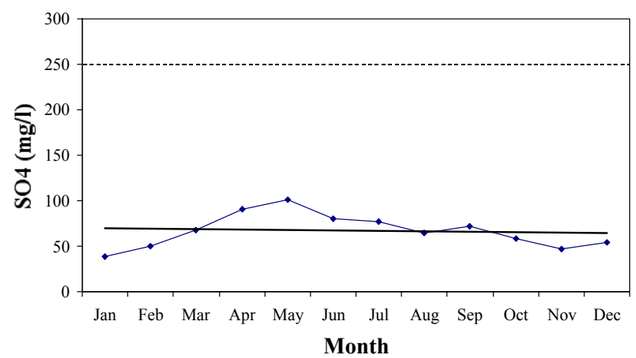
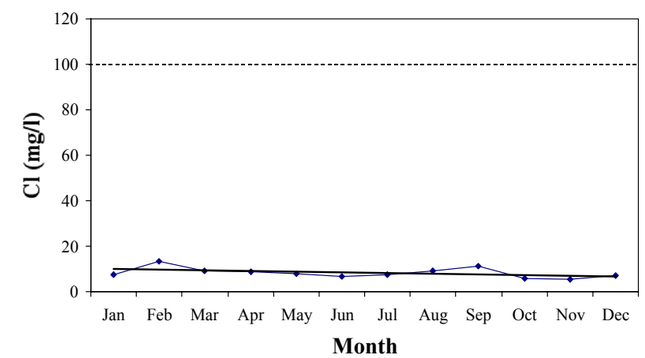
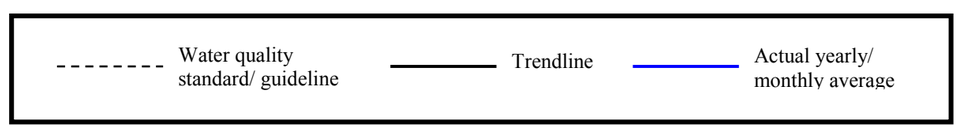


Red River of the North at Fargo



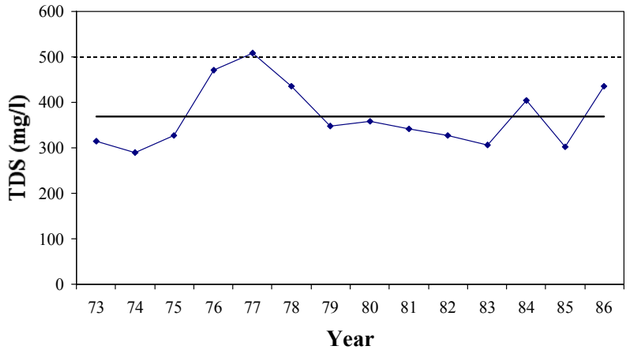
Red River of the North at Fargo



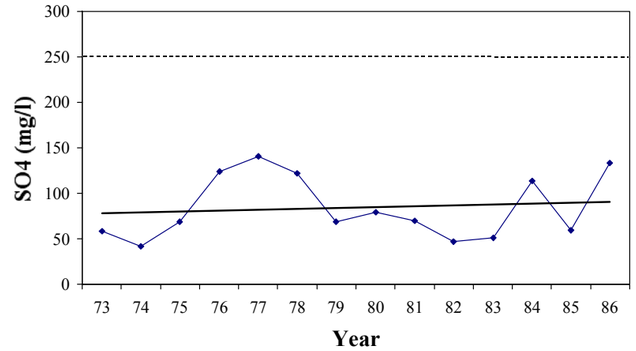


APPENDIX B-4
HISTORIC WATER QUALITY BELOW FARGO
Final Aquatic Impact Analysis Report

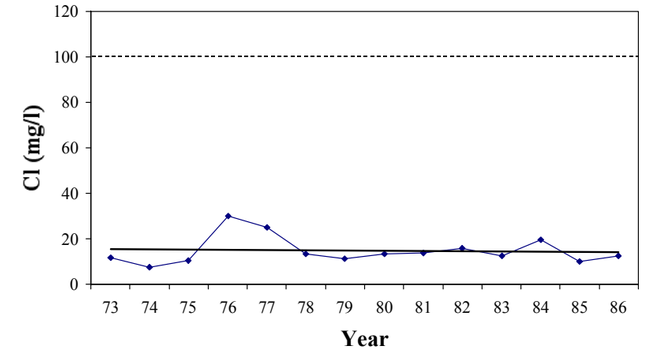
Red River of the North Below Fargo



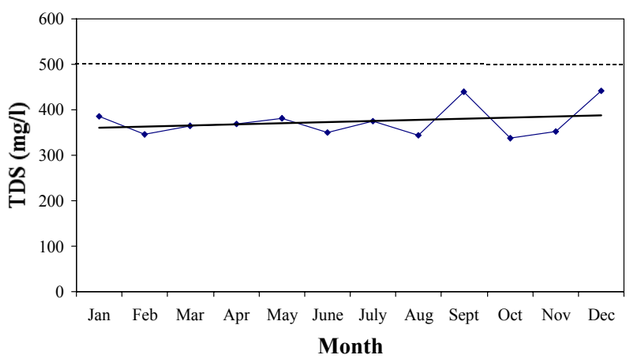
Red River of the North Below Fargo



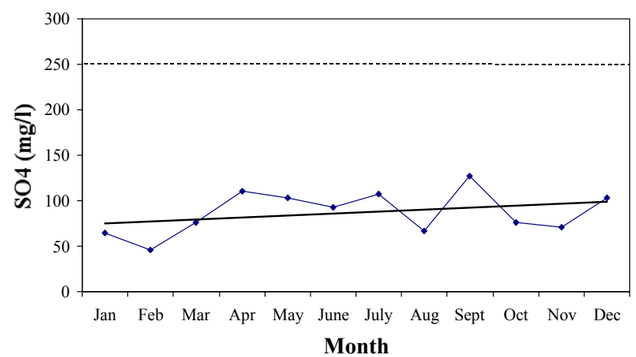
Red River of the North Below Fargo



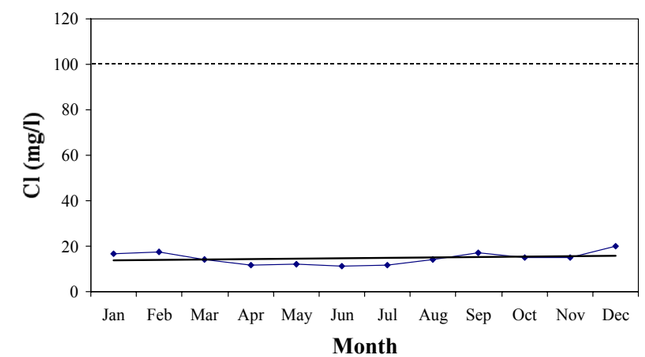
Red River of the North Below Fargo

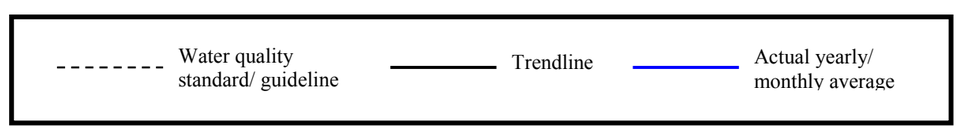


Red River of the North Below Fargo



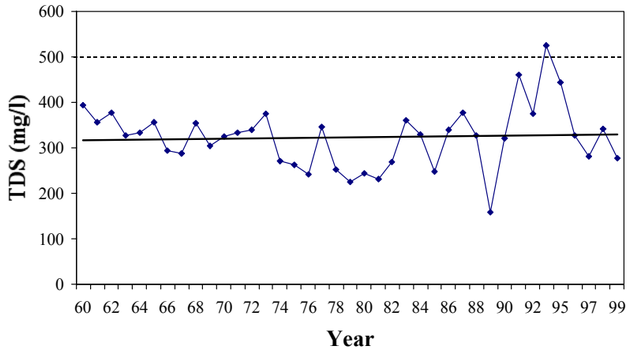
Red River of the North Below Fargo



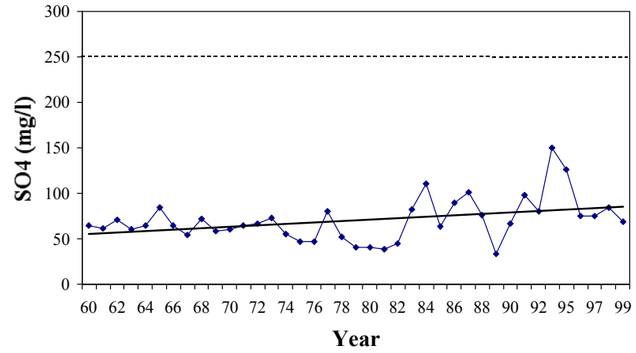


APPENDIX B-5
HISTORIC WATER QUALITY AT GRAND FORKS
Final Aquatic Impact Analysis Report

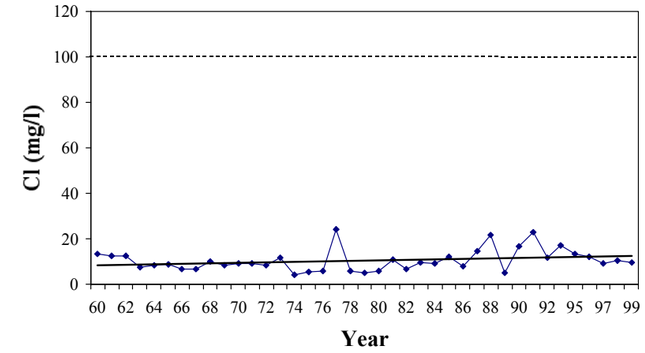
Red River of the North at Grand Forks



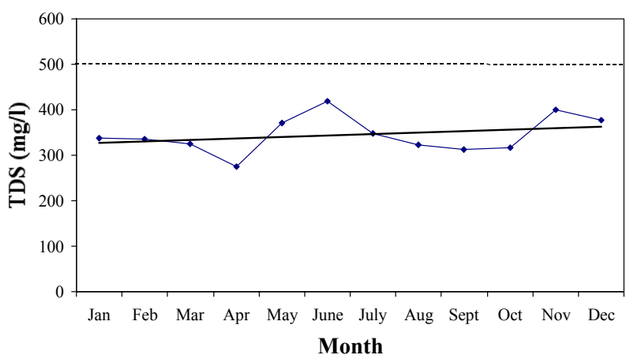
Red River of the North at Grand Forks



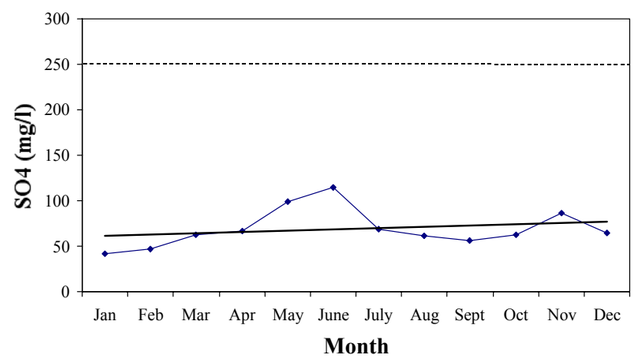
Red River of the North at Grand Forks



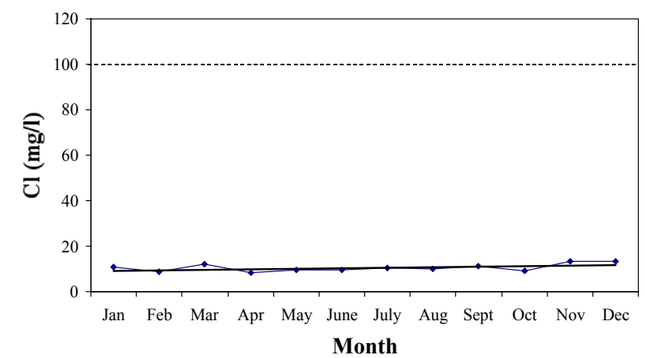
Red River of the North at Grand Forks

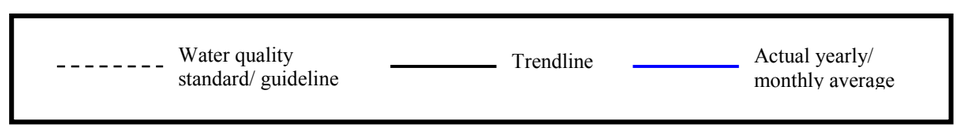


Red River of the North at Grand Forks



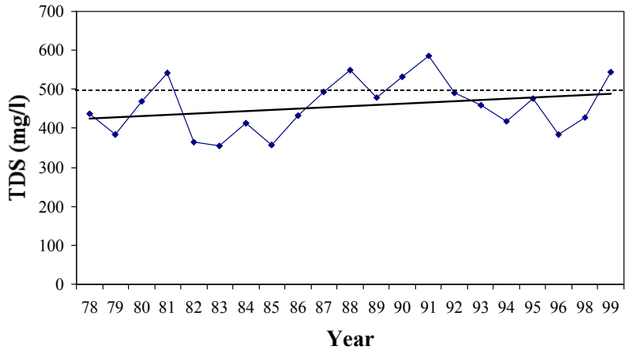
Red River of the North at Grand Forks



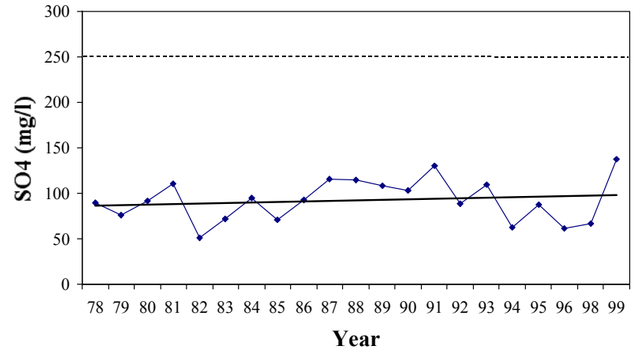


APPENDIX B-6
HISTORIC WATER QUALITY AT EMERSON
Final Aquatic Impact Analysis Report

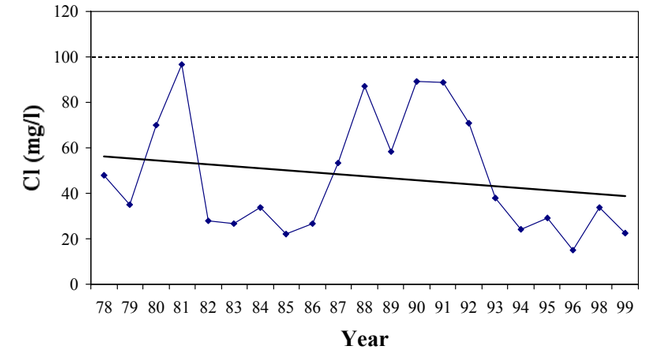
Red River of the North at Emerson



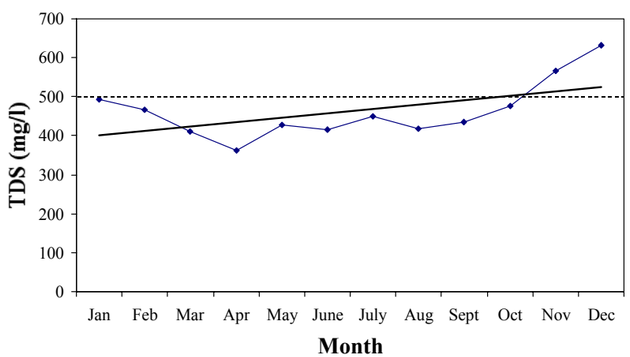
Red River of the North at Emerson



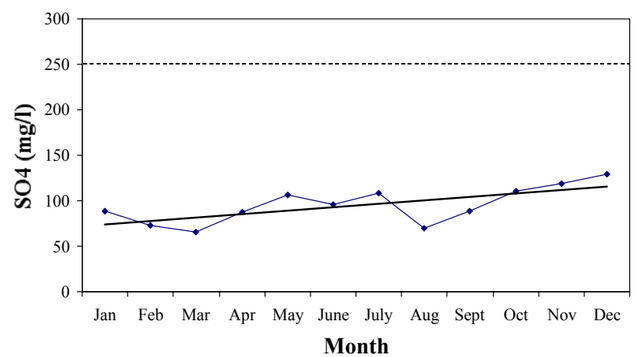
Red River of the North at Emerson



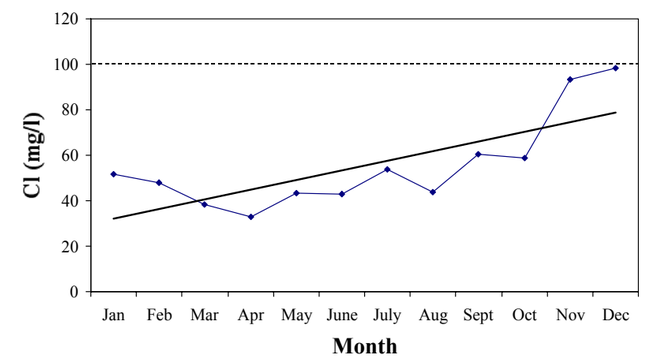
Red River of the North at Emerson

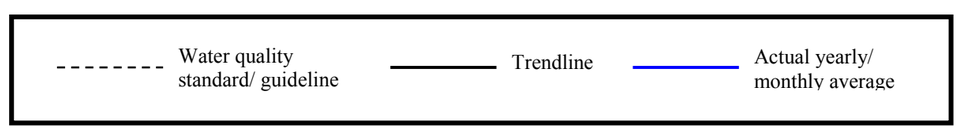


Red River of the North at Emerson



Red River of the North at Emerson





APPENDIX C

HISTORIC IHA STATISTICS

Appendix C-1a
HISTORIC IHA STATISTICS FROM WARWICK (GAGE 05056000)-MONTHLY AVERAGE FLOW (CFS)
Final Aquatic Impact Analysis Report

Year	October	November	December	January	February	March	April	May	June	July	August	September
1971	3.8	8.1	4.3	3.2	2.1	4.6	674.7	66.7	163.6	79.6	6.9	18.3
1972	32.4	24.2	9.1	4.1	3.1	325.9	151.4	78.1	34.3	2.9	2.0	1.9
1973	3.8	8.8	3.4	2.4	1.9	72.9	25.5	20.1	6.7	1.6	1.9	3.3
1974	8.0	4.9	4.2	2.3	2.5	15.3	464.3	488.9	89.1	9.8	0.9	0.9
1975	3.7	11.9	5.7	6.0	5.8	51.6	561.2	369.5	67.5	45.4	6.4	8.1
1976	7.1	10.8	6.0	5.2	11.0	297.5	280.1	64.5	18.5	3.6	1.2	1.6
1977	2.0	2.2	2.7	3.3	3.4	15.4	15.8	12.5	2.2	1.1	1.2	1.7
1978	3.3	3.9	4.7	4.4	2.4	30.5	348.2	21.5	15.3	13.9	12.2	2.5
1979	2.7	9.0	4.4	7.1	4.8	5.8	701.3	288.9	56.2	117.5	52.0	8.3
1980	8.1	12.7	7.2	4.7	4.4	26.3	175.6	21.7	36.0	5.6	21.6	42.0
1981	41.7	50.3	19.7	12.3	153.7	165.3	71.6	53.7	135.2	40.6	19.7	28.0
1982	25.1	20.6	15.1	5.9	3.9	153.6	608.6	134.1	92.1	159.3	42.2	11.0
1983	73.2	33.9	29.6	26.3	55.9	793.0	309.2	105.1	45.2	21.4	5.5	8.4
1984	26.7	18.8	7.0	4.3	26.6	247.7	266.5	190.4	44.3	4.2	2.5	1.9
1985	8.5	8.6	5.9	3.7	4.1	249.9	39.8	29.4	29.0	7.0	80.3	44.6
1986	43.5	26.5	12.6	8.5	7.8	423.4	250.7	132.8	14.5	22.3	32.3	28.3
1987	18.5	18.7	19.3	13.1	16.1	215.7	545.1	52.8	18.7	142.1	60.2	16.9
1988	18.3	17.8	15.6	5.7	8.0	65.2	49.0	24.7	11.5	0.7	0.8	2.7
1989	2.5	4.0	3.6	3.9	3.5	4.4	186.5	23.1	4.7	0.4	0.4	0.8
1990	1.3	3.6	1.5	0.5	0.8	5.4	24.9	10.4	26.7	8.6	3.6	2.1
1991	2.4	11.2	3.8	1.6	2.6	10.5	17.0	34.5	23.8	31.9	14.6	22.1
1992	14.0	13.4	9.1	7.3	13.7	346.1	39.0	22.3	4.9	1.7	0.6	0.8
1993	1.3	3.1	4.1	3.0	3.0	82.5	182.1	49.6	20.7	299.2	423.4	37.8
1994	12.7	13.7	14.3	10.7	9.9	339.9	198.8	78.9	163.2	53.3	10.4	11.5
1995	49.9	65.5	42.8	22.6	15.7	696.4	479.6	282.9	91.4	88.8	53.5	12.1
1996	14.4	11.7	9.1	8.8	7.6	143.6	1165.0	302.4	103.5	56.0	33.2	13.3
1997	16.5	13.5	9.1	7.7	6.9	35.0	1793.6	414.0	61.7	104.2	34.7	18.4
1998	20.4	16.2	12.9	9.3	58.6	406.0	354.6	71.7	44.4	21.7	6.3	7.2
1999	10.6	13.7	18.9	10.0	11.1	205.1	1106.1	518.3	190.9	181.9	196.6	125.4

Variance Data

	October	November	December	January	February	March	April	May	June	July	August	September
Historical Distribution												
1-day min	1.3	2.2	1.5	0.5	0.8	4.4	15.8	10.4	2.2	0.4	0.4	0.8
- 1 S.D.	-0.9	2.0	1.5	1.4	-14.5	-17.5	-25.9	-15.8	3.1	-17.9	-44.9	-7.9
Mean	16.4	15.9	10.5	7.2	15.5	187.4	382.3	136.7	55.7	52.6	38.9	16.6
+ 1 S.D.	33.8	29.8	19.6	12.9	45.6	392.3	790.4	289.2	108.3	123.2	122.6	41.1
1-day max	73.2	65.5	42.8	26.3	153.7	793.0	1793.6	518.3	190.9	299.2	423.4	125.4
CV[1]	105.7	87.5	85.8	80.4	193.5	109.4	106.8	111.6	94.4	134.1	215.5	147.5

[1]CV=coefficient of variation (SD *100/mean)

Appendix C-1b

HISTORIC IHA STATISTICS FROM WARWICK (GAGE 05056000)-MAGNITUDE (CFS), FREQUENCY (PER YEAR), AND DURATION (DAYS) OF EXTREME EVENTS.

Final Aquatic Impact Analysis Report

Year	1-day min	3-day min	7-day min	30-day min	90-day min	1-day max	3-day max	7-day max	30-day max	90-day max	Zero days	Base flow	Date min	Date max	Lo pulse #	Lo pulse	Hi pulse #	Hi pulse	Rise rate	Fall rate	Reversals
1971	1.3	1.6	1.9	2.1	3.0	2330.0	2266.7	1880.0	691.2	308.1	0.0	0.0	233.0	102.0	7.0	19.9	1.0	15.0	39.6	-20.4	48.0
1972	0.7	0.8	0.9	1.3	2.0	1330.0	1213.3	1023.0	415.7	195.8	0.0	0.0	247.0	81.0	6.0	24.2	1.0	11.0	20.3	-12.9	78.0
1973	0.8	1.0	1.0	1.4	1.9	166.0	155.3	133.6	78.3	40.5	0.0	0.1	196.0	74.0	4.0	45.0	0.0	0.0	2.7	-2.1	97.0
1974	0.3	0.4	0.5	0.7	1.8	2000.0	1926.7	1484.6	521.4	355.5	0.0	0.0	219.0	145.0	8.0	22.1	2.0	12.5	46.0	-23.3	56.0
1975	0.8	1.0	1.4	3.7	5.8	1780.0	1686.7	1437.1	826.4	342.9	0.0	0.0	275.0	112.0	6.0	4.2	1.0	27.0	35.3	-19.4	59.0
1976	1.0	1.0	1.1	1.2	1.5	1050.0	1012.7	956.3	500.2	217.6	0.0	0.0	242.0	91.0	2.0	43.5	1.0	17.0	15.6	-10.6	53.0
1977	0.5	0.7	0.8	0.9	1.2	56.0	50.0	34.9	19.7	14.9	0.0	0.2	214.0	126.0	4.0	35.3	0.0	0.0	1.2	-1.2	84.0
1978	0.0	0.0	0.6	1.0	3.8	1400.0	1266.7	1025.9	367.8	137.0	3.0	0.0	331.0	96.0	7.0	18.4	1.0	12.0	17.7	-11.0	59.0
1979	0.6	0.6	0.9	2.6	5.3	2550.0	2466.7	2275.7	936.6	386.8	0.0	0.0	275.0	116.0	6.0	5.7	2.0	12.5	41.5	-21.3	36.0
1980	2.3	2.3	2.5	4.2	4.8	525.0	508.3	448.3	193.2	84.8	0.0	0.1	212.0	94.0	5.0	7.2	1.0	8.0	9.0	-6.1	57.0
1981	7.6	8.3	8.8	10.2	18.4	572.0	542.3	477.0	257.3	136.9	0.0	0.1	45.0	55.0	0.0	0.0	1.0	8.0	16.0	-7.6	69.0
1982	2.6	2.6	2.6	3.4	6.2	1380.0	1343.3	1232.6	701.1	319.1	0.0	0.0	38.0	95.0	2.0	13.5	2.0	14.5	25.6	-13.3	49.0
1983	0.5	0.6	0.9	5.2	9.9	1460.0	1450.0	1428.6	866.6	412.0	0.0	0.0	229.0	73.0	5.0	8.2	1.0	37.0	20.5	-11.7	70.0
1984	0.5	0.6	0.6	1.3	2.3	1010.0	966.7	899.7	429.3	239.4	0.0	0.0	244.0	88.0	7.0	14.4	2.0	8.0	15.2	-8.6	86.0
1985	1.3	1.7	2.4	3.2	4.6	560.0	541.0	511.1	262.9	111.6	0.0	0.1	223.0	77.0	6.0	14.2	1.0	12.0	11.3	-7.0	89.0
1986	1.8	1.9	2.9	7.8	9.2	950.0	923.3	841.4	480.6	275.5	0.0	0.0	248.0	79.0	1.0	6.0	2.0	14.5	22.3	-12.3	65.0
1987	5.9	7.0	7.6	8.9	16.2	1680.0	1610.0	1490.0	705.4	274.4	0.0	0.1	199.0	96.0	0.0	0.0	2.0	14.0	26.7	-16.4	55.0
1988	0.0	0.0	0.0	0.3	1.4	143.0	120.3	97.6	69.1	47.7	0.0	0.0	221.0	85.0	4.0	24.3	0.0	0.0	3.5	-3.0	80.0
1989	0.2	0.2	0.2	0.3	0.5	662.0	598.3	471.4	187.3	72.1	0.0	0.0	219.0	98.0	8.0	34.0	1.0	6.0	5.3	-4.4	116.0
1990	0.3	0.4	0.4	0.5	0.7	60.0	54.0	43.9	27.1	20.5	0.0	0.1	358.0	157.0	5.0	34.2	0.0	0.0	1.6	-1.2	94.0
1991	0.5	0.5	0.6	1.6	2.2	112.0	93.0	72.7	40.6	31.9	0.0	0.0	279.0	184.0	5.0	16.2	0.0	0.0	4.5	-3.3	98.0
1992	0.0	0.0	0.1	0.5	0.7	942.0	898.3	804.3	356.4	141.1	0.0	0.0	234.0	67.0	4.0	28.5	1.0	12.0	9.4	-6.1	88.0
1993	0.7	0.7	0.7	1.3	2.8	1450.0	1416.7	1282.9	658.2	262.0	0.0	0.0	280.0	214.0	6.0	13.5	2.0	15.0	21.4	-15.1	72.0
1994	6.4	6.6	6.9	8.2	11.0	1130.0	1100.0	1011.7	500.8	224.4	0.0	0.1	238.0	87.0	0.0	0.0	2.0	10.0	18.8	-11.9	72.0
1995	9.0	8.8	9.0	10.9	11.8	1900.0	1850.0	1707.1	1035.5	511.2	0.0	0.1	274.0	81.0	0.0	0.0	3.0	14.3	31.0	-13.7	49.0
1996	4.1	4.5	5.8	7.5	7.9	3650.0	3486.7	3014.3	1217.7	563.3	0.0	0.0	71.0	106.0	1.0	1.0	3.0	12.7	53.4	-25.3	45.0
1997	5.9	6.3	6.5	6.9	7.6	3910.0	3650.0	3218.6	1805.5	767.9	0.0	0.0	32.0	112.0	0.0	0.0	1.0	46.0	61.6	-42.0	83.0
1998	3.0	3.2	3.5	5.3	7.8	1410.0	1336.7	1128.7	537.0	292.9	0.0	0.0	219.0	91.0	5.0	3.4	3.0	10.3	17.6	-12.9	75.0
1999	8.4	8.7	9.0	9.6	12.0	3100.0	2766.7	2328.6	1240.7	659.7	0.0	0.0	284.0	92.0	0.0	0.0	4.0	15.0	51.4	-31.5	67.0

Variance Data

	1-day min	3-day min	7-day min	30-day min	90-day min	1-day max	3-day max	7-day max	30-day max	90-day max	Zero days	Base flow	Date min	Date max	Lo pulse #	Lo pulse	Hi pulse #	Hi pulse	Rise rate	Fall rate	Reversals
Historical Distribution																					
1-day min	0.0	0.0	0.0	0.3	0.5	56.0	50.0	34.9	19.7	14.9	0.0	0.0	32.0	55.0	0.0	0.0	0.0	0.0	1.2	-42.0	36.0
- 1 S.D.	-0.5	-0.4	-0.2	0.4	0.9	335.5	326.1	293.0	128.9	64.3	-0.5	0.0	172.1	92.9	1.2	1.2	0.4	2.4	5.6	-22.4	51.8
Mean	2.3	2.5	2.8	3.9	5.7	1354.1	1286.2	1129.7	549.3	256.8	0.1	0.0	220.0	102.6	3.9	15.1	1.4	12.6	22.3	-12.9	70.7
+ 1 S.D.	5.1	5.4	5.8	7.3	10.4	2372.6	2246.4	1966.4	969.7	449.3	0.7	0.1	267.8	112.2	6.6	28.9	2.4	22.7	38.9	-3.5	89.6
1-day max	9.0	8.8	9.0	10.9	18.4	3910.0	3650.0	3218.6	1805.5	767.9	3.0	0.2	358.0	214.0	8.0	45.0	4.0	46.0	61.6	-1.2	116.0
CV[1]	119.9	117.0	108.7	88.8	84.6	75.2	74.7	74.1	76.5	75.0	550.0	100.0	21.7	9.4	69.0	92.0	71.6	80.7	74.7	-72.7	26.7

[1] CV=coefficient of variation (SD *100/mean)

Appendix C-2a
HISTORIC IHA STATISTICS FROM COOPERSTOWN (GAGE 05057000)-MONTHLY AVERAGE FLOW (CFS)
Final Aquatic Impact Analysis Report

Year	October	November	December	January	February	March	April	May	June	July	August	September
1971	16.3	22.7	15.0	9.5	8.9	43.8	992.3	170.0	219.2	159.2	25.9	32.5
1972	51.5	52.4	23.9	10.1	7.1	462.0	478.5	266.6	130.7	21.4	15.5	7.8
1973	14.6	21.2	17.7	11.8	8.8	142.8	73.5	48.1	31.1	6.4	1.9	17.3
1974	42.1	17.8	13.3	7.8	5.8	10.3	1111.4	659.9	435.2	41.9	16.7	5.3
1975	14.8	35.0	15.5	12.3	14.0	104.4	715.0	670.0	168.3	95.3	17.9	11.0
1976	21.6	21.3	15.7	11.7	12.1	196.3	596.4	115.9	39.0	16.7	3.1	0.9
1977	1.4	2.8	3.1	3.1	3.5	21.9	59.2	39.1	11.2	9.3	0.8	3.3
1978	11.3	12.2	9.2	8.5	5.0	91.3	707.9	93.8	50.6	21.5	21.5	30.8
1979	4.6	9.2	8.2	6.8	6.5	6.1	1322.1	949.1	127.5	187.0	69.2	21.5
1980	11.7	23.7	15.5	11.2	10.5	43.3	283.5	57.4	53.4	15.1	8.1	50.6
1981	48.1	61.1	23.8	15.6	74.7	303.6	127.8	73.7	149.4	87.3	29.7	26.1
1982	40.7	32.6	21.1	8.8	4.6	104.5	875.5	214.5	165.9	195.4	61.5	17.0
1983	114.2	65.0	61.0	28.9	26.9	1093.9	542.2	176.5	161.5	120.9	115.0	97.5
1984	49.3	46.4	37.1	25.5	16.6	354.5	770.9	328.3	115.0	40.9	9.0	1.0
1985	17.2	18.5	12.1	5.1	5.5	299.6	128.7	105.1	80.2	18.3	17.4	56.9
1986	54.2	71.0	24.1	20.2	10.7	500.9	421.1	298.7	49.0	71.6	42.1	24.3
1987	39.7	29.2	30.2	22.9	28.0	247.9	1603.2	141.4	93.9	229.4	213.7	53.2
1988	52.3	52.8	43.0	16.5	17.6	154.6	183.0	72.3	29.3	24.3	8.4	1.8
1989	3.6	12.7	7.3	2.6	7.6	11.2	305.4	68.2	37.8	8.1	1.9	7.1
1990	4.4	11.1	4.1	6.2	5.8	7.8	69.5	38.4	76.8	40.7	13.5	6.4
1991	2.6	11.5	6.9	3.2	8.7	22.5	42.4	61.8	30.0	45.4	10.4	15.0
1992	25.6	22.9	16.9	13.0	19.6	516.9	96.5	64.0	39.1	80.8	15.3	8.6
1993	9.0	19.4	11.9	8.9	9.4	43.3	397.5	125.6	73.6	640.2	1033.0	220.4
1994	79.2	50.1	41.2	31.4	31.2	426.1	686.1	179.3	318.7	314.8	108.1	321.0
1995	391.7	254.7	118.9	68.2	64.4	1380.9	1243.5	533.5	222.8	205.3	118.1	51.3
1996	69.7	70.7	32.9	34.0	33.0	116.3	2623.3	578.6	252.6	203.5	107.8	35.6
1997	69.8	46.3	37.5	31.3	26.4	41.1	2390.0	1153.3	202.2	213.2	101.7	47.1
1998	48.2	49.1	42.2	30.9	112.3	329.1	740.8	209.5	119.2	76.5	25.9	17.6
1999	53.8	46.2	38.3	20.9	22.1	190.9	1940.4	820.6	480.3	409.2	262.9	224.7

Variance Data

	October	November	December	January	February	March	April	May	June	July	August	September
Historical Distribution												
1-day min	1.4	2.8	3.1	2.6	3.5	6.1	42.4	38.4	11.2	6.4	0.8	0.9
- 1 S.D.	-24.8	-4.6	2.9	3.1	-3.4	-68.1	52.2	-16.7	18.8	-18.4	-107.9	-27.5
Mean	47.0	41.0	25.8	16.8	20.9	250.6	742.3	286.7	136.7	124.1	85.4	48.7
+ 1 S.D.	118.8	86.7	48.6	30.5	45.2	569.3	1432.4	590.0	254.6	266.6	278.7	125.0
1-day max	391.7	254.7	118.9	68.2	112.3	1380.9	2623.3	1153.3	480.3	640.2	1033.0	321.0
CV[1]	152.7	111.3	88.7	81.7	116.1	127.2	93.0	105.8	86.2	114.8	226.4	156.4

[1]CV=coefficient of variation (SD *100/mean)

Appendix C-2b

HISTORIC IHA STATISTICS FROM COOPERSTOWN (GAGE 05057000)-MAGNITUDE (CFS), FREQUENCY (PER YEAR), AND DURATION (DAYS) OF EXTREME EVENTS.

Final Aquatic Impact Analysis Report

Year	1-day min	3-day min	7-day min	30-day min	90-day min	1-day max	3-day max	7-day max	30-day max	90-day max	Zero days	Base flow	Date min	Date max	Lo pulse #	Lo pulse	Hi pulse #	Hi pulse	Rise rate	Fall rate	Reversals
1971	7.0	7.0	7.0	7.9	10.5	2280.0	2160.0	1927.1	996.6	460.0	0.0	0.1	33.0	108.0	4.0	20.5	1.0	19.0	35.0	-18.4	52.0
1972	4.6	5.0	5.3	6.9	10.6	1080.0	1053.3	995.7	678.2	434.8	0.0	0.0	266.0	87.0	3.0	30.7	4.0	6.8	33.7	-17.7	74.0
1973	0.8	0.9	1.2	1.8	4.8	250.0	236.7	222.1	168.6	91.1	0.0	0.0	233.0	75.0	5.0	28.2	0.0	0.0	6.0	-3.6	78.0
1974	2.0	2.1	2.6	4.7	7.7	2440.0	2400.0	2257.1	1226.4	745.0	0.0	0.0	266.0	107.0	4.0	35.3	2.0	19.0	58.2	-23.6	51.0
1975	3.3	4.0	5.7	8.2	13.5	1490.0	1476.7	1431.4	1042.0	530.1	0.0	0.0	275.0	117.0	5.0	12.2	1.0	35.0	23.6	-13.8	67.0
1976	0.4	0.4	0.5	0.6	1.5	1360.0	1313.3	1240.0	670.6	307.0	0.0	0.0	265.0	93.0	5.0	24.4	1.0	13.0	20.3	-9.5	62.0
1977	0.0	0.0	0.0	0.3	2.4	95.0	91.0	86.9	63.4	42.4	0.0	0.0	238.0	96.0	6.0	20.7	0.0	0.0	3.0	-1.9	77.0
1978	3.0	3.0	3.0	3.5	6.5	1440.0	1393.3	1240.0	755.1	310.8	0.0	0.0	62.0	103.0	5.0	33.6	1.0	19.0	23.3	-12.8	58.0
1979	2.6	2.9	3.3	4.5	6.4	4350.0	3740.0	3202.9	2137.2	847.5	0.0	0.0	290.0	111.0	3.0	16.7	1.0	28.0	80.2	-37.5	36.0
1980	3.4	3.5	3.7	5.5	11.7	730.0	695.0	594.3	298.7	140.0	0.0	0.1	227.0	100.0	5.0	18.0	1.0	4.0	10.6	-6.6	69.0
1981	14.0	14.0	14.0	14.0	22.4	480.0	473.3	447.1	313.0	184.6	0.0	0.2	11.0	63.0	0.0	0.0	0.0	0.0	12.6	-8.3	61.0
1982	3.5	3.5	3.5	4.7	8.7	1800.0	1666.7	1408.6	900.9	437.9	0.0	0.0	39.0	103.0	3.0	27.3	2.0	13.5	32.4	-15.8	46.0
1983	7.8	8.0	9.1	14.9	36.0	1600.0	1586.7	1522.9	1157.6	616.1	0.0	0.0	275.0	77.0	2.0	4.0	2.0	22.0	43.8	-15.8	51.0
1984	0.1	0.1	0.2	0.5	6.8	1840.0	1763.3	1637.1	940.2	491.5	0.0	0.0	266.0	94.0	3.0	20.7	1.0	20.0	26.7	-11.5	50.0
1985	0.2	0.2	0.2	3.4	7.6	740.0	723.3	669.9	355.1	190.7	0.0	0.0	276.0	83.0	6.0	17.3	1.0	7.0	14.4	-7.6	78.0
1986	5.3	6.2	8.3	9.7	17.5	1700.0	1620.0	1454.3	705.9	421.5	0.0	0.1	259.0	86.0	3.0	13.0	2.0	11.0	22.9	-13.9	59.0
1987	18.0	18.7	19.3	22.7	26.1	4660.0	4416.7	3764.3	1714.5	683.5	0.0	0.1	318.0	96.0	0.0	0.0	3.0	12.7	70.2	-32.0	52.0
1988	0.2	0.3	0.5	1.5	4.3	382.0	359.7	327.1	224.8	138.7	0.0	0.0	247.0	96.0	3.0	18.7	0.0	0.0	7.0	-4.4	77.0
1989	0.0	0.0	0.1	1.0	3.9	781.0	762.0	644.3	311.1	137.7	10.0	0.0	285.0	108.0	5.0	38.8	1.0	5.0	9.3	-6.1	84.0
1990	0.0	0.0	0.2	2.0	4.7	154.0	129.0	98.7	84.9	63.9	3.0	0.0	355.0	182.0	9.0	18.2	0.0	0.0	3.8	-2.9	84.0
1991	0.6	0.7	1.1	2.6	6.2	81.0	79.7	76.6	62.3	46.7	0.0	0.1	278.0	127.0	4.0	38.0	0.0	0.0	2.6	-1.5	73.0
1992	1.7	2.1	3.9	5.5	10.3	1090.0	1076.7	1004.3	532.9	231.1	0.0	0.1	266.0	76.0	6.0	10.3	1.0	14.0	19.3	-8.8	68.0
1993	2.1	3.3	4.4	8.8	9.5	2380.0	2200.0	1870.0	1444.4	647.4	0.0	0.0	275.0	207.0	6.0	17.5	2.0	18.5	34.5	-22.5	65.0
1994	19.0	21.3	23.6	27.3	34.7	1740.0	1720.0	1622.9	967.4	474.0	0.0	0.1	40.0	92.0	0.0	0.0	3.0	10.3	33.0	-19.5	72.0
1995	28.0	31.0	34.3	50.3	57.8	3320.0	3243.3	3052.9	2206.0	1105.2	0.0	0.1	274.0	86.0	0.0	0.0	3.0	22.0	50.9	-23.4	74.0
1996	15.0	15.0	15.6	27.9	31.3	6650.0	5780.0	4948.6	2651.3	1164.7	0.0	0.1	33.0	109.0	0.0	0.0	1.0	40.0	71.6	-38.8	60.0
1997	25.0	25.7	25.9	26.4	28.9	4970.0	4626.7	4144.3	2743.0	1260.7	0.0	0.1	32.0	115.0	0.0	0.0	1.0	50.0	89.6	-45.8	34.0
1998	12.0	12.7	14.1	17.1	30.0	1510.0	1466.7	1307.1	795.2	444.7	0.0	0.1	272.0	99.0	1.0	1.0	2.0	12.5	21.9	-11.5	74.0
1999	19.0	20.0	20.0	20.5	22.2	3660.0	3486.7	3175.7	1985.1	1117.0	0.0	0.1	277.0	97.0	0.0	0.0	4.0	17.5	65.8	-33.1	48.0

Variance Data

	1-day min	3-day min	7-day min	30-day min	90-day min	1-day max	3-day max	7-day max	30-day max	90-day max	Zero days	Base flow	Date min	Date max	Lo pulse #	Lo pulse	Hi pulse #	Hi pulse	Rise rate	Fall rate	Reversals
Historical Distribution																					
1-day min	0.0	0.0	0.0	0.3	1.5	81.0	79.7	76.6	62.3	42.4	0.0	0.0	11.0	63.0	0.0	0.0	0.0	0.0	2.6	-45.8	34.0
- 1 S.D.	-1.4	-1.4	-1.2	-1.0	2.1	269.0	317.6	320.1	199.7	120.0	-1.5	0.0	152.8	95.0	0.9	3.3	0.3	2.0	7.2	-28.0	49.6
Mean	6.9	7.3	8.0	10.5	15.3	1898.4	1784.1	1599.1	970.1	474.7	0.5	0.0	214.9	103.2	3.3	16.0	1.4	14.5	31.9	-16.2	63.2
+ 1 S.D.	15.1	16.0	17.1	22.0	28.6	3527.7	3250.7	2878.2	1740.4	829.4	2.4	0.1	277.0	111.4	5.7	28.8	2.6	27.0	56.7	-4.3	76.9
1-day max	28.0	31.0	34.3	50.3	57.8	6650.0	5780.0	4948.6	2743.0	1260.7	10.0	0.2	355.0	207.0	9.0	38.8	4.0	50.0	89.6	-1.5	84.0
CV[1]	119.7	119.2	114.7	109.7	86.4	85.8	82.2	80.0	79.4	74.7	426.7	75.0	28.9	7.9	73.1	79.5	81.6	86.2	77.5	-73.3	21.5

[1]CV=coefficient of variation (SD *100/mean)

Appendix C-3a
HISTORIC IHA STATISTICS FROM BALDHILL DAM (GAGE 05058000)-MONTHLY AVERAGE FLOW (CFS)
Final Aquatic Impact Analysis Report

Year	October	November	December	January	February	March	April	May	June	July	August	September
1971	11.3	21.5	40.4	40.6	104.5	215.1	686.3	158.2	222.6	182.5	25.2	24.5
1972	46.4	127.6	156.5	125.0	48.1	192.8	794.6	335.2	218.6	18.2	16.8	18.6
1973	13.4	44.1	49.0	55.2	62.7	61.5	31.5	15.5	15.2	9.8	17.8	14.7
1974	20.0	43.4	37.5	70.4	180.1	219.1	920.8	684.4	507.5	17.0	16.3	13.4
1975	10.9	32.2	52.1	55.6	56.4	68.3	668.4	830.5	227.4	119.5	56.3	18.6
1976	29.2	52.0	69.6	78.1	68.3	64.3	493.3	106.7	18.0	17.7	24.1	36.1
1977	32.2	23.3	16.7	14.6	9.2	9.9	9.3	9.1	8.5	8.6	6.7	8.1
1978	11.0	32.7	45.2	63.0	104.1	143.7	703.4	128.7	41.8	19.2	20.3	39.1
1979	66.6	51.3	36.2	30.8	56.4	172.9	1796.2	1345.6	156.7	146.2	52.7	27.8
1980	93.8	156.4	4.3	10.4	10.9	83.1	153.2	9.3	19.4	17.4	10.1	152.0
1981	127.2	94.9	23.5	9.1	9.6	98.2	136.5	70.2	136.2	84.6	25.7	43.0
1982	152.7	134.6	8.6	7.9	32.3	173.8	892.4	233.3	176.7	226.9	56.9	14.2
1983	144.7	237.9	113.5	119.6	76.4	1236.5	659.0	202.8	219.1	117.1	41.3	77.0
1984	106.2	140.4	133.7	78.3	64.0	256.8	911.6	351.0	113.9	33.5	37.1	41.0
1985	102.9	48.5	51.1	28.1	11.7	96.4	142.2	117.6	77.6	23.3	44.0	23.8
1986	31.7	98.6	142.9	140.4	197.9	166.5	391.2	307.2	51.1	66.5	60.9	28.2
1987	15.2	111.4	190.9	124.1	78.2	969.7	1268.5	155.8	109.5	215.4	215.6	66.8
1988	89.7	96.4	110.0	117.9	112.4	58.2	17.7	52.0	30.6	18.4	25.4	12.0
1989	13.4	23.8	35.5	45.8	56.2	107.4	198.3	19.8	25.4	21.7	24.9	20.0
1990	33.0	23.1	22.1	13.3	12.2	14.8	10.0	7.4	10.2	13.3	44.9	57.3
1991	5.7	9.2	8.2	7.8	8.5	8.0	7.9	11.7	14.9	26.7	29.0	15.8
1992	12.2	26.0	55.8	45.7	18.4	448.5	86.2	40.0	32.3	60.6	30.9	29.7
1993	15.2	9.4	44.6	76.3	93.9	214.9	263.7	193.3	131.4	1271.8	1555.2	353.1
1994	118.6	152.9	127.6	98.0	181.6	427.7	718.7	163.0	404.9	538.5	192.1	576.8
1995	621.9	290.8	230.8	181.7	167.3	1567.0	1998.0	797.9	285.9	246.8	292.5	188.3
1996	70.5	75.9	104.7	124.8	300.1	336.9	2969.3	953.2	294.5	248.1	107.9	19.6
1997	32.1	131.8	187.5	168.1	172.7	187.1	3329.3	1539.7	192.2	224.6	82.1	45.6
1998	54.5	131.3	115.9	66.7	147.6	490.6	560.9	174.8	150.2	62.2	26.0	38.0
1999	23.7	258.1	89.5	108.3	193.0	772.9	1942.3	1140.8	691.6	509.5	336.2	256.3

Variance Data

	October	November	December	January	February	March	April	May	June	July	August	September
Historical Distribution												
1-day min	5.7	9.2	4.3	7.8	8.5	8.0	7.9	7.4	8.5	8.6	6.7	8.1
- 1 S.D.	-42.2	16.9	18.2	22.6	16.7	-72.0	-81.1	-82.9	-3.5	-98.0	-168.6	-46.8
Mean	72.6	92.4	79.4	72.6	90.9	305.6	784.9	350.2	158.1	157.4	119.8	77.9
+ 1 S.D.	187.4	167.9	140.7	122.6	165.0	683.2	1650.9	783.2	319.7	412.8	408.3	202.6
1-day max	621.9	290.8	230.8	181.7	300.1	1567.0	3329.3	1539.7	691.6	1271.8	1555.2	576.8
CV[1]	158.1	81.7	77.1	68.9	81.6	123.6	110.3	123.7	102.2	162.2	240.7	160.0

[1]CV=coefficient of variation (SD *100/mean)

Appendix C-3b

HISTORIC IHA STATISTICS FROM BALD HILL DAM (GAGE 05058000)-MAGNITUDE (CFS), FREQUENCY (PER YEAR), AND DURATION (DAYS) OF EXTREME EVENTS.

Final Aquatic Impact Analysis Report

Year	1-day min	3-day min	7-day min	30-day min	90-day min	1-day max	3-day max	7-day max	30-day max	90-day max	Zero days	Base flow	Date min	Date max	Lo pulse #	Lo pulse	Hi pulse #	Hi pulse	Rise rate	Fall rate	Reversals
1971	1.1	8.1	8.4	11.2	24.1	1800.0	1786.7	1761.4	764.4	397.7	0.0	0.1	47.0	111.0	3.0	26.3	1.0	11.0	30.3	-32.3	72.0
1972	8.5	10.7	11.5	13.0	16.2	983.0	980.0	976.6	868.3	508.4	0.0	0.1	237.0	115.0	5.0	14.0	3.0	11.7	28.4	-20.2	91.0
1973	7.9	8.5	9.0	9.6	13.5	89.0	89.0	88.1	75.8	62.5	0.0	0.3	201.0	89.0	8.0	18.6	0.0	0.0	2.7	-2.8	60.0
1974	8.8	10.3	11.3	11.0	13.1	1930.0	1910.0	1801.4	1027.6	723.2	0.0	0.1	231.0	113.0	4.0	22.0	2.0	19.5	42.9	-41.2	76.0
1975	6.1	8.3	10.0	10.7	24.9	1620.0	1606.7	1588.6	1160.3	583.6	0.0	0.1	241.0	120.0	3.0	10.3	1.0	33.0	29.3	-29.9	54.0
1976	7.3	7.5	8.4	12.6	15.9	920.0	890.0	760.9	494.5	227.5	0.0	0.1	228.0	101.0	8.0	9.8	1.0	5.0	16.5	-14.7	62.0
1977	4.6	4.8	4.9	6.2	7.4	36.0	34.0	33.6	32.2	28.9	0.0	0.4	215.0	275.0	1.0	319.0	0.0	0.0	0.9	-1.0	60.0
1978	7.6	7.7	7.9	10.6	21.0	1360.0	1353.3	1345.7	707.4	328.4	0.0	0.1	275.0	99.0	4.0	11.8	1.0	13.0	22.6	-17.7	66.0
1979	4.4	17.7	14.7	15.5	37.7	4710.0	4706.7	4662.9	2745.0	1138.8	0.0	0.0	277.0	115.0	2.0	1.5	1.0	33.0	75.9	-50.1	56.0
1980	2.8	3.2	3.5	4.2	8.5	492.0	492.0	454.1	238.0	126.5	0.0	0.1	341.0	95.0	6.0	39.7	0.0	0.0	12.6	-13.4	59.0
1981	7.6	8.0	8.8	8.9	9.5	490.0	488.7	404.0	187.9	119.9	0.0	0.1	102.0	95.0	7.0	23.1	0.0	0.0	17.0	-18.2	56.0
1982	7.6	7.6	7.6	7.6	8.9	1780.0	1776.7	1652.9	902.8	448.0	0.0	0.0	355.0	104.0	7.0	23.9	3.0	6.3	61.6	-55.8	65.0
1983	10.0	10.0	10.0	22.4	63.9	1870.0	1860.0	1820.0	1416.2	719.2	0.0	0.0	275.0	70.0	3.0	1.7	2.0	21.5	51.2	-46.7	72.0
1984	17.0	17.7	18.7	21.5	34.7	1780.0	1770.0	1685.7	948.6	525.2	0.0	0.1	217.0	95.0	1.0	2.0	1.0	18.0	31.3	-27.1	54.0
1985	5.0	5.0	5.1	10.7	28.3	588.0	531.3	372.1	177.3	126.9	0.0	0.1	43.0	137.0	7.0	6.6	0.0	0.0	15.0	-11.5	81.0
1986	7.4	8.2	8.8	16.8	32.9	1690.0	1156.7	695.9	509.1	308.8	0.0	0.1	258.0	110.0	3.0	12.0	2.0	2.5	30.3	-31.3	120.0
1987	4.4	5.3	7.3	10.4	80.7	2170.0	2153.3	2051.4	1694.4	805.0	0.0	0.0	187.0	105.0	3.0	22.3	4.0	11.5	46.1	-42.6	115.0
1988	6.7	7.2	7.5	10.4	14.2	133.0	131.7	130.7	127.4	114.7	0.0	0.1	197.0	23.0	4.0	25.0	0.0	0.0	3.3	-3.8	116.0
1989	8.0	9.2	9.8	12.0	19.4	641.0	639.7	633.1	278.6	130.3	0.0	0.2	322.0	99.0	8.0	8.8	0.0	0.0	9.5	-11.2	61.0
1990	6.1	6.2	6.6	5.3	7.8	110.0	109.3	105.7	59.4	38.9	0.0	0.3	131.0	259.0	3.0	71.0	0.0	0.0	2.8	-2.5	55.0
1991	0.0	0.0	0.1	5.5	7.5	32.0	31.3	31.0	29.4	30.4	0.0	0.0	294.0	235.0	3.0	48.3	0.0	0.0	1.1	-0.8	76.0
1992	11.0	11.0	11.0	11.4	16.1	1230.0	1129.0	921.6	469.2	196.6	0.0	0.2	288.0	68.0	3.0	9.0	1.0	11.0	24.5	-16.1	78.0
1993	9.1	9.1	9.1	9.4	22.2	3680.0	3636.7	3557.1	2445.7	1087.7	0.0	0.0	309.0	210.0	1.0	53.0	4.0	10.0	63.6	-51.7	89.0
1994	47.0	60.3	62.0	96.0	124.0	1570.0	1493.3	1352.9	902.0	504.4	0.0	0.2	240.0	93.0	0.0	0.0	5.0	8.2	44.0	-35.8	111.0
1995	36.0	45.0	64.4	68.5	81.0	3950.0	3880.0	3821.4	2976.3	1528.1	0.0	0.1	169.0	89.0	0.0	0.0	5.0	16.6	61.0	-53.5	85.0
1996	10.0	10.0	10.4	18.8	39.9	5410.0	5283.3	4938.6	3366.8	1471.9	0.0	0.0	256.0	111.0	2.0	6.5	4.0	11.0	61.5	-51.9	91.0
1997	18.0	19.3	22.7	31.2	59.2	4480.0	4396.7	4187.1	3480.0	1724.1	0.0	0.0	298.0	118.0	1.0	2.0	2.0	26.0	68.1	-56.3	108.0
1998	7.9	20.0	21.1	24.5	29.3	1330.0	1303.3	1078.6	633.1	441.6	0.0	0.1	282.0	59.0	2.0	1.5	2.0	8.5	22.5	-23.0	124.0
1999	13.0	13.0	13.3	23.5	108.1	2560.0	2510.0	2457.1	2119.7	1390.5	0.0	0.0	294.0	100.0	2.0	7.5	3.0	25.3	52.1	-47.1	119.0

Variance Data

	1-day min	3-day min	7-day min	30-day min	90-day min	1-day max	3-day max	7-day max	30-day max	90-day max	Zero days	Base flow	Date min	Date max	Lo pulse #	Lo pulse	Hi pulse #	Hi pulse	Rise rate	Fall rate	Reversals
Historical Distribution																					
1-day min	0.0	0.0	0.1	4.2	7.4	32.0	31.3	31.0	29.4	28.9	0.0	0.0	43.0	23.0	0.0	0.0	0.0	0.0	0.9	-56.3	54.0
- 1 S.D.	0.4	0.2	-1.0	-1.4	2.7	233.1	205.0	143.2	19.3	46.6	0.0	0.0	184.6	99.4	1.1	-31.2	0.1	0.3	9.3	-46.6	57.0
Mean	10.0	12.4	13.6	17.9	33.4	1704.6	1659.6	1564.5	1063.4	546.1	0.0	0.1	234.8	117.7	3.6	27.5	1.7	10.4	32.0	-27.9	80.4
+ 1 S.D.	19.7	24.6	28.1	37.2	64.2	3176.1	3114.2	2985.8	2107.4	1045.7	0.0	0.2	285.0	135.9	6.0	86.2	3.3	20.6	54.7	-9.3	103.8
1-day max	47.0	60.3	64.4	96.0	124.0	5410.0	5283.3	4938.6	3480.0	1724.1	0.0	0.4	355.0	275.0	8.0	319.0	5.0	33.0	75.9	-0.8	124.0
CV[1]	96.1	98.8	107.1	107.6	92.0	86.3	87.6	90.8	98.2	91.5	--	90.0	21.4	15.5	68.2	213.4	97.0	97.4	70.9	-66.8	29.1

[1]CV=coefficient of variation (SD *100/mean)

Appendix C-4a
HISTORIC IHA STATISTICS FROM LISBON (GAGE 05058700)-MONTHLY AVERAGE FLOW (CFS)
Final Aquatic Impact Analysis Report

Year	October	November	December	January	February	March	April	May	June	July	August	September
1971	16.5	29.7	42.2	39.6	79.1	356.5	732.5	222.4	244.3	228.8	30.4	22.4
1972	56.6	106.6	158.6	138.2	78.6	363.5	927.8	289.4	235.5	39.8	24.9	19.2
1973	23.9	42.3	48.6	53.5	70.4	165.0	62.2	27.2	21.7	6.1	11.6	25.0
1974	22.4	32.8	34.7	63.7	177.9	283.8	1005.8	685.7	555.4	20.1	16.7	10.1
1975	14.5	38.7	53.2	54.8	56.2	81.6	736.6	970.5	512.9	700.2	95.3	27.1
1976	38.1	62.7	92.7	93.7	107.0	169.3	601.5	172.3	51.6	21.3	10.7	29.9
1977	43.7	30.5	19.8	19.7	17.0	51.9	36.9	67.7	19.7	18.5	7.4	24.6
1978	23.9	40.6	48.3	55.3	98.8	426.8	806.5	180.5	79.2	42.2	22.2	61.5
1979	57.7	54.6	24.6	31.1	56.5	225.0	1787.7	1989.0	207.4	151.7	74.3	37.9
1980	73.7	180.4	22.7	15.9	15.9	209.4	246.9	18.9	34.8	28.4	15.8	158.9
1981	126.2	113.9	39.3	15.8	29.1	83.6	152.7	65.2	113.1	127.4	29.1	26.4
1982	140.6	167.6	18.2	14.0	15.6	189.9	1244.4	297.5	171.3	184.6	72.7	13.7
1983	134.9	195.1	122.5	126.9	76.4	1213.7	788.5	208.7	267.9	218.4	20.9	88.6
1984	106.9	137.3	136.3	109.4	76.0	415.7	1092.0	382.0	109.8	35.0	16.4	32.5
1985	95.5	56.5	53.2	40.7	29.0	158.0	171.6	141.7	81.4	22.2	40.3	25.1
1986	36.2	100.2	143.0	139.9	193.7	354.3	509.8	490.0	81.8	72.4	90.2	34.0
1987	35.3	98.8	190.2	132.1	74.4	1328.4	1624.3	200.8	148.8	127.9	262.9	61.8
1988	89.8	102.4	112.7	118.3	139.4	145.6	38.0	54.1	34.6	6.5	18.2	13.5
1989	14.9	28.2	34.0	36.3	46.3	207.5	380.5	31.8	46.1	19.3	27.1	27.1
1990	32.5	27.4	17.5	21.5	16.8	30.9	28.7	18.6	60.3	20.8	23.9	55.8
1991	16.8	12.2	8.7	8.2	10.7	34.3	20.3	51.2	39.2	56.9	27.5	23.1
1992	15.9	24.2	60.6	70.1	63.6	585.1	134.4	70.6	56.1	97.1	46.1	52.2
1993	25.4	23.1	31.0	80.0	102.5	325.1	444.2	158.3	249.4	1423.8	1945.0	377.9
1994	150.3	147.3	190.7	125.7	202.1	565.5	988.3	304.4	354.8	624.4	276.0	560.8
1995	715.9	453.9	289.8	203.9	166.8	1525.5	2539.5	907.6	326.6	273.8	275.7	205.1
1996	92.8	70.6	108.9	151.5	412.8	729.2	2848.3	1438.9	393.8	232.9	156.8	33.8
1997	45.8	140.4	211.8	190.3	195.7	250.7	4180.7	2394.4	439.1	378.2	129.1	79.4
1998	87.3	169.6	177.7	113.6	204.3	869.0	913.5	308.7	275.5	169.7	56.0	44.1
1999	88.1	312.6	116.3	98.8	129.6	931.6	2324.3	1460.5	749.5	490.3	281.9	344.6

Variance Data

	October	November	December	January	February	March	April	May	June	July	August	September
Historical Distribution												
1-day min	14.5	12.2	8.7	8.2	10.7	30.9	20.3	18.6	19.7	6.1	7.4	10.1
- 1 S.D.	-45.2	6.8	17.4	26.3	15.3	23.9	-44.2	-150.4	19.6	-96.8	-216.3	-42.3
Mean	83.5	103.5	89.9	81.5	101.5	423.3	943.7	469.3	205.6	201.3	141.6	86.8
+ 1 S.D.	212.2	200.1	162.4	136.6	187.6	822.8	1931.7	1088.9	391.6	499.5	499.4	215.8
1-day max	715.9	453.9	289.8	203.9	412.8	1525.5	4180.7	2394.4	749.5	1423.8	1945.0	560.8
CV[1]	154.1	93.4	80.6	67.7	84.9	94.4	104.7	132.0	90.5	148.1	252.8	148.7

[1]CV=coefficient of variation (SD *100/mean)

Appendix C-4b

HISTORIC IHA STATISTICS FROM LISBON (GAGE 05058700)-MAGNITUDE (CFS), FREQUENCY (PER YEAR), AND DURATION (DAYS) OF EXTREME EVENTS
Final Aquatic Impact Analysis Report

Year	1-day min	3-day min	7-day min	30-day min	90-day min	1-day max	3-day max	7-day max	30-day max	90-day max	Zero days	Base flow	Date min	Date max	Lo pulse #	Lo pulse	Hi pulse #	Hi pulse	Rise rate	Fall rate	Reversals
1971	5.6	5.9	7.3	16.0	29.2	1840.0	1833.3	1795.7	798.7	443.7	0.0	0.0	277.0	118.0	6.0	13.5	1.0	11.0	32.8	-25.5	79.0
1972	13.0	15.0	15.6	19.1	22.5	1350.0	1240.0	1002.1	948.8	585.7	0.0	0.1	247.0	76.0	7.0	9.7	2.0	16.5	36.8	-19.4	83.0
1973	2.8	2.8	3.0	5.5	11.7	543.0	443.7	297.3	170.9	103.9	0.0	0.1	203.0	78.0	10.0	15.3	0.0	0.0	7.6	-6.0	105.0
1974	3.2	4.2	4.9	8.9	13.5	1980.0	1976.7	1900.0	1127.0	778.5	0.0	0.0	270.0	116.0	4.0	32.0	2.0	19.0	42.5	-32.6	84.0
1975	5.4	6.3	8.8	14.3	35.0	5210.0	4873.3	3099.4	1287.2	917.9	0.0	0.0	275.0	183.0	4.0	7.5	4.0	10.0	74.8	-62.3	81.0
1976	5.1	5.8	6.1	9.6	19.9	979.0	962.7	883.7	618.2	323.7	0.0	0.1	236.0	104.0	8.0	11.4	2.0	3.5	21.0	-15.3	86.0
1977	4.6	4.8	5.5	6.6	12.7	838.0	380.7	207.7	70.3	53.7	0.0	0.2	225.0	126.0	13.0	19.2	1.0	1.0	14.3	-9.6	102.0
1978	14.0	16.3	16.7	20.5	37.3	1390.0	1380.0	1367.1	941.2	475.7	0.0	0.1	280.0	103.0	6.0	14.2	2.0	9.5	34.6	-29.8	61.0
1979	13.0	13.3	14.0	21.8	33.1	4860.0	4823.3	4658.6	3223.0	1379.4	0.0	0.0	354.0	123.0	2.0	25.5	1.0	37.0	56.1	-44.8	58.0
1980	7.6	8.4	8.8	13.2	16.5	682.0	638.7	559.9	424.5	163.8	0.0	0.1	218.0	98.0	7.0	27.6	0.0	0.0	17.2	-13.5	82.0
1981	7.1	7.9	9.2	13.2	21.7	450.0	448.3	388.4	191.9	121.8	0.0	0.1	249.0	96.0	8.0	17.8	0.0	0.0	17.0	-11.0	77.0
1982	9.1	9.4	10.3	13.1	15.7	2260.0	2223.3	2171.4	1244.4	593.2	0.0	0.1	240.0	107.0	6.0	24.0	2.0	9.5	63.1	-48.3	92.0
1983	10.0	10.7	12.0	18.6	66.8	2330.0	2243.3	2032.9	1468.1	753.3	0.0	0.0	228.0	76.0	3.0	10.3	3.0	11.7	52.6	-43.9	74.0
1984	7.5	8.0	8.6	12.7	23.8	1990.0	1983.3	1891.4	1282.2	649.1	0.0	0.0	232.0	98.0	3.0	17.7	1.0	23.0	29.3	-21.0	96.0
1985	6.2	7.9	8.8	21.8	27.7	627.0	578.0	418.1	234.8	159.9	0.0	0.1	199.0	140.0	10.0	9.0	0.0	0.0	18.6	-14.0	92.0
1986	0.7	0.8	9.4	33.4	47.1	1970.0	1650.0	1051.6	780.6	470.9	0.0	0.1	256.0	112.0	5.0	2.8	2.0	4.0	34.0	-30.7	109.0
1987	0.0	1.8	12.9	25.4	82.0	2810.0	2376.7	2284.3	2079.7	1066.3	0.0	0.0	283.0	83.0	7.0	5.0	2.0	22.5	41.8	-38.9	107.0
1988	1.1	1.3	2.2	6.0	11.7	250.0	238.3	200.7	160.2	135.6	0.0	0.0	216.0	63.0	7.0	15.7	0.0	0.0	6.1	-4.7	88.0
1989	7.4	7.9	9.4	14.6	24.2	968.0	937.3	895.4	526.3	213.2	0.0	0.1	197.0	96.0	15.0	6.7	1.0	13.0	11.2	-8.6	102.0
1990	1.7	9.6	9.7	14.6	13.4	289.0	207.3	135.1	61.5	35.7	0.0	0.3	302.0	156.0	13.0	18.2	0.0	0.0	6.9	-5.0	97.0
1991	3.6	3.8	4.8	7.0	9.1	243.0	184.7	124.4	63.3	49.9	0.0	0.2	288.0	184.0	13.0	19.2	0.0	0.0	5.9	-4.3	109.0
1992	0.0	0.0	1.4	14.8	23.5	1400.0	1233.3	1132.9	600.3	270.6	0.0	0.0	289.0	71.0	7.0	8.9	1.0	10.0	26.4	-15.8	87.0
1993	7.5	8.2	9.1	16.4	25.5	3770.0	3760.0	3702.9	2807.0	1294.9	0.0	0.0	344.0	215.0	5.0	11.0	2.0	23.0	64.2	-47.8	86.0
1994	68.0	72.3	103.1	123.6	153.4	1950.0	1910.0	1737.1	1235.8	642.4	0.0	0.3	330.0	95.0	0.0	0.0	3.0	13.3	42.0	-35.9	85.0
1995	100.0	103.3	109.0	94.5	90.7	4080.0	4066.7	4018.6	3227.7	1726.9	0.0	0.2	62.0	97.0	0.0	0.0	4.0	20.0	68.4	-45.7	78.0
1996	18.0	18.0	18.3	31.2	57.9	5050.0	4956.7	4655.7	3507.0	1713.7	0.0	0.0	257.0	117.0	1.0	12.0	3.0	19.7	59.0	-50.8	83.0
1997	26.0	27.3	28.3	45.4	94.2	5650.0	5603.3	5392.9	4516.0	2381.5	0.0	0.0	281.0	114.0	2.0	2.0	3.0	21.7	105.8	-72.4	78.0
1998	14.0	19.7	29.9	44.1	53.5	1800.0	1733.3	1568.6	1045.3	739.7	0.0	0.1	273.0	64.0	1.0	3.0	4.0	8.0	45.8	-32.4	96.0
1999	40.0	42.0	52.6	86.8	110.9	2850.0	2803.3	2755.7	2387.3	1671.9	0.0	0.1	277.0	95.0	0.0	0.0	3.0	28.0	66.0	-48.6	67.0

Variance Data

	1-day min	3-day min	7-day min	30-day min	90-day min	1-day max	3-day max	7-day max	30-day max	90-day max	Zero days	Base flow	Date min	Date max	Lo pulse #	Lo pulse	Hi pulse #	Hi pulse	Rise rate	Fall rate	Reversals
Historical Distribution																					
1-day min	0.0	0.0	1.4	5.5	9.1	243.0	184.7	124.4	61.5	35.7	0.0	0.0	62.0	63.0	0.0	0.0	0.0	0.0	5.9	-72.4	58.0
- 1 S.D.	-7.7	-7.0	-7.7	-1.6	5.6	481.4	395.3	307.6	90.5	74.8	0.0	0.0	216.6	99.6	1.8	3.9	0.4	1.5	13.3	-47.7	73.7
Mean	13.9	15.3	18.6	26.6	40.8	2083.1	1989.3	1804.5	1276.9	686.8	0.0	0.1	254.8	110.5	6.0	12.4	1.7	11.6	38.0	-28.9	87.0
+ 1 S.D.	35.4	37.6	44.9	54.9	76.0	3684.7	3583.3	3301.4	2463.2	1298.8	0.0	0.2	292.9	121.4	10.2	20.9	3.0	21.6	62.7	-10.1	100.4
1-day max	100.0	103.3	109.0	123.6	153.4	5650.0	5603.3	5392.9	4516.0	2381.5	0.0	0.3	354.0	215.0	15.0	32.0	4.0	37.0	105.8	-4.3	109.0
CV[1]	155.4	145.9	141.2	106.1	86.2	76.9	80.1	83.0	92.9	89.1	--	88.9	15.0	9.9	70.2	68.7	77.5	86.9	65.0	-65.0	15.3

[1]CV=coefficient of variation (SD *100/mean)

Appendix C-5a
HISTORIC IHA STATISTICS FROM KINDRED (GAGE 05059000)-MONTHLY AVERAGE FLOW (CFS)
Final Aquatic Impact Analysis Report

Year	October	November	December	January	February	March	April	May	June	July	August	September
1971	41.3	55.9	48.3	57.4	62.5	393.6	662.7	424.7	304.9	316.1	64.3	66.9
1972	99.1	135.8	164.6	165.2	108.8	446.6	963.0	468.3	364.8	121.5	75.0	54.4
1973	62.6	69.6	55.9	58.9	94.3	308.6	156.0	72.5	58.0	32.3	30.7	44.6
1974	50.9	50.4	50.1	49.9	123.6	309.8	937.7	845.3	680.1	73.3	54.2	34.8
1975	42.4	58.1	57.6	71.9	67.3	97.4	762.1	1191.0	634.2	1465.7	190.8	113.7
1976	102.3	115.2	114.9	115.9	221.4	315.4	625.3	281.9	97.6	60.0	35.0	36.9
1977	38.4	45.2	41.2	38.0	41.6	109.7	103.7	102.2	56.9	39.9	22.6	40.9
1978	57.6	60.0	58.6	52.9	100.8	415.7	879.6	275.3	144.2	94.9	42.1	123.5
1979	81.5	86.8	49.4	44.6	51.2	148.6	1817.0	2306.4	355.8	218.0	153.4	81.3
1980	78.8	231.5	65.8	42.6	42.7	193.4	380.8	61.5	88.3	59.8	44.9	142.7
1981	132.3	140.7	69.0	36.9	49.4	120.3	210.7	105.4	133.1	178.2	57.7	35.7
1982	160.1	193.8	38.7	27.2	31.5	144.8	1255.1	371.3	240.0	190.0	111.1	32.9
1983	134.7	182.1	164.5	138.7	86.0	1165.0	931.4	287.0	266.6	311.9	45.2	103.7
1984	102.3	148.8	152.9	138.2	96.3	397.9	1202.5	456.3	207.7	84.7	29.5	54.9
1985	115.0	85.8	64.8	58.5	38.3	212.7	224.6	206.8	143.6	62.7	51.5	59.7
1986	58.2	76.6	142.5	163.4	187.5	512.2	647.1	689.2	167.2	113.4	132.6	90.5
1987	86.5	105.7	205.5	170.1	115.9	1256.3	1796.3	303.6	226.1	93.7	313.7	85.7
1988	110.7	120.7	127.4	125.0	140.2	277.4	113.8	68.8	52.8	26.7	17.6	29.4
1989	34.4	37.1	33.7	37.7	54.8	174.7	711.9	86.0	74.7	38.0	35.5	42.7
1990	54.2	55.3	33.3	24.9	32.8	91.8	107.0	53.6	95.3	40.6	26.6	55.5
1991	47.2	31.7	18.5	17.6	26.6	65.6	71.7	85.8	69.1	65.1	30.1	45.7
1992	31.0	32.5	51.9	59.7	61.5	545.7	201.2	84.0	90.2	124.1	73.8	83.2
1993	54.6	48.8	31.9	73.7	106.8	253.4	681.9	221.3	316.6	1250.2	2231.0	483.2
1994	224.5	180.1	246.6	164.8	214.5	614.4	1202.9	460.3	374.3	759.8	252.7	467.3
1995	692.6	588.5	338.8	204.8	196.9	1182.2	2964.0	1196.8	511.0	426.6	331.1	275.2
1996	181.6	143.9	119.0	126.4	316.9	965.0	2798.7	2170.8	684.4	296.4	268.8	89.4
1997	91.0	169.7	226.8	188.4	204.2	210.0	3957.3	2907.4	533.7	453.0	179.5	113.9
1998	140.6	188.6	186.1	158.9	198.6	1133.9	1065.2	606.2	569.0	454.6	123.8	119.8
1999	171.9	389.3	225.4	146.6	167.0	1040.3	2448.0	1631.3	886.8	604.4	352.6	528.1

Variance Data

	October	November	December	January	February	March	April	May	June	July	August	September
Historical Distribution												
1-day min	31.0	31.7	18.5	17.6	26.6	65.6	71.7	53.6	52.8	26.7	17.6	29.4
- 1 S.D.	-8.9	15.1	28.1	37.0	38.1	73.1	62.8	-129.7	59.3	-76.1	-220.9	-15.6
Mean	113.0	132.0	109.8	95.1	111.7	451.8	1030.3	621.4	290.6	277.8	185.4	121.9
+ 1 S.D.	235.0	249.0	191.4	153.2	185.3	830.6	1997.9	1372.5	521.9	631.6	591.8	259.5
1-day max	692.6	588.5	338.8	204.8	316.9	1256.3	3957.3	2907.4	886.8	1465.7	2231.0	528.1
CV[1]	107.9	88.6	74.4	61.1	65.9	83.8	93.9	120.9	79.6	127.4	219.1	112.8

[1]CV=coefficient of variation (SD *100/mean)

Appendix C-5b

HISTORIC IHA STATISTICS FROM KINDRED (GAGE 05059000)-MAGNITUDE (CFS), FREQUENCY (PER YEAR), AND DURATION (DAYS) OF EXTREME EVENTS.

Final Aquatic Impact Analysis Report

Year	1-day min	3-day min	7-day min	30-day min	90-day min	1-day max	3-day max	7-day max	30-day max	90-day max	Zero days	Base flow	Date min	Date max	Lo pulse #	Lo pulse	Hi pulse #	Hi pulse	Rise rate	Fall rate	Reversals
1971	31.0	31.0	31.4	40.6	48.3	1740.0	1726.7	1640.0	806.4	502.7	0.0	0.2	277.0	121.0	9.0	12.4	1.0	11.0	29.8	-20.7	62.0
1972	49.0	49.7	50.7	53.0	62.1	1490.0	1363.3	1070.9	963.0	707.6	0.0	0.2	253.0	79.0	1.0	24.0	3.0	11.0	35.5	-21.8	88.0
1973	20.0	21.3	25.6	29.1	34.2	676.0	595.3	493.3	330.4	188.7	0.0	0.3	210.0	82.0	7.0	19.1	0.0	0.0	10.3	-6.8	67.0
1974	23.0	21.3	22.4	32.6	42.8	1930.0	1910.0	1841.4	1190.4	834.8	0.0	0.1	271.0	120.0	7.0	16.9	2.0	19.0	35.8	-28.7	74.0
1975	19.0	21.7	31.9	42.2	52.3	4590.0	4563.3	4154.3	1768.7	1246.1	0.0	0.1	275.0	188.0	4.0	4.3	4.0	14.3	76.2	-55.8	60.0
1976	28.0	29.3	29.7	34.0	36.5	920.0	905.0	844.1	643.3	430.7	0.0	0.2	231.0	107.0	1.0	75.0	1.0	4.0	19.7	-12.4	53.0
1977	14.0	16.0	19.3	21.9	31.5	479.0	318.3	207.9	145.0	108.6	0.0	0.3	261.0	129.0	7.0	15.4	0.0	0.0	12.5	-7.6	53.0
1978	26.0	27.0	30.4	41.7	56.5	1400.0	1370.0	1300.0	1026.9	534.8	0.0	0.2	224.0	88.0	8.0	12.5	2.0	11.0	30.8	-21.7	52.0
1979	34.0	34.7	36.4	41.3	47.9	4160.0	4153.3	4120.0	3397.7	1522.6	0.0	0.1	359.0	127.0	2.0	39.0	1.0	42.0	61.6	-43.8	48.0
1980	30.0	31.7	36.4	39.2	44.7	720.0	701.0	685.6	493.1	220.2	0.0	0.3	19.0	95.0	12.0	13.7	0.0	0.0	19.4	-11.3	51.0
1981	30.0	31.3	32.4	35.0	51.2	432.0	428.0	391.4	238.2	157.9	0.0	0.3	257.0	101.0	3.0	37.0	0.0	0.0	14.1	-9.9	65.0
1982	20.0	20.0	21.1	25.8	31.5	2020.0	1996.7	1954.3	1267.5	629.8	0.0	0.1	34.0	107.0	2.0	69.0	1.0	21.0	50.9	-35.9	65.0
1983	26.0	26.7	28.1	34.6	82.2	2040.0	2013.3	1910.0	1545.9	817.0	0.0	0.1	235.0	81.0	3.0	11.7	3.0	11.3	47.3	-28.3	72.0
1984	21.0	21.7	23.4	29.1	45.8	1800.0	1796.7	1754.3	1387.3	721.9	0.0	0.1	232.0	101.0	2.0	28.5	1.0	25.0	23.6	-14.8	67.0
1985	27.0	27.7	29.4	38.3	52.9	528.0	510.7	439.3	292.0	223.2	0.0	0.3	211.0	77.0	15.0	6.5	0.0	0.0	15.3	-11.6	95.0
1986	38.0	39.7	45.7	57.7	90.9	1700.0	1480.0	1178.1	935.9	626.3	0.0	0.2	276.0	115.0	2.0	1.0	5.0	2.8	27.4	-22.0	102.0
1987	31.0	34.0	41.0	62.6	105.2	2930.0	2763.3	2425.7	2152.7	1140.3	0.0	0.1	201.0	86.0	2.0	5.5	2.0	23.0	37.4	-28.8	88.0
1988	11.0	12.7	14.3	16.4	22.7	442.0	424.0	371.3	280.2	188.7	0.0	0.1	258.0	67.0	4.0	25.3	0.0	0.0	6.4	-5.3	92.0
1989	14.0	19.3	23.3	31.8	34.8	1400.0	1366.7	1328.6	784.9	327.9	0.0	0.2	350.0	94.0	6.0	32.3	1.0	15.0	14.3	-11.6	105.0
1990	9.2	11.1	13.0	20.1	29.9	265.0	234.7	170.0	133.0	92.4	0.0	0.2	229.0	160.0	7.0	30.7	0.0	0.0	8.6	-5.8	91.0
1991	10.0	10.7	11.3	15.2	20.4	148.0	138.3	112.0	90.5	80.9	0.0	0.2	365.0	189.0	4.0	57.0	0.0	0.0	5.1	-3.9	82.0
1992	10.0	18.0	20.6	29.7	38.0	1300.0	1120.0	1044.3	584.1	282.1	0.0	0.2	307.0	75.0	11.0	7.9	1.0	8.0	19.2	-12.6	88.0
1993	10.0	11.3	14.0	27.1	44.6	3500.0	3450.0	3374.3	2715.3	1366.1	0.0	0.0	352.0	222.0	8.0	8.3	2.0	24.5	47.9	-41.3	59.0
1994	90.0	101.3	136.3	164.7	196.8	2020.0	2003.3	1885.7	1411.8	773.7	0.0	0.3	329.0	99.0	0.0	0.0	4.0	11.0	37.5	-34.7	56.0
1995	120.0	121.3	123.4	167.7	150.0	3960.0	3953.3	3918.6	3181.3	1884.3	0.0	0.2	68.0	101.0	0.0	0.0	4.0	22.5	63.1	-37.5	73.0
1996	71.0	71.7	74.0	83.6	104.7	5010.0	4916.7	4645.7	3679.0	2063.3	0.0	0.1	262.0	121.0	0.0	0.0	2.0	42.0	57.9	-42.0	64.0
1997	73.0	74.0	74.4	89.2	132.1	5610.0	5583.3	5484.3	4758.7	2492.9	0.0	0.1	317.0	120.0	0.0	0.0	3.0	21.7	88.5	-59.3	81.0
1998	89.0	95.0	94.0	116.7	131.5	1900.0	1850.0	1671.4	1230.0	957.3	0.0	0.2	247.0	68.0	0.0	0.0	4.0	13.8	57.3	-37.7	83.0
1999	78.0	83.0	101.0	139.8	177.3	2830.0	2823.3	2797.1	2448.0	1810.6	0.0	0.1	278.0	98.0	0.0	0.0	3.0	30.0	67.7	-45.6	62.0

√ariance Data

	1-day min	3-day min	7-day min	30-day min	90-day min	1-day max	3-day max	7-day max	30-day max	90-day max	Zero days	Base flow	Date min	Date max	Lo pulse #	Lo pulse	Hi pulse #	Hi pulse	Rise rate	Fall rate	Reversals
Historical Distribution																					
1-day min	9.2	10.7	11.3	15.2	20.4	148.0	138.3	112.0	90.5	80.9	0.0	0.0	19.0	67.0	0.0	0.0	0.0	0.0	5.1	-59.3	48.0
- 1 S.D.	7.4	8.6	9.3	11.4	21.4	496.0	441.0	362.0	173.0	135.5	0.0	0.1	190.1	99.6	0.3	-1.4	0.2	1.0	12.5	-40.7	56.0
Mean	36.3	38.4	42.6	53.8	68.9	1997.9	1946.9	1835.0	1375.2	790.8	0.0	0.2	247.9	111.0	4.4	19.1	1.7	13.2	35.2	-24.8	72.3
+ 1 S.D.	65.1	68.2	75.8	96.2	116.5	3499.8	3452.7	3307.9	2577.5	1446.2	0.0	0.3	305.6	122.3	8.4	39.6	3.3	25.5	57.9	-8.9	88.7
1-day max	120.0	121.3	136.3	167.7	196.8	5610.0	5583.3	5484.3	4758.7	2492.9	0.0	0.3	365.0	222.0	15.0	75.0	5.0	42.0	88.5	-3.9	105.0
CV[1]	79.5	77.6	78.1	78.8	69.0	75.2	77.3	80.3	87.4	82.9	--	47.1	23.3	10.2	92.9	107.4	89.0	92.5	64.6	-64.3	22.6

[1]CV=coefficient of variation (SD *100/mean)

Appendix C-6a
HISTORIC IHA STATISTICS FROM HALSTAD (GAGE 05064500)-MONTHLY AVERAGE FLOW (CFS)
Final Aquatic Impact Analysis Report

Year	October	November	December	January	February	March	April	May	June	July	August	September
1971	188.5	409.4	253.4	210.6	226.1	1555.6	3085.0	1481.4	936.8	1327.5	345.5	679.5
1972	1602.5	1771.0	1164.2	963.0	828.1	5948.9	7169.0	4400.0	3331.7	1476.1	1109.5	671.2
1973	632.1	612.8	445.8	435.5	578.9	2918.7	1381.7	803.5	608.3	313.7	265.0	1284.7
1974	1386.1	999.6	947.7	771.5	731.3	1305.3	7269.7	5016.8	3012.7	1438.4	821.5	372.6
1975	486.5	606.2	386.5	329.4	445.3	724.2	11250.0	6194.8	4582.7	20062.9	1494.2	757.7
1976	682.4	761.5	484.2	500.2	616.4	2582.3	3786.0	1181.0	430.2	241.5	87.8	38.4
1977	61.5	92.3	51.2	32.1	45.9	330.8	733.3	449.0	241.6	250.7	59.6	221.4
1978	646.5	592.7	730.8	706.0	480.2	1628.9	16737.7	2949.7	1963.7	2018.7	598.7	320.0
1979	301.6	283.6	258.4	178.1	173.9	461.5	17349.3	8993.9	2811.7	2487.4	1399.7	847.1
1980	635.4	813.7	517.9	498.7	453.3	774.0	3881.0	979.6	776.3	289.4	229.7	259.6
1981	266.4	367.0	223.7	140.3	203.2	618.1	704.7	923.3	567.7	678.2	540.9	291.3
1982	617.5	756.1	483.1	310.7	356.4	1173.7	9298.7	2322.3	1365.6	1049.7	506.3	281.5
1983	1209.5	915.4	681.9	411.0	314.6	3674.2	2924.0	1056.7	1606.6	3441.6	776.9	743.2
1984	737.3	776.6	600.6	506.1	594.1	4191.6	9232.7	2173.2	5361.3	1501.4	571.4	285.8
1985	1350.1	1227.6	818.3	680.2	502.1	3163.9	2197.7	5094.5	4250.3	2394.5	1812.9	1604.0
1986	1341.0	1143.5	1056.2	950.6	940.1	4642.0	11721.7	8639.4	4218.3	2854.8	1324.2	2034.7
1987	2188.1	1419.7	1252.6	1022.9	1052.2	4974.5	4332.7	2043.6	1420.4	1444.2	899.0	465.9
1988	414.8	477.2	461.6	319.9	484.6	2614.8	2145.8	801.2	449.0	153.3	154.2	171.6
1989	163.7	216.4	201.6	150.4	249.3	560.4	14273.0	2259.4	1534.7	544.9	281.3	885.8
1990	304.9	284.8	129.9	118.4	160.1	324.7	1249.3	1111.7	1462.4	635.5	268.6	256.0
1991	204.8	204.9	140.2	94.4	168.0	638.1	1141.8	2041.6	1604.0	2282.6	688.4	861.6
1992	440.2	325.3	313.2	316.0	349.0	2446.8	1118.8	951.4	1600.4	1892.2	904.7	802.6
1993	393.6	375.7	411.5	407.4	479.3	1353.6	8045.0	2122.6	3107.3	10958.4	11696.5	3360.3
1994	1949.7	1403.7	1129.4	894.1	911.3	4221.3	8797.0	4675.5	2950.3	5993.2	1819.0	2145.9
1995	2874.8	1843.0	1004.2	881.0	885.0	9444.2	12195.3	6045.5	2957.3	4363.9	1348.4	842.0
1996	1866.1	1586.3	1178.9	796.8	792.2	3523.9	14075.0	9748.4	3761.0	1267.7	854.8	477.5
1997	478.4	831.1	726.1	794.8	1270.0	1922.6	38460.0	15570.7	4747.3	4952.9	1621.6	1180.3
1998	1501.8	1182.3	1135.2	930.0	1952.5	8800.7	6062.3	8453.9	5675.0	8468.4	1766.1	1029.7
1999	1914.5	1512.0	1485.8	923.2	805.4	6848.4	10083.7	8216.8	4529.7	3526.1	2496.5	4705.0

Variance Data

	October	November	December	January	February	March	April	May	June	July	August	September
Historical Distribution												
1-day min	61.5	92.3	51.2	32.1	45.9	324.7	704.7	449.0	241.6	153.3	59.6	38.4
- 1 S.D.	194.8	317.2	244.6	211.7	186.5	401.8	212.1	357.0	845.0	-1080.8	-834.0	-53.5
Mean	925.5	820.4	643.9	526.7	587.9	2874.7	7955.2	4024.2	2478.1	3045.2	1267.0	961.3
+ 1 S.D.	1656.2	1323.6	1043.3	841.7	989.3	5347.7	15698.4	7691.3	4111.2	7171.1	3368.0	1976.1
1-day max	2874.8	1843.0	1485.8	1022.9	1952.5	9444.2	38460.0	15570.7	5675.0	20062.9	11696.5	4705.0
CV[1]	78.9	61.3	62.0	59.8	68.3	86.0	97.3	91.1	65.9	135.5	165.8	105.6

[1] CV=coefficient of variation (SD *100/mean)

Appendix C-6b

HISTORIC IHA STATISTICS FROM KINDRED (GAGE 05064500)-MAGNITUDE (CFS), FREQUENCY (PER YEAR), AND DURATION (DAYS) OF EXTREME EVENTS

Final Aquatic Impact Analysis Report

Year	1-day min	3-day min	7-day min	30-day min	90-day min	1-day max	3-day max	7-day max	30-day max	90-day max	Zero days	Base flow	Date min	Date max	Lo pulse #	Lo pulse	Hi pulse #	Hi pulse	Rise rate	Fall rate	Reversals
1971	121.0	125.7	136.1	184.9	229.7	5400.0	5003.3	4312.9	3511.3	2138.1	0.0	0.2	279.0	92.0	4.0	46.5	0.0	0.0	101.2	-65.8	47.0
1972	474.0	516.3	535.1	590.3	567.4	16200.0	15833.3	14971.4	9619.0	6527.3	0.0	0.2	275.0	85.0	0.0	0.0	4.0	7.0	390.9	-189.5	65.0
1973	185.0	187.3	200.1	252.3	372.1	6120.0	6003.3	5634.3	3283.7	1734.2	0.0	0.2	243.0	78.0	3.0	31.0	0.0	0.0	92.0	-50.7	64.0
1974	275.0	276.7	279.9	357.7	485.6	16400.0	15900.0	14014.3	8799.3	5162.4	0.0	0.1	267.0	107.0	2.0	12.5	2.0	10.0	259.7	-138.9	59.0
1975	174.0	185.3	243.0	327.2	383.5	39900.0	39566.7	38271.4	22766.7	12462.4	0.0	0.1	18.0	192.0	3.0	23.7	2.0	26.5	541.1	-293.9	48.0
1976	10.0	11.7	16.9	36.0	61.3	9850.0	9733.3	9107.1	5047.3	2553.5	0.0	0.0	246.0	91.0	6.0	20.0	1.0	9.0	108.9	-59.1	56.0
1977	24.0	25.0	25.0	31.7	43.0	1980.0	1491.0	1074.3	794.3	652.6	0.0	0.1	283.0	128.0	8.0	19.4	0.0	0.0	50.6	-34.9	59.0
1978	188.0	193.3	198.3	304.0	283.7	28700.0	28666.7	28200.0	17012.0	7479.7	0.0	0.1	257.0	100.0	7.0	6.3	1.0	24.0	269.8	-180.9	57.0
1979	160.0	160.0	160.0	165.7	197.4	41500.0	40300.0	38342.9	22753.3	9978.9	0.0	0.1	21.0	113.0	2.0	9.0	1.0	34.0	451.3	-224.3	31.0
1980	173.0	181.7	192.6	219.5	237.0	11100.0	10066.7	8504.3	3933.0	1951.6	0.0	0.2	252.0	97.0	3.0	37.3	1.0	6.0	96.4	-82.0	63.0
1981	123.0	123.3	124.9	137.2	187.5	3800.0	3350.0	2364.3	974.2	765.1	0.0	0.3	18.0	146.0	6.0	27.7	0.0	0.0	45.8	-38.8	75.0
1982	168.0	178.0	242.6	274.1	369.7	13100.0	13100.0	13042.9	9422.3	4493.3	0.0	0.2	275.0	97.0	4.0	26.8	1.0	22.0	142.4	-92.8	49.0
1983	250.0	259.3	275.7	312.3	458.7	7050.0	6820.0	6107.1	4522.3	2597.2	0.0	0.2	275.0	188.0	2.0	22.5	1.0	3.0	186.4	-101.7	53.0
1984	148.0	151.0	158.0	189.7	486.4	21800.0	21600.0	20728.6	11676.3	6399.0	0.0	0.1	273.0	93.0	4.0	10.8	2.0	14.5	324.7	-150.5	54.0
1985	124.0	125.3	136.9	503.0	638.8	10100.0	9846.7	9770.0	6476.3	4262.3	0.0	0.1	282.0	134.0	1.0	0.0	3.0	7.0	268.6	-142.0	69.0
1986	894.0	918.7	922.1	939.0	983.4	17300.0	17133.3	16600.0	12385.0	9037.0	0.0	0.3	7.0	91.0	0.0	0.0	2.0	28.5	261.5	-174.5	68.0
1987	378.0	382.7	395.7	409.5	448.0	9740.0	9663.3	8987.1	6064.0	3891.7	0.0	0.2	251.0	91.0	2.0	6.0	1.0	8.0	153.1	-105.3	54.0
1988	64.0	65.7	75.4	111.7	152.4	4940.0	4923.3	4767.1	3475.0	1878.4	0.0	0.1	212.0	88.0	5.0	29.8	0.0	0.0	51.0	-40.9	90.0
1989	131.0	132.3	133.1	144.7	188.8	25600.0	25566.7	25142.9	14273.0	6057.8	0.0	0.1	289.0	101.0	5.0	15.8	1.0	21.0	227.1	-154.5	62.0
1990	100.0	102.3	105.6	110.3	135.2	2580.0	2380.0	2035.7	1468.0	1277.6	0.0	0.2	357.0	156.0	3.0	29.7	0.0	0.0	47.9	-34.6	69.0
1991	70.0	71.3	74.0	86.3	132.6	3600.0	3533.3	3352.9	2398.0	1998.4	0.0	0.1	2.0	190.0	5.0	5.4	0.0	0.0	76.6	-63.3	56.0
1992	150.0	160.0	194.3	300.9	316.9	5000.0	4766.7	4128.6	2631.7	1547.1	0.0	0.2	313.0	70.0	3.0	46.3	0.0	0.0	120.4	-77.3	55.0
1993	270.0	276.7	295.0	312.4	376.9	22300.0	22166.7	21485.7	17386.7	8977.0	0.0	0.1	320.0	215.0	5.0	20.2	2.0	26.5	338.0	-202.9	47.0
1994	741.0	785.3	835.4	869.4	971.0	16400.0	16133.3	15585.7	10579.0	6272.0	0.0	0.3	253.0	93.0	0.0	0.0	3.0	11.3	389.9	-185.2	48.0
1995	474.0	483.3	531.6	833.7	911.9	23000.0	22866.7	22085.7	16927.3	9742.9	0.0	0.1	271.0	91.0	0.0	0.0	3.0	20.0	493.4	-176.7	39.0
1996	228.0	233.3	256.1	406.2	569.2	25100.0	24766.7	23871.4	15096.0	9792.8	0.0	0.1	266.0	109.0	2.0	5.5	3.0	17.7	347.7	-200.4	67.0
1997	258.0	265.7	284.3	460.0	675.2	69900.0	68666.7	63328.6	42786.7	19759.7	0.0	0.1	291.0	110.0	1.0	10.0	5.0	12.8	677.6	-477.9	45.0
1998	658.0	717.7	789.1	923.0	1031.3	19200.0	18966.7	17785.7	10872.3	7966.8	0.0	0.2	271.0	141.0	0.0	0.0	5.0	15.4	504.1	-303.2	57.0
1999	740.0	740.0	742.9	813.3	1038.1	17900.0	17566.7	17142.9	13379.3	8994.8	0.0	0.2	41.0	89.0	0.0	0.0	3.0	18.3	432.2	-241.1	47.0

√ariance Data

	1-day min	3-day min	7-day min	30-day min	90-day min	1-day max	3-day max	7-day max	30-day max	90-day max	Zero days	Base flow	Date min	Date max	Lo pulse #	Lo pulse	Hi pulse #	Hi pulse	Rise rate	Fall rate	Reversals
Historical Distribution																					
1-day min	10.0	11.7	16.9	31.7	43.0	1980.0	1491.0	1074.3	794.3	652.6	0.0	0.0	2.0	70.0	0.0	0.0	0.0	0.0	45.8	-477.9	31.0
- 1 S.D.	36.8	36.6	46.9	92.9	144.9	2543.1	2395.8	2257.6	1459.5	1420.8	0.0	0.1	155.3	104.2	0.7	1.7	0.1	1.5	82.5	-247.2	45.3
Mean	267.3	277.1	295.2	365.7	446.0	17088.3	16771.8	15887.8	10355.6	5736.3	0.0	0.2	221.0	116.4	3.0	15.9	1.6	11.8	256.9	-147.7	57.0
+ 1 S.D.	497.9	517.6	543.5	638.6	747.0	31633.4	31147.7	29517.9	19251.8	10051.7	0.0	0.2	286.7	128.6	5.2	30.1	3.1	22.2	431.3	-48.2	68.7
1-day max	894.0	918.7	922.1	939.0	1038.1	69900.0	68666.7	63328.6	42786.7	19759.7	0.0	0.3	357.0	215.0	8.0	46.5	5.0	34.0	677.6	-34.6	90.0
CV[1]	86.2	86.8	84.1	74.6	67.5	85.1	85.7	85.8	85.9	75.2	--	53.3	29.7	10.5	76.8	89.1	92.6	87.7	67.9	-67.3	20.5

[1] CV=coefficient of variation (SD *100/mean)

Appendix C-7a
HISTORIC IHA STATISTICS FROM GRAND FORKS (GAGE 05082500)-MONTHLY AVERAGE FLOW (CFS)
Final Aquatic Impact Analysis Report

Year	October	November	December	January	February	March	April	May	June	July	August	September
1971	1131.3	1415.3	1133.9	1100.0	1153.6	2422.6	7095.7	3034.5	2175.0	2123.6	1028.1	1235.3
1972	4290.0	5218.0	3072.6	1827.4	1479.7	8595.2	15704.7	7597.1	5197.0	2276.5	2267.4	1905.3
1973	1800.3	1408.8	1162.6	1123.6	1162.1	5467.1	1959.3	1356.5	1029.1	559.8	736.7	3067.1
1974	3737.1	2421.0	1945.2	1700.7	1657.9	2047.7	16668.7	13154.8	5927.7	2860.0	2698.7	1792.7
1975	1939.0	1972.3	1240.3	1301.0	1433.9	1739.7	18742.3	14641.9	6172.7	25274.2	3003.9	2228.3
1976	2345.5	2315.3	1771.6	1704.5	1698.6	3703.9	9236.7	2514.8	1556.3	1106.4	976.3	700.2
1977	406.7	300.3	196.1	215.0	215.4	493.6	1335.5	834.4	549.2	592.4	227.3	593.9
1978	1222.8	1083.6	1360.3	1284.8	1113.2	2504.2	30178.3	4977.1	3150.7	3065.5	1404.9	972.6
1979	879.7	803.5	761.2	683.5	683.0	962.3	31483.3	18331.6	5957.7	5773.2	3300.3	1940.7
1980	1651.6	1832.3	1521.9	1341.3	1404.1	1852.6	8707.0	1848.4	1451.3	669.4	456.1	767.4
1981	424.1	436.4	353.4	292.4	386.2	936.5	978.9	1351.8	1269.7	2414.8	1468.1	1803.7
1982	2473.0	1819.7	1129.4	1136.5	1071.1	2379.7	17403.7	6015.2	3353.3	3200.3	1897.7	1267.7
1983	3686.8	2346.7	1909.0	1600.0	1473.2	7695.5	7047.0	2993.6	5036.3	6027.7	2613.9	2486.0
1984	2153.2	2020.6	1935.5	1679.0	1813.1	5607.1	15463.3	3845.8	11529.7	3061.9	1482.4	954.8
1985	2226.6	2018.3	1443.7	1388.4	1357.1	5791.9	4898.0	9056.5	7507.7	6016.5	6472.9	4701.7
1986	3966.5	2426.7	2026.5	1889.4	1827.9	6539.7	19583.3	14632.6	6190.7	4368.7	2407.1	3175.0
1987	3335.2	2009.7	2046.8	1714.5	1790.4	8049.4	7556.0	3460.0	2481.3	3323.2	1913.9	1015.2
1988	644.8	658.6	619.6	452.7	520.0	2939.3	4320.3	1096.5	641.8	295.7	312.7	373.1
1989	312.5	341.4	259.5	278.3	357.9	507.4	21851.7	3328.4	2047.0	862.0	443.6	944.5
1990	500.4	442.6	248.2	189.9	258.3	1067.1	2476.0	1501.6	2077.7	946.1	452.6	356.7
1991	350.8	316.2	218.0	195.0	304.0	764.3	1587.0	2820.7	2008.0	3027.4	1035.0	1351.7
1992	672.2	494.5	468.7	519.0	524.2	4219.2	2692.3	1975.2	1982.3	2690.7	1440.9	2118.3
1993	1041.8	756.7	879.5	809.5	1090.4	2191.9	13763.7	3398.4	4493.0	12216.1	17053.2	6251.0
1994	3536.8	1929.7	2015.8	1570.0	1519.3	6458.1	12459.7	6496.1	5751.7	12931.9	3590.3	3910.0
1995	5126.8	3575.3	2456.1	1819.4	1785.4	15368.1	18525.3	10114.5	4175.0	7299.0	2664.5	2119.7
1996	3628.4	2781.3	2224.8	2030.0	1922.4	5037.1	28330.0	20567.7	7562.7	3750.3	2657.4	1677.3
1997	1715.2	2098.0	2175.8	1873.2	1873.9	2249.7	56209.7	24938.7	8483.0	13680.7	3264.2	2410.7
1998	3107.7	2740.7	2638.7	1891.3	3519.6	13929.0	8980.0	13088.1	9073.3	12616.8	2971.6	2053.7
1999	3481.0	3246.3	3571.3	1721.9	1655.7	11737.1	25692.7	16450.0	9801.7	6602.3	5348.1	11339.0

Variance Data

	October	November	December	January	February	March	April	May	June	July	August	September
Historical Distribution												
1-day min	312.5	300.3	196.1	189.9	215.4	493.6	978.9	834.4	549.2	295.7	227.3	356.7
- 1 S.D.	727.7	624.1	580.6	601.9	572.0	627.6	2022.2	703.1	1430.5	-348.8	-532.1	73.1
Mean	2130.6	1766.6	1475.4	1218.4	1277.6	4595.1	14170.0	7428.4	4435.6	5159.8	2606.6	2259.1
+ 1 S.D.	3533.5	2909.0	2370.2	1834.8	1983.3	8562.6	26317.8	14153.6	7440.7	10668.3	5745.2	4445.1
1-day max	5126.8	5218.0	3571.3	2030.0	3519.6	15368.1	56209.7	24938.7	11529.7	25274.2	17053.2	11339.0
CV[1]	65.8	64.7	60.7	50.6	55.2	86.3	85.7	90.5	67.7	106.8	120.4	96.8

[1] CV=coefficient of variation (SD *100/mean)

Appendix C-7b

HISTORIC IHA STATISTICS FROM GRAND FORKS (GAGE 05082500)-MAGNITUDE (CFS), FREQUENCY (PER YEAR), AND DURATION (DAYS) OF EXTREME EVENTS

Final Aquatic Impact Analysis Report

Year	1-day min	3-day min	7-day min	30-day min	90-day min	1-day max	3-day max	7-day max	30-day max	90-day max	Zero days	Base flow	Date min	Date max	Lo pulse #	Lo pulse	Hi pulse #	Hi pulse	Rise rate	Fall rate	Reversals
1971	696.0	696.0	726.9	944.2	1113.3	15800.0	15066.7	12792.9	7228.7	4364.8	0.0	0.4	271.0	102.0	7.0	9.1	1.0	5.0	224.5	-150.7	49.0
1972	1000.0	1450.0	1450.0	1480.3	1469.8	30800.0	29700.0	27185.7	17444.7	11626.6	0.0	0.3	275.0	109.0	1.0	0.0	2.0	15.0	787.2	-391.9	40.0
1973	429.0	433.0	439.4	542.0	737.8	11200.0	11133.3	10345.7	5965.7	3158.9	0.0	0.3	207.0	79.0	4.0	23.8	0.0	0.0	178.1	-94.8	62.0
1974	1520.0	1520.0	1520.0	1579.3	1726.4	34100.0	33900.0	30985.7	21750.0	12095.2	0.0	0.3	33.0	110.0	0.0	0.0	2.0	17.0	614.4	-293.8	40.0
1975	1000.0	1116.7	1165.7	1209.7	1300.1	42400.0	41933.3	40928.6	28463.3	18625.3	0.0	0.2	16.0	113.0	1.0	1.0	2.0	28.5	636.4	-509.3	45.0
1976	513.0	514.0	477.1	412.3	306.4	22900.0	22833.3	20328.6	10311.0	5194.1	0.0	0.2	270.0	95.0	2.0	38.0	1.0	10.0	250.1	-138.9	63.0
1977	1.8	135.3	172.3	195.5	208.2	2150.0	2096.7	1910.0	1391.7	1222.2	0.0	0.4	246.0	102.0	6.0	30.5	0.0	0.0	75.0	-46.9	58.0
1978	695.0	711.0	747.6	876.8	818.6	54100.0	53600.0	51557.1	30420.0	13125.0	0.0	0.2	251.0	102.0	7.0	8.3	1.0	27.0	498.9	-327.3	54.0
1979	562.0	597.3	654.1	663.0	703.7	80900.0	80366.7	78628.6	43953.3	19627.6	0.0	0.1	321.0	114.0	2.0	11.0	2.0	18.0	743.3	-514.3	60.0
1980	312.0	338.7	346.9	419.7	409.8	21800.0	21133.3	18914.3	8886.3	4149.0	0.0	0.2	253.0	97.0	3.0	29.7	1.0	8.0	218.9	-178.5	52.0
1981	250.0	250.0	250.0	273.8	320.6	6590.0	5823.3	4415.7	2568.3	2061.0	0.0	0.3	35.0	183.0	6.0	15.5	0.0	0.0	164.5	-119.0	66.0
1982	884.0	990.0	990.0	1043.7	1110.1	23900.0	23800.0	23600.0	17489.7	9163.4	0.0	0.3	275.0	104.0	5.0	6.2	1.0	24.0	295.0	-197.4	56.0
1983	1270.0	1273.3	1297.1	1461.3	1630.8	14200.0	13800.0	12542.9	9743.7	6021.6	0.0	0.4	55.0	97.0	0.0	0.0	4.0	3.5	465.9	-260.0	59.0
1984	634.0	611.0	540.9	656.6	1209.5	32200.0	31900.0	30428.6	17917.0	11052.6	0.0	0.1	274.0	93.0	3.0	13.0	2.0	16.5	598.4	-288.9	66.0
1985	306.0	320.0	355.3	1352.3	1391.3	17700.0	17600.0	17028.6	11533.3	7885.2	0.0	0.1	284.0	139.0	3.0	2.3	3.0	6.7	441.5	-292.8	72.0
1986	1630.0	1680.0	1802.9	1825.7	1894.0	31800.0	31166.7	29157.1	20330.0	14665.4	0.0	0.3	329.0	93.0	0.0	0.0	2.0	28.5	454.1	-316.1	67.0
1987	855.0	865.7	835.9	655.1	645.2	17200.0	16766.7	16000.0	10906.7	6635.2	0.0	0.3	254.0	89.0	6.0	4.5	1.0	13.0	346.6	-200.3	66.0
1988	168.0	180.7	202.3	242.6	306.9	8400.0	8323.3	7932.9	5260.3	2827.9	0.0	0.2	213.0	97.0	2.0	67.5	0.0	0.0	79.0	-69.7	103.0
1989	208.0	209.3	217.4	252.8	287.3	39500.0	38900.0	37785.7	21995.3	9092.0	0.0	0.1	349.0	104.0	5.0	21.8	1.0	20.0	274.4	-241.1	79.0
1990	110.0	113.7	118.7	146.2	225.0	4880.0	4776.7	4372.9	2595.0	2015.8	0.0	0.1	359.0	95.0	3.0	32.7	0.0	0.0	77.7	-62.8	92.0
1991	168.0	177.0	180.9	186.9	231.5	4850.0	4826.7	4617.1	3100.7	2651.8	0.0	0.2	359.0	190.0	5.0	13.2	0.0	0.0	107.4	-93.7	95.0
1992	285.0	302.0	353.4	446.2	494.1	7940.0	7856.7	7291.4	4720.7	3033.9	0.0	0.2	308.0	73.0	4.0	7.3	0.0	0.0	179.2	-117.5	80.0
1993	540.0	565.3	666.4	754.4	805.7	26200.0	26166.7	25985.7	21790.0	12111.9	0.0	0.1	334.0	216.0	2.0	64.0	2.0	25.5	464.1	-296.0	52.0
1994	1030.0	1046.7	1210.0	1509.0	1682.4	26500.0	25800.0	23842.9	15366.0	8978.8	0.0	0.2	329.0	194.0	1.0	3.0	3.0	14.0	594.7	-330.6	46.0
1995	1310.0	1326.7	1397.1	1765.0	1875.6	34700.0	34300.0	32814.3	26650.0	15361.4	0.0	0.2	272.0	92.0	0.0	0.0	3.0	18.7	644.3	-298.7	63.0
1996	1390.0	1403.3	1415.7	1516.3	1811.0	58100.0	56400.0	51085.7	33203.3	19429.7	0.0	0.2	269.0	112.0	0.0	0.0	2.0	26.0	690.5	-437.8	80.0
1997	1440.0	1453.3	1478.6	1687.3	1957.6	127000.0	115666.7	110128.6	64003.3	30367.7	0.0	0.2	282.0	109.0	0.0	0.0	2.0	41.5	1225.9	-791.4	62.0
1998	1560.0	1576.7	1635.7	1835.3	2283.7	29600.0	29100.0	27214.3	15970.7	12151.8	0.0	0.3	273.0	142.0	0.0	0.0	4.0	16.5	683.6	-429.8	61.0
1999	1500.0	1500.0	1511.4	1618.7	2016.0	49700.0	49000.0	46571.4	31090.0	19773.8	0.0	0.2	41.0	92.0	0.0	0.0	4.0	19.0	863.6	-554.4	47.0

√ariance Data

	1-day min	3-day min	7-day min	30-day min	90-day min	1-day max	3-day max	7-day max	30-day max	90-day max	Zero days	Base flow	Date min	Date max	Lo pulse #	Lo pulse	Hi pulse #	Hi pulse	Rise rate	Fall rate	Reversals
Historical Distribution																					
1-day min	1.8	113.7	118.7	146.2	208.2	2150.0	2096.7	1910.0	1391.7	1222.2	0.0	0.1	16.0	73.0	0.0	0.0	0.0	0.0	75.0	-791.4	40.0
- 1 S.D.	256.1	281.1	295.5	366.2	404.8	4271.2	5012.3	4320.1	3687.2	2948.1	0.0	0.1	174.1	103.7	0.3	-4.5	0.3	2.7	163.6	-450.6	47.5
Mean	767.8	805.4	833.1	950.1	1068.0	30245.2	29439.2	27806.7	17656.9	9947.2	0.0	0.2	242.7	115.1	2.7	13.9	1.6	13.9	444.0	-277.4	63.3
+ 1 S.D.	1279.6	1329.7	1370.7	1534.0	1731.3	56219.2	53866.1	51293.2	31626.5	16946.4	0.0	0.3	311.2	126.4	5.1	32.2	2.9	25.1	724.5	-104.2	79.1
1-day max	1630.0	1680.0	1802.9	1835.3	2283.7	127000.0	115666.7	110128.6	64003.3	30367.7	0.0	0.4	359.0	216.0	7.0	67.5	4.0	41.5	1225.9	-46.9	103.0
CV[1]	66.6	65.1	64.5	61.5	62.1	85.9	83.0	84.5	79.1	70.4	--	38.1	28.2	9.9	88.5	132.2	79.9	80.8	63.2	-62.4	24.9

[1]CV=coefficient of variation (SD *100/mean)

Appendix C-8a
HISTORIC IHA STATISTICS FROM EMERSON (GAGE 05092000)-MONTHLY AVERAGE FLOW (CFS)
Final Aquatic Impact Analysis Report

Year	October	November	December	January	February	March	April	May	June	July	August	September
1971	1105.2	1357.2	1096.5	1065.2	1130.7	2640.0	11127.3	3480.0	2429.0	2471.3	1135.5	1412.8
1972	4462.7	5653.3	3071.6	1861.0	1449.3	7256.5	22230.0	9170.7	6078.7	2395.5	2439.0	2079.0
1973	1774.5	1473.0	1148.7	1125.8	1196.8	6105.8	2449.7	1575.5	1200.0	578.7	801.9	3008.4
1974	4411.9	2707.0	2014.2	1744.2	1671.8	2016.1	18946.0	18261.3	7633.3	3297.4	3231.6	1967.0
1975	1950.7	2079.0	1283.6	1328.7	1434.6	1686.1	16281.0	22893.6	5970.7	28238.7	4002.6	2478.7
1976	2363.9	2573.3	1723.6	1630.3	1728.6	3298.1	13302.3	3016.5	1914.3	1358.7	1162.9	712.8
1977	375.1	276.6	149.3	197.4	201.4	428.6	1793.5	938.1	676.4	638.7	243.3	521.0
1978	1287.1	1121.0	1449.4	1342.6	1124.3	2171.0	36743.3	7427.4	3797.7	3710.3	1537.1	1073.7
1979	986.1	813.6	797.1	725.2	723.2	879.7	29260.3	32087.1	6653.3	6267.7	3341.0	2097.0
1980	1661.0	1800.0	1491.3	1387.7	1462.8	1653.9	10040.7	2071.9	1531.7	758.1	488.8	846.2
1981	556.1	650.7	411.0	304.2	339.6	1232.6	1274.6	1365.4	1311.0	2764.5	1509.0	1896.6
1982	2571.3	1903.3	1186.5	1112.3	1040.9	1946.5	23654.0	7805.5	3704.7	4246.1	2291.9	1263.0
1983	4271.6	2457.3	2113.6	1606.8	1471.1	9329.0	10945.0	3387.7	5121.7	6550.0	2885.8	2941.3
1984	2194.5	1978.0	1804.8	1581.0	1582.1	4442.6	19242.3	4246.1	11915.3	3330.7	1442.3	975.3
1985	2208.4	2152.0	1540.1	1325.8	1323.2	6441.3	5750.7	9248.1	8251.7	6962.3	7247.1	4909.3
1986	3845.2	2427.7	2312.9	1977.4	1680.7	5311.0	21643.3	16856.8	6436.7	4763.6	2715.5	2992.7
1987	3496.5	2037.3	2339.4	1844.8	1673.2	7776.1	15172.7	3426.8	2983.7	2864.6	2502.3	1096.1
1988	763.6	767.4	695.9	461.5	513.1	2419.0	6250.3	1426.7	946.4	347.7	274.6	328.7
1989	350.0	332.2	271.0	269.5	356.4	424.8	23902.2	4576.1	2291.7	1145.4	451.5	1048.4
1990	474.4	450.9	285.2	174.4	251.8	1116.7	2848.3	1512.6	1988.7	1108.8	434.7	364.4
1991	316.7	336.5	245.3	187.0	289.6	680.2	1893.7	2746.1	2055.7	3178.7	1103.8	1404.9
1992	792.4	593.9	521.7	520.7	500.5	4886.6	4205.3	2656.8	2176.0	2983.6	1556.0	2556.7
1993	1141.8	729.2	821.0	813.0	998.0	1571.6	14996.3	3914.8	4584.7	10762.6	21577.4	7911.7
1994	3800.0	2029.3	1858.4	1538.7	1487.9	7432.6	15545.7	6834.5	6069.7	13922.3	3986.5	4210.7
1995	5194.2	4005.0	2720.7	1966.5	1769.6	15721.3	25363.3	11238.4	4526.3	7816.5	2736.5	2259.0
1996	3335.5	2923.7	2183.2	2051.6	1977.9	4981.0	30882.3	31416.1	10930.3	4051.6	2950.7	1766.3
1997	1735.5	2319.3	2362.6	1972.6	1853.6	2372.6	54708.7	37496.8	9020.3	14979.0	3653.6	2723.3
1998	3439.4	3109.3	3137.1	2254.5	2598.2	16290.3	12188.3	13335.8	9383.0	15511.3	3437.1	2187.3
1999	3491.3	3395.7	4168.1	1919.4	1885.7	8125.8	39396.7	20054.2	12308.0	8111.0	6318.7	12141.3

Variance Data

	October	November	December	January	February	March	April	May	June	July	August	September
Historical Distribution												
1-day min	316.7	276.6	149.3	174.4	201.4	424.8	1274.6	938.1	676.4	347.7	243.3	328.7
- 1 S.D.	752.1	637.1	563.9	594.6	614.7	385.2	4195.7	-437.4	1532.5	-385.9	-933.5	28.1
Mean	2219.2	1877.7	1558.7	1251.4	1231.6	4504.7	16966.8	9809.2	4961.7	5693.6	3015.8	2454.3
+ 1 S.D.	3686.2	3118.2	2553.6	1908.2	1848.5	8624.3	29738.0	20055.9	8391.0	11773.1	6965.2	4880.4
1-day max	5194.2	5653.3	4168.1	2254.5	2598.2	16290.3	54708.7	37496.8	12308.0	28238.7	21577.4	12141.3
CV[1]	66.1	66.1	63.8	52.5	50.1	91.5	75.3	104.5	69.1	106.8	131.0	98.9

[1] CV=coefficient of variation (SD *100/mean)

Appendix C-8b

HISTORIC IHA STATISTICS FROM GRAND FORKS (GAGE 05092000)-MAGNITUDE (CFS), FREQUENCY (PER YEAR), AND DURATION (DAYS) OF EXTREME EVENTS

Final Aquatic Impact Analysis Report

Year	1-day min	3-day min	7-day min	30-day min	90-day min	1-day max	3-day max	7-day max	30-day max	90-day max	Zero days	Base flow	Date min	Date max	Lo pulse #	Lo pulse	Hi pulse #	Hi pulse	Rise rate	Fall rate	Reversals
1971	739.0	781.7	835.3	1024.5	1056.6	23300.0	22666.7	20900.0	11268.7	5992.0	0.0	0.3	328.0	102.0	8.0	16.5	1.0	9.0	261.4	-170.4	42.0
1972	793.0	961.0	1404.3	1439.3	1478.3	31000.0	30800.0	30342.9	22230.0	14103.4	0.0	0.3	275.0	111.0	1.0	0.0	1.0	44.0	602.1	-342.1	36.0
1973	380.0	398.3	408.3	532.0	802.4	13300.0	13166.7	12628.6	7049.7	3506.8	0.0	0.2	205.0	85.0	5.0	23.4	1.0	3.0	203.2	-115.6	62.0
1974	1560.0	1563.3	1567.1	1646.0	1766.0	43500.0	42166.7	38742.9	27656.7	15233.2	0.0	0.3	35.0	116.0	0.0	0.0	1.0	47.0	657.4	-271.3	39.0
1975	1010.0	1050.0	1140.0	1245.0	1329.0	44000.0	43766.7	42800.0	32776.7	19982.5	0.0	0.2	19.0	125.0	1.0	3.0	2.0	33.0	651.5	-519.3	32.0
1976	526.0	491.3	471.6	384.9	272.4	27500.0	27233.3	25528.6	14000.7	6570.3	0.0	0.2	268.0	98.0	2.0	22.5	1.0	13.0	325.8	-167.8	42.0
1977	120.0	120.7	123.1	147.6	181.3	3250.0	3093.3	2818.6	1800.3	1281.2	0.0	0.2	343.0	101.0	8.0	21.4	0.0	0.0	81.0	-55.8	60.0
1978	664.0	683.7	778.7	993.3	872.1	56200.0	56100.0	54957.1	37103.3	16215.0	0.0	0.2	255.0	107.0	8.0	7.3	1.0	33.0	546.9	-328.0	42.0
1979	523.0	560.3	652.4	712.7	740.9	91000.0	90000.0	85514.3	53936.7	24124.5	0.0	0.1	324.0	119.0	2.0	13.5	2.0	20.5	942.5	-573.2	34.0
1980	394.0	398.0	403.4	470.4	546.8	22300.0	22066.7	20814.3	10054.0	4598.4	0.0	0.2	221.0	101.0	3.0	27.3	1.0	9.0	229.1	-180.4	57.0
1981	250.0	250.0	250.0	268.7	345.6	7380.0	6860.0	5242.9	2854.7	2161.6	0.0	0.2	35.0	185.0	7.0	11.4	0.0	0.0	177.4	-108.2	56.0
1982	912.0	924.7	937.7	993.1	1097.3	35400.0	35333.3	33900.0	23663.3	11864.3	0.0	0.2	35.0	107.0	5.0	10.8	1.0	27.0	436.8	-297.3	56.0
1983	1250.0	1256.7	1301.4	1453.3	1689.9	21300.0	21033.3	19742.9	13820.0	8033.8	0.0	0.3	275.0	100.0	0.0	0.0	1.0	11.0	542.9	-285.0	33.0
1984	834.0	770.0	682.7	661.2	1163.7	32400.0	32100.0	31142.9	20644.3	12199.1	0.0	0.2	274.0	97.0	1.0	37.0	2.0	17.0	582.6	-283.7	38.0
1985	298.0	305.3	346.0	1284.3	1374.8	17400.0	17266.7	16571.4	12283.3	8739.7	0.0	0.1	287.0	142.0	2.0	2.0	3.0	6.0	549.4	-328.9	48.0
1986	1600.0	1640.0	1640.0	1656.7	1865.8	29500.0	29233.3	28542.9	21943.3	15846.7	0.0	0.3	318.0	97.0	0.0	0.0	1.0	59.0	480.6	-239.1	39.0
1987	960.0	960.0	956.4	771.6	749.2	27500.0	27300.0	26185.7	18111.7	9257.0	0.0	0.2	259.0	98.0	3.0	11.7	1.0	22.0	475.0	-247.7	41.0
1988	144.0	145.7	158.3	206.5	295.4	13800.0	13233.3	12114.3	6837.7	3482.9	0.0	0.1	255.0	98.0	3.0	40.0	1.0	2.0	143.7	-100.2	59.0
1989	225.0	226.7	231.1	253.0	283.5	41800.0	41633.3	40500.0	25216.7	10315.7	0.0	0.1	351.0	110.0	4.0	25.5	1.0	25.0	404.8	-228.3	51.0
1990	110.0	110.0	117.9	144.7	225.1	5000.0	4953.3	4722.9	3063.3	2124.9	0.0	0.1	358.0	98.0	3.0	32.3	0.0	0.0	66.2	-55.7	79.0
1991	156.0	157.7	161.7	177.9	238.8	4940.0	4906.7	4731.4	3223.3	2701.0	0.0	0.1	3.0	193.0	6.0	10.5	0.0	0.0	130.8	-92.7	73.0
1992	449.0	453.7	455.0	494.4	510.2	8600.0	8500.0	8121.4	6461.3	4030.0	0.0	0.2	347.0	76.0	3.0	4.3	0.0	0.0	219.3	-131.7	60.0
1993	474.0	483.3	557.9	705.5	784.1	27500.0	27466.7	26942.9	23590.0	13669.3	0.0	0.1	337.0	226.0	2.0	72.5	2.0	27.0	380.9	-302.7	60.0
1994	1060.0	1086.7	1187.1	1478.7	1602.3	27900.0	27400.0	26114.3	19446.7	10461.4	0.0	0.2	333.0	97.0	1.0	3.0	2.0	21.0	641.3	-317.5	26.0
1995	1370.0	1366.7	1462.9	1736.7	1962.9	37800.0	37700.0	37500.0	32260.0	18228.1	0.0	0.2	274.0	92.0	0.0	0.0	3.0	18.0	805.4	-335.4	32.0
1996	1350.0	1423.3	1435.7	1560.7	1928.4	60500.0	60333.3	58285.7	41320.0	25252.7	0.0	0.2	275.0	116.0	0.0	0.0	2.0	31.0	795.8	-399.4	29.0
1997	1440.0	1530.0	1578.6	1716.3	2037.1	124000.0	122666.7	114571.4	69443.3	34534.6	0.0	0.1	275.0	115.0	0.0	0.0	2.0	43.0	1417.4	-872.1	32.0
1998	1700.0	1650.0	1658.6	1839.0	2622.3	28200.0	27833.3	26571.4	18488.7	13984.0	0.0	0.2	274.0	145.0	0.0	0.0	4.0	18.0	786.8	-389.5	33.0
1999	1610.0	1616.7	1671.4	1820.0	2238.2	59100.0	58566.7	56828.6	40476.7	24982.0	0.0	0.2	276.0	100.0	0.0	0.0	4.0	20.5	925.5	-721.0	30.0

Variance Data

	1-day min	3-day min	7-day min	30-day min	90-day min	1-day max	3-day max	7-day max	30-day max	90-day max	Zero days	Base flow	Date min	Date max	Lo pulse #	Lo pulse	Hi pulse #	Hi pulse	Rise rate	Fall rate	Reversals
Historical Distribution																					
1-day min	110.0	110.0	117.9	144.7	181.3	3250.0	3093.3	2818.6	1800.3	1281.2	0.0	0.1	3.0	76.0	0.0	0.0	0.0	0.0	66.2	-872.1	26.0
- 1 S.D.	272.7	281.1	302.7	372.4	401.1	7125.7	6994.6	6862.5	5409.8	3566.8	0.0	0.1	172.3	105.2	0.0	-3.1	0.3	3.3	190.5	-481.7	31.5
Mean	789.7	805.7	847.4	959.2	1105.5	33288.6	32944.1	31495.9	21414.7	11844.0	0.0	0.2	245.3	115.8	2.7	13.7	1.4	19.3	498.7	-291.7	45.6
+ 1 S.D.	1306.7	1330.3	1392.2	1546.1	1810.0	59451.5	58893.7	56129.3	37419.5	20121.2	0.0	0.3	318.4	126.3	5.4	30.4	2.5	35.2	806.9	-101.7	59.6
1-day max	1700.0	1650.0	1671.4	1839.0	2622.3	124000.0	122666.7	114571.4	69443.3	34534.6	0.0	0.3	358.0	226.0	8.0	72.5	4.0	59.0	1417.4	-55.7	79.0
CV[1]	65.5	65.1	64.3	61.2	63.7	78.6	78.8	78.2	74.7	69.9	--	36.8	29.8	9.1	98.9	122.3	76.6	82.8	61.8	-65.1	30.8

[1] CV=coefficient of variation (SD *100/mean)

APPENDIX D

HABITAT DATA

APPENDIX D

HABITAT DATA[1]
Final Aquatic Impact Analysis Report

	Habitat transect	Trans no.	Width (ft)		Depth (ft)		Velocity (ft/sec)		Substrate[2]		Cover		Comments	Sinuosity[3]	Bank Slope[3]		Channel slope[3]	Habitats[4]	
			Top	Channel	Min	Max	Min	Max	Banks	Mid channel	Banks	Midchannel			Left	Right	(ft/mile)	Near bank	Mid channel
Reach 1	L1	1	156	23	0.0	0.4	-0.1	1.5	50gr/50st-cl	100gr	0	0	mussels	1.83	3.3	2		shallow pool	slow riffle
		2	153	23	0.0	0.4	-0.2	0.8	100gr	5cb/95gr	boulder	0	mussels					shallow pool	shallow pool
		3	97	50	0.8	3.4	-0.1	0.1	50gr/50st-cl	10cb/20gr/20sd/50st-cl	veg	0						shallow pool	deep pool
		4	120	26	0.6	1.3	-0.1	0.1	75gr/25st-cl	10cb/70gr/20st-cl	0	0						shallow pool	shallow pool
		5	76	33	0.4	2.1	-0.1	0.1	10cb/40gr/50st-cl	10cb/80gr/10st-cl	boulder	0						shallow pool	shallow pool
		6	95	42	1.0	4.0	0.0	0.0	100st-cl	40sd/60st-cl	boulder/undercut/veg	0						shallow pool	deep pool
		7	116	34	0.3	1.6	-0.1	0.1	25gr/75st-cl	100gr	veg	boulder	mussels					shallow pool	shallow pool
		8	69	24	0.7	1.4	0.0	0.1	50gr/50st-cl	5cb/95gr	veg	0						shallow pool	shallow pool
		9	104	62	0.4	3.2	-0.1	0.1	100st-cl	5cb/45gr/25sd/25st-cl	0	0						shallow pool	medium pool
		10	154	27	0.7	1.0	-0.1	0.3	10gr/20sd/70st-cl	10gr/45sd/45st-cl	woody debris/veg	0	mussels					shallow pool	shallow pool
		11	121	26	0.1	0.4	0.0	0.3	25cb/75gr	40cb/60gr	0	veg	mussels					shallow pool	shallow pool
	K3	0	90	50	0.5	1.5	-0.1	0.1	5ru/20cb/60gr/15st-cl	30bd/50ru/10cb/10gr	0	0		1.81	2.2	1.7	1.2	shallow pool	shallow pool
		1	83	27	0.1	0.8	-0.3	0.2	10ru/20cb/10gr/20sd/40st-cl	10ru/80cb/10gr	0	0						shallow pool	shallow pool
		2	78	42	0.4	2.0	-0.1	0.0	15ru/5cb/5gr/75st-cl	30ru/20cb/50gr	0	0						shallow pool	shallow pool
		3	137	89	0.2	3.2	-0.1	0.0	100st-cl	100st-cl	0	boulder						shallow pool	medium pool
		4	119	57	0.4	2.6	-0.1	0.1	100st-cl	5cb/20gr/75st-cl	veg	0						shallow pool	medium pool
		5	117	67	0.2	1.3	-0.1	0.1	100st-cl	5bd/5cb/10gr/40sd/40st-cl	veg	0	mussels					shallow pool	shallow pool
		6	143	93	0.1	3.1	-0.1	0.1	100st-cl	5bd/5cb/5gr/5sd/80st-cl	veg/boulder	0						shallow pool	medium pool
		7	130	33	0.4	2.2	-0.1	0.1	100st-cl	75cb/25gr	boulder	0						shallow pool	medium pool
		8	123	38	0.1	1.7	0.0	0.1	25gr/75st-cl	10bd/10rb/10cb/70gr	undercut/veg	boulder	mussels					shallow pool	shallow pool
	J1	1	175	80	0.5	2.8	-0.1	0.1	100st-cl, detritus	10sd/90 st-cl, detritus	veg	0		1.04	8.3	6.9	1.2	shallow pool	medium pool
		2	194	80	0.4	2.6	0.0	0.1	100st-cl, detritus	100st-cl, detritus	veg	veg						shallow pool	medium pool
		3	203	90	0.4	2.8	0.0	0.1	100st-cl, detritus	40sd/60st-cl, detritus	veg	0						shallow pool	medium pool
		4	220	70	0.7	3.0	0.0	0.1	100st-cl, detritus	40sd/60st-cl, detritus	0	0			4.6	7.6		shallow pool	medium pool
	I4	1	75	54	0.1	1.0	-0.1	1.2	20bd/30ru/40cb/10gr	30bd/60ru/10cb	boulder	0	mussels	1.98	3.5	0.1	1.4	shallow pool	slow riffle
		2	87	54	0.5	2.4	-0.1	0.1	20gr/20sd/60st-cl	25ru/20cb/25gr/20sd/10st-cl	boulder/woody debris	0	mussels					shallow pool	medium pool
		3	78	57	0.1	2.4	0.0	0.2	30gr/70st-cl	10bd/10ru/25cb/25gr/25sd/5st-cl	veg/overhang/woody debris	boulder						shallow pool	medium pool
		4	83	55	1.0	3.0	-0.1	0.3	10cb/40gr/50st-cl	10bd/10ru/20cb/50gr/5sd/5st-cl	veg/overhang/woody debris	boulder	mussels					shallow pool	medium pool
		5	71	43	0.6	2.3	-0.1	0.4	20ru/10sd/70st-cl	5bd/15ru/20gr/30sd/30st-cl	boulder/woody debris	boulder/woody debris	mussels					shallow pool	medium pool
		6	104	46	0.1	2.2	-0.1	0.3	10bd/10ru/10cb/10gr/30sd/30st-cl	10bd/20ru/10cb/30gr/15sd/15st-cl	boulder	veg						shallow pool	medium pool
		7	91	46	0.1	3.0	-0.1	0.3	10ru/10cb/60sd/20st-cl	10bd/40ru/25cb/25sd	boulder	boulder	mussels					shallow pool	medium pool
		8	93	41	0.4	2.1	-0.1	0.3	10bd/10ru/10cb/5gr/30sd/35st-cl	50bd/30ru/20cb	veg/woody debris	boulder						shallow pool	medium pool

[1] EarthTech, Inc. 1998

[2] Bd=boulder, Cb=cobble, Ru=rubble, Gr=gravel, Sd=sand, St-cl=silt and/or clay

[3] WEST 2001

[4] Habitat definitions (Aadland 1993) see Table 4-15

APPENDIX D (cont.)

HABITAT DATA[1]
Final Aquatic Impact Analysis Report

	Habitat transect	Trans no.	Width (ft)		Depth (ft)		Velocity (ft/sec)		Substrate[2]		Cover		Comments	Sinuosity[3]	Bank Slope[3]		Channel slope[3]	Habitats[4]	
			Top	Channel	Min	Max	Min	Max	Banks	Mid channel	Banks	Midchannel			Left	Right	(ft/mile)	Near bank	Mid channel
Reach 1 (cont.)	H2	1	64	29	0.1	0.8	0.0	2.7	20cb/80gr	20cb/80gr	0	0	mussels	1.73	3.1	1.9	1.1	shallow pool	fast riffle
		2	70	32	0.3	2.1	-0.3	2.1	90gr/10sd	20cb/80gr	veg	0	mussels					shallow pool	raceway
		3	66	33	0.1	0.9	-0.1	2.8	90gr/10sd	90gr/10sd	veg	0	mussels					shallow pool	fast riffle
		4	60	35	0.1	1.2	-0.1	1.5	80gr/20sd	70cb/30gr	0	0						shallow pool	slow riffle
		5	67	53	0.1	2.6	-0.3	1.8	80gr/20sd	70bd/30gr	woody debris	boulder						shallow pool	raceway
		6	57	36	0.1	1.9	0.0	1.1	70gr/30sd	25bd/50cb/25gr	woody debris	boulder						shallow pool	slow riffle
		7	65	32	0.1	2.3	-0.1	1.0	90gr/10sd	40bd/30cb/30gr	0	boulder	mussels					shallow pool	raceway
		8	66	27	0.3	1.5	-0.2	1.5	40bd/40gr/20sd	30cb/50gr/20sd	undercut	0	mussels					shallow pool	slow riffle
		9	57	29	0.1	1.4	-0.2	1.3	30cb/60gr/10sd	80gr/20sd	0	0						shallow pool	slow riffle
	F2	1	90	46	0.7	2.7	0.0	0.3	10sd/90st-cl, detritus	10cb/60gr/20sd/10st-cl	veg	0	mussels	2.22	0.3	3.1	1.1	shallow pool	medium pool
		2	99	50	0.8	2.5	0.1	0.5	100st-cl, detritus	50gr/50st-cl	woody debris	woody debris	mussels					shallow pool	medium pool
Reach 3	E2	1	84	56	1.6	4.1	-0.1	0.8	100st-cl	30ru/30cb/20gr/20sd	overhang/veg	boulder		1.98	0.5	2.1	0.7	shallow pool	raceway
		2	113	70	0.1	2.4	0.0	1.4	100st-cl	50gr/50sd	veg	woody debris						shallow pool	raceway
		3	101	59	0.3	2	0.4	1.8	50sd/50st-cl	50ru/30cb/20sd	veg	none	mussels					shallow pool	raceway
		4	104	63	0.3	2	-0.1	2.8	50gr/50sd	40ru/20cb/40gr	woody debris	boulder						shallow pool	raceway
		5	147	60	0.1	3	-0.2	4.2	100st-cl	25bd/25ru/25gr/25sd	overhang/woody debris	boulder						shallow pool	raceway
		6	116	69	0.1	1.8	-0.3	3.2	30bd/10ru/20gr/20sd/20st-cl	40bd/30ru/10cb/20gr	overhang/woody debris/boulder	boulder			0.4	2.7		shallow pool	raceway
		7	112	75	0.1	2.1	-0.6	1.2	100st-cl	25bd/25ru/25gr/25sd	boulder	boulder	mussels					shallow pool	raceway
		8	126	72	0.7	4	0.1	0.4	100st-cl	50cb/30gr/20sd	boulder/overhang	overhang	mussels		0.5	1.9		shallow pool	deep pool
Reach 5	B3	1	56	52	0.1	10.6	-0.3	1.6	20sd/80st-cl	30gr/60sd/10st-cl	overhang	none		3.44	2.5	2.6	0.6	shallow pool	deep raceway
		2	56	52	1.8	7.5	-0.1	2.0	20sd/80st-cl	50sd/50st-cl	overhang/woody debris	woody debris						shallow pool	deep pool
		3	56	56	0.8	7.4	0.2	1.7	100st-cl	80sd/20st-cl	overhang/veg	woody debris						shallow pool	deep pool
		4	62	62	0.8	7.8	0.3	1.2	100st-cl	100st-cl	overhang/veg	woody debris			1.2	1.9		shallow pool	deep pool

[1] EarthTech, Inc. 1998

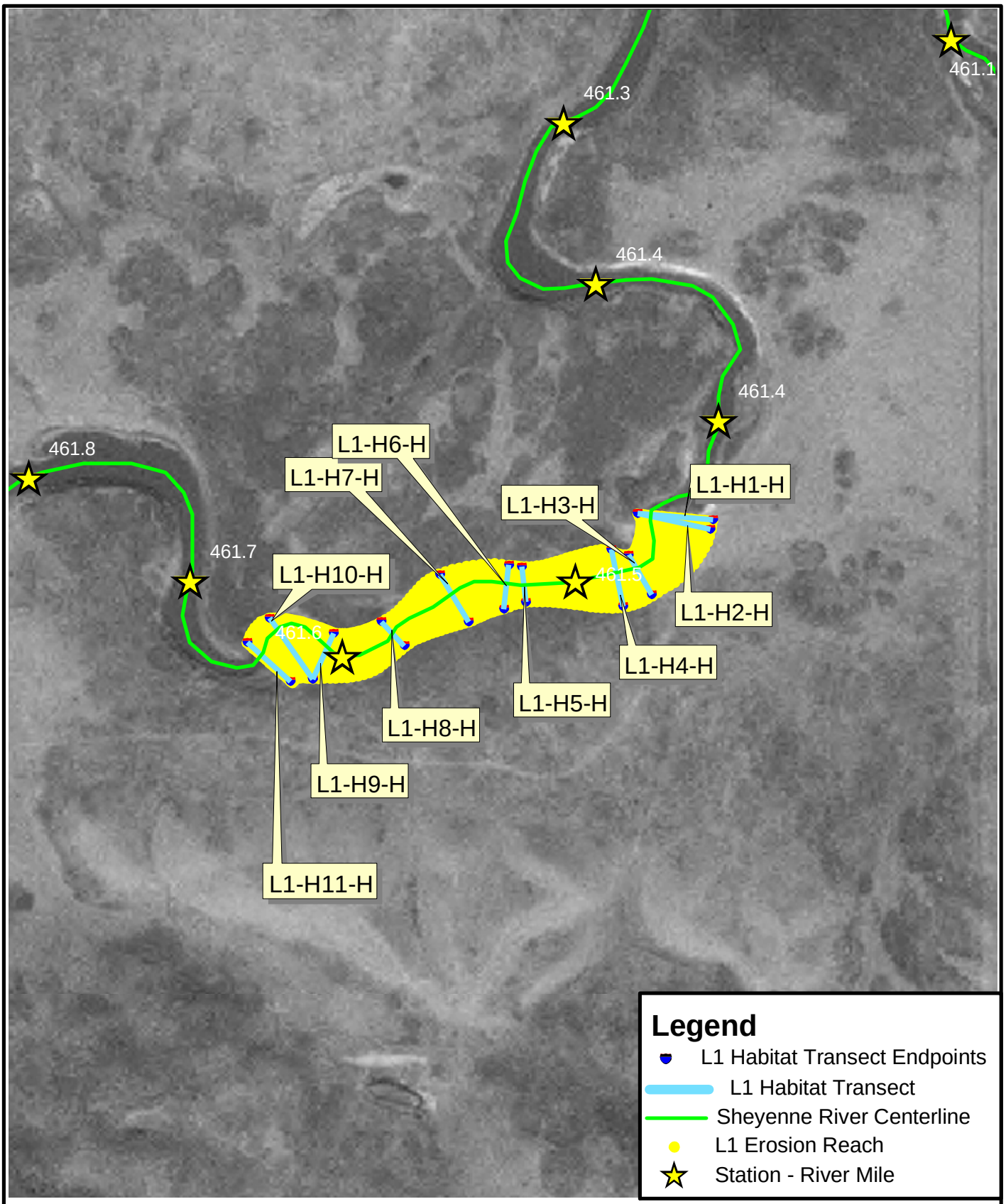
[2] Bd=boulder, Cb=cobble, Ru=rubble, Gr=gravel, Sd=sand, St-cl=silt and/or clay

[3] WEST 2001

[4] Habitat definitions (Aadland 1993) see Table 4-15

APPENDIX E

LOCATION OF HABITAT CROSS-SECTIONS



Map Source: U.S. Army Corps of Engineers DOQQ Data and Habitat Cross-Section Data, 2001.

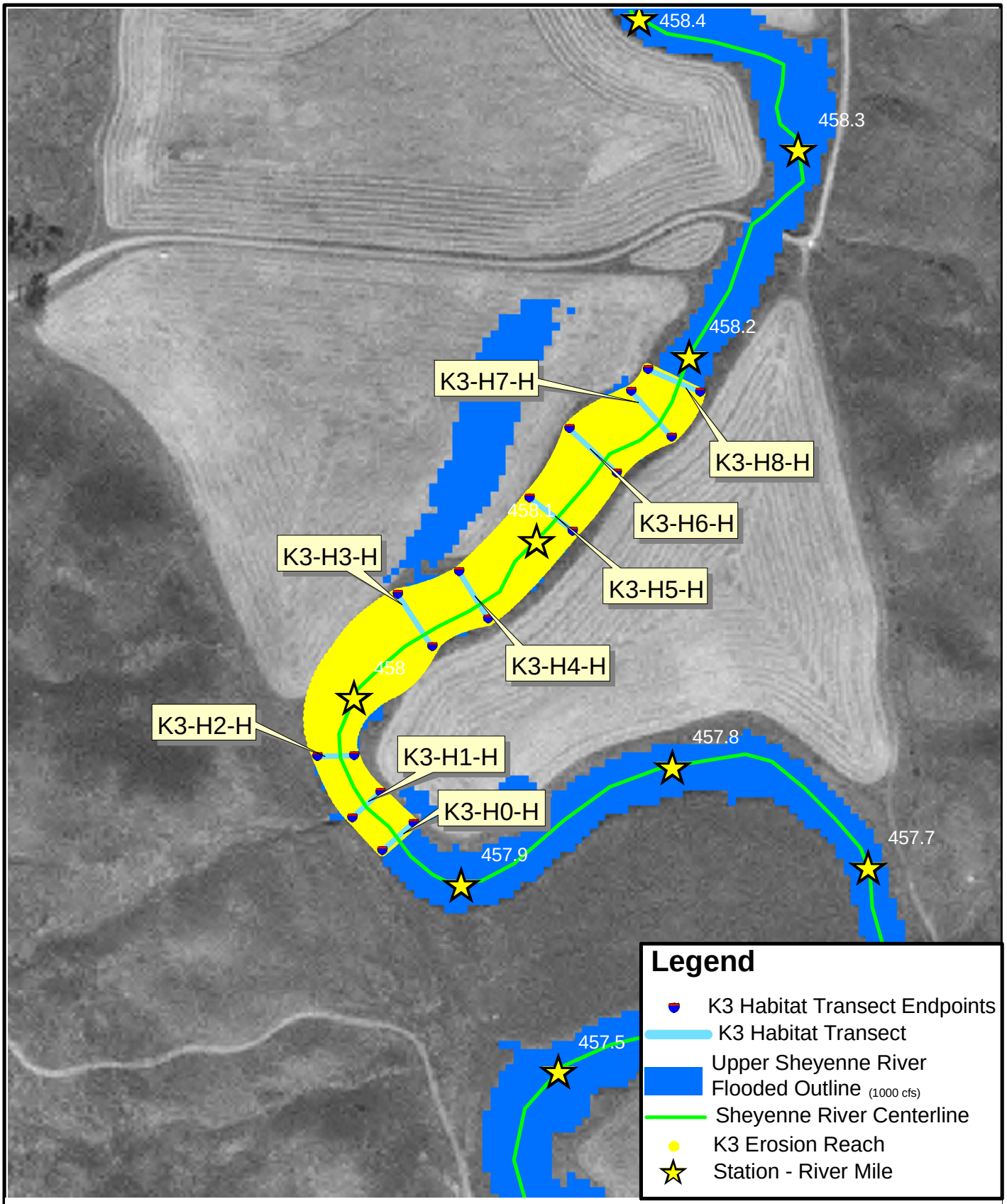
0 75 150 300 Feet

N W E S

APPENDIX E-1
LOCATION OF HABITAT CROSS-SECTIONS IN REACH L1
SHEYENNE RIVER, NORTH DAKOTA
Final Aquatic Impact Analysis Report

April 2002 DACW37-00-D0003, T.O. 0004

EARTH TECH



Map Source: U.S. Army Corps of Engineers DOQQ Data and Habitat Cross-Section Data, 2001.

N W E S

0 75 150 300 Feet

APPENDIX E-2
LOCATION OF HABITAT CROSS-SECTIONS IN REACH K3
SHEYENNE RIVER, NORTH DAKOTA
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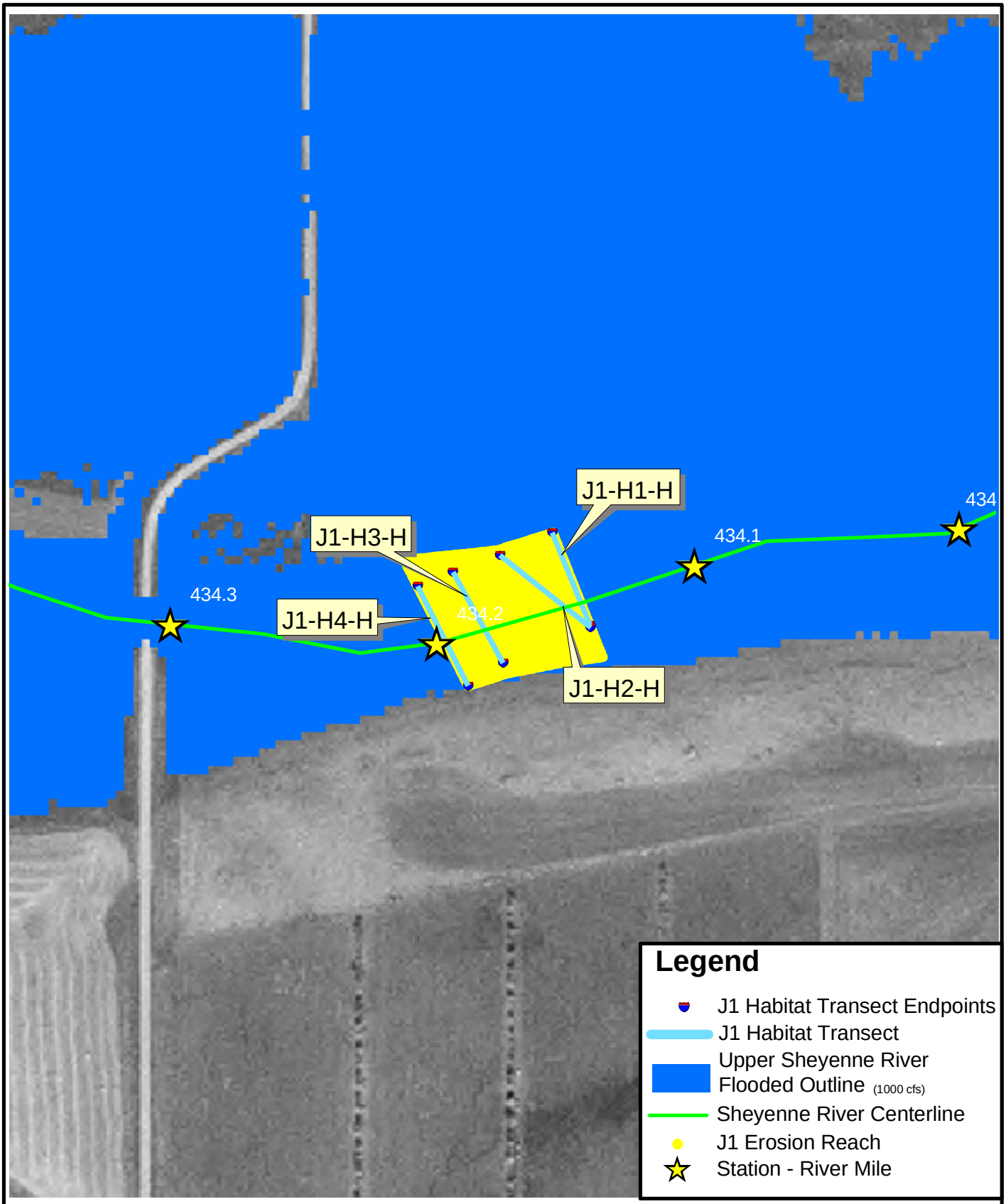
DACW37-00-D0003, T.O. 0004

EARTH TECH



Map Source: U.S. Army Corps of Engineers DOQQ Data and Habitat Cross-Section Data, 2001.

N W E S

0 80 160 320 Feet

APPENDIX E-3

LOCATION OF HABITAT CROSS-SECTIONS IN REACH J1

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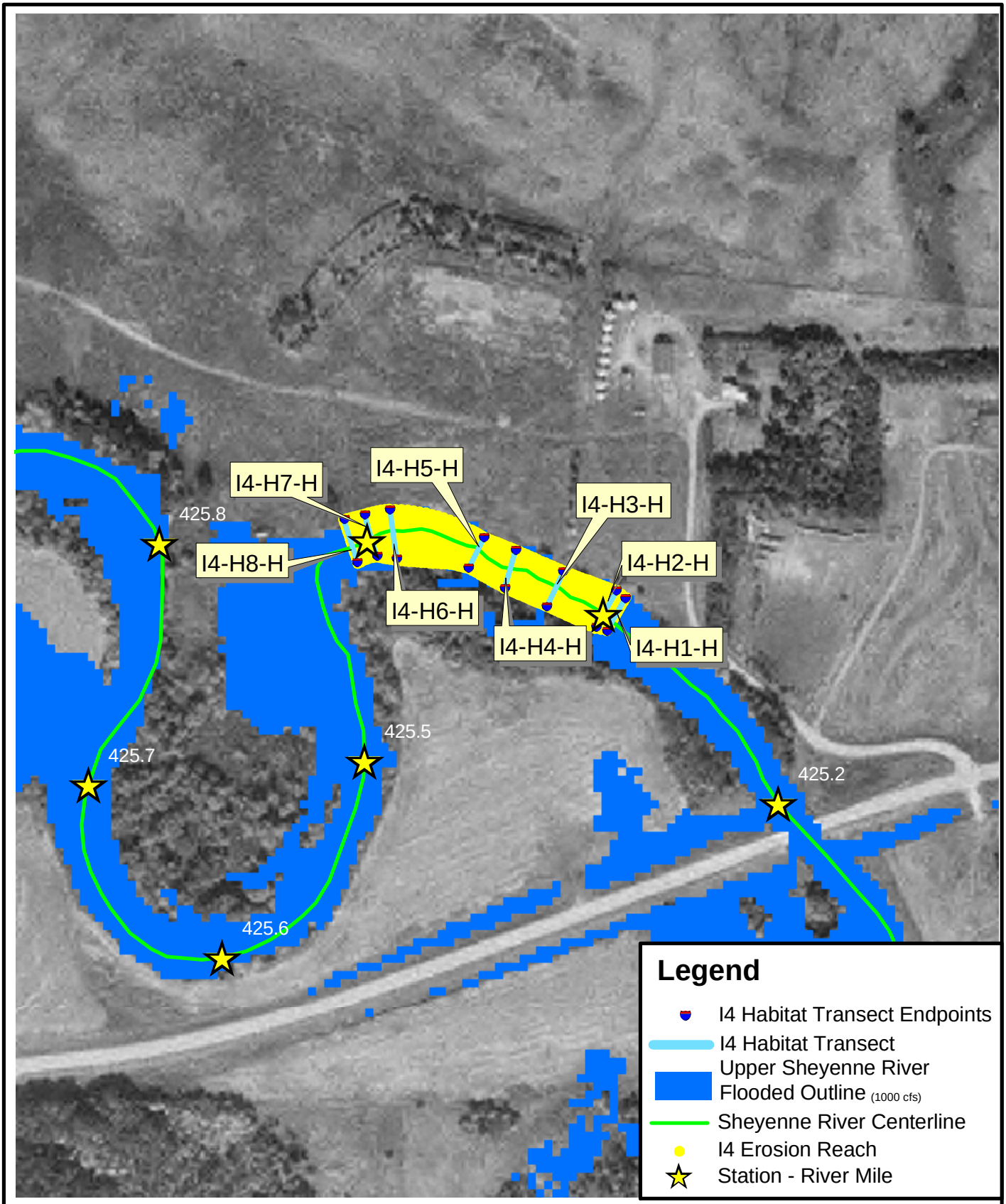
EARTH TECH



Map Source: U.S. Army Corps of Engineers DOQQ Data and Habitat Cross-Section Data, 2001.

0 75 150 300 Feet

N W E S

APPENDIX E-4

LOCATION OF HABITAT CROSS-SECTIONS IN REACH I4
SHEYENNE RIVER, NORTH DAKOTA
Final Aquatic Impact Analysis Report

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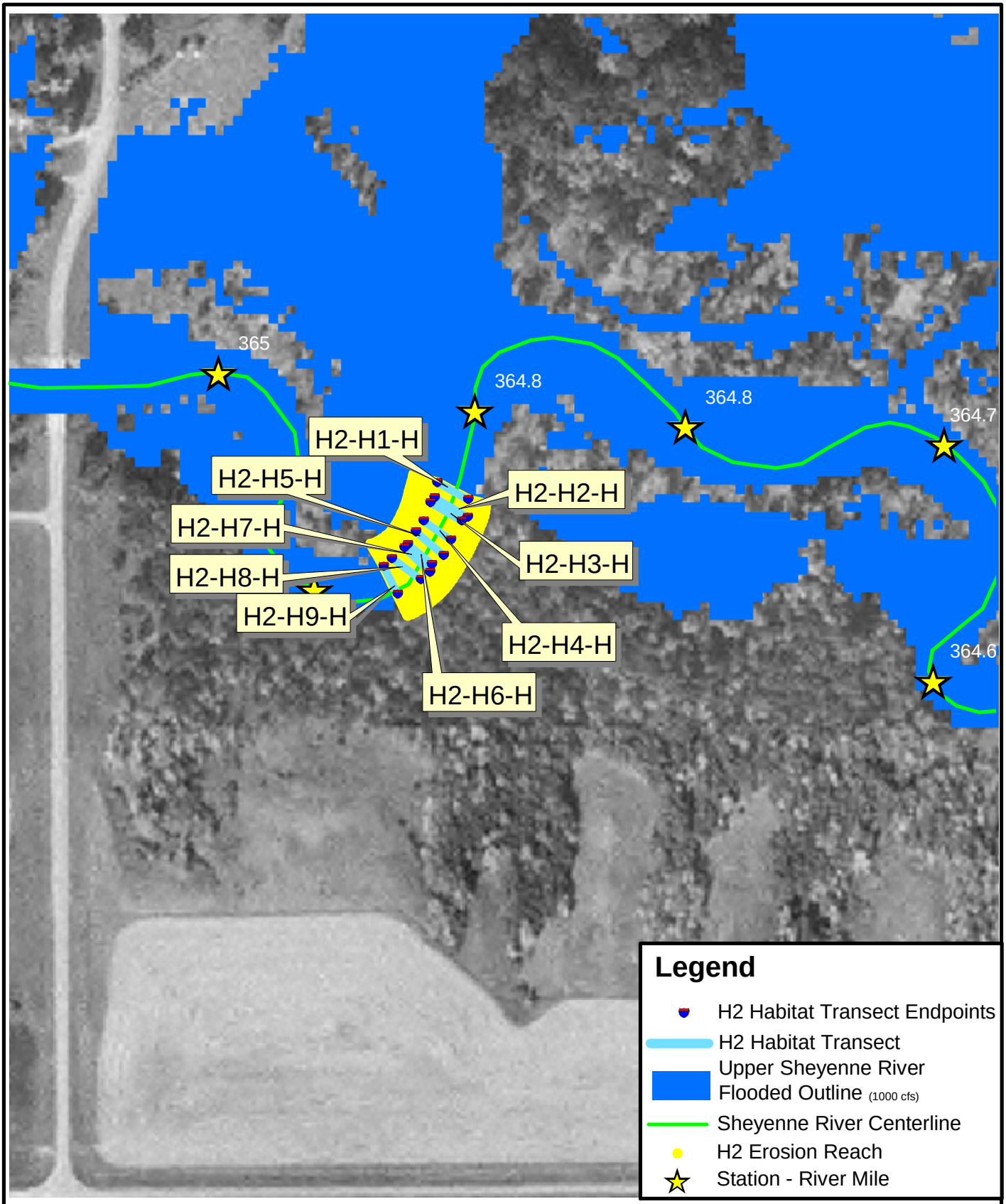
EARTH TECH



Map Source: U.S. Army Corps of Engineers DOQQ Data and Habitat Cross-Section Data, 2001.

0 80 160 320 Feet

N W E S

APPENDIX E-5

LOCATION OF HABITAT CROSS-SECTIONS IN REACH H2

SHEYENNE RIVER, NORTH DAKOTA

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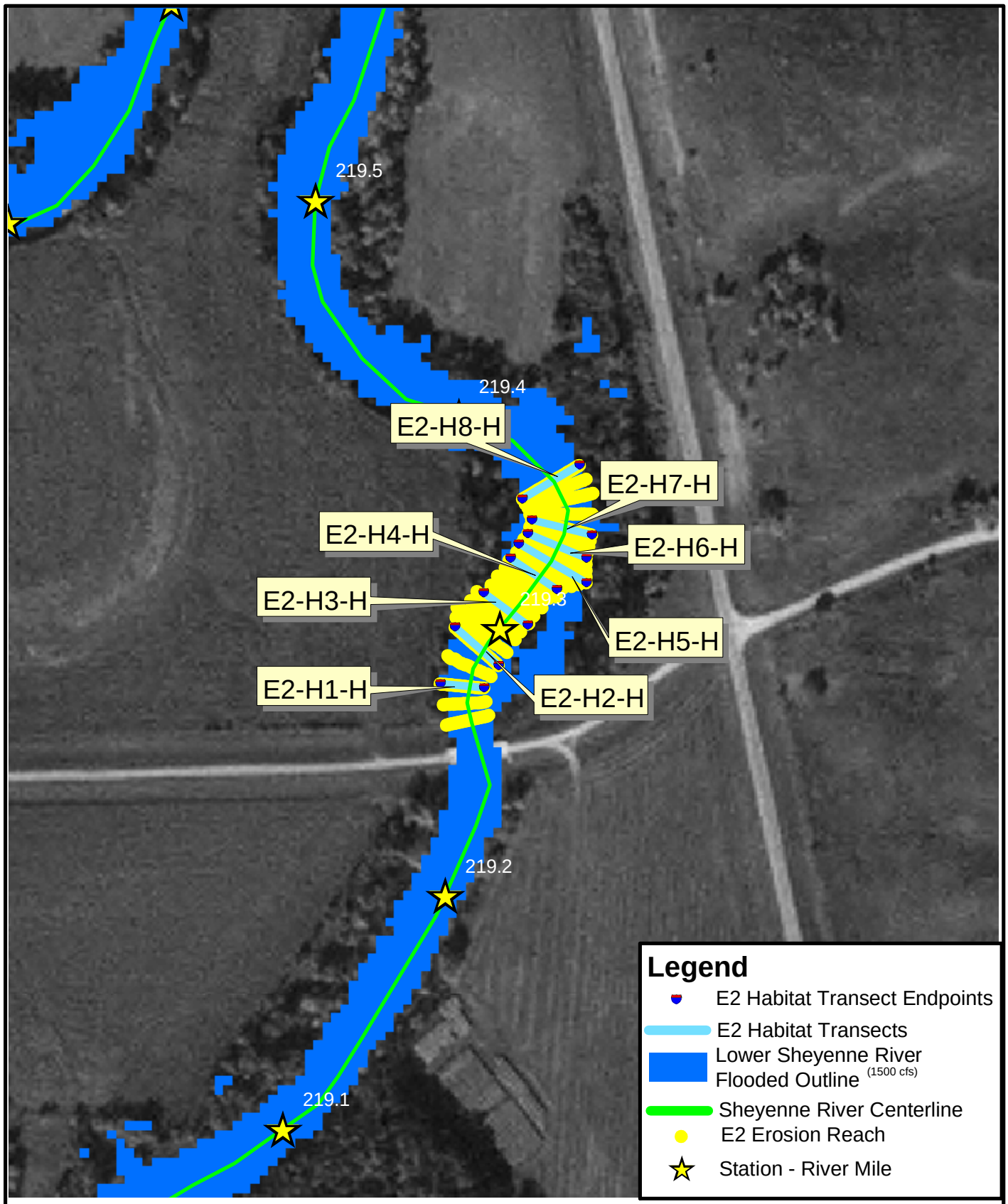
EARTH TECH



Map Source: U.S. Army Corps of Engineers DOQQ Data and Habitat Cross-Section Data, 2001.

0 75 150 300 Feet

APPENDIX E-6
LOCATION OF HABITAT CROSS-SECTIONS IN REACH E2
SHEYENNE RIVER, NORTH DAKOTA
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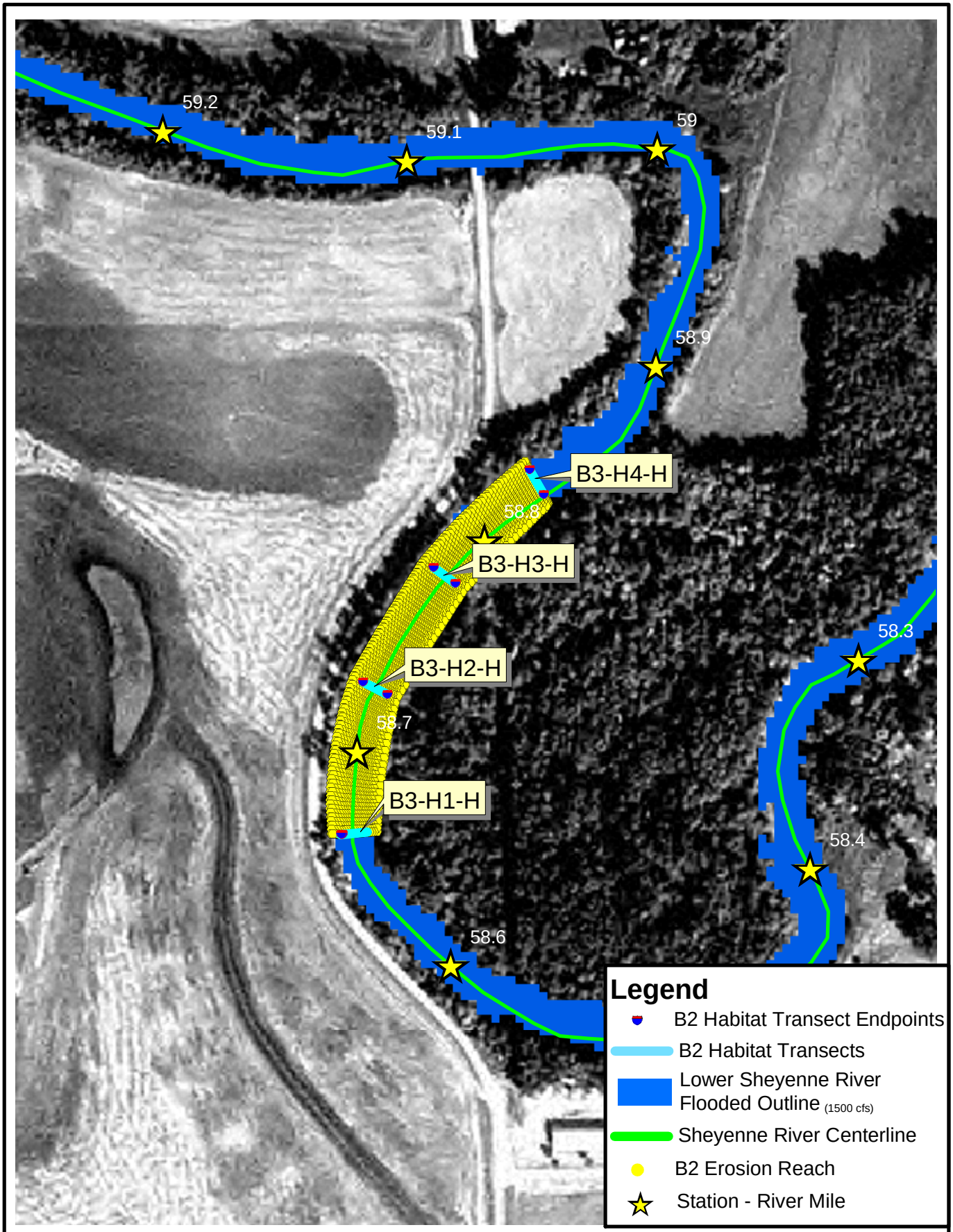
EARTH TECH



Map Source: U.S. Army Corps of Engineers DOQQ Data and Habitat Cross-Section Data, 2001.

0 80 160 320 Feet

APPENDIX E-7
LOCATION OF HABITAT CROSS-SECTIONS IN REACH B2
SHEYENNE RIVER, NORTH DAKOTA
Final Aquatic Impact Analysis Report

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EARTH TECH

APPENDIX F

PHOTOGRAPHS OF HABITAT CROSS-SECTIONS

B3 Habitat Transect

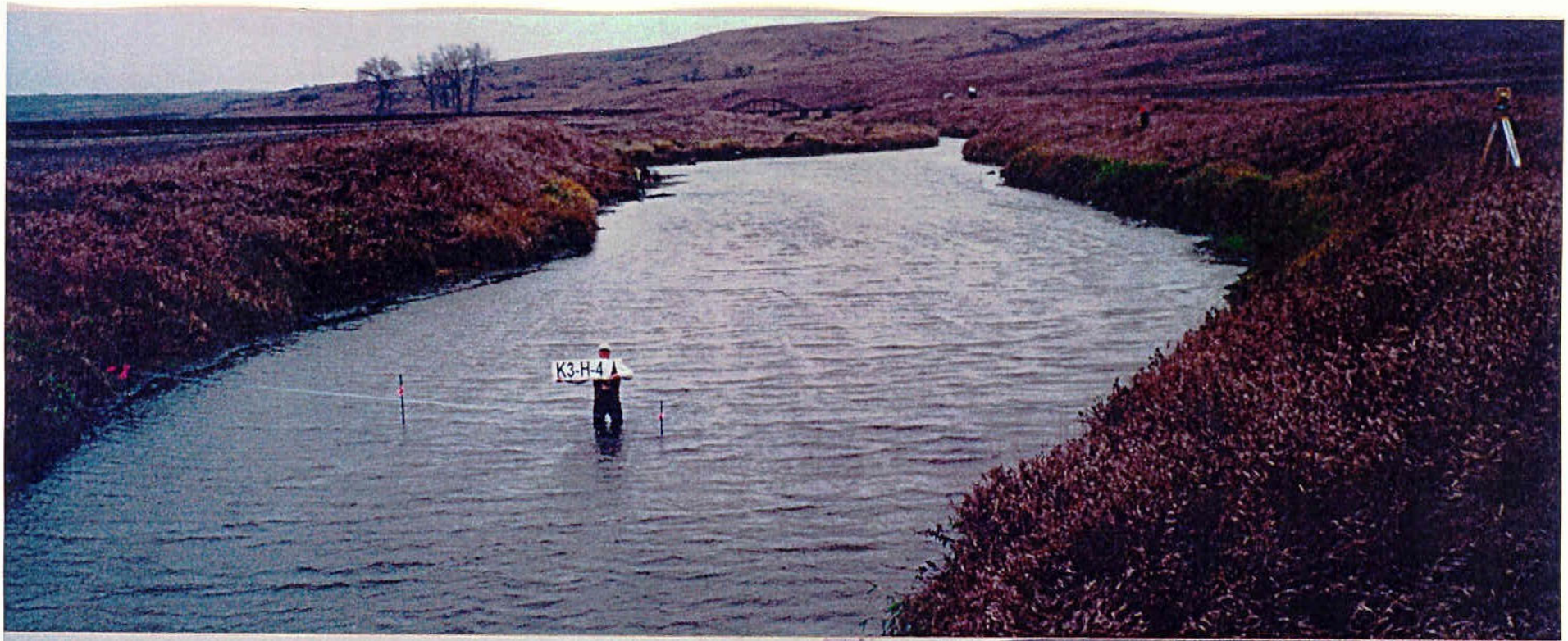
E2 Habitat Transect

F2 Habitat Transect

H2 Habitat Transect

14 Habitat Transect

J1 Habitat Transect



K3 Habitat Transect

L1 Habitat Transect

APPENDIX G

COMPARISON OF UNIONIDS AND FISH HOST SPECIES OCCURENCES IN THE SHEYENNE RIVER

APPENDIX G-1

COMPARISON OF UNIONIDS AND FISH HOST SPECIES[1] OCCURRENCE IN SHEYENNE RIVER REACH 1

Final Aquatic Impact Analysis Report

	Ambleminae		Anodontinae					Lampsilinae	
	Amblema plicata	*Fusconaia flava*	*Anodontoides ferussacianus*	*Lasmigona complanata*	*Lasmigona compressa*	*Pyganodon grandis*	*Strophitus undulatus*	*Lampsilis cardium*[2]	*Lampsilis siliquoidea*
Salmonidae									
Onchorynchus mykiss									
Esocidae									
Esox lucius	x								
Cyprinidae									
Luxilus cornutus			n		n	x	x		
Notemigonus chrysoleucas						x			
Notropis blennius	n								
Notropis hudsonius									
Notropis stramineus							x		
Rhinichthys atratulus			n			x	x		
Rhinichthys cataractae							x		
Semotilus atromaculatus		x	n		n	x*	x		
Catastomidae									
Catostomus commersoni			n			x*			x
Ictaluridae									
Ameiurus melas	x						x		
Ameiurus nebulosus	x						x		
Notorus gyrinus									
Percopsidae									
Percopsis omiscomaycus									
Gasterosteidae									
Culea inconstans					x-n	x	x		
Percichthyidae									
Morone chrysops	n					n			x
Centrarchidae									
Lepomis gibbosus	x	x				x	x		x
Lepomis humilis				x		x			x*
Lepomis macrochirus	x		x			x	x	x*	xx
Micropterus dolomieu						x	x	x	x
Micropterus salmoides	x		x	x		x	x	x	xx
Pomoxis annularis	xx	x-n		x		x	x		x
Pomoxis nigromaculatus	x	x-n	x		x	x	x	x	x
Percidae									
Etheostoma exile			n			x	x		
Etheostoma nigrum						x	x		
Perca flavescens	x				x	x	x	x	x
Percina maculata							x		
Stizostedion vitreum						x	x	x	x

[1] Identification of fish hosts based on Hillegass and Hove 1997; Hove and Haas 2001; Hove *et al* . 1995a, 1995b, 1997; Keller and Ruessler 1997; Milam *et al* . 1998; O'Dee and Watters 2000; Watters 1994, 1995; Watters and O'Dee 1997, 1999; Watters *et al.* 1998; Weiss and Layzer 1995; van Snik Gray *et al.* 1999.

[2] Shells of this species were collected, but no live specimens were found.

n - natural infestation was observed.

x - artificial infestation experiments produced juveniles and, in some cases, natural infestation was observed as well.

x* - conflicting results, artificial infestation experiments produced juveniles more often than artificial infestation did not produce juveniles.

x** - conflicting results, artificial infestation experiments did not produce juveniles more often than artificial infestation produced juveniles.

x-n - natural infestation observed, but artificial infestation experiments did not produce juveniles.

xx - 10 or more tests conducted, both natural infestation observed and artificial infestation experiments produced juveniles.

APPENDIX G-2

OMPARISON OF UNIONIDS AND FISH HOST SPECIES[1] OCCURRENCE IN SHEYENNE RIVER REACH

Final Aquatic Impact Analysis Report

	Ambleminae		Anodontinae			Lampsilinae	
	Amblema plicata	*Fusconaia flava* [2]	*Lasmigona complanata*	*Pyganodon grandis*	*Strophitus undulatus* [2]	*Lampsilis siliquoidea*	*Ligumia recta* [2]
Esocidae							
Esox lucius	x						
Cyprinidae							
Luxilus cornutus				x	x		
Notropis dorsalis							
Notropis hudsonius							
Rhinichthys atratulus				x	x		
Rhinichthys cataractae					x		
Semotilus atromaculatus		x		x*	x		
Catastomidae							
Catostomus commersoni				x*		x	
Ictaluridae							
Ameiurus melas	x				x		
Ameiurus nebulosus	x				x		
Notorus gyrinus							
Percopsidae							
Percopsis omiscomaycus							
Percichthyidae							
Morone chrysops	n			n		x	
Centrarchidae							
Lepomis cyanellus	x		x	x	x*	x	x**
Lepomis gibbosus	x	x		x	x	x	x**
Lepomis humilis			x	x		x*	x
Lepomis macrochirus	x			x	x	xx	x
Micropterus dolomieu				x	x	x	
Micropterus salmoides	x		x	x	x	xx	x*
Pomoxis annularis	xx	x-n	x	x	x	x	x
Pomoxis nigromaculatus	x	x-n		x	x	x	x**
Percidae							
Etheostoma exile				x	x		
Etheostoma nigrum				x	x		
Perca flavescens	x			x	x	x	x**
Percina maculata					x		
Stizostedion vitreum				x	x	x	x

[1] Identification of fish hosts based on Hillegass and Hove 1997; Hove and Haas 2001; Hove *et al.* 1994a, 1994b, 1995a, 1995b, 1997, 1998; Keller and Ruessler 1997; Khym and Layzer 2000; Milam *et al.* 1998; O'Dee and Watters 2000; Steg and Neves 1997; Watters 1994, 1995; Watters and O'Dee 1997, 1999; Watters *et al.* 1998, 1999; Weiss and Layzer 1995; van Snik Gray *et al.* 1999.

[2] Shells of this species were collected, but no live specimens were found.

n - natural infestation was observed.

x - artificial infestation experiments produced juveniles and, in some cases, natural infestation was observed as well.

x* - conflicting results, artificial infestation experiments produced juveniles more often than artificial infestation did not produce juveniles.

x** - conflicting results, artificial infestation experiments did not produce juveniles more often than artificial infestation produced juveniles.

x-n - natural infestation observed, but artificial infestation experiments did not produce juveniles.

xx - 10 or more tests conducted, both natural infestation observed and artificial infestation experiments produced juveniles.

APPENDIX G-3

COMPARISON OF UNIONIDS AND HOST FISH SPECIES[1] OCCURRENCE IN SHEYENNE RIVER REACH 3

Final Aquatic Impact Analysis Report

	Ambleminae			Anodontinae					Lampsilinae			
	Amblema plicata	*Fusconaia flava*	*Quadrula quadrula*[2]	*Anodontoides ferussacianus*	*Lasmigona complanata*	*Lasmigona compressa*	*Pyganodon grandis*	*Strophitus undulatus*	*Lampsilis cardium*	*Lampsilis siliquoidea*	*Ligumia recta*	*Potamilus alatus*
Petromyzontidae												
Ichthyomyzon castaneus												
Hiodontidae												
Hiodon alosoides												
Esocidae												
Esox lucius	x											
Cyprinidae												
Cyprinella spiloptera	n			x		x*		x				
Cyprinus carpio					x		x					
Hybognathus hankinsoni				n								
Luxilus cornutus				n		n	x					
Nocomis biguttatus				n								
Notemigonus chrysoleucas							x					
Notropis anogenus												
Notropis blennius												
Notropis dorsalis												
Notropis heterolepis				n			x					
Notropis hudsonius												
Notropis rubellus											x	
Notropis stramineus								x				
Pimephales notatus				n			x	x*				
Rhinichthys atratulus				n			x	x				
Rhinichthys cataractae								x				
Semotilus atromaculatus		x		n		n		x				
Catostomidae												
Catostomus commersoni				n			x*			x		
Moxostoma anisurum												
Moxostoma erythrurum	n											
Moxostoma macrolepidotum												
Moxostoma valenciennesi												
Ictaluridae												
Ameiurus melas	x							x				
Ameiurus nebulosus	x							x				
Ictalurus punctatus	x-n							x				
Notorus flavus												
Notorus gyrinus										x		
Percopsidae												
Percopsis omiscomaycus												
Cyprinodontidae												
Fundulus diaphanus					x		x		x	n	x	
Gasterosteidae												
Culea inconstans						x-n	x	x				
Percichthyidae												
Morone chrysops	n						n			x		
Centrarchidae												
Ambloplites rupestris	x					n	x	x		x	x*	
Lepomis cyanellus	x				x		x	x*	x	x	x**	
Lepomis gibbosus	x	x					x	x		x	x**	
Lepomis humilis					x		x			x*	x	
Lepomis macrochirus	x			x			x	x	x*	xx	x	
Micropterus dolomieu							x	x	x	x		
Micropterus salmoides	x			x	x		x	x	x	xx	x*	
Pomoxis annularis	x	x-n			x		x	x**	x*	x	x	
Pomoxis nigromaculatus	x	x-n		x		x	x	x	x	x		
Percidae												
Etheostoma exile				n			x	x				
Etheostoma nigrum							x	x				
Perca flavescens	x					x	x	x	x	x	x**	
Percina maculata								x				
Percina shumardi												
Stizostedion vitreum							x	x	x	x	x	
Sciaenidae												
Aplodinotus grunniens	n						n					x

[1] Identification of fish hosts based on Hillegass and Hove 1997; Hove and Haas 2001; Hove *et al.* 1994a, 1994b, 1995a, 1995b, 1997, 1998; Keller and Ruessler 1997; Khym and Layzer 2000; Milam *et al.* 1998; O'Dee and Watters 2000; Steg and Neves 1997; Watters 1994, 1995; Watters and O'Dee 1997, 1999; Watters *et al.* 1998, 1999; Weiss and Layzer 1995; van Snik Gray *et al.* 1999.

[2] Reported live by Kreil *et al*. (unpublished manuscript) in lower Sheyenne, but no site specific data was available.

n - natural infestation was observed.

x - artificial infestation experiments produced juveniles and, in some cases, natural infestation was observed as well.

x* - conflicting results, artificial infestation experiments produced juveniles more often than artificial infestation did not produce juveniles.

x** - conflicting results, artificial infestation experiments did not produce juveniles more often than artificial infestation produced juveniles.

x-n - natural infestation observed, but artificial infestation experiments did not produce juveniles.

xx - 10 or more tests conducted, both natural infestation observed and artificial infestation experiments produced juveniles.

APPENDIX G-4

COMPARISON OF UNIONIDS AND FISH HOST SPECIES[1] OCCURRENCE IN SHEYENNE RIVER REACH 4

Final Aquatic Impact Analysis Report

	Ambleminae			Anodontinae					Lampsilinae			
	Amblema plicata	*Fusconaia flava*	*Quadrula quadrula*[2]	*Anodontoides ferussacianus*	*Lasmigona complanata*	*Lasmigona compressa*	*Pyganodon grandis*	*Strophitus undulatus*	*Lampsilis cardium*[2]	*Lampsilis siliquoidea*	*Ligumia recta*	*Potamilus alatus*
Hiodontidae												
Hiodon tergisus	x											
Esocidae												
Esox lucius	x											
Cyprinidae												
Cyprinella spiloptera	n			x		x*		x				
Cyprinus carpio					x		x					
Hybognathus hankinsoni				n								
Luxilus cornutus				n		n	x					
Notemigonus chrysoleucas							x					
Notropis atherinoides	n											
Notropis blennius												
Notropis dorsalis												
Notropis heterodon							x					
Notropis heterolepis				n			x					
Notropis hudsonius												
Notropis rubellus											x	
Notropis stramineus								x				
Phoxinus eos				n				x				
Pimephales notatus				n			x	x**				
Rhinichthys atratulus				n			x	x				
Rhinichthys cataractae								x				
Semotilus atromaculatus		x		n		n		x				
Catostomidae												
Carpiodes cyprinus												
Catostomus commersoni				n			x*			x		
Moxostoma anisurum												
Moxostoma erythrurum	n											
Moxostoma macrolepidotum												
Moxostoma valenciennesi												
Ictaluridae												
Ameiurus melas	x							x				
Ictalurus punctatus	x-n							x				
Notorus flavus												
Notorus gyrinus										x		
Percopsidae												
Percopsis omiscomaycus												
Gasterosteidae												
Culea inconstans						x-n	x	x				
Centrarchidae												
Ambloplites rupestris	x					n	x	x		x	x**	
Lepomis gibbosus	x	x					x	x		x	x**	
Percidae												
Etheostoma exile				n			x	x				
Etheostoma nigrum							x	x				
Perca flavescens	x					x	x	x	x	x	x**	
Stizostedion vitreum							x	x	x	x	x	

[1] Identification of fish hosts based on Hillegass and Hove 1997; Hove and Haas 2001; Hove *et al*. 1994a, 1994b, 1995a, 1995b, 1997, 1998; Keller and Ruessler 1997; Khym and Layzer 2000; Milam *et al*. 1998; O'Dee and Watters 2000; Steg and Neves 1997; Watters 1994, 1995; Watters and O'Dee 1997, 1999; Watters *et al*. 1998, 1999; Weiss and Layzer 1995; van Snik Gray *et al*. 1999.

[2] Reported live by Kreil *et al*. (unpublished manuscript) in lower Sheyenne, but no site specific data was available.

n - natural infestation was observed.

x - artificial infestation experiments produced juveniles and, in some cases, natural infestation was observed as well.

x* - conflicting results, artificial infestation experiments produced juveniles more often than artificial infestation did not produce juveniles.

x** - conflicting results, artificial infestation experiments did not produce juveniles more often than artificial infestation produced juveniles.

x-n - natural infestation observed, but artificial infestation experiments did not produce juveniles.

xx - 10 or more tests conducted, both natural infestation observed and artificial infestation experiments produced juveniles.

APPENDIX G-5

COMPARISON OF UNIONIDS AND FISH HOST SPECIES[1] OCCURRENCE IN SHEYENNE RIVER REACH 5

Final Aquatic Impact Analysis Report

	Ambleminae			Anodontinae					Lampsilinae			
	Amblema plicata	*Fusconaia flava*	*Quadrula quadrula* [2,3]	*Anodontoides ferussacianus*	*Lasmigona complanata*	*Lasmigona compressa*	*Pyganodon grandis*	*Strophitus undulatus*	*Lampsilis cardium*	*Lampsilis siliquoidea*	*Ligumia recta*	*Potamilus alatus*
Hiodontidae												
Hiodon alosoides												
Esocidae												
Esox lucius	x											
Cyprinidae												
Cyprinella spiloptera	n			x		x*		x				
Cyprinus carpio					x		x					
Hybognathus hankinsoni				n								
Luxilus cornutus				n		n	x					
Macrhybopsis storeiana												
Notropis atherinoides	n											
Notropis dorsalis												
Notropis hudsonius												
Notropis stramineus								x				
Pimephales notatus				n			x	x**				
Catostomidae												
Carpiodes cyprinus												
Catostomus commersoni				n			x*			x		
Ictiobus cyprinellus												
Moxostoma anisurum												
Moxostoma erythrurum	n											
Moxostoma macrolepidotum												
Ictaluridae												
Ameiurus melas	x							x				
Ictalurus punctatus	x-n							x				
Notorus flavus												
Notorus gyrinus										x		
Percopsidae												
Percopsis omiscomaycus												
Centrarchidae												
Ambloplites rupestris	x					n	x	x		x	x**	
Lepomis cyanellus	x				x		x	x*	x	x	x**	
Pomoxis annularis	x	x-n			x		x	x**	x*	x	x	
Pomoxis nigromaculatus	x	x-n		x		x	x	x	x	x		
Percidae												
Etheostoma nigrum							x	x				
Stizostedion canadense	n				n				n	x	x	
Stizostedion vitreum							x	x	x	x	x	
Sciaenidae												
Aplodinotus grunniens	n						n					x

[1] Identification of fish hosts based on Hillegass and Hove 1997; Hove and Haas 2001; Hove *et al* . 1994a, 1994b, 1995a, 1995b, 1997, 1998; Keller and Ruessler 1997; Khym and Layzer 2000; Milam *et al.* 1998; O'Dee and Watters 2000; Steg and Neves 1997; Watters 1994, 1995; Watters and O'Dee 1997, 1999; Watters *et al.* 1998, 1999; Weiss and Layzer 1995; van Snik Gray *et al.* 1999.

[2] Shells of this species were collected, but no live specimens were found.

[3] Reported live by Kreil *et al* . (unpublished manuscript) in lower Sheyenne, but no site specific data was available.

n - natural infestation was observed.

x - artificial infestation experiments produced juveniles and, in some cases, natural infestation was observed as well.

x* - conflicting results, artificial infestation experiments produced juveniles more often than artificial infestation did not produce juveniles.

x** - conflicting results, artificial infestation experiments did not produce juveniles more often than artificial infestation produced juveniles.

x-n - natural infestation observed, but artificial infestation experiments did not produce juveniles.

xx - 10 or more tests conducted, both natural infestation observed and artificial infestation experiments produced juveniles.

APPENDIX G-6

COMPARISON OF UNIONIDS AND FISH HOST[1] OCCURRENCE IN THE RED RIVER OF THE NORTH REACH 1

Final Aquatic Impact Analysis Report

	Ambleminae			Anodontinae				Lampsilinae				
	Amblema plicata	*Fusconaia flava*	*Quadrula quadrula*	*Anodontoides ferussacianus*	*Lasmigona complanata*	*Pyganodon grandis*	*Strophitus undulatus*	*Lampsilis cardium*	*Lampsilis siliquoidea*	*Ligumia recta*	*Potamilus alatus*	*Potamilus ohiensis*
Petromyzontidae												
Ichthyomyzon castaneus												
Ichthyomyzon unicuspis												
Hiodontidae												
Hiodon alosoides												
Hiodon tergisus	n											
Osmeridae												
Osmerus mordax(?)												
Esocidae												
Esox lucius	x											
Cyprinidae												
Cyprinella spiloptera	n			x			x					
Cyprinus carpio					x	x						
Luxilus cornutus				n		x						
Macrhybopsis storeiana												
Notemigonus chrysoleucas(?)						x						
Notropis atherinoides	n											
Notropis blennius												
Notropis dorsalis												
Notropis hudsonius												
Notropis rubellus										x		
Notropis stramineus							x					
Notropis volucellus												
Pimephales notatus(?)				n		x	x*					
Rhinichthys cataractae							x					
Semotilus atromaculatus		x		x			x					
Catostomidae												
Carpiodes cyprinus												
Catostomus commersoni				n		x*			x			
Moxostoma anisurum												
Moxostoma erythrurum	n											
Moxostoma macrolepidotum												
Moxostoma valenciennesi(?)												
Ictaluridae												
Ameiurus melas	x						x					
Ictalurus punctatus	x-n						x					
Notorus flavus												
Notorus gyrinus									x			
Centrarchidae												
Ambloplites rupestris	x					x	x		x	x**		
Lepomis cyanellus(?)	x				x	x	x*	x	x	x**		
Lepomis gibbosus(?)	x	x				x	x		x	x**		
Lepomis humilis(?)					x	x			x*	x		
Lepomis macrochirus(?)	x			x		x	x	x*	xx	x		
Micropterus salmoides(?)	x			x	x	x	x	x	xx	x*		
Pomoxis nigromaculatus	x	x-n		x		x	x	x	x			
Percopsidae												
Percopsis omiscomaycus												
Gadidae												
Lota lota							x					
Gasterosteidae												
Culea inconstans						x	x					
Percichthyidae												
Morone chrysops	n					n			x			
Percidae												
Etheostoma exile(?)				n		x	x					
Stizostedion canadense	n				n			n	x		x	
Stizostedion vitreum						x	x	x	x	x		
Sciaenidae												
Aplodinotus grunniens	x					n					x	n

[1] Identification of fish hosts based on Hillegass and Hove 1997; Hove and Haas 2001; Hove *et al.* 1994a, 1994b, 1995a, 1995b, 1997, 1998; Keller and Ruessler 1997; Khym and Layzer 2000; Milam *et al.* 1998; O'Dee and Watters 2000; Steg and Neves 1997; Watters 1994, 1995; Watters and O'Dee 1997, 1999; Watters *et al.* 1998, 1999; Weiss and Layzer 1995; van Snik Gray *et al.* 1999.

? - indicates species was found in river but site specific data was not available.

n - natural infestation was observed.

x - artificial infestation experiments produced juveniles and, in some cases, natural infestation was observed as well.

x* - conflicting results, artificial infestation experiments produced juveniles more often than artificial infestation did not produce juveniles.

x** - conflicting results, artificial infestation experiments did not produce juveniles more often than artificial infestation produced juveniles.

x-n - natural infestation observed, but artificial infestation experiments did not produce juveniles.

xx - 10 or more tests conducted, both natural infestation observed and artificial infestation experiments produced juveniles.

APPENDIX G-7

COMPARISON OF UNIONIDS AND HOST[1] FISH SPECIES OF THE RED RIVER OF THE NORTH REACH 2

Final Aquatic Impact Analysis Report

	Ambleminae			Anodontinae			Lampsilinae			
	Amblema plicata	*Fusconaia flava*	*Quadrula quadrula*	*Anodontoides ferussacianus*	*Lasmigona complanata*	*Pyganodon grandis*	*Lampsilis cardium*	*Lampsilis siliquoidea*	*Ligumia recta*	*Potamilus alatus*
Petromyzontidae										
Ichthyomyzon castaneus										
Hiodontidae										
Hiodon alosoides										
Hiodon tergisus	n									
Osmeridae										
Osmerus mordax(?)										
Esocidae										
Esox lucius	x									
Cyprinidae										
Cyprinella spiloptera	n			x						
Cyprinus carpio					x	x				
Luxilus cornutus				n		x				
Macrhybopsis storeiana										
Notemigonus chrysoleucas(?)										
Notropis atherinoides	n									
Notropis blennius										
Notropis dorsalis										
Notropis hudsonius										
Notropis rubellus										
Notropis stramineus									x	
Pimephales notatus(?)				n		x				
Platygobio gracilis										
Rhinichthys cataractae										
Semotilus atromaculatus		x		n						
Catostomidae										
Carpiodes cyprinus										
Catostomus commersoni				n		x*		x		
Ictiobus cyprinellus										
Moxostoma anisurum						x		x		
Moxostoma erythrurum	n									
Moxostoma macrolepidotum										
Moxostoma valenciennesi(?)										
Ictaluridae										
Ameiurus melas	x									
Ictalurus punctatus	x-n									
Notorus flavus						x				
Notorus gyrinus								x		
Percopsidae										
Percopsis omiscomaycus										
Gadidae										
Lota lota										
Gasterosteidae										
Culea inconstans						x				
Centrarchidae										
Lepomis cyanellus(?)	x				x	x	x	x	x**	
Lepomis gibbosus(?)	x	x				x		x	x**	
Lepomis humilis(?)					x	x		x*	x	
Lepomis macrochirus(?)	x			x		x	x*	xx	x	
Micropterus salmoides(?)	x			x	x	x	x	xx	x*	
Pomoxis nigromaculatus	x	x-n		x		x	x	x		
Percidae										
Etheostoma exile(?)				n		x				
Perca flavescens	x					x	x	x	x**	
Percina caprodes	x									
Percina maculata										
Percina shumardi										
Stizostedion canadense	n				n		n	x		x
Stizostedion vitreum						x	x	x	x	
Sciaenidae										
Aplodinotus grunniens	x					n				x

[1] Identification of fish hosts based on Hillegass and Hove 1997; Hove and Haas 2001; Hove *et al.* 1994a, 1994b, 1995a, 1995b, 1997, 1998; Keller and Ruessler 1997; Khym and Layzer 2000; Milam *et al.* 1998; O'Dee and Watters 2000; Steg and Neves 1997; Watters 1994, 1995; Watters and O'Dee 1997, 1999; Watters *et al.* 1998, 1999; Weiss and Layzer 1995; van Snik Gray *et al.* 1999.

? - indicates species were found in river but site specific data was not available.

n - natural infestation was observed.

x - artificial infestation experiments produced juveniles and, in some cases, natural infestation was observed as well.

x* - conflicting results, artificial infestation experiments produced juveniles more often than artificial infestation did not produce juveniles.

x** - conflicting results, artificial infestation experiments did not produce juveniles more often than artificial infestation produced juveniles.

x-n - natural infestation observed, but artificial infestation experiments did not produce juveniles.

xx - 10 or more tests conducted, both natural infestation observed and artificial infestation experiments produced juveniles.

APPENDIX G-8

COMPARISON OF UNIONIDS AND FISH HOSTS[1] OF THE RED RIVER OF THE NORTH REACH 3

Final Aquatic Impact Analysis Report

	Ambleminae			Anodontinae			Lampsilinae			
	Amblema plicata	*Fusconaia flava*	*Quadrula quadrula*	*Anodontoides ferussacianus*	*Lasmigona complanata*	*Pyganodon grandis*	*Lampsilis cardium*	*Lampsilis siliquoidea*	*Ligumia recta*	*Potamilus alatus*[1]
Hiodontidae										
Hiodon alosoides										
Hiodon tergisus	n									
Osmeridae										
Osmerus mordax(?)										
Esocidae										
Esox lucius	n									
Cyprinidae										
Cyprinella spiloptera	n			x						
Cyprinus carpio					x	x				
Luxilus cornutus				n		x				
Macrhybopsis storeiana										
Notemigonus chrysoleucas(?)										
Notropis atherinoides	n							x		
Notropis blennius										
Notropis dorsalis										
Notropis hudsonius										
Notropis stramineus									x	
Pimephales notatus(?)				n		x				
Rhinichthys cataractae										
Semotilus atromaculatus		x		n						
Catostomidae										
Carpiodes cyprinus										
Catostomus commersoni				n		x*		x		
Ictiobus cyprinellus										
Moxostoma anisurum										
Moxostoma erythrurum	n					x		x		
Moxostoma macrolepidotum	x									
Moxostoma valenciennesi(?)										
Ictaluridae										
Ameiurus melas	x									
Ameiurus nebulosus	x									
Ictalurus punctatus	x-n									
Notorus flavus						x				
Notorus gyrinus										
Percopsidae										
Percopsis omiscomaycus										
Gadidae										
Lota lota										
Gasterosteidae										
Culea inconstans						x				
Centrarchidae										
Ambloplites rupestris	x					x		x	x*	
Lepomis cyanellus(?)	x				x	x	x*	x	x**	
Lepomis gibbosus(?)	x	x				x		x	x**	
Lepomis humilis(?)					x	x		x*	x	
Lepomis macrochirus(?)	x			x		x	x*	xx	x*	
Micropterus salmoides(?)	x			x	x	x	x	xx	x*	
Pomoxis annularis	xx	x-n			x	x		x	x	
Pomoxis nigromaculatus	x	x-n		x		x	x	x		
Percidae										
Etheostoma exile(?)				n		x				
Etheostoma nigrum						x				
Perca flavescens	x					x	x	x	x**	
Percina caprodes	n									
Percina maculata										
Percina shumardi										
Stizostedion canadense	n				n		n	x	x	
Stizostedion vitreum						x	x	x	x	
Sciaenidae										
Aplodinotus grunniens	n					n				x

[1] Identification of fish hosts based on Hillegass and Hove 1997; Hove and Haas 2001; Hove *et al* . 1994a, 1994b, 1995a, 1995b, 1997, 1998; Keller and Ruessler 1997; Khym and Layzer 2000; Milam *et al.* 1998; O'Dee and Watters 2000; Steg and Neves 1997; Watters 1994, 1995; Watters and O'Dee 1997, 1999; Watters *et al.* 1998, 1999; Weiss and Layzer 1995; van Snik Gray *et al.* 1999.

? - indicates species were found in river but site specific data was not available.

n - natural infestation was observed

x - artificial infestation experiments produced juveniles and, in some cases, natural infestation was observed as well

x* - conflicting results, artificial infestation experiments produced juveniles more often than artificial infestation did not produce juveniles

x** - conflicting results, artificial infestation experiments did not produce juveniles more often than artificial infestation produced juveniles

x-n - natural infestation observed, but artificial infestation experiments did not produce juveniles

xx - 10 or more tests conducted, both natural infestation observed and artificial infestation experiments produced juveniles

APPENDIX H

PERIPHYTON, PHYTOPLANKTON, AND MACROPHYTE SPECIES REPORTED FROM THE SHEYENNE AND RED RIVERS

APPENDIX H-1

PERIPHYTON SPECIES REPORTED FROM THE SHEYENNE RIVER[1]
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Periphyton	Sheyenne River			
	1	2	3	5
Cyanobacteria				
Anabena flos-aqua	X			
Aphanizominon sp.			X	
Aphanocapsa elachista	X			
Calothrix sp.1	X			
Chamesphion sp.1	X			
Chroococcus limneticus	X	X	X	
Dermocarpa sp.1	X			X
Gleocapsa sp.	X			
Gleocapsa aerginosa				X
Lyngbia lagerheimii				X
Lyngbia luridium	X	X		
Merismopedia tenuissima	X			
Myxosarcina spectablis	X	X		
Oscillatoria angutussima	X			X
Oscillatoria lacustris	X	X		
Oscillatoria minima			X	
Oscillatoria sp. 2		X		
Oscillatoria terebriformis		X		
Phormidium sp. 1	X	X	X	
Rivularia sp. 1 (fat)		X		
Schizothrix sp.		X		
Siphonema sp. 1		X		
Chlorophyta				
Actinotaenium cucurbitinum				X
Aestrococcus sp. 1	X	X	X	X
Binuclearia sp.	X	X		
Botryococcus sp.		X		
Carteria sp. 1	X			
Chaetophora sp. 1		X	X	
Chlamydomonas globosa	X		X	X
Chlamydomonas sp. 1	X	X	X	
Chlamydomonas sp. 2 (small)		X		
Cladophora sp. 1	X	X		
Closterium lunata	X	X		
Closterium sp. 1	X			
Dictyosphaerium sp.	X			
Gleocystis giga	X			
Gleocystis sp. 1	X	X		
Gonium sp. 1	X	X		
Monoraphidium contortum		X		
Monoraphidium sp. 1			X	X
Monoraphidium sp. 2	X	X		
Monoraphidium sp. 3	X		X	X
Monoraphidium sp. 4		X		
Monoraphidium sp. 6		X		
Oedogonium sp.		X		
Oocystis sp. 1		X		

[1]Phillips *et al* . 2000

APPENDIX H-1

PERIPHYTON SPECIES REPORTED FROM THE SHEYENNE RIVER[1]
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Periphyton	Sheyenne River			
	1	2	3	5
Chlorophyta (cont.)				
Pediastrum biradiatum	X			
Protoderma sp. 1	X			
Rhizoclonium sp. 1	X	X	X	
Scenedesmus sp. 1	X			
Scenedesmus sp. 2				X
Scenedesmus sp. 3	X	X	X	
Scenedesmus sp. 4		X		
Spirogyro sp. 1	X			
Stigeoclonium sp. 1	X	X		
Stigeoclonium sp. 2	X	X		
Stigeoclonium sp. 3	X		X	
Stigeoclonium sp. 4		X		
Tetrastrum staruogemaeforme				X
Ulothrix sp. 1	X			
Ulothrix variblis	X			
Cryptophyta				
Cryptomonas erosa			X	
Cryptomonas sp. 1			X	X
Euglenophyta				
Euglena caudata	X			X
Euglena gracilis			X	
Euglena oxyurus				X
Leptocynclis sp. 1				X
Phacus sp. 1	X			
Strobomonas planktonica	X		X	X
Trachelomonas bulba	X			
Trachelomonas hisipida	X		X	X
Trachelomonas hisipida v. papillata				X
Trachelomonas pulchella	X			
Chysophyceae				
Bioseca sp. 1			X	
Chrysocapsa sp. 1	X	X		
Chrysococcus minutulus	X		X	X
Kephyrion limneticum	X			
Xanthophyceae				
Characium gracilipes	X			
Characium sp. 1	X			
Characium sp. 2	X			
Characium sp. 3	X			
Perionella planctonica	X		X	
Bacillariophyceae				
Achanthes hungarica	X		X	X
Achanthes lanceolatum	X		X	X
Achanthes minima			X	
Achanthes minutissima v. 1	X			X
Achanthes similis	X			

[1]Phillips *et al* . 2000

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PERIPHYTON SPECIES REPORTED FROM THE SHEYENNE RIVER[1]
Final Aquatic Impact Analysis Report

Periphyton	Sheyenne River			
	1	2	3	5
Bacillariophyceae (cont.)				
Achanthes sp. 1	X			
Amphora ovalis	X	X	X	X
Amphora pediculus	X		X	
Amphora sp. 1			X	X
Aulocoseira ambigua	X			
Aulocoseira granulata v. ang		X	X	
Aulocoseira granulata v. gran		X	X	
Bacillaria paradoxa	X		X	
Caloneis sp. 1	X			X
Cocconeis placentula v. eu	X	X	X	X
Cocconeis placentula v. lin	X		X	X
Craticula cuspidata			X	
Cyclotella comensis		X	X	
Cyclotella menighaniana	X			
Cyclotella sp. 3	X			
Cymbella cistula	X			
Cymbella mexicanum	X	X		
Cymbella minutum				X
Cymbella muelleri	X			
Cymbella prostrata		X		
Cymbella proxima	X	X		
Cymbella triangularum	X			
Cymtapleura elliptica	X		X	
Cymtapleura solea	X	X	X	
Diatoma tenue	X	X	X	
Diatoma vulgare	X	X	X	
Diploneis sp. 1	X		X	X
Diploneis sp. 2	X			
Epithemia adnata	X			
Epithemia adnata v. 1	X		X	
Epithemia sorex	X	X		
Epithemia turgida	X			
Eunotia naegelii	X			
Eunotia paradoxa	X			
Fragilaria alpestris	X		X	
Fragilaria capucina v. mes	X	X	X	
Fragilaria vaucheriae	X	X	X	X
Gomphoneis sp. 1	X	X	X	
Gomphoneis sp. 2	X	X		
Gomphonema affine	X			X
Gomphonema angustatum	X	X	X	X
Gomphonema angustum	X		X	
Gomphonema clevei	X			
Gomphonema gracile	X			
Gomphonema intricatum	X			
Gomphonema olivaceum	X	X	X	X
Gomphonema olivaceum v. 1	X	X	X	X
Gomphonema parvulum	X	X	X	

[1]Phillips *et al* . 2000

APPENDIX H-1

PERIPHYTON SPECIES REPORTED FROM THE SHEYENNE RIVER[1]
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Periphyton	Sheyenne River			
	1	2	3	5
Bacillariophyceae (cont.)				
Gomphonema pseudotenellum	X		X	X
Gomphonema sp. 3	X			
Gomphonema sp. 2	X			
Gomphonema subclavatum v. mex	X	X		
Gomphonema subclavatum v. small	X			
Gomphonema subclavatum v. sub	X	X	X	
Gomphonema truncatum v. cap	X			
Gyrosigma accenuatum	X			
Hantzschia amphioxys	X			
Hantzschia gracilis	X			
Melosira varians	X		X	X
Meridian circulare v. con	X		X	
Navicula arvensis			X	X
Navicula capitaradiata	X		X	X
Navicula capitata	X	X	X	
Navicula cincta	X	X	X	X
Navicula circumtexta	X		X	
Navicula cryptocephla			X	X
Navicula heulferi	X		X	X
Navicula lanceolata	X	X	X	
Navicula rheinhardii	X	X	X	
Navicula sp. 3		X	X	
Navicula tripunctata	X	X	X	X
Navicula tripunctata v. sch.	X	X		
Nitzschia capitellata				X
Nitzschia dissipata	X	X	X	X
Nitzschia filaformis	X	X		
Nitzschia fonticola		X		
Nitzschia frustulum	X			
Nitzschia gracilis	X			
Nitzschia inconspicua	X	X	X	X
Nitzschia paleacea			X	
Nitzschia parvulum			X	
Nitzschia recta	X			
Nitzschia rosenstockii	X			
Nitzschia scalaris	X		X	
Nitzschia sigma	X			
Nitzschia socialis				X
Nitzschia sp. 1	X			
Nitzschia sp. 2 (thin)		X		
Nitzschia sp. 3			X	
Nitzschia sp. 6 (long)			X	
Pinnularia sp. 1	X			
Pleurosigma elongatum	X			
Reimeria sinuata	X		X	
Rhoicosphenia curvata	X	X	X	X
Rhopalodia gibba	X		X	

[1]Phillips *et al* . 2000

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PERIPHYTON SPECIES REPORTED FROM THE SHEYENNE RIVER[1]
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Periphyton	Sheyenne River			
	1	2	3	5
Bacillariophyceae (cont.)				
Rhopalodia gibberula	X		X	
Staurioseira construens	X			
Staurioseira lapponica			X	
Stephanodiscus invisitus		X		
Stephanodiscus minutulus	X			
Stephanodiscus niagare		X	X	
Stephanodiscus sp. 2	X		X	
Stephanodiscus sp. 3		X	X	X
Surirella angustatum		X	X	X
Surirella bifrons	X			
Surirella brebissionii	X			
Surirella hoeferi		X		
Surirella minutum	X			
Surirella ovalis	X		X	
Surirella ovata	X		X	
Surirella ovata v. 1	X	X		
Surirella ovata v. pinnata	X			
Surirella sp. 1				X
Surirella sp. 2	X			
Surirella sp. 3	X	X		
Synedra acus	X	X	X	
Synedra delicatissima	X			
Synedra fasiculata	X		X	
Synedra oxythyncus		X	X	
Synedra parasitica v. constrictum	X			
Synedra rumpens		X	X	
Synedra ulna			X	
Synedra ulna v. sub		X		
Triblionella aciminata			X	
Triblionella appiculata	X		X	
Triblionella laevidenis	X			
Triblionella laevis	X		X	
Triblionella sp.1	X			

[1]Phillips *et al* . 2000

APPENDIX H-2

PHYTOPLANKTON SPECIES RECORDED FROM THE SHEYENNE RIVER[1]
Final Aquatic Impact Analysis Report

Phytoplankton	Sheyenne River Reach			
	1	2	3	5
Chlorophyta				
Ankistrodesmus elong.	X			
Ankistrodesmus hantzchii	X			
Ankistrodesmus gracilmum	X			
Botryococcus sp.			X	
Chlamydomonas sp. 1	X			
Chlamydomonas sp. 2	X			
Chlamydomonas sp. 3	X			
Coelastrium microporum	X			
Dictyosphaerium e.	X			X
Dictyosphaerium pulcherrum	X			
Gloeocystis ves.	X			
Kirchneriella sp. 1	X			
Kirchneriella sp. 2	X		X	X
Monoraphidium tortile	X		X	X
Monoraphidium contortum	X		X	X
Monoraphidium minutum	X	X	X	X
Monoraphidium pusillum	X	X	X	X
Monoraphidium sp.			X	X
Nephrocytium agardhianum	X			
Nephrocytium lunatum	X			
Pediastrum boryanum	X			
Pediastrum duplex v. clath.	X			
Pediastrum duplex v. unknown	X			X
Pediastrum tetras ver. Tetradon	X			
Pediastrum sp.	X			
Platydorina tetras	X			
Pyramimonas sp 1	X			
Pyramimonas sp 2	X			
Pyramimonas sp 3	X			
Raphidonema sp 1	X	X	X	X
Raphidonema sp 2	X		X	X
Scenedesmus bijuga	X			
Scenedesmus diamorphus	X			
Scenedesmus quadricauda	X			
Westella botryoides	X			
Westella linearis	X			
Westella sp. 1	X			
Chryptophyceae				
Chroomonas acuta	X		X	X
Chroomonas nordstedtii	X	X	X	
Cryptochrysis sp.	X			
Cryptomonas erosa	X		X	X
Cryptomonas gracilis	X		X	X

[1] Phillips *et al* . 2000

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PHYTOPLANKTON SPECIES RECORDED FROM THE SHEYENNE RIVER[1]
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Phytoplankton	Sheyenne River Reach			
	1	2	3	5
Chryptophyceae (cont.)				
Cryptomonas marssoni	X	X		X
Cryptomonas ovata	X		X	X
Cryptomonas platyuris			X	X
Cryptomonas reflexa	X		X	
Cryptomonas tetrapyren	X		X	
Rhodomonas minuta v. nannoplanctica	X	X	X	X
Rhodomonas minuta	X	X	X	X
Rhodomonas pusilla	X	X	X	X
Rhodomonas tenuis			X	
Cyanophyceae				
Anabaena sp.	X			
Aphanizomenon flos-aquae			X	
Chroococcus minor	X		X	X
Chroococcus sp.	X	X		
Gloecocapsa aeruginosa	X	X	X	X
Gloecocapsa rupetris	X			
Merismopedia glauca			X	
Merismopedia tenuissima	X			
Microcystis incerta		X		
Oscillatoria acutissima			X	X
Oscillatoria augustissima	X	X	X	X
Tetrepedia sp.	X			
Euglenophycaea				
Euglena acus v. rigida	X			
Euglena caudata v. minor	X		X	X
Euglena elastica	X			
Euglena gracilis	X			
Euglena limnophila			X	
Euglena limnophila v. minor	X		X	
Euglena minuta	X			
Euglena rostrata	X			
Euglena sciotensis	X			
Euglena spathirhyncha	X			X
Euglena spiroides	X			
Lepocinclis acuta	X			
Lepocinclis glaba v. minor	X			
Lepocinclis ovum	X			
Lepocinclis playfairiana	X			
Lepocinclis sp. 1				X
Monomorpha sp. 1	X			
Phacus acuminatus v. drez	X			
Phacus caudatus v. ovalis	X			

[1] Phillips *et al* . 2000

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PHYTOPLANKTON SPECIES RECORDED FROM THE SHEYENNE RIVER[1]
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Phytoplankton	Sheyenne River Reach			
	1	2	3	5
Euglenophycaea (cont.)				
Phacus globosus	X			
Phacus pleurnectes	X			
Phacus pseudoswirenkai	X			
Phacus sp.1	X			
Strobomonas fluviatilis			X	
Strobomonas planctonica	X		X	
Trachelomonas acanthoscoma			X	
Trachelomonas bacillifera v. minor	X			
Trachelomonas cylindrica			X	
Trachelomonas dybowskii			X	
Trachelomonas hexangulata	X			
Trachelomonas hispida	X			
Trachelomonas hispida v. coronata			X	X
Trachelomonas hispida v. papillata	X			
Trachelomonas hispida v. punctata	X			
Trachelomonas lefevrei			X	
Trachelomonas pulchella			X	
Trachelomonas pulcherrima v. minor	X			
Trachelomonas regulosa			X	
Trachelomonas scabra v. long	X			
Trachelomonas triangularis			X	
Trachelomonas varians	X			
Trachelomonas volvocina			X	X
Trachelomonas volvocina v. punctata			X	X
Trachelomonas sp. 1	X			
Dinophyceae				
Cystodinium sp.	X			
Gymnodinium sp.	X			
Peridinium sp.	X		X	
Chrysophyceae				
Bicosoeca fettii			X	
Bicosoeca planctonica			X	
Chromulina dubia			X	
Chromulina ferrea			X	
Chromulina lunaris			X	
Chromulina nannos		X	X	X
Chromulina nebulosa	X		X	X
Chromulina ovalis			X	X
Chromulina parva				X
Chromulina pseudonebulosa	X		X	
Chromulina pigra			X	
Chrysococcus cordiformis	X	X	X	X

[1] Phillips *et al* . 2000

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PHYTOPLANKTON SPECIES RECORDED FROM THE SHEYENNE RIVER[1]
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Phytoplankton	Sheyenne River Reach			
	1	2	3	5
Chrysophyceae (cont.)				
Chrysococcus cordiformis v. astigma			X	
Chrysococcus cordiformis v. biconcus			X	
Chrysococcus elegans			X	
Chrysococcus klesianus			X	
Chrysococcus minuta	X		X	
Chrysococcus porifer	X			
Chrysococcus neglectus	X		X	X
Chrysococcus punctiformis	X	X	X	X
Chrysococcus refescens	X		X	X
Chrysococcus refescens v. compressa			X	
Chrysococcus triporus				X
Dinobryon urceolatum	X			
Kephyrion cordatum			X	
Kephyrion culpiforme	X			
Kephyrion cylindrica	X			
Kephyrion doliolum	X			
Kephyrion limneticum			X	
Kephyrion litorale	X	X	X	X
Kephyrion obliquum			X	
Kephyrion ovum			X	
Kephyrion petasatum	X			
Kephyrion rubrii-claustri	X		X	
Kephyrion schmidii				X
Kephyrion sitta	X		X	X
Mallamonas aerolata			X	
Mallamonas sp. 1	X			
Microglena punctifera			X	
Monochrysis hyalina			X	X
Monochrysis parva	X	X	X	X
Monochrysis vesiculifera			X	X
Ochromonas danica				X
Ochromonas minuta	X		X	X
Ochromonas reptans	X			
Ochromonas sp. 1	X			
Ochromonas sp. 2	X			
Ochromonas socialis				X
Ochromonas viridis				X
Syncrypta sp.			X	
Synura sp.	X	X	X	X

[1] Phillips *et al* . 2000

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PHYTOPLANKTON SPECIES RECORDED FROM THE SHEYENNE RIVER[1]
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Phytoplankton	Sheyenne River Reach			
	1	2	3	5
Bacillariophyceae				
Asterionella formosa	X			
Aulacoseira distans	X			
Aulacoseira granulata	X		X	
Aulacoseira granulata v. augustissima			X	
Bacillaria paradoxa	X			
Centric sp.1	X		X	X
Centric sp.2	X		X	
Centric sp.3	X			
Centric sp.4	X		X	
Cyclotella sp. 1	X		X	
Cyclotella sp. 2	X		X	X
Cyclotella sp. 3	X		X	
Cyclotella sp. 4	X		X	
Cyclotella sp. 5			X	
Fragilaria sp. 1	X			
Fragilaria sp. 2	X			
Fragilaria sp. 3	X			
Fragilaria sp. 4	X			
Gyrosigma spen.				X
Navicula sp.1	X			
Navicula sp.2	X			
Navicula sp.3	X			
Navicula sp.4	X			
Navicula sp.5	X			
Nitzschia frustulum	X		X	
Nitzschia inconspicua	X	X	X	X
Nitzschia sp. 1	X			
Nitzschia sp. 2	X			
Nitzschia sp. 3	X			
Nitzschia sp. 4	X			
Nitzschia sp. 5	X			
Nitzschia sp. 6	X			
Nitzschia sp. 7	X			
Nitzschia sp. 8	X			
Nitzschia sp. 9	X			
Nitzschia sp. 10	X			
Nitzschia sp. 11	X			
Nitzschia sp. 12	X			
Nitzschia sp. 13	X			
Nitzschia sp. 14	X			
Nitzschia sp. 15	X			
Nitzschia sp. 16	X		X	
Nitzschia sp. 17	X			

[1] Phillips *et al* . 2000

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PHYTOPLANKTON SPECIES RECORDED FROM THE SHEYENNE RIVER[1]
Final Aquatic Impact Analysis Report

Phytoplankton	Sheyenne River Reach			
	1	2	3	5
Bacillariophyceae (cont.)				
Nitzschia sp. 18	X			
Nitzschia sp. 19	X			
Nitzschia sp. 20	X			
Nitzschia sp. 21	X			
Nitzschia sp. 22	X			
Nitzschia sp. 23	X			
Nitzschia sp. 24	X			
Nitzschia sp. 25	X			
Nitzschia sp. 26	X			
Nitzschia sp. 27	X			
Nitzschia sp. 28		X		
Nitzschia sp. 29			X	
Pleurosigma/Gyrosigma sp. 1	X			
Pleurosigma/Gyrosigma sp. 2	X			
Skeletonema potomus	X		X	
Synedra sp. 1	X			
Synedra sp. 2	X			
Synedra sp. 3	X		X	
Synedra sp. 4	X			
Synedra sp. 5	X			

[1] Phillips *et al* . 2000

APPENDIX H-3

PERIPHYTON AND PHYTOPLANKTON SPECIES REPORTED FROM THE RED RIVER[1]
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Class	Order	Family	Genus species
Cyanophyta			
	Chroococcales		
		Chroococceaceae	
			Aphanocapsa pulchra
			Aphanothece sp.
			Chroococcus dispersus
			Chroococcus limneticus
			Chroococcus minutus
			Coelosphaerium kuetzingianum
			Coelosphaerium naegelianum
			Coelosphaerium pallidum
			Dactylococcopsis rhaphidiodes
			Gloeotheae linearis
			Gomphosphaeria aponina
			Gomphosphaeria lacustris
			Merismopedia elegans
			Merismopedia glauca
			Merismopedia punctata
			Merismopedia tenuissima
			Microcystis aeruginosa
			Microcystis incerta
	Nostocales		
		Nostocaceae	
			Anabaena affinis
			Anabaena ocillarioides
			Nodularia harveyana
			Nostoc spongiiforme
			Raphidiopsis curvata
		Oscillatoriaceae	
			Hydrocoleum brebissonii
			Lyngbya aerugineo-caerulea
			Lyngbya aestuarii
			Lyngbya epiphytica
			Lyngbya limnetica
			Lyngbya lutea
			Lyngbya major
			Lyngbya martensiana
			Microcoleus vaginatus
			Oscillatoria limnetica
			Oscillatoria limosa
			Oscillatoria lutea
			Oscillatoria princeps
			Oscillatoria prolifica
			Oscillatoria spledida
			Oscillatoria subbrevis
			Oscillatoria tenuis
			Porphyrosiphon splendidus
			Schizothrix arenaria
			Schizothrix friesii
			Spirulina laxa
			Spirulina subsalsa
		Rivulariaceae	
			Amphithrix janthina
			Calothrix braunii
			Calothrix epiphytica
			Calothrix fusca
			Calothrix parietina
			Leptochaete stagnalis
		Scytonemataceae	
			Scytonema hofmannii

[1]Lorenz in Schmidt 1999

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PERIPHYTON AND PHYTOPLANKTON SPECIES REPORTED FROM THE RED RIVER[1]
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Class	Order	Family	Genus species
Rhodophyta			
	Batrachospermales		
		Batrachospermiaceae	
			Batrachospermum vagan
	Nemaliales		
		Acrochaeticeae	
			Audouinella violacea
Cryptophyta			
	Cryptomonadales		
		Cryptomondaceae	
			Cryptomonas sp.
Pyrrophyta			
	Peridiniales		
		Glenodiniaceae	
			Glenodinium pulvisculus
		Peridiniaceae	
			Peridinium cinctum
			Peridinium inconspicuum
	Gonyaulacales		
		Ceratiaceae	
			Ceratium hirudinella
Euglenophyta			
	Euglenales		
		Euglenaceae	
			Euglena acus
			Euglena sprirogyra
			Lepocinclis fusiformis
			Phacus curvicaudata
			Phacus longicauda
			Trachelmonas abrupta
			Trachelmonas acanthophora
			Trachelmonas cylindrica
			Trachelmonas hispida
			Trachelmonas intermedia
			Trachelmonas oblonga
			Trachelmonas volvocina
Chrysophyta			
	Ochramonadales		
		Dinobryaceae	
			Dinobryon cylindricum
			Dinobryon sertularia
		Synuraceae	
			Mallomanas sp.
Bacillariophyta			
	Thalassiosirales		
		Skeletonemanceae	
			Skeletonema potamos
		Stephanodiscaceae	
			Cyclostephanos costatilimbus
			Cyclostephanos dubius
			Cyclostephanos invisitatus
			Cyclostephanos tholiformis
			Cyclotella aliquantula
			Cyclotella atomus
			Cyclotella bodanica
			Cyclotella bodanica affinis
			Cyclotella distinguenda
			Cyclotella glomerata
			Cyclotella kuetzingiana
			Cyclotella meneghiniana
			Cyclotella ocellata

(continued next page)

[1]Lorenz in Schmidt 1999

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PERIPHYTON AND PHYTOPLANKTON SPECIES REPORTED FROM THE RED RIVER[1]
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Class	Order	Family	Genus species
Bacillariophyta (cont.)			(see previous page)
	Thalassiosirales (cont.)	Stephanodiscaceae (cont.)	*Cyclotella pseudostelligera* *Cyclotella radiosa* *Cyclotella rossii* *Cyclotella stelligera* *Cyclotella striata* *Stephanodiscus agassizensis* *Stephanodiscus alpinus* *Stephanodiscus astraea* *Stephanodiscus hantzschii* *Stephanodiscus hantzschii hantzschii* *Stephanodiscus hantzschii f. tenuis* *Stephanodiscus medius* *Stephanodiscus minutulus* *Stephanodiscus niagarae* *Stephanodiscus parvus*
		Thalassiosiraceae	*Thalassiosira psuedonana* *Thalassiosira weissflogii*
	Melosirales	Melosiraceae	*Melosira varians*
	Orthoseirales	Orthoseiaceae	*Orthoseira roseana*
	Paraliales	Paraliaceae	*Paralia siberica* *Paralia siberica laevis*
	Aulacoseirales	Aulacoseiraceae	*Aulacoseira alpigena* *Aulacoseira ambigua* *Aulacoseira distans* *Aulacoseira granulata* *Aulacoseira italica* *Aulacoseira italica tennuissima* *Aulacoseira italica multistriata* *Aulacoseira tenella*
	Coscinodiscales	Hemidiscaceae	*Actinocyclus sp.*
	Triceratiales	Triceratiaceae	*Pleurosira laevis*
	Biddulphiales	Biddulphiaceae	*Biddulphia sp.* *Terpsinoe musica*
	(continued next page)		

[1]Lorenz in Schmidt 1999

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PERIPHYTON AND PHYTOPLANKTON SPECIES REPORTED FROM THE RED RIVER[1]
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Class	Order	Family	Genus species
Bacillariophyta (cont.)	(see previous page)		
	Fragilariales		
		Fragilariaceae	
			Asterionella formosa
			Ctenophora pulchella
			Ctenophora pulchella lacerata
			Diatoma anceps
			Diatoma mesodon
			Diatoma tenue
			Diatoma tenue elongatum
			Diatoma vulgare
			Fragilaria capucina
			Fragilaria capucina mesolepta
			Fragilaria crotonensis
			Fragilaria intermedia
			Fragilaria vaucheriae
			Fragilaria constricta trinodis
			Fragilaria hungarica tumida
			Fragilaria virescens clavata
			Fragilaria virescens exigua
			Frangilariforma strangulata
			Frangilariforma bicapitata
			Frangilariforma constricta
			Frangilariforma hungarica
			Frangilariforma virescens
			Hannaea arcus
			Hannaea arcus amphioxys
			Martyana martyi
			Meridion circulare
			Meridion circulare constrictum
			Opephora sp.
			Pseudostaurosira brevistriata
			Pseudostaurosira brevistriata capitata
			Pseudostaurosira brevistriata inflata
			Pseudostaurosira pseudoconstruens
			Staurosira construens
			Staurosira consturens pumila
			Staurosira construens subsalina
			Staurosira construens binodis
			Staurosira construens venter
			Staurosirella leptostauron
			Staurosirella leptostauron dubia
			Staurosirella pinnata
			Staurosirella pinnata acuminata
			Staurosirella pinnata intercedens
			Staurosirella pinnata lancettula
			Staurosirella pinnata subcapitata
			Synedra acus
			Synedra cyclopum
			Synedra delicatissima
			Synedra delicatissima angustissima
			Synedra fasciculata
			Synedra fasciculata truncata
			Synedra mazamaensis
			Synedra minuscuka
			Synedra nana
			Synedra parasitica
			Synedra parasitica subconstricta
			Synedra rumpens
			Synedra rumpens familiaris
			Synedra rumpens gragilarioides
			Synedra rumpens meneghiniana
			Synedra tenera
			Synedra ulna
			Synedra ulna contracta
			Synedra ulna danica
			Synedra ulna oxyrhynchus
	(continued next page)		*Synedra ulna oxyrhynchus mediocontracta*

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Class	Order	Family	Genus species
Bacillariophyta (cont.)	(see previous page)		
	Tabellariales		
		Tabellariaceae	
			Tabellaria frenestrata
			Tabellaria flocculosa
			Tetracyclus lacustris
	Eunotiales		
		Eunotiaceae	
			Actinella punctata
			Eunotia bidentula
			Eunotia carolina
			Eunotia curvata
			Eunotia curvata subarcuata
			Eunotia lunaris subarcuata
			Eunotia diodon
			Eunotia exigua
			Eunotia flexuosa
			Eunotia formica
			Eunotia incisa
			Eunotia major
			Eunotia microcephala
			Eunotia monodon
			Eunotia naegelii
			Eunotia pectinalis
			Eunotia pectinalis biarcuata
			Eunotia pectinalis minor
			Eunotia pectinalis undulata
			Eunotia perpusilla
			Eunotia praerupta
			Eunotia praerupta bidens
			Eunotia rabenhorstii
			Eunotia rabenhorstii monodon
			Eunotia serra
			Eunotia serra diadema
			Eunotia siberica
			Eunotia tautoniensis
			Eunotia tenella
	Mastogloiales		
		Mastogloiaceae	
			Aneumastus tusculus
			Mastogloia elliptica
			Mastogloia elliptica dansei
			Mastogloia grevillei
			Mastogloia smithii
			Mastogloia smithii lacustris
	Cymbellales		
		Anomoeoneidaceae	
			Anomoeoneis sphaerophora
			Anomoeoneis sphaerophora sculpta
		Cymbellaceae	
			Cymbella affinis
			Cymbella amphicephala
			Cymbella angustata
			Cymbella aspera
			Cymbella brehmii
			Cymbella cistula
			Cymbella cuspidata
			Cymbella cymbiformis
			Cymbella delicatula
			Cymbella divuviana
			(continued next page)

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Class	Order	Family	Genus species
Bacillariophyta (cont.)			(see previous page)
	Cymbellales (cont.)		
		Cymbellaceae (cont.)	*Cymbella hauckii*
			Cymbella heteropleura
			Cymbella heteropleura subrostrata
			Cymbella hustedtii
			Cymbella hybrida
			Cymbella laevis
			Cymbella lanceolata
			Cymbella leptoceros
			Cymbella mexicana
			Cymbella naviculiformis
			Cymbella perpusilla
			Cymbella pusilla
			Cymbella subaequalis
			Cymbella subaequalis krasskei
			Cymbella tumida
			Cymbella turgidula
			Encyonema auerswaldii
			Encyonema latens
			Encyonema lunatum
			Encyonema minutum
			Encyonema minuta psuedogracilis
			Encyonema muelleri
			Encyonema muelleri ventricosa
			Encyonema prostratum
			Encyonema silesiacum
			Encyonema triangulum
			Encyonopsis cesatii
			Encyonopsis microcephala
			Encyonopsis microcephala crassa
			Placoneis elginensis
			Placoneis elginensis lata
			Placoneis elginensis neglecta
			Placoneis gastrum
			Placoneis placentula
			Placoneis placentula lata
			Reimeria lacus-idahoensis
			Reimeria sinuata
			Reimeria sinuata antiqua
		Gomphonemataceae	*Didymosphenia geninata*
			Gomphoneis eriense
			Gomphoneis eriense variabilis
			Gomphoneis herculeana
			Gomphoneis minuta
			Gomphonema acuminatum
			Gomphonema acuminatum laticeps
			Gomphonema affine
			Gomphonema angustatum
			Gomphonema angustatum intermedia
			Gomphonema angustatum productum
			Gomphonema angustatum sarcophagus
			Gomphonema apuncto
			Gomphonema augur
			Gomphonema clevei
			Gomphonema dichotomum
			Gomphonema gracile
			Gomphonema grunowii
			Gomphonema instabilis
			(continued next page)

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Class	Order	Family	Genus species
Bacillariophyta (cont.)			(see previous page)
	Cymbellales (cont.)	Gomphonemataceae (cont.)	*Gomphonema intricatum*
			Gomphonema mexicanum
			Gomphonema olivaceoides
			Gomphonema olivaceoides hutchinsoniana
			Gomphonema olivaceum
			Gomphonema parvulum parvulius
			Gomphonema rhombicum
			Gomphonema sphaerophorum
			Gomphonema subclavatum
			Gomphonema tenellum
			Gomphonema truncatum
			Gomphonema truncatum capitatum
			Gomphonema ventricosum
			Gomphosphenia grovei
			Gomphosphenia lingulatiformis
		Rhoicospheniaceae	*Rhoicosphenia abbreviata*
	Achnanthales	Achnanthaceae	*Achnanthes decipiens*
			Achnanthes flexella
			Achnanthes grana
			Achnanthes helvetica
			Achnanthes inflata
			Achnanthes lapidosa
			Achnanthes lauenburgiana
			Achnanthes recurvata
			Lemnicola hungarica
		Achnanthidiaceae	*Achnanthes chlidanos*
			Achnanthes conspicua
			Achnanthes deflexa
			Achnanthes laevis
			Achnanthes lapponica
			Achnanthes lapponica ninckei
			Achnanthes lata
			Achnanthes lemmermannii
			Ahnanthes oblongella
			Achanthes pinnata
			Achnanthes stewartii
			Achnanthes subhudsonis
			Achnanthes subhudonis kraeuelii
			Achnanthes suchlandtii
			Achnanthidium affine
			Achnanthidium biasolettianum
			Achnanthidium biporomum
			Achnanthidium exiguum
			Achnanthidium exigua elliptica
			Achnanthidium exiguum heterovalvum
			Achnanthidium exilis
			Achnanthidium jackii
			Achnanthidium microcephalum
			Achnanthidium minutissimum
			Karayevia clevei
			Karayevia clevei rostratum
			Karayevia laterostrata
			Planothidium dubium
			Planothidium hauckianum
			Planothidium hauckianum rostrata
			(continued next page)

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Class	Order	Family	Genus species
Bacillariophyta (cont.)			(see previous page)
	Achnanthales (cont.)	Achnanthidiaceae (cont.)	*Planothidium lanceolatum*
			Planothidium lanceolatum abbreviata
			Planothidium lanceolatum apiculata
			Planothidium lanceolatum bimaculata
			Planothidium lanceolatum moissa
			Planothidium peragallii
			Planothidium peragalli parvula
			Psammonthidium bioretii
			Psammonthidium grischunum
			Psammonthidium grischunum daensis
			Psammonthidium grischunum f. daenensis
			Psammonthidium levanderi
			Psammonthidium marginulatum
			Psammonthidium subatomoides
			Psammonthidium ventralis
			Rossothidium linearis
			Rossothidium linearis curta
			Rossothidium petersenii
			Rossothidium pusillum
		Cocconeidaceae	*Cocconeis diminuta*
			Cocconeis fluviatilis
			Cocconeis pediculus
			Cocconeis placentula
			Cocconeis placentula euglypta
			Cocconeis placentula lineata
			Cocconeis placentula pseudolineata
			Cocconeis thumensis
	Naviculales	Amphipleuraceae	*Amphipleura pellucida*
			Frustulia rhomboides
			Frustulia rhomboides amphipleuroides
			Frustulia rhomboides crassinervia
			Frustulia rhomboides saxonica
			Frustulia vulgaris
			Frustulia weinholdii
		Brachysiraceae	*Brachysira serians*
			Brachysira serians acuta
			Brachysira brebissonii
			Brachysira vitrea
		Cavinulaceae	*Cavinula cocconeiformis*
		Diadesmidaceae	*Diadesmis confervacea*
			Diadesmis contenta
			Diadesmis contenta biceps
			Diadesmis gallica
			Luticola cohnii
			Luticola goepperitana
			Luticola mutica
			Luticola mutica stigma
		Diploneidaceae	*Diploneis elliptica*
			Diploneis marginestriata
			Diploneis oblongella
			Diploneis psuedovalis
			Diploneis puella
			Diploneis smithii
			Diploneis subvalis
		(continued next page)	

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Class	Order	Family	Genus species
Bacillariophyta (cont.)		(see previous page)	
	Naviculales (cont.)		
		Naviculaceae	
			Chamaepinnularia mediocris
			Geissleria decussis
			Geissleria schoenfeldii
			Navicula abiskoensis
			Navicula acceptata
			Navicula adnata
			Navicula agrestis
			Navicula aikenensis
			Navicula anglica
			Navicula angusta
			Navicula arvensis
			Navicula arvensis major
			Navicula atomus
			Navicula aurora
			Navicula bacilloides
			Navicula bicephala
			Navicula biconica
			Navicula bremensis
			Navicula bryophila
			Navicula canalis
			Navicula canoris
			Navicula capitata
			Navicula capitata hungarica
			Navicula capitata luneburgensis
			Navicula capitellata
			Navicula cari
			Navicula carminata
			Navicula cincta
			Navicula cincta rostrata
			Navicula circumtexta
			Navicula cirtrus
			Navicula clementioides
			Navicula clementis
			Navicula convergens
			Navicula cruezburgensis
			Navicula cruesburgensis multistriata
			Navicula cryptocephala
			Navicula cryptocephala exilis
			Navicula cryptocephala veneta
			Navicula detenta
			Navicula difficillima
			Navicula exigua
			Navicula exigua capitata
			Navicula genovefae
			Navicula gracilis
			Navicula gracilis minor
			Navicula graciloides
			Navicula gregaria
			Navicula grimmii
			Navicula gysingensis
			Navicula halophila
			Navicula hambergii
			Navicula hassiaca
			Navicula hasta
			Navicula heufleri
			Navicula heufleri leptocephala
			Navicula heufleriana
			Navicula hustedtii
			Navicula ignota
			Navicula ignota palustris
			Navicula incertata
			(continued next page)

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Class	Order	Family	Genus species
Bacillariophyta (cont.)			(see previous page)
	Naviculales (cont.)		
		Naviculaceae (cont.)	
			Navicula incomposita
			Navicula ingenua
			Navicula integra
			Navicula jaernefelti
			Navicula kotschyi
			Navicula lanceolata
			Navicula latelongintudinalis
			Navicula latens
			Navicula lateropunctata
			Navicula laterostrata
			Navicula libonensis
			Navicula luzonensis
			Navicula medioconvexa
			Navicula menisculus
			Navicula minusculoides
			Navicula mobiliensis
			Navicula mobiliensis minor
			Navicula ,olestiformis
			Navicula monoculata
			Navicula muralis
			Navicula neoventricosa
			Navicula notha
			Navicula oblonga
			Navicula ochridana
			Navicula omissa
			Navicula oppugnata
			Navicula paratunkae
			Navicula paucivisitata
			Navicula pelliculosa
			Navicula peregrina
			Navicula perminuta
			Navicula perpusilla
			Navicula protracta
			Navicula pseudobryophila
			Navicula pseudolanceolata
			Navicula pseudoreinhardtii
			Navicula pseudocutiformis
			Navicula radiosa
			Navicula radiosa parva
			Navicula radiosa tenella
			Navicula reinhardtii
			Navicula rhynchocephala
			Navicula rhynchocephala amphiceros
			Navicula rhynchocephala germainii
			Navicula salinarum
			Navicula salinarum intermedia
			Navicula sancaecrucis
			Navicula schroeteri
			Navicula schroeteri escambia
			Navicula scutelloides
			Navicula scutiformis
			Navicula sectreta
			Navicula sectreta apiculata
			Navicula seminuloides
			Navicula similis
			Navicula sparsistriata
			Navicula stroemii
			Navicula subarvensis
			Navicula submolesta
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Class	Order	Family	Genus species
Bacillariophyta (cont.)			(see previous page)
	Naviculales (cont.)		
		Naviculaceae (cont.)	*Navicula subtilissima*
			Navicula symmetrica
			Navicula tantula
			Navicula tenelloides
			Navicula tenera
			Navicula tridentula
			Navicula tripunctata
			Navicula tripunctata schizonemoides
			Navicula vandamii
			Navicula viridula
			Navicula viridula argunensis
			Navicula viridula avenacea
			Navicula viridula linearis
			Navicula viridula rostellata
			Navicula wallacei
		Neidiaceae	*Neidium affine*
			Neidium affine longiceps
			Neidium tenuirostris
			Neidium alpinum
			Neidium ampliatum
			Neidium binode
			Neidium bisulcatum
			Neidium dubium
			Neidium dubium constrictum
			Neidium hankensis
			Neidium hercynicum
			Neidium iridis
			Neidium ladogense
			Neidium ladogense gensestriatum
			Neidium productum
		Pinnulariaceae	*Caloneis amphisbaena*
			Caloneis bacillum
			Caloneis bacillum fontinalis
			Caloneis branderii
			Caloneis hyalina
			Caloneis lewisii
			Caloneis limosa
			Caloneis macedonica
			Caloneis tenuis
			Caloneis undulata
			Caloneis ventricosa
			Caloneis ventricosa alpina
			Caloneis vwntricosa minuta
			Caloneis ventricosa truncatula
			Diatomella balfouriana
			Pinnularia abaujensis
			Pinnularia abaujensis linearis
			Pinnularia abaujensis subundulata
			Pinnularia acrosphaeria
			Pinnularia acrosphaeria turgidula
			Pinnularia appendiculata
			Pinnularia biceps
			Pinnularia borealis
			Pinnularia boyeri
			Pinnularia braunii
			Pinnularia brebissonii
			Pinnularia brebbissonii diminuta
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Class	Order	Family	Genus species
Bacillariophyta (cont.)			(see previous page)
	Naviculales (cont.)		
		Naviculaceae (cont.)	*Pinnularia divergens* *Pinnularia formica* *Pinnularia ignobilis* *Pinnularia intermedia* *Pinnularia lata* *Pinnularia legumen* *Pinnularia lundii* *Pinnularia macilenta* *Pinnularia major* *Pinnularia mesogongyla* *Pinnularia mesolepta* *Pinnularia mesolepta robusta* *Pinnularia microstauron* *Pinnularia microstauron bebissonii* *Pinnularia nodosa* *Pinnularia obscura* *Pinnularia suncapitata* *Pinnularia subcapitata paucistriata* *Pinnularia viridis*
		Plagiotroidaceae	*Plagiotropis lepidoptera* *Plagiotropis lepidoptera proboscidea*
		Pleurosigmataceae	*Gyrosigma acuminatum* *Gyrosigma attenuatum* *Gyrosigma exilis* *Gyrosigma macrum* *Gyrosigma nodiferum* *Gyrosigma obscurum* *Gyrosigma scalproides* *Pleurosigma delicatulum* *Pleurosigma elongatum* *Pleurosigma salinarum*
		Sellaphoraceae	*Fallacia insociabilis* *Fallacia pygmaea* *Fallacia subhamulata* *Sellaphora americana* *Sellaphora bacillum* *Sellaphora laevissima* *Sellaphora pupula* *Sellaphora pupula capitata* *Sellaphora pupula mutata* *Sellaphora pupula rectangularis* *Sellaphora seminulum*
		Stauroneidaceae	*Capartogramma crucicula* *Craticula accomoda* *Craticula cuspidata* *Stauroneis anceps* *Stauroneis anceps americana* *Stauroneis anceps gracilis* *Stauroneis kriegeri* *Stauroneis legumen* *Stauroneis livingstonii* *Stauroneis phoenicenteron* *Stauroneis phoenicenteron gracilis* *Stauroneis smithii* *Stauroneis smithii incisa* *Stauroneis smithii sagitta* *Stauroneis thermicola* *Stauroneis thermicola lanceolata*
	(continued next page)		

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Class	Order	Family	Genus species
Bacillariophyta (cont.)	(see previous page)		
	Thalassiophysales		
		Catenulaceae	
			Amphora acutiuscula
			Amphora angusta
			Amphora coffeaeformis
			Amphora normanii
			Amphora ocellata
			Amphora ovalis
			Amphora ovalis affinis
			Amphora ovalis pediculus
			Amphora perpusilla
			Amphora sabiniana
			Amphora submontana
			Amphora tenuissima
			Amphora thumensis
			Amphora veneta
	Bacillariales		
		Bacillariaceae	
			Bacillaria paxillifer
			Cylindrotheca gracilis
			Cymbellonitzschia divuvuana
			Denticula tenuissima
			Denticula tenuis crassula
			Gomphonitzschia agma
			Hantzschia amphioxys
			Hantzschia distinctpunctata
			Hantzschia virgata
			Nitzschia accommodata
			Nitzschia acicularioides
			Nitzschia acicularis
			Nitzschia acula
			Nitzschia admissa
			Nitzschia aequorea
			Nitzschia agnita
			Nitzschia ambigua
			Nitzschia amphibia
			Nitzschia amphiboides
			Nitzschia angustata
			Nitzschia angustatula
			Nitzschia apiculata
			Nitzschia bacata
			Nitzschia biacrula
			Nitzschia bita
			Nitzschia brevissima
			Nitzschia capitellata
			Nitzschia circumsuta
			Nitzschia clausii
			Nitzschia communis
			Nitzschia compressa
			Nitzschia compressa balatonis
			Nitzschia compressa vexans
			Nitzschia cinfinis
			Nitzschia constricta
			Nitzschia constricta subconstricta
			Nitzschia denticula
			Nitzschia diserta
			Nitzschia dissipata
			Nitzschia dissipata media
			Nitzschia draveillensis
			Nitzschia dubia
			Nitzschia elegantula
			(continued next page)

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Class	Order	Family	Genus species
Bacillariophyta (cont.)			(see previous page)
	Bacillariales (cont.)		
		Bacillariaceae (cont.)	
			Nitzschia filiformis
			Nitzschia fonticola
			Nitzschia fionticola pelagica
			Nitzschia frequens
			Nitzschia frustulum
			Nitzschia frustulum perminuta
			Nitzschia frustulum subsalina
			Nitzschia fruticosa
			Nitzschia gracilis
			Nitzschia hantzschiana
			Nitzschia intermedia
			Nitzschia intermediopsis
			Nitzschia kuetzingiana
			Nitzschia lacum
			Nitzschia liebethruthii
			Nitzschia linearis
			Nitzschia linearis tenuis
			Nitzschia lorenziana
			Nitzschia lorenziana subtilis
			Nitzschia mediastalsis
			Nitzschia microcephala
			Nitzschia obtusa
			Nitzschia obtusa scalpelliformis
			Nitzschia palea
			Nitzschia palea debilis
			Nitzschia palea sumatrana
			Nitzschia paleacea
			Nitzschia panduriformis
			Nitzschia panduriformis minor
			Nitzschia punctata
			Nitzschia pura
			Nitzschia pusilla
			Nitzschia recta
			Nitzschia reversa
			Nitzschia romana
			Nitzschia sicula
			Nitzschia sicula migrans
			Nitzschia sigma
			Nitzschia sigmoidea
			Nitzschia siliqua
			Nitzschia sinuata
			Nitzschia sinuata delongnei
			Nitzschia sinuata tabellaria
			Nitzschia sociabilis
			Nitzschia solita
			Nitzschia stagnorum
			Nitzschia subacularis
			Nitzschia subtilis
			Nitzschia tarda
			Nitzschia thermalis
			Nitzschia tropica
			Nitzschia umbonata
			Nitzschia valdestriata
			Nitzschia vasta
			Nitzschia vermicularis
			Nitzschia vitrea
			Simonsenia delongnei
			Tryblionella calida
			Tryblionella debilis
			Tryblionella gracilis
			Tryblionella tryblionella maxima
			Tryblionella hungarica
			Tryblionella levidensis
	(continued next page)		*Tryblionella victoriae*

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Bacillariophyta (cont.)	(see previous page)		
	Rhopalodiales		
		Rhopalodiaceae	
			Epithemia adnata
			Epithemia argus
			Epithemia argus longicornis
			Epithemia sorex
			Epithemia turgida
			Rhopalodia brebissonii
			Rhopalodia gibba
			Rhopalodia gibbaventricosa
			Rhopalodia gibberula
			Rhopalodia musculus
	Surirellales		
		Entomoneidaceae	
			Entomoneis alata
			Entomoneis ornata
			Entomoneis paludosa
		Surirellaceae	
			Campylodiscus hibernicus
			Cymatopleura elliptica
			Cymatopleura elliptica hibernica
			Stenopterobia curvula
			Stenopterobia delicatissima
			Stenopterobia densestriata
			Stenopterobia intermedia
			Surirella aligncula
			Surirella angusta
			Surirella brightwellii
			Surirella iowensis
			Surirella linearis
			Surirella minuta
			Surirella nervosa
			Surirella ovalis
			Surirella ovata
			Surirella ovata pinnata
			Surirella spiralis
			Surirella stalagma
			Surirella suecica
			Surirella tenera
Phaeophyta			
			unidentified species
Xanthophyta			
	Mischococcales		
		Ophiocytiaceae	
			Ophiocytium capitatum
	Vaucheriales		
		Vaucheriaceae	
			Vaucheria geminata
Craspedophyta			
			unidentified species
Chlorophyta			
	Volvocales		
		Chlamydomonadaceae	
			Carteria polychloris
			Chlamydomonas sp.
		Volvocaceae	
			Eudorina elegans
			Pandorina morum
			Volvox tertius
	(continued next page)		

[1]Lorenz in Schmidt 1999

APPENDIX H-3

PERIPHYTON AND PHYTOPLANKTON SPECIES REPORTED FROM THE RED RIVER[1]
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Class	Order	Family	Genus species
Chlorophyta (cont.)	(see previous page)		
	Tetrasporales		
		Gloecystaceae	
			Gloecystis gigas
			Gloecystis vesiculosa
		Tetrasporaceae	
			Tetraspora cylindrica
			Tetraspora gelatinosa
			Tetraspora lubrica
		Chlorococcaceae	
			Characium ambiguum
			Characium hookeri
			Characium limneticum
			Characium obtusum
			Characium pringsheimii
			Schroederia setigera
			Sphaerocystis schroeteri
			Tetraehedron caudatum
			Tetraehedron gracile
			Tetraehedron minimum
			Tetraehedron muticum
			Tetraehedron pentaedricum
			Tetraehedron trigonum
		Dictyosphaeriaceae	
			Dictyosphaerium ehrenbergianum
			Dictyosphaerium pulchellum
			Westella botryoides
		Hydrodictyaceae	
			Hydrodictyon reticulatum
			Pediastrum biradiatum
			Pediastrum boryanum
			Pediastrum boryanum longicorne
			Pediastrum duplex
			Pediastrum duplex clathratum
			Pediastrum duplex gracilimum
			Pediastrum integrum
			Pediastrum muticum
			Pediastrum obtusum
			Pediastrum simplex
			Pediastrum tetras
			Sorastrum spinulosm
		Micractiniaceae	
			Golenkinia radiata
			Micractinium pusillum
			Micractinium quadrisetum
		Oocystaceae	
			Ankistrodesmus convolutus
			Ankistrodesmus falcatus
			Ankistrodesmus spiralis
			Cerasterias longissima
			Dactylococcus infusionum
			Lagerheimia wratislawiensis
			Nephrocytium limneticum
			Oocystis borgei
			Oocystis eremosphaeria
			Oocystis lacustris
			Oocystis pusilla
			Oocystis solitaria
			Quadrigula chodatii
			Quadrigula lacustris
			Treubaria crassipina
		(continued next page)	*Treubaria setigerum*

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PERIPHYTON AND PHYTOPLANKTON SPECIES REPORTED FROM THE RED RIVER[1]
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Class	Order	Family	Genus species
Chlorophyta (cont.)		(see previous page)	
	Oocystaceae (cont.)		
		Scenedesmaceae	
			Actinastrum hantzschii
			Coelastrum cambricum
			Coelastrum microporum
			Coelastrum sphaericum
			Crucigenia apiculata
			Crucigenia crucifera
			Crucigenia fenestrata
			Crucigenia irregularis
			Crucigenia quadratus
			Crucigenia rectangularis
			Crucigenia tetrapedia
			Scenedesmus abundans
			Scenedesmus acuminatus
			Scenedesmus acutus
			Scenedesmus arcuatus
			Scenedesmus armatus
			Scenedesmus bernardii
			Scenedesmus bicaudatus
			Scenedesmus bijuga
			Scenedesmus bijuga alternans
			Scenedesmus brasiliensis
			Scenedesmus circumfusus
			Scenedesmus denticulatus
			Scenedesmus dimorphus
			Scenedesmus dispar
			Scenedesmus ecornis
			Scenedesmus hystrix
			Scenedesmus obliquus
			Scenedesmus quadricauda
			Scenedesmus quadricauda longispina
			Scenedesmus quadricauda longispina assymetricus
			Scenedesmus serratus
			Scenedesmus spinosus
			Tetradesmus sp.
			Tetrastrum heteracanthum
			Tetrastrum staurogeniaeforme
	Microsporales		
		Microsporaceae	
			Microspora amoena
			Microspora pachyderma
			Microspora quadrata
			Microspora stagnorum
	Chaetophorales		
		Chaetophoraceae	
			Chaetophora sp.
			Schizomeris leibleinii
			Stigeoclonium lubricum
	Chlorosarcinales		
		Aphanochaetaceae	
			Aphanochaete repens
		Chlorosarcinaceae	
			Draparnaldia glomerata
			Draparnaldia plumosa
	Oedogoniales		
		Oedogoniaceae	
			Bulbochaete sp.
			Oedogonium sp.
	(continued next page)		

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PERIPHYTON AND PHYTOPLANKTON SPECIES REPORTED FROM THE RED RIVER[1]
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Class	Order	Family	Genus species
Chlorophyta (cont.)	(see previous page)		
	Zygnematales		
		Desmidiaceae	
			Actinotaenium cucurbitinum
			Arthrodesmus incus
			Closterium acerosum
			Closterium angustatum
			Closterium dianae
			Closterium didymotocum
			Closterium ehrenbergii
			Closterium gracile
			Closterium incurvum
			Closterium intermedium
			Closterium kutzingii
			Closterium leibellula
			Closterium lineatum
			Closterium littorale
			Closterium lunula
			Closterium moniliferum
			Closterium parvulum
			Closterium ralfsii
			Closterium ralfsii hybridum
			Closterium rostratum
			Closterium setaceum
			Closterium venus
			Cosmarium angulosum
			Cosmarium botrytis
			Cosmarium circulare
			Cosmarium contractum
			Cosmarium formosulum
			Cosmarium galeritum
			Cosmarium granatum
			Cosmarium humile
			Cosmarium impressulum
			Cosmarium laeve
			Cosmarium margaritatum
			Cosmarium microsphinctum
			Cosmarium monilforme
			Cosmarium obtusatum
			Cosmarium protractum
			Cosmarium punctulatum
			Cosmarium pyramidatum
			Cosmarium pyramidatum convexum
			Cosmarium regnesi
			Cosmarium regnesi montanum
			Cosmarium reniforme
			Cosmarium repandum
			Cosmarium subcrenatum
			Cosmarium subreniforme
			Cosmarium trilobulatum
			Cosmarium terpinii
			Cosmarium undulatum
			Euastrum abruptum
			Euastrum ansatum
			Euastrum denticulatum
			Euastrum dubium
			Euastrum elegans
			Euastrum punctulatum
			Euastrum turneri
			Hyalotheca dissiliens
			Micrasterius truncata
			(continued next page)

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PERIPHYTON AND PHYTOPLANKTON SPECIES REPORTED FROM THE RED RIVER[1]
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Class	Order	Family	Genus species
Chlorophyta (cont.)			(see previous page)
	Zygnematales (cont.)		
		Desmidiaceae (cont.)	
			Penium margaritaceum
			Sphaerozosma granulatum
			Staurastrum alternans
			Staurastrum anatinum
			Staurastrum anatinum parvum
			Staurastrum aspinosum
			Staurastrum brevispinum
			Staurastrum chaetoceras
			Staurastrum dickiei
			Staurastrum dilatatum
			Staurastrum furcigerum
			Staurastrum margaritaceum
			Staurastrum muticum
			Staurastrum orbiculare
			Staurastrum paradoxum
			Staurastrum punctulatum
			Staurastrum tetracerum
			Staurastrum turgescens
			Xanthidium antilopaeum
		Mesotaeniaceae	
			Cylindrocystis americana
			Cylindrocystis americana minor
			Mesotaenium endlicherianum
			Netrium interruptum
			Netrium oblongum
		Zygnemataceae	
			Cosmocladium constrictum
			Mougeotia sp.
			Pleurodiscus sp.
			Spirogyra sp.
			Zygnema sp.
	Pyramimonadales		
		Pyramimonadeae	
			Pyramimonas sp.
	Cladophorales		
		Cladophoraceae	
			Cladophora glomerata
			Rhizoclonium hieroglyphicum
	Ulotrichales		
		Cylindrocapsaceae	
			Cylindrocapsa conferta
		Ulotrichaceae	
			Geminella sp.
			Ulothrix tenerrima
			Ulothrix zonata
			Uronema elongatum

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APPENDIX H-4

AQUATIC AND WETLAND VEGETATION REPORTED FROM THE SHEYENNE AND RED RIVERS

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Scientific name	Common name	General habitat	Upper Sheyenne	Lake Ashtabula	Lower Sheyenne	Red River
Actaea rubra	baneberry	wetland fringe	X			
Agropyron repens	quackgrass	wetland fringe		X		X
Agrostis stolonifera	redtop	wetland		X		
Alisma gramineum	water plantain	emergent marsh	X			
Alisma plantago-aquatica	water plantain	emergent marsh		X	X	
Alisma subcordatum	water plantain	emergent marsh	X			
Alnus rugosa	speckled alder	scrub shrub			X	
Alopecurus aequalis	short-awn foxtail	wetland	X			X
Amorpha fruitocosa	false indigo	emergent marsh				X
Anemone canadensis	anemone	wetland		X		
Apocynum androsaemifolium	spreading dogbane	wetland	X			
Apocynum sibiricum	dogbane	wetland		X		
Artemisia biennis	biennial wormwood	wetland	X			
Asclepias incarnata	swamp milkweed	wetland	X	X		
Aster brachyactis	rayless aster	wetland	X			
Aster ciliolatus	aster	wetland	X			
Aster hesperius	marsh aster	wetland	X			
Aster lateriflorus	aster	wetland				X
Aster pansus	aster	wetland	X			
Aster simplex	panicled aster	wetland			X	X
Athyrium filix-femina	lady fern	wetland			X	
Atriplix subspicata (A. littoralis)	spearscale	wetland	X			
Beckmannia syzigachne	western sloughgrass	emergent marsh	X	X	X	X
Bidens acuta	beggarticks	wetland			X	
Bidens cernua	nodding beggarticks	wetland	X	X	X	
Bidens comosa	beggarticks	wetland	X			
Bidens frondosa	beggarticks	wetland	X		X	X
Butomus umbrellatrus	flowering rush	emergent marsh			X	
Calamagrostis canadensis	bluejoint reedgrass	wetland		X		
Calamagrostis neglecta	reedgrass	wetland				X
Callitriche hermaphroditica	water starwort	emergent marsh	X		X	
Caltha palustris	marsh marigold	wetland	X			
Campanula rapunculoides	creeping bellflower	emergent marsh	X			
Carex aquatilis	water sedge	emergent marsh		X	X	X
Carex atherodes	slough sedge	emergent marsh	X	X	X	
Carex aurea	golden sedge	wetland	X			
Carex bicknellii	Bicknell's sedge	wetland fringe			X	
Carex blanda	slough sedge	wetland fringe		X		
Carex brevoir	fescue sedge	wetland fringe		X	X	
Carex buxbaumii	slough sedge	wetland		X		
Carex crawei	slough sedge	wetland		X		
Carex cristella	sedge	wetland	X			
Carex gravida	heavy sedge	wetland fringe		X		
Carex hystericina	bottlebrush sedge	emergent marsh		X	X	
Carex interior	sedge	wetland		X		
Carex lacustris	sedge	emergent marsh	X			
Carex lanuginosa	woolly sedge	wetland	X	X	X	

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Scientific name	Common name	General habitat	Upper Sheyenne	Lake Ashtabula	Lower Sheyenne	Red River
Carex praegracilis	clustered field sedge	wetland		X	X	
Carex prairea	sedge	wetland	X	X		
Carex rosea	sedge	wetland				X
Carex sp.	sedge	wetland				X
Carex stipata	saw-beak sedge	wetland	X			
Carex stricta	tussock sedge	wetland	X		X	
Carex tenera	sedge	wetland fringe		X		
Carex viridula	sedge	wetland		X		
Carex vulpinoidea	fox sedge	wetland		X	X	
Catabrosa aquatica	brookgrass	wetland fringe			X	
Ceratophyllum demersum	coontail	open water	X	X	X	
Chenopodium glaucum	pale goosefoot	wetland		X		
Chenopodium rubrum	red goosefoot	wetland		X		
Cicta maculata	common water hemlock	emergent marsh	X	X		
Cicuta bubifera	bulbous water hemlock	emergent marsh	X			
Cicuta maculata	common water hemlock	emergent marsh	X	X		
Cirsium arvense	Canada thistle	wetland fringe		X		X
Conyza canadensis	horseweed	wetland fringe		X		
Cornus foemina	gray dogwood	scrub shrub				X
Cornus stolonifera	red-osier dogwood	scrub shrub	X	X	X	X
Crepis runcinata	hawk's-beard	wetland		X		
Cyperacea sp.	sedge	wetland				
Cyperus aristatus	awned cyperus	wetland			X	
Cyperus esculentus	yellow nut sedge	wetland	X			
Cyperus rivularis	brook cyperus	wetland			X	
Distichlis spicata	inland saltgrass	wetland fringe			X	
Dryopteris cristata	crested fern	wetland			X	
Echinochloa crusgalli	barnyard grass	wetland			X	X
Echinochloa muricata	barnyard grass	wetland	X			
Echinochloa sp.	barnyard grass	wetland		X		
Eleocharis acicularis	slender spikerush	wetland				X
Eleocharis calva	spikerush	wetland		X		
Eleocharis compressa	flatstem spikerush	wetland		X		
Eleocharis erythropoda	spikerush	wetland	X			
Eleocharis macrostachya	spikerush	wetland	X			
Eleocharis palustris	creeping spikerush	wetland		X	X	X
Eleocharis smallii	spikerush	wetland	X			
Elodea canadensis	waterweed	open water	X		X	
Elymus glaucus	wheatgrass	wetland fringe				X
Epilobium glandulosum	willow herb	wetland	X	X		
Epilobium leptophyllum	narrow-leaved willow herb	wetland		X		

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Scientific name	Common name	General habitat	Upper Sheyenne	Lake Ashtabula	Lower Sheyenne	Red River
Equisetum arvense	common horsetail	wetland fringe	X	X		
Equisetum hyemale	common scouring rush	wetland		X		
Equisetum laevigatum	smooth scouring rush	wetland		X	X	
Eragrostis hypnoides	teal lovegrass	wetland			X	
Erigeron lonchophyllus	fleabane	wetland				X
Erigeron philadelphicus	Philadelphia fleabane	wetland	X	X		
Eriophorum augustifolium	narrowleaf cottensedge	wetland		X		
Eupatorium maculatum	Joe-pye weed	wetland		X		
Gentianopsis crinita	fringed gentian	wetland	X			
Gentianopsis procera	small fringed gentian	wetland		X		
Gerardia tenuifolia	slender gerardia	wetland		X		
Glyceria grandis	American mannagrass	emergent marsh	X	X	X	X
Glyceria striata	fowl mannagrass	emergent marsh	X	X		
Glycyrrhiza lepidot	wild licorice	wetland fringe	X	X		X
Habenaria hyperborea	northern green orchid	wetland		X		
Helianthus tuberosus	Jerusalem artichoke	wetland fringe				X
Heliotropium curassavicum	seaside heliotrope	wetland			X	
Heteranthera dubia	water stargrass	emergent marsh		X	X	
Hippuris vulgaris	mare's tail	emergent marsh	X		X	
Humulus lupulus	American hop	wetland fringe		X		
Impatiens capensis	spotted touch-me-not	wetland	X	X		
Juncus balticus	Baltic rush	emergent marsh	X	X	X	
Juncus bufonius	toad rush	wetland		X		
Juncus dudleyi	Dudley's rush	wetland		X		
Juncus nodosus	jointed rush	wetland		X	X	
Juncus torreyi	Torrey's rush	wetland			X	
Lactuca biennis	blue wood lettuce	wetland fringe	X			
Laporta canadensis	wood nettle	wetland	X			
Leersia oryzoides	rice cutgrass	emergent marsh	X		X	
Lemna minor	duckweed	emergent marsh	X	X	X	
Lemna trisulca	star duckweed	emergent marsh	X	X	X	
Lemna turionifera	duckweed	emergent marsh	X			
Lilium philadelphicum	water lily	wetland fringe		X		
Lobelia kalmii	Kalm's lobelia	wetland		X		
Lobelia spicata	pale-spike lobelia	wetland		X	X	
Lycos americanus	American bugleweed	wetland	X	X		
Lycos asper	rough bugleweed	wetland	X	X		
Lycos uniflorus	bugleweed	wetland		X		
Lysimachia ciliata	fringed loosestrife	emergent marsh		X		
Lythrum salicaria	purple loosestrife	emergent marsh			X	
Mentha arvensis	common mint	wetland	X	X	X	X
Mimulus ringens	Allegheny monkeyflower	wetland	X		X	
Muhlenbergia racemosa	marsh muhly	wetland		X		
Muhlenbergia richardsonis	mat muhly	wetland fringe		X		
Myriophyllum exalbescens	water milfoil	open water			X	

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Scientific name	Common name	General habitat	Upper Sheyenne	Lake Ashtabula	Lower Sheyenne	Red River
Myriophyllum spicatum	Eurasian water milfoil	open water			X	
Naumburgia thyrsiflora (Lysimachia thrysiflora)	tufted loosestrife	emergent marsh				X
Nuphar luteum	yellow waterlily	open water	X		X	
Nuphar variegatum	waterlily	open water			X	
Oryzopsis racemosa	ricegrass	wetland fringe			X	
Panicum capillare	common witchgrass	wetland			X	
Panicum virgatum	witchgrass	wetland			X	X
Parnassia glauca	grass-of-Parnassus	wetland		X		
Parnassia palustris	northern grass-of-Parnassus	wetland		X		
*Petasites vitifolius (*P frigidis*)*	sweet coltsfoot	wetland				X
Phalaris arundiancea	reed canary grass	wetland			X	X
Phragmites australis	common reed	emergent marsh		X	X	X
Phragmites communis	reed	emergent marsh	X			X
Physostegia sp.	obedient plant	wetland	X	X		
Plantago eriopoda	alkali plantain	wetland fringe		X		
Plantago major	common plantain	wetland fringe	X	X		X
Poa compressa	Canada bluegrass	wetland fringe		X		
Poa palustris	fowl bluegrass	wetland		X		
Poa pratensis	Kenucky bluegrass	wetland fringe		X	X	X
Poa sp.	bluegrass	wetland fringe				
Polygonaceae sp.	smartweed family	wetland				X
polygonum amphibium	water smartweed	emergent marsh	X			X
Polygonum coccineum	marsh smartweed	emergent marsh		X		
Polygonum hydropiper	water pepper	wetland				X
Polygonum lapathifolium	pale smartweed	wetland	X	X	X	X
Polygonum pensylvanicum	Pennsylvania smartweed	wetland			X	
Polygonum persicaria	lady's thumb	wetland		X		
Polygonum ramosissimum	bushy knotweed	wetland fringe		X		
Populus deltoides	cottonwood	wetland fringe			X	X
Potamogeton sp.	pondweeds	open water		X		X
Potamogeton crispus	curly pondweed	open water			X	
Potamogeton filiformis	slender pondweed	open water			X	
Potamogeton nodosus	longleaf pondweed	open water			X	
Potamogeton pectinatus	sago pondweed	open water	X	X	X	
Potamogeton pusillus	small pondweed	open water		X	X	
Potamogeton richardsonii	claspingleaf pondweed	open water	X	X	X	
Potamogeton species	pondweed	open water				X
Potamogeton zosteriformis	flatstem pondweed	open water	X		X	
Potentilla anserina	silverweed	wetland	X	X		X
Potentilla norvegica	rough cinquefoil	wetland	X	X		
Potentilla rivalis	brook cinquefoil	wetland		X		
Prunella vulgaris	selfheal	wetland fringe		X		
Puccinellia nuttallianna	Nuttall's alkaligrass	emergent marsh	X	X	X	
Ranunculus cymbalaria	seaside buttercup	wetland	X	X	X	
Ranunculus gmelinii	yellow water crowfoot	emergent marsh	X			

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Scientific name	Common name	General habitat	Upper Sheyenne	Lake Ashtabula	Lower Sheyenne	Red River
Ranunculus longirostris	white water crowfoot	open water	X	X		
Ranunculus macounii	Macoun's buttercup	wetland	X		X	
Ranunculus pensylvanicus	bristly crowfoot	wetland	X		X	
Ranunculus sceleratus	cursed crowfoot	emergent marsh	X	X	X	
Ribes americanum	wild black currant	wetland				X
Ribes hirtellum	hairy stem gooseberry	wetland	X			
Rorippa curvipes	blunt-leaved yellow cress	wetland	X			
Rorippa islandica	March yellow cress	emergent marsh		X		
Rumex crispus	curled dock	wetland	X	X		X
Rumex maritimus	golden dock	wetland	X	X		
Rumex mexicanus	Mexican dock	wetland fringe	X			
Rumex occidentalis	western dock	wetland		X		
Rumex stenophyllus	dock	wetland	X			
Sagittaria cuneata	arrowhead	emergent marsh	X	X	X	
Sagittaria latifolia	arrowhead	emergent marsh	X			
Salicacea species	willow family	scrub shrub				X
Salicornia rubra	glasswort	wetland			X	
Salix amygdaloides	peachleaf willow	scrub shrub	X	X	X	X
Salix bebbiana	beaked willow	scrub shrub		X		
Salix candida	hoary willow	scrub shrub		X		
Salix discolor	pussy willow	scrub shrub				X
Salix exigua	sandbar willow	scrub shrub	X	X	X	X
Salix interior	sandbar willow	scrub shrub				X
Salix lutea	yellow willow	scrub shrub		X		
Salix petiolaris	meadow willow	scrub shrub		X		
Salix rigida	heartleaf willow	scrub shrub			X	
Salix serissima	autumn willow	scrub shrub		X		
Scirpus acutus	hardstem bulrush	emergent marsh	X		X	
Scirpus americanus	three square bulrush	emergent marsh		X	X	
Scirpus atrovirens	darkgreen bulrush	wetland		X	X	
Scirpus fluviatilis	river bulrush	emergent marsh	X	X		
Scirpus heterochaetus	slender bulrush	emergent marsh	X		X	
Scirpus microcarpus	redstem bulrush	emergent marsh	X			
Scirpus paludosus	prairie bulrush	emergent marsh	X	X	X	
Scirpus rubrotinctus	bulrush	emergent marsh		X		
Scirpus sp.	bulrush	emergent marsh		X		
Scirpus validus	common bulrush	emergent marsh		X	X	
Scophularia lanceolata	figwort	wetland fringe		X		
Scutellaria lateriflora	blue skullcap	wetland	X	X	X	
Senecio congestus	swamp ragwort	wetland	X			
Sisyrinchium montanum	blue-eyed grass	wetland		X		
Sium suave	water parsnip	wetland		X	X	
Solanum dulcamara	bittersweet nightshade	wetland fringe	X			
Solidago canadensis	Canada goldenrod	wetland fringe			X	
Solidago gigantea	late goldenrod	wetland	X			
Sonchus arvensis	sow-thistle	wetland fringe				X

APPENDIX H-4

AQUATIC AND WETLAND VEGETATION REPORTED FROM THE SHEYENNE AND RED RIVERS

Final Aquatic Impact Analysis Report

Scientific name	Common name	General habitat	Upper Sheyenne	Lake Ashtabula	Lower Sheyenne	Red River
Sparganium eurycarpum	giant burrweed	emergent marsh		X	X	
Spartina pectina	prairie cordgrass	wetland	X	X	X	X
Sphenopholis obtusata	prairie wedgegrass	wetland fringe				X
Spirodela polyrhiza	greater duckweed	emergent marsh			X	
Stachys palustris	hedge nettle	wetland	X	X		
Stellaria crassifolia	stichwort	wetland		X		
Stellaria longifolia	long-leaved stitchwort	wetland fringe		X		
Suaeda depressa	sea blight	wetland			X	
Teucrium canadense	germander	wetland	X	X	X	
Trifolium repens	white clover	wetland fringe		X		X
Triglochin maritima	arrowgrass	emergent marsh	X	X		
Triglochin palustre	arrowhead	emergent marsh		X		
Typha angustifolia	narrrow-leaf cattail	emergent marsh	X	X	X	
Typha glauca	hydrid cattail	emergent marsh	X			
Typha latifolia	broad-leaf cattail	emergent marsh	X	X	X	
Typha sp.	cattail	emergent marsh		X		X
Urtica diocia	stinging nettle	wetland	X	X		X
Urticularia Vvulgaris	common bladderwort	open water	X		X	
Verbena hastata	blue vervain	wetland	X	X		
Veronica anagallis-aquatica	water speedwell	emergent marsh	X			
Veronica perigrina	purslane speedwell	wetland	X			
Viola nephrophylla	northern bog violet	wetland		X		
Viola pubescens	downey yellow violet	wetland fringe	X			
Vitis riparia	riverbank grape	wetland				X
Xanthium strumarium	cocklebur	wetland fringe				X
Zizania aquatica	wild rice	emergent marsh	X		X	
Zosterella dubia	water stargrass	emergent marsh	X			

APPENDIX I

PREDICTED IHA STATISTIC COMPARISON BETWEEN BASELINE AND PUMPING/OVERFLOW

APPENDIX I-1A

PREDICTED IHA STATISTICS, MOD50 VS. 300MOD50 AT HWY 30 (CALIBRATED FROM WARWICK GAGE) - MONTHLY AVERAGE FLOW (CFS)

Final Aquatic Impact Analysis Report

Year	October	November	December	January	February	March	April	May	June	July	August	September
MOD50 Baseline												
2005	3.0	9.6	4.6	4.8	4.6	41.5	451.3	297.1	54.3	36.5	5.1	6.5
2006	13.2	10.8	7.3	6.2	5.5	28.0	1435.5	331.4	49.4	83.4	27.8	14.7
2007	3.0	6.2	3.3	2.4	1.6	3.5	516.1	51.0	125.1	60.9	5.2	14.0
2008	5.2	8.0	4.6	3.0	2.8	25.7	102.6	13.7	22.3	3.5	15.0	26.0
2009	13.5	11.1	8.1	3.2	2.1	82.8	327.9	72.3	49.6	85.8	22.8	5.9
2010	20.8	15.6	5.9	2.6	2.0	209.9	97.5	50.3	22.1	1.9	1.3	1.2
2011	33.4	32.6	28.6	10.5	11.4	119.4	89.6	45.2	21.0	1.3	1.4	4.9
2012	9.8	15.2	8.7	5.6	5.3	48.7	194.9	26.0	42.4	6.6	28.5	48.7
2013	16.6	25.9	14.8	9.5	9.0	53.7	358.8	44.3	73.6	11.4	44.1	85.9
2014	16.4	13.5	9.1	7.7	6.9	34.9	1784.8	412.0	61.4	103.7	34.6	18.3
2015	9.3	12.1	16.6	8.8	9.8	180.7	974.6	456.6	168.3	160.3	173.3	110.5
300MOD50												
2005	3.0	9.6	4.6	4.8	4.6	41.5	451.3	297.1	54.3	36.5	5.1	6.5
2006	13.2	10.8	7.3	6.2	5.5	28.0	1435.5	331.4	49.4	83.4	27.8	14.7
2007	3.0	6.2	3.3	2.4	1.6	3.5	516.1	51.0	125.1	60.9	5.2	14.0
2008	5.2	8.0	4.6	3.0	2.8	25.7	102.6	13.7	22.3	3.5	15.0	26.0
2009	13.5	11.1	8.1	3.2	2.1	82.8	327.9	72.3	49.6	85.8	22.8	5.9
2010	20.8	15.6	5.9	2.6	2.0	209.9	97.5	50.3	22.1	1.9	1.3	1.2
2011	33.4	32.6	28.6	10.5	11.4	119.4	89.6	45.2	21.0	1.3	1.4	4.9
2012	9.8	15.2	8.7	5.6	5.4	48.7	194.9	26.0	42.4	6.6	28.5	48.7
2013	16.6	25.9	14.8	9.5	9.0	53.7	358.8	44.3	73.6	11.4	44.1	85.9
2014	16.4	13.5	9.1	7.7	6.9	34.9	1784.8	412.0	61.4	103.7	34.6	18.3
2015	9.3	12.1	16.6	8.8	9.8	180.7	974.6	456.6	168.3	160.3	173.3	110.5

Variance Data

	October	November	December	January	February	March	April	May	June	July	August	September
MOD50 Baseline												
1-day min	3.0	6.2	3.3	2.4	1.6	3.5	89.6	13.7	21.0	1.3	1.3	1.2
- 1 S.D.	4.2	6.7	2.7	2.9	2.2	8.2	-0.5	-8.8	16.8	-2.4	-16.2	-5.7
Mean	13.9	14.6	10.1	5.8	5.5	75.3	575.8	163.6	62.7	50.5	32.6	30.6
+ 1 S.D.	22.0	22.5	17.5	8.8	8.9	142.4	1152.1	336.0	108.5	103.3	81.5	66.9
1-day max	33.4	32.6	28.6	10.5	11.4	209.9	1784.8	456.6	168.3	160.3	173.3	110.5
CV[1]	58.1	54.4	73.0	50.2	61.0	89.1	100.1	105.3	73.1	104.8	149.5	118.7
300MOD50												
1-day min	3.0	6.2	3.3	2.4	1.6	3.5	89.6	13.7	21.0	1.3	1.3	1.2
- 1 S.D.	4.2	6.7	2.7	2.9	2.2	8.2	-0.5	-8.8	16.8	-2.4	-16.2	-5.7
Mean	13.9	14.6	10.1	5.8	5.5	75.3	575.8	163.6	62.7	50.5	32.6	30.6
+ 1 S.D.	22.0	22.5	17.5	8.8	8.9	142.4	1152.1	336.0	108.5	103.3	81.5	66.9
1-day max	33.4	32.6	28.6	10.5	11.4	209.9	1784.8	456.6	168.3	160.3	173.3	110.5
CV[1]	58.1	54.4	73.0	50.2	61.0	89.1	100.1	105.3	73.1	104.8	149.5	118.7

[1]CV=coefficient of variation (=SD*100/mean)

APPENDIX I-1B

PREDICTED IHA STATISTICS, MOD50 VS. 300MOD50 AT HWY 30 (CALIBRATED FROM WARWICK GAGE) - MAGNITUDE (CFS), FREQUENCY (PER YEAR), AND DURATION (DAYS) OF EXTREME EVENTS

Final Aquatic Impact Analysis Report

Year	1-day min	3-day min	7-day min	30-day min	90-day min	1-day max	3-day max	7-day max	30-day max	90-day max	Zero days	Base flow	Date min	Date max	Low pulse #	Low pulse duration	High pulse #	High pulse duration	Rise rate	Fall rate	Reversals
MOD50 Baseline																					
2005	0.6	0.8	1.1	3.0	4.6	1431.5	1356.4	1155.7	664.6	275.8	0.0	0.0	275.0	112.0	8.0	21.0	2.0	10.5	28.4	-15.6	59.0
2006	4.7	4.3	3.1	3.0	4.2	3129.3	2921.2	2575.9	1445.0	614.6	0.0	0.0	32.0	112.0	2.0	9.5	1.0	40.0	48.9	-33.8	83.0
2007	1.0	1.2	1.5	1.6	2.3	1782.5	1734.1	1438.3	528.8	235.7	0.0	0.0	233.0	102.0	4.0	37.0	1.0	12.0	30.3	-15.6	48.0
2008	1.5	1.5	1.6	2.6	3.1	332.8	322.2	284.2	122.5	53.7	0.0	0.1	211.0	93.0	8.0	21.5	0.0	0.0	5.7	-3.9	58.0
2009	1.4	1.4	1.4	1.8	3.4	743.4	723.6	664.0	377.7	171.9	0.0	0.0	38.0	95.0	3.0	32.3	1.0	11.0	13.8	-7.2	49.0
2010	0.4	0.5	0.6	0.9	1.4	856.6	781.5	658.9	267.8	126.1	0.0	0.0	247.0	81.0	3.0	60.7	1.0	8.0	12.9	-8.3	78.0
2011	0.0	0.0	0.0	0.6	2.5	261.8	220.3	178.6	126.6	86.4	5.0	0.0	220.0	85.0	3.0	28.3	0.0	0.0	5.4	-5.7	78.0
2012	2.8	2.8	3.0	5.0	5.8	632.0	611.9	539.6	232.6	102.0	0.0	0.1	211.0	93.0	8.0	9.4	1.0	9.0	10.9	-7.4	57.0
2013	4.7	4.7	5.1	8.5	9.9	1072.7	1038.7	916.0	394.8	173.2	0.0	0.1	212.0	94.0	1.0	6.0	1.0	12.0	18.5	-12.5	57.0
2014	5.9	6.3	6.5	6.9	7.5	3890.8	3632.1	3202.8	1796.7	764.2	0.0	0.0	32.0	112.0	0.0	0.0	1.0	44.0	60.3	-41.8	83.0
2015	7.4	7.6	8.0	4.8	6.3	2731.5	2437.8	2051.8	1093.2	581.3	0.0	0.0	284.0	92.0	0.0	0.0	2.0	23.0	45.3	-27.9	67.0
300MOD50																					
2005	0.6	0.8	1.1	3.0	4.6	1431.5	1356.4	1155.7	664.6	275.8	0.0	0.0	275.0	112.0	8.0	17.1	2.0	10.5	28.4	-15.6	59.0
2006	4.7	4.3	3.1	3.0	4.2	3129.3	2921.2	2575.9	1445.0	614.6	0.0	0.0	32.0	112.0	2.0	9.5	1.0	40.0	49.7	-33.8	83.0
2007	1.0	1.2	1.5	1.6	2.3	1782.5	1734.1	1438.3	528.8	235.7	0.0	0.0	233.0	102.0	4.0	37.0	1.0	12.0	30.3	-15.6	48.0
2008	1.5	1.5	1.6	2.6	3.1	332.8	322.2	284.2	122.5	53.7	0.0	0.1	211.0	93.0	8.0	21.6	0.0	0.0	5.6	-3.9	58.0
2009	1.4	1.4	1.4	1.8	3.4	743.4	723.6	664.0	377.7	171.9	0.0	0.0	38.0	95.0	3.0	32.3	1.0	11.0	13.8	-7.2	49.0
2010	0.4	0.5	0.6	0.9	1.4	856.6	781.5	658.9	267.8	126.1	0.0	0.0	247.0	81.0	3.0	60.3	1.0	8.0	13.2	-8.3	78.0
2011	0.0	0.0	0.0	0.6	2.5	261.8	220.3	178.6	126.6	86.4	5.0	0.0	220.0	85.0	3.0	28.3	0.0	0.0	5.4	-5.7	78.0
2012	2.8	2.8	3.0	5.0	5.8	632.0	611.9	539.6	232.6	102.0	0.0	0.1	211.0	93.0	8.0	9.4	1.0	9.0	10.8	-7.4	57.0
2013	4.7	4.7	5.1	8.5	9.9	1072.7	1038.7	916.0	394.8	173.2	0.0	0.1	212.0	94.0	1.0	6.0	1.0	12.0	18.5	-12.5	57.0
2014	5.9	6.3	6.5	6.9	7.6	3890.8	3632.1	3202.8	1796.7	764.2	0.0	0.0	32.0	112.0	0.0	0.0	1.0	44.0	61.3	-41.8	83.0
2015	7.4	7.6	8.0	8.5	10.6	2731.5	2437.8	2051.8	1093.2	581.3	0.0	0.0	284.0	92.0	0.0	0.0	2.0	23.0	45.3	-27.9	67.0

Variance Data

	1-day min	3-day min	7-day min	30-day min	90-day min	1-day max	3-day max	7-day max	30-day max	90-day max	Zero days	Base flow	Date min	Date max	Low pulse #	Low pulse duration	High pulse #	High pulse duration	Rise rate	Fall rate	Reversals
MOD50 Baseline																					
1-day min	0.0	0.0	0.0	0.6	1.4	261.8	220.3	178.6	122.5	53.7	0.0	0.0	32.0	81.0	0.0	0.0	0.0	0.0	5.4	-41.8	48.0
- 1 S.D.	0.3	0.3	0.3	1.0	2.1	317.6	311.2	260.1	78.0	43.5	-1.1	0.0	132.9	94.5	0.6	2.1	0.4	0.9	6.7	-29.0	52.0
Mean	2.8	2.8	2.9	3.5	4.6	1533.2	1434.5	1242.3	640.9	289.5	0.5	0.0	181.4	97.4	3.6	20.5	1.0	15.4	25.5	-16.3	65.2
+ 1 S.D.	5.3	5.4	5.5	6.0	7.2	2748.8	2557.9	2224.6	1203.9	535.6	2.0	0.1	229.8	100.2	6.7	38.9	1.6	30.0	44.3	-3.7	78.4
1-day max	7.4	7.6	8.0	8.5	9.9	3890.8	3632.1	3202.8	1796.7	764.2	5.0	0.1	284.0	112.0	8.0	60.7	2.0	44.0	60.3	-3.9	83.0
CV[1]	91.3	90.4	88.6	71.8	55.3	79.3	78.3	79.1	87.8	85.0	335.6	75.0	26.7	3.0	84.3	89.6	63.0	94.4	73.8	-77.4	20.3
300MOD50																					
1-day min	0.0	0.0	0.0	0.6	1.4	261.8	220.3	178.6	122.5	53.7	0.0	0.0	32.0	81.0	0.0	0.0	0.0	0.0	5.4	-41.8	48.0
- 1 S.D.	0.3	0.3	0.3	0.9	1.9	317.6	311.2	260.1	78.0	43.5	-1.1	0.0	132.9	94.5	0.6	1.8	0.4	0.9	6.6	-29.0	52.0
Mean	2.8	2.8	2.9	3.8	5.0	1533.2	1434.5	1242.3	640.9	289.5	0.5	0.0	181.4	97.4	3.6	20.2	1.0	15.4	25.7	-16.3	65.2
+ 1 S.D.	5.3	5.4	5.5	6.8	8.1	2748.8	2557.9	2224.6	1203.9	535.6	2.0	0.1	229.8	100.2	6.7	38.5	1.6	30.0	44.8	-3.7	78.4
1-day max	7.4	7.6	8.0	8.5	10.6	3890.8	3632.1	3202.8	1796.7	764.2	5.0	0.1	284.0	112.0	8.0	60.3	2.0	44.0	61.3	-3.9	83.0
CV[1]	91.3	90.4	88.6	76.3	61.8	79.3	78.3	79.1	87.8	85.0	335.6	75.0	26.7	3.0	84.3	91.1	63.0	94.4	74.4	-77.4	20.3

[1]CV=coefficient of variation (=SD*100/mean)

APPENDIX I-2A

PREDICTED IHA STATISTICS, MOD50 VS. 300MOD50 AT COOPERSTOWN (GAGE 05057000) - MONTHLY AVERAGE FLOW (CFS)

Final Aquatic Impact Analysis Report

Year	October	November	December	January	February	March	April	May	June	July	August	September
MOD50 Baseline												
2005	14.4	34.8	15.8	12.5	14.0	101.6	804.8	717.0	174.6	100.3	21.1	12.0
2006	66.5	48.6	38.3	31.9	27.0	41.5	2661.4	1261.8	216.1	219.1	110.6	49.9
2007	19.0	21.7	14.7	9.3	8.5	41.3	1030.5	175.7	213.1	166.3	29.5	31.5
2008	12.6	19.1	12.8	9.1	8.4	33.7	245.4	47.8	45.7	13.5	9.8	45.6
2009	31.4	22.9	15.3	6.5	3.3	62.1	660.8	152.3	120.1	146.1	50.3	15.0
2010	40.8	43.6	20.7	8.4	5.8	392.8	416.5	213.6	122.5	19.8	12.8	6.3
2011	111.2	125.3	102.6	40.7	41.0	357.9	446.9	173.5	75.9	61.9	21.0	6.2
2012	17.8	36.3	24.2	17.2	15.9	64.3	468.9	88.3	87.1	25.5	19.1	87.0
2013	30.1	61.7	41.2	29.3	27.0	87.4	817.6	148.6	149.8	44.1	31.0	148.2
2014	111.9	60.3	47.6	39.7	33.5	51.7	3315.2	1559.8	265.1	274.1	135.0	62.0
2015	63.5	52.3	44.4	24.5	25.5	207.4	2327.0	953.5	558.4	470.9	307.3	264.8
300MOD50												
2005	14.4	34.8	15.8	12.5	14.0	101.6	804.8	843.4	222.9	136.0	32.8	18.0
2006	77.9	65.5	41.8	32.0	26.9	41.5	2661.4	1401.6	301.4	297.6	153.9	70.9
2007	26.0	28.4	17.3	9.3	8.5	41.3	1030.5	222.1	312.4	242.5	39.6	42.8
2008	20.1	27.3	15.8	9.1	8.4	33.7	245.4	57.5	64.0	18.9	14.6	71.6
2009	48.7	33.8	19.5	6.5	3.3	62.1	660.8	208.0	174.0	216.1	80.1	25.1
2010	53.8	60.9	26.3	8.4	5.8	392.8	416.5	235.2	159.9	25.1	14.1	7.3
2011	130.2	157.1	112.2	40.7	41.0	357.9	446.9	197.9	92.9	67.6	21.8	8.6
2012	22.9	45.7	28.3	17.2	16.0	64.3	468.9	98.6	112.6	32.7	26.2	119.0
2013	38.8	79.3	47.4	29.3	27.0	87.4	817.6	168.9	187.3	52.9	42.8	206.9
2014	131.5	72.2	50.1	39.7	33.5	51.7	3315.2	1678.6	362.8	377.5	199.5	90.9
2015	75.4	63.1	50.7	24.5	25.5	207.4	2327.0	1061.5	768.3	664.5	475.8	423.6

Variance Data

	October	November	December	January	February	March	April	May	June	July	August	September
MOD50 Baseline												
1-day min	12.6	19.1	12.8	6.5	3.3	33.7	245.4	47.8	45.7	13.5	9.8	6.2
- 1 S.D.	10.5	18.2	8.1	7.9	6.7	0.8	144.6	-36.3	43.7	0.5	-21.5	-12.1
Mean	47.2	47.9	34.3	20.8	19.1	131.1	1199.5	499.3	184.4	140.1	68.0	66.2
+ 1 S.D.	83.9	77.6	60.5	33.8	31.5	261.3	2254.5	1034.8	325.1	279.7	157.4	144.5
1-day max	111.9	125.3	102.6	40.7	41.0	392.8	3315.2	1559.8	558.4	470.9	307.3	264.8
CV[1]	77.7	62.0	76.3	62.1	65.0	99.4	87.9	107.3	76.3	99.6	131.6	118.2
300MOD50												
1-day min	14.4	27.3	15.8	6.5	3.3	33.7	245.4	57.5	64.0	18.9	14.1	7.3
- 1 S.D.	16.5	23.9	10.5	7.9	6.7	0.8	144.6	-20.6	54.7	-4.5	-38.5	-24.2
Mean	58.2	60.7	38.7	20.8	19.1	131.1	1199.5	561.2	250.8	193.8	100.1	98.6
+ 1 S.D.	99.8	97.6	66.8	33.8	31.5	261.3	2254.5	1143.0	446.9	392.0	238.7	221.4
1-day max	131.5	157.1	112.2	40.7	41.0	392.8	3315.2	1678.6	768.3	664.5	475.8	423.6
CV[1]	71.7	60.7	72.7	62.1	64.9	99.4	87.9	103.7	78.2	102.3	138.5	124.5

[1]CV=coefficient of variation (=SD*100/mean)

APPENDIX I-2B

PREDICTED IHA STATISTICS, MOD50 VS. 300MOD50 AT COOPERSTOWN (GAGE 05057000) - MAGNITUDE (CFS), FREQUENCY (PER YEAR), AND DURATION (DAYS) OF EXTREME EVENTS

Final Aquatic Impact Analysis Report

Year	1-day min	3-day min	7-day min	30-day min	90-day min	1-day max	3-day max	7-day max	30-day max	90-day max	Zero days	Base flow	Date min	Date max	Low pulse #	Low pulse duration	High pulse #	High pulse duration	Rise rate	Fall rate	Reversals
MOD50 Baseline																					
2005	2.9	3.5	5.3	9.9	13.6	1741.6	1720.4	1638.5	1166.2	577.2	0.0	0.0	275.0	118.0	6.0	28.8	1.0	26.0	17.8	-11.6	97.0
2006	25.6	26.3	25.3	19.5	18.9	4842.3	4639.8	4236.1	2951.5	1393.1	0.0	0.1	32.0	115.0	0.0	0.0	1.0	46.0	46.6	-27.4	84.0
2007	6.8	6.8	6.8	7.6	10.1	2386.3	2357.5	2116.6	1033.0	472.3	0.0	0.1	41.0	109.0	6.0	24.7	1.0	17.0	27.6	-13.4	88.0
2008	3.3	3.4	3.6	5.4	9.5	589.3	562.3	489.9	256.0	119.0	0.0	0.1	224.0	100.0	7.0	27.6	0.0	0.0	5.9	-3.4	85.0
2009	2.5	2.5	2.6	3.4	6.3	1291.8	1202.8	1024.8	669.8	321.1	0.0	0.0	49.0	103.0	4.0	31.8	1.0	12.0	16.6	-8.8	73.0
2010	3.8	4.1	4.4	5.7	8.8	962.6	946.7	917.8	604.8	371.3	0.0	0.0	267.0	90.0	3.0	55.7	2.0	6.0	19.4	-10.1	94.0
2011	1.9	1.9	2.1	4.5	14.7	897.9	845.2	773.8	539.7	331.8	0.0	0.0	249.0	97.0	1.0	41.0	1.0	5.0	11.1	-8.6	96.0
2012	6.3	6.4	6.9	10.3	18.0	1117.6	1068.8	936.0	490.5	226.6	0.0	0.1	224.0	100.0	5.0	17.6	1.0	7.0	10.4	-6.3	87.0
2013	10.6	10.9	11.6	17.5	30.5	1925.1	1839.2	1607.0	839.9	385.8	0.0	0.1	225.0	101.0	3.0	7.7	1.0	15.0	16.6	-11.2	80.0
2014	31.9	32.7	32.9	33.5	36.5	6059.0	5802.4	5268.3	3666.5	1729.8	0.0	0.1	32.0	115.0	0.0	0.0	1.0	50.0	64.9	-33.2	78.0
2015	23.0	23.4	23.7	19.3	23.4	4209.0	4130.7	3832.1	2365.8	1318.2	0.0	0.1	24.0	97.0	0.0	0.0	3.0	20.0	60.0	-31.7	80.0
300MOD50																					
2005	2.9	3.5	5.3	11.8	13.6	1741.6	1720.4	1638.5	1213.8	633.2	0.0	0.0	275.0	118.0	6.0	22.0	1.0	31.0	18.3	-12.0	93.0
2006	25.6	26.3	26.5	26.9	24.6	4842.3	4639.8	4236.1	2951.6	1468.8	0.0	0.1	32.0	115.0	0.0	0.0	1.0	53.0	51.2	-26.7	72.0
2007	6.8	6.8	6.8	7.6	10.2	2386.3	2357.5	2116.6	1033.4	527.6	0.0	0.0	41.0	109.0	2.0	49.0	1.0	17.0	28.5	-13.7	90.0
2008	5.6	5.7	6.0	7.6	9.5	589.3	562.3	489.9	256.0	127.4	0.0	0.1	224.0	100.0	5.0	33.2	0.0	0.0	5.9	-3.7	81.0
2009	2.5	2.5	2.6	3.4	6.4	1291.8	1202.8	1024.8	669.8	356.1	0.0	0.0	49.0	103.0	2.0	52.0	1.0	12.0	19.1	-9.1	63.0
2010	4.9	5.2	5.5	5.7	9.3	962.6	946.7	917.8	604.8	387.7	0.0	0.1	256.0	90.0	2.0	79.5	2.0	6.0	20.0	-10.3	88.0
2011	2.9	2.9	3.1	5.8	17.4	897.9	845.2	773.8	539.7	340.8	0.0	0.0	250.0	97.0	1.0	40.0	1.0	5.0	12.0	-8.4	88.0
2012	9.1	9.2	9.8	14.3	18.0	1117.6	1068.8	936.0	490.5	237.2	0.0	0.1	224.0	100.0	4.0	19.8	1.0	7.0	10.8	-6.6	81.0
2013	14.9	15.3	16.2	23.9	30.6	1925.1	1839.2	1607.0	839.9	404.0	0.0	0.1	225.0	101.0	2.0	5.0	1.0	15.0	17.7	-11.6	78.0
2014	31.9	32.7	32.9	33.5	36.6	6059.0	5802.4	5268.3	3666.5	1802.4	0.0	0.1	32.0	115.0	0.0	0.0	1.0	58.0	73.4	-31.9	66.0
2015	23.0	23.4	23.7	24.4	26.0	4209.0	4130.7	3832.1	2365.8	1415.9	0.0	0.1	24.0	97.0	0.0	0.0	5.0	17.2	59.7	-33.6	70.0

Variance Data

	1-day min	3-day min	7-day min	30-day min	90-day min	1-day max	3-day max	7-day max	30-day max	90-day max	Zero days	Base flow	Date min	Date max	Low pulse #	Low pulse duration	High pulse #	High pulse duration	Rise rate	Fall rate	Reversals
MOD50 Baseline																					
1-day min	1.9	1.9	2.1	3.4	6.3	589.3	562.3	489.9	256.0	119.0	0.0	0.0	24.0	90.0	0.0	0.0	0.0	0.0	5.9	-33.2	73.0
- 1 S.D.	0.0	0.1	0.6	3.3	7.8	528.7	513.3	454.4	187.3	109.3	0.0	0.0	104.3	101.6	0.5	3.1	0.4	2.2	6.4	-25.6	77.9
Mean	10.8	11.1	11.4	12.4	17.3	2365.7	2283.3	2076.5	1325.8	658.7	0.0	0.1	149.3	104.1	3.2	21.3	1.2	18.6	27.0	-15.1	85.6
+ 1 S.D.	21.6	22.1	22.2	21.6	26.9	4202.7	4053.3	3698.5	2464.3	1208.2	0.0	0.1	194.2	106.6	5.8	39.6	1.9	34.9	47.6	-4.5	93.4
1-day max	31.9	32.7	32.9	33.5	36.5	6059.0	5802.4	5268.3	3666.5	1729.8	0.0	0.1	275.0	118.0	7.0	55.7	3.0	50.0	64.9	-3.4	97.0
CV[1]	100.3	99.4	94.8	73.8	55.2	77.7	77.5	78.1	85.9	83.4		60.0	30.1	2.4	83.0	85.7	63.6	88.2	76.3	-69.9	9.0
300MOD50																					
1-day min	2.5	2.5	2.6	3.4	6.4	589.3	562.3	489.9	256.0	127.4	0.0	0.0	24.0	90.0	0.0	0.0	0.0	0.0	5.9	-33.6	63.0
- 1 S.D.	1.4	1.5	2.0	4.6	8.5	528.7	513.3	454.4	192.3	123.3	0.0	0.0	104.1	101.6	0.1	1.2	0.1	0.7	6.5	-25.7	68.9
Mean	11.8	12.1	12.6	15.0	18.4	2365.7	2283.3	2076.5	1330.2	700.1	0.0	0.1	148.4	104.1	2.2	27.3	1.4	20.1	28.8	-15.2	79.1
+ 1 S.D.	22.3	22.8	23.2	25.4	28.3	4202.7	4053.3	3698.5	2468.1	1276.9	0.0	0.1	192.6	106.6	4.2	53.4	2.7	39.5	51.1	-4.8	89.3
1-day max	31.9	32.7	32.9	33.5	36.6	6059.0	5802.4	5268.3	3666.5	1802.4	0.0	0.1	275.0	118.0	6.0	79.5	5.0	58.0	73.4	-3.7	93.0
CV[1]	88.5	88.0	84.3	69.2	53.7	77.7	77.5	78.1	85.5	82.4		66.7	29.8	2.4	93.6	95.6	94.9	96.3	77.6	-68.5	12.9

[1]CV=coefficient of variation (=SD*100/mean)

APPENDIX I-3A

PREDICTED IHA STATISTICS, MOD50 VS. 300MOD50 AT BALDHILL (GAGE 05058000) - MONTHLY AVERAGE FLOW (CFS)

Final Aquatic Impact Analysis Report

Year	October	November	December	January	February	March	April	May	June	July	August	September
MOD50 Baseline												
2005	151.5	146.3	120.2	17.1	17.3	109.8	727.7	795.6	244.3	134.0	28.3	19.9
2006	191.6	177.2	165.3	36.3	38.4	130.7	3424.0	1946.9	256.4	237.4	128.9	68.1
2007	141.0	139.9	116.5	13.1	13.0	78.9	800.4	219.9	234.8	179.7	36.7	39.6
2008	133.4	129.7	116.4	14.5	13.0	69.3	13.0	20.6	61.5	17.9	33.3	55.7
2009	145.4	139.1	119.6	13.6	13.0	112.2	521.5	187.7	145.7	182.7	57.6	18.4
2010	161.2	162.8	134.0	19.6	13.8	471.7	239.7	283.0	161.7	31.1	24.9	15.7
2011	232.3	246.6	247.8	62.8	58.8	456.3	196.8	253.9	98.5	76.2	58.9	57.9
2012	155.9	155.9	130.7	24.2	20.2	139.2	242.1	97.8	117.2	32.9	64.5	106.4
2013	194.3	194.6	151.8	41.1	34.3	199.6	664.3	164.4	197.2	60.2	89.5	200.8
2014	246.5	195.7	180.9	45.1	47.7	162.1	4459.5	2289.5	315.0	296.6	157.9	84.5
2015	220.0	197.6	179.9	59.4	71.7	640.9	2685.4	1316.8	812.7	572.1	392.6	316.7
300MOD50												
2005	151.5	146.3	120.2	17.1	17.3	109.8	727.7	917.8	295.4	170.4	40.5	25.9
2006	202.8	194.2	169.1	36.3	38.1	130.7	3424.0	2080.3	347.1	313.7	174.8	89.3
2007	148.4	146.5	119.4	13.1	13.0	78.9	800.4	265.4	329.8	260.1	47.5	50.6
2008	141.1	137.8	119.7	14.5	13.0	69.3	13.0	30.0	79.6	23.3	37.9	81.5
2009	163.0	150.1	124.2	13.6	13.0	112.2	521.5	240.3	201.7	251.7	88.9	27.8
2010	175.1	180.1	140.2	19.6	13.8	471.7	239.7	301.8	201.4	36.6	26.2	16.6
2011	250.5	278.4	258.3	62.8	58.8	456.3	196.8	277.4	115.8	82.5	59.4	60.5
2012	161.0	165.1	135.1	24.2	20.4	139.2	242.1	107.8	142.6	40.4	70.7	138.7
2013	202.9	212.1	158.6	41.1	34.3	199.6	664.3	184.2	234.6	69.3	99.8	259.2
2014	267.8	207.7	183.6	45.1	47.3	162.1	4459.5	2401.7	418.0	397.1	225.5	114.0
2015	232.1	208.4	186.6	59.4	71.7	640.9	2685.4	1418.9	1022.5	768.1	556.5	480.7

Variance Data

	October	November	December	January	February	March	April	May	June	July	August	September
MOD50 Baseline												
1-day min	133.4	129.7	116.4	13.1	13.0	69.3	13.0	20.6	61.5	17.9	24.9	15.7
- 1 S.D.	139.7	136.5	110.8	13.0	10.2	39.0	-249.7	-114.2	36.1	2.5	-9.1	-2.6
Mean	179.4	171.4	151.2	31.5	31.0	233.7	1270.4	688.7	240.4	165.5	97.6	89.4
+ 1 S.D.	219.0	206.4	191.6	50.0	51.9	428.4	2790.5	1491.6	444.8	328.5	204.3	181.5
1-day max	246.5	246.6	247.8	62.8	71.7	640.9	4459.5	2289.5	812.7	572.1	392.6	316.7
CV[1]	22.1	20.4	26.7	58.6	67.2	83.3	119.7	116.6	85.0	98.5	109.4	103.0
300MOD50												
1-day min	141.1	137.8	119.4	13.1	13.0	69.3	13.0	30.0	79.6	23.3	26.2	16.6
- 1 S.D.	146.7	142.5	113.5	13.0	10.2	39.0	-249.7	-97.4	49.4	-2.4	-24.6	-15.1
Mean	190.6	184.2	155.9	31.5	31.0	233.7	1270.4	747.8	308.1	219.4	129.8	122.2
+ 1 S.D.	234.4	226.0	198.3	50.0	51.8	428.4	2790.5	1593.0	566.8	441.2	284.1	259.6
1-day max	267.8	278.4	258.3	62.8	71.7	640.9	4459.5	2401.7	1022.5	768.1	556.5	480.7
CV[1]	23.0	22.7	27.2	58.6	67.1	83.3	119.7	113.0	84.0	101.1	118.9	112.4

[1]CV=coefficient of variation (=SD*100/mean)

APPENDIX I-3B

PREDICTED IHA STATISTICS, MOD50 VS. 300MOD50 AT BALDHILL (GAGE 05058000) - MAGNITUDE (CFS), FREQUENCY (PER YEAR), AND DURATION (DAYS) OF EXTREME EVENTS

Final Aquatic Impact Analysis Report

Year	1-day min	3-day min	7-day min	30-day min	90-day min	1-day max	3-day max	7-day max	30-day max	90-day max	Zero days	Base flow	Date min	Date max	Low pulse #	Low pulse duration	High pulse #	High pulse duration	Rise rate	Fall rate	Reversals
MOD50 Baseline																					
2005	13.0	13.0	13.0	15.9	36.2	2312.6	2270.7	2049.7	1342.7	627.4	0.0	0.1	13.0	120.0	8.0	17.1	3.0	8.0	39.3	-29.4	155.0
2006	26.6	27.6	28.7	31.7	44.0	5474.8	5347.5	5022.5	3765.2	1914.5	0.0	0.1	83.0	117.0	6.0	4.8	1.0	47.0	67.1	-55.7	145.0
2007	13.0	13.0	13.0	13.0	31.5	2315.4	2200.8	1911.1	890.9	445.9	0.0	0.1	1.0	111.0	8.0	13.9	1.0	12.0	40.6	-27.5	151.0
2008	13.0	13.0	13.0	13.0	26.1	367.4	294.5	197.0	143.7	134.4	0.0	0.2	8.0	91.0	10.0	19.0	0.0	0.0	21.3	-16.3	98.0
2009	13.0	13.0	13.0	13.0	27.7	1001.4	864.3	745.9	557.4	305.4	0.0	0.1	7.0	91.0	3.0	39.0	1.0	1.0	32.4	-20.8	96.0
2010	13.0	13.0	13.0	13.0	23.7	1016.2	976.7	960.9	515.4	371.0	0.0	0.1	14.0	89.0	12.0	13.4	2.0	3.0	34.4	-27.0	187.0
2011	13.0	13.0	13.0	15.4	58.1	719.9	711.2	643.5	493.8	308.1	0.0	0.1	106.0	90.0	9.0	6.1	0.0	0.0	47.7	-41.2	135.0
2012	13.0	13.0	13.0	18.4	37.8	699.5	609.2	507.8	315.2	181.3	0.0	0.1	107.0	91.0	14.0	7.9	0.0	0.0	32.6	-25.2	157.0
2013	13.0	13.0	13.6	31.3	53.1	1477.6	1381.7	1220.2	719.8	381.6	0.0	0.1	111.0	102.0	15.0	4.9	2.0	4.5	52.8	-42.5	165.0
2014	33.1	34.3	35.7	39.4	53.5	7283.7	6903.1	6485.0	4662.1	2401.4	0.0	0.1	83.0	110.0	5.0	1.2	2.0	25.0	76.7	-58.1	141.0
2015	24.1	24.1	24.6	50.3	79.2	3380.8	3380.4	3373.6	2924.8	1736.8	0.0	0.0	69.0	108.0	5.0	2.8	4.0	16.3	72.7	-56.3	132.0
300MOD50																					
2005	13.0	13.0	13.0	15.9	36.2	2312.6	2270.7	2049.7	1389.4	692.8	0.0	0.1	13.0	120.0	7.0	18.6	4.0	6.5	38.8	-28.9	147.0
2006	26.6	27.6	28.7	31.7	44.9	5474.8	5347.5	5022.5	3765.2	1988.1	0.0	0.1	83.0	117.0	6.0	4.8	1.0	54.0	67.6	-53.4	137.0
2007	13.0	13.0	13.0	13.0	31.5	2315.4	2200.8	1911.1	899.5	506.7	0.0	0.1	1.0	111.0	5.0	19.2	1.0	12.0	40.7	-28.0	151.0
2008	13.0	13.0	13.0	13.0	25.0	367.4	294.5	197.0	159.2	146.0	0.0	0.2	8.0	91.0	8.0	21.5	0.0	0.0	21.9	-16.2	97.0
2009	13.0	13.0	13.0	13.0	27.7	1001.4	864.3	745.9	557.4	339.6	0.0	0.1	7.0	91.0	3.0	32.7	1.0	1.0	33.6	-20.7	96.0
2010	13.0	13.0	13.0	13.0	26.1	1016.2	976.7	960.9	515.4	386.6	0.0	0.1	14.0	89.0	13.0	11.6	2.0	3.0	35.1	-26.3	189.0
2011	13.0	13.0	13.0	16.3	62.5	719.9	711.2	643.5	493.8	315.2	0.0	0.1	106.0	90.0	9.0	6.1	0.0	0.0	47.2	-40.9	139.0
2012	13.0	13.0	13.0	18.4	36.8	699.5	609.2	507.8	315.2	191.8	0.0	0.1	107.0	91.0	15.0	7.1	0.0	0.0	33.6	-24.2	155.0
2013	13.0	15.7	17.6	31.3	53.2	1477.6	1381.7	1220.2	719.8	395.4	0.0	0.1	111.0	102.0	13.0	4.9	2.0	4.5	52.1	-42.7	165.0
2014	33.1	34.3	35.7	39.4	54.4	7283.7	6903.1	6485.0	4669.4	2471.4	0.0	0.1	83.0	110.0	5.0	1.2	2.0	27.0	83.4	-58.4	133.0
2015	24.1	24.1	24.6	50.3	79.5	3380.8	3380.4	3373.6	2924.8	1824.9	0.0	0.0	69.0	108.0	5.0	2.8	2.0	38.0	76.3	-56.1	128.0

Variance Data

Year	1-day min	3-day min	7-day min	30-day min	90-day min	1-day max	3-day max	7-day max	30-day max	90-day max	Zero days	Base flow	Date min	Date max	Low pulse #	Low pulse duration	High pulse #	High pulse duration	Rise rate	Fall rate	Reversals
MOD50 Baseline																					
1-day min	13.0	13.0	13.0	13.0	23.7	367.4	294.5	197.0	143.7	134.4	0.0	0.0	1.0	89.0	3.0	1.2	0.0	0.0	21.3	-58.1	96.0
- 1 S.D.	9.8	9.6	9.5	10.2	25.9	158.2	129.5	61.7	-73.4	-6.2	0.0	0.0	47.9	98.5	4.8	1.0	0.2	-3.9	28.8	-51.5	115.1
Mean	17.1	17.3	17.6	23.1	42.8	2368.1	2267.3	2101.6	1484.6	800.7	0.0	0.1	54.7	101.8	8.6	11.8	1.5	10.6	47.0	-36.4	142.0
+ 1 S.D.	24.3	24.9	25.7	36.1	59.7	4578.1	4405.1	4141.5	3042.7	1607.6	0.0	0.1	61.6	105.1	12.5	22.6	2.8	25.1	65.3	-21.3	168.9
1-day max	33.1	34.3	35.7	50.3	79.2	7283.7	6903.1	6485.0	4662.1	2401.4	0.0	0.2	111.0	120.0	15.0	39.0	4.0	47.0	76.7	-16.3	187.0
CV[1]	42.6	44.4	46.2	56.1	39.5	93.3	94.3	97.1	104.9	100.8		55.6	12.5	3.2	44.6	91.2	89.7	136.6	38.8	-41.6	19.0
300MOD50																					
1-day min	13.0	13.0	13.0	13.0	25.0	367.4	294.5	197.0	159.2	146.0	0.0	0.0	1.0	89.0	3.0	1.2	0.0	0.0	21.9	-58.4	96.0
- 1 S.D.	9.8	10.0	9.9	10.3	26.1	158.2	129.5	61.7	-65.8	10.2	0.0	0.0	47.9	98.5	4.1	2.0	0.2	-5.1	28.6	-51.0	112.5
Mean	17.1	17.5	18.0	23.2	43.4	2368.1	2267.3	2101.6	1491.7	841.7	0.0	0.1	54.7	101.8	8.1	11.9	1.4	13.3	48.2	-36.0	139.7
+ 1 S.D.	24.3	25.1	26.0	36.2	60.8	4578.1	4405.1	4141.5	3049.3	1673.1	0.0	0.1	61.6	105.1	12.1	21.7	2.6	31.6	67.8	-21.0	167.0
1-day max	33.1	34.3	35.7	50.3	79.5	7283.7	6903.1	6485.0	4669.4	2471.4	0.0	0.2	111.0	120.0	15.0	32.7	4.0	54.0	83.4	-16.2	189.0
CV[1]	42.6	43.2	44.7	55.7	39.9	93.3	94.3	97.1	104.4	98.8		62.5	12.5	3.2	48.9	83.2	89.0	138.3	40.7	-41.7	19.5

[1]CV=coefficient of variation (=SD*100/mean)

APPENDIX I-4A

PREDICTED IHA STATISTICS, MOD50 VS. 300MOD50 AT LISBON (GAGE 05058700) - MONTHLY AVERAGE FLOW (CFS)

Final Aquatic Impact Analysis

Year	October	November	December	January	February	March	April	May	June	July	August	September
MOD50 Baseline												
2005	141.7	169.6	125.4	35.6	19.4	102.7	781.7	1035.2	547.1	703.6	59.0	30.6
2006	183.3	214.0	197.9	75.0	57.7	163.5	4195.5	2793.7	481.9	388.6	162.2	119.6
2007	127.0	156.8	120.0	31.9	25.2	147.4	834.6	270.6	236.7	233.0	49.6	39.7
2008	115.9	147.8	126.6	35.6	15.9	130.3	87.1	20.6	74.1	27.2	22.3	80.8
2009	150.4	151.4	125.4	33.7	15.5	82.4	726.8	235.4	172.0	195.5	80.5	22.7
2010	147.1	169.8	143.8	42.6	28.4	511.0	360.1	274.8	216.3	45.7	31.0	17.9
2011	214.9	259.3	263.7	98.6	91.1	550.4	285.0	277.2	118.1	82.1	68.4	61.5
2012	133.0	189.8	150.0	49.5	24.8	262.3	355.5	116.6	144.5	47.4	44.9	155.0
2013	173.8	250.4	184.6	71.2	42.2	420.4	849.7	193.1	248.1	78.5	73.8	268.9
2014	257.3	241.0	221.3	88.7	72.3	205.8	5420.3	3337.4	592.6	484.1	197.6	148.1
2015	251.6	266.1	217.7	78.3	83.3	689.5	3079.4	1604.1	918.7	613.9	414.6	402.0
300MOD50												
2005	141.7	169.6	125.4	35.6	19.4	102.7	781.7	1144.4	607.7	740.1	73.5	36.1
2006	194.9	230.9	203.2	75.0	58.0	163.5	4195.5	2910.4	585.9	459.4	214.3	141.6
2007	136.4	162.9	123.9	31.9	25.2	147.4	834.6	312.5	321.2	323.3	63.5	48.2
2008	126.2	155.5	131.0	35.6	15.9	130.3	87.1	26.9	92.7	34.4	26.0	104.4
2009	169.0	162.8	131.2	33.8	15.5	82.4	726.8	277.1	234.4	260.1	116.8	35.8
2010	159.4	187.1	152.0	42.6	28.7	511.0	360.1	289.5	258.4	52.9	32.4	18.9
2011	230.6	290.7	277.4	98.6	91.1	550.4	285.0	297.5	136.3	90.6	68.9	63.2
2012	138.3	198.3	155.8	49.5	24.9	262.3	355.5	124.9	168.9	56.6	49.7	186.1
2013	181.9	266.6	193.8	71.3	42.2	420.4	849.7	210.5	285.3	88.7	81.7	323.7
2014	285.2	252.9	225.1	88.7	72.6	205.8	5420.3	3433.3	708.2	576.9	272.5	179.4
2015	265.7	276.7	225.6	78.4	83.3	689.5	3079.4	1697.2	1124.8	811.3	566.9	577.8

Variance Data

	October	November	December	January	February	March	April	May	June	July	August	September
MOD50 Baseline												
1-day min	115.9	147.8	120.0	31.9	15.5	82.4	87.1	20.6	74.1	27.2	22.3	17.9
- 1 S.D.	123.1	155.4	121.5	33.7	15.1	87.0	-278.0	-240.0	79.7	17.9	-5.2	2.9
Mean	172.4	201.5	170.6	58.2	43.3	296.9	1543.2	923.5	340.9	263.6	109.4	122.4
+ 1 S.D.	221.6	247.5	219.7	82.8	71.4	506.8	3364.5	2087.1	602.2	509.3	224.1	242.0
1-day max	257.3	266.1	263.7	98.6	91.1	689.5	5420.3	3337.4	918.7	703.6	414.6	402.0
CV[1]	28.6	22.8	28.8	42.2	65.1	70.7	118.0	126.0	76.6	93.2	104.8	97.6
300MOD50												
1-day min	126.2	155.5	123.9	31.9	15.5	82.4	87.1	26.9	92.7	34.4	26.0	18.9
- 1 S.D.	130.1	163.0	125.3	33.7	15.2	87.0	-278.0	-225.1	98.1	28.6	-18.0	-10.9
Mean	184.5	214.0	176.8	58.3	43.3	296.9	1543.2	974.9	411.3	317.6	142.4	155.9
+ 1 S.D.	238.8	265.0	228.3	82.9	71.5	506.8	3364.5	2174.9	724.4	606.7	302.8	322.7
1-day max	285.2	290.7	277.4	98.6	91.1	689.5	5420.3	3433.3	1124.8	811.3	566.9	577.8
CV[1]	29.5	23.8	29.1	42.2	65.0	70.7	118.0	123.1	76.2	91.0	112.6	107.0

[1]CV=coefficient of variation (=SD*100/mean)

APPENDIX I-4B

PREDICTED IHA STATISTICS, MOD50 VS. 300MOD50 AT LISBON (GAGE 05058700) - MAGNITUDE (CFS), FREQUENCY (PER YEAR), AND DURATION (DAYS) OF EXTREME EVENTS

Final Aquatic Impact Analysis Report

	1-day min	3-day min	7-day min	30-day min	90-day min	1-day max	3-day max	7-day max	30-day max	90-day max	Zero days	Base flow	Date min	Date max	Low pulse #	Low pulse duration	High pulse #	High pulse duration	Rise rate	Fall rate	Reversals
MOD50 Baseline																					
2005	16.0	16.3	16.8	17.9	41.9	5052.1	4749.6	3104.5	1489.9	988.8	0.0	0.1	40.0	183.0	4.0	28.8	2.0	15.0	62.9	-39.8	100.0
2006	44.4	45.4	46.7	51.1	67.1	6042.1	5955.1	5737.6	4738.0	2533.2	0.0	0.1	54.0	118.0	6.0	7.3	2.0	25.5	85.4	-54.4	104.0
2007	13.1	13.4	14.1	15.7	48.5	2141.4	2093.3	1897.3	924.7	475.5	0.0	0.1	44.0	113.0	4.0	29.3	1.0	10.0	27.0	-15.5	66.0
2008	13.3	13.4	13.5	15.2	39.0	372.9	341.9	298.6	201.0	142.1	0.0	0.2	218.0	83.0	8.0	24.4	0.0	0.0	8.1	-5.8	89.0
2009	13.4	13.5	13.9	15.3	38.4	1163.7	1091.4	986.9	726.8	385.2	0.0	0.1	55.0	93.0	2.0	56.5	0.0	0.0	25.9	-16.6	80.0
2010	13.7	13.8	14.0	17.9	30.6	1195.5	1149.2	1001.7	663.0	434.0	0.0	0.1	256.0	78.0	4.0	38.5	1.0	1.0	20.9	-13.8	80.0
2011	14.6	14.7	14.9	27.0	63.7	767.0	754.4	715.0	597.6	375.0	0.0	0.1	255.0	74.0	8.0	6.1	0.0	0.0	21.3	-14.7	72.0
2012	19.9	20.9	21.9	24.7	51.6	787.0	720.1	617.4	541.7	269.7	0.0	0.2	232.0	83.0	3.0	38.0	0.0	0.0	16.9	-12.5	97.0
2013	26.3	32.8	37.2	42.1	71.1	1405.4	1361.2	1306.8	1087.9	532.5	0.0	0.2	233.0	104.0	5.0	17.8	3.0	4.3	30.7	-21.7	95.0
2014	55.3	56.8	58.7	63.8	81.1	8204.9	8089.5	7865.3	5877.4	3169.4	0.0	0.1	54.0	114.0	3.0	1.0	4.0	14.0	110.3	-65.2	106.0
2015	58.8	59.4	61.6	65.9	114.8	3674.1	3645.2	3608.3	3169.1	1987.3	0.0	0.1	26.0	106.0	0.0	0.0	3.0	20.7	58.8	-41.3	77.0
300MOD50																					
2005	16.0	16.3	16.8	17.9	41.9	5099.4	4794.8	3145.4	1519.3	1052.3	0.0	0.1	40.0	183.0	3.0	37.7	2.0	16.0	63.4	-40.0	94.0
2006	44.4	45.4	46.7	51.3	68.3	6042.1	5955.1	5737.6	4738.0	2606.7	0.0	0.1	54.0	118.0	5.0	8.2	3.0	19.3	89.7	-53.1	100.0
2007	13.1	13.4	14.1	15.7	48.9	2141.4	2093.3	1897.3	933.3	536.2	0.0	0.1	44.0	113.0	3.0	36.7	1.0	10.0	28.1	-15.7	68.0
2008	13.4	13.5	13.8	15.2	38.0	372.9	341.9	298.6	201.0	154.5	0.0	0.2	68.0	83.0	5.0	35.4	0.0	0.0	8.1	-6.0	92.0
2009	13.4	13.5	13.9	15.3	38.5	1163.7	1091.4	986.9	726.8	418.9	0.0	0.1	55.0	93.0	2.0	52.0	0.0	0.0	26.6	-17.1	70.0
2010	13.9	13.9	14.2	18.8	33.2	1195.5	1149.2	1001.7	663.0	448.7	0.0	0.1	256.0	78.0	4.0	37.3	1.0	1.0	21.0	-14.1	76.0
2011	14.8	14.9	15.1	27.7	68.4	767.0	754.4	715.0	597.6	381.6	0.0	0.1	254.0	74.0	6.0	6.3	0.0	0.0	21.3	-14.9	70.0
2012	20.6	20.9	21.9	24.7	50.6	787.0	720.1	617.4	541.7	275.3	0.0	0.2	68.0	83.0	3.0	37.0	0.0	0.0	16.5	-12.8	91.0
2013	31.0	35.4	37.2	42.1	71.4	1405.4	1361.2	1306.8	1087.9	543.5	0.0	0.2	233.0	104.0	4.0	21.0	3.0	4.3	30.5	-22.3	93.0
2014	55.3	56.8	58.7	63.9	82.3	8204.9	8089.5	7865.3	5877.4	3239.4	0.0	0.1	54.0	114.0	3.0	1.0	3.0	20.3	115.9	-64.6	106.0
2015	58.8	59.4	61.6	65.9	115.3	3674.1	3645.2	3608.3	3169.1	2063.2	0.0	0.1	26.0	106.0	0.0	0.0	3.0	23.7	61.9	-42.9	71.0

Variance Data

	1-day min	3-day min	7-day min	30-day min	90-day min	1-day max	3-day max	7-day max	30-day max	90-day max	Zero days	Base flow	Date min	Date max	Low pulse #	Low pulse duration	High pulse #	High pulse duration	Rise rate	Fall rate	Reversals
MOD50 Baseline																					
1-day min	13.1	13.4	13.5	15.2	30.6	372.9	341.9	298.6	201.0	142.1	0.0	0.1	26.0	74.0	0.0	0.0	0.0	0.0	8.1	-65.2	66.0
- 1 S.D.	8.4	9.0	9.4	12.6	34.6	207.0	170.4	43.4	-91.5	-16.3	0.0	0.1	96.3	95.8	1.9	4.5	0.0	-1.1	10.1	-47.0	74.2
Mean	26.3	27.3	28.5	32.4	58.9	2800.5	2722.8	2467.2	1819.7	1026.6	0.0	0.1	133.4	104.5	4.3	22.5	1.5	8.2	42.6	-27.4	87.8
+ 1 S.D.	44.1	45.6	47.6	52.2	83.2	5394.1	5275.3	4891.0	3730.9	2069.5	0.0	0.1	170.5	113.1	6.7	40.5	2.9	17.6	75.0	-7.8	101.4
1-day max	58.8	59.4	61.6	65.9	114.8	8204.9	8089.5	7865.3	5877.4	3169.4	0.0	0.2	256.0	183.0	8.0	56.5	4.0	25.5	110.3	-5.8	106.0
CV[1]	67.9	66.9	66.9	61.1	41.3	92.6	93.7	98.2	105.0	101.6		40.0	27.8	8.3	56.4	79.8	99.3	113.5	76.2	-71.5	15.5
300MOD50																					
1-day min	13.1	13.4	13.8	15.2	33.2	372.9	341.9	298.6	201.0	154.5	0.0	0.1	26.0	74.0	0.0	0.0	0.0	0.0	8.1	-64.6	68.0
- 1 S.D.	9.0	9.2	9.5	12.8	35.1	207.1	170.8	46.0	-87.1	-0.8	0.0	0.1	78.2	95.8	1.8	6.7	0.1	-0.9	9.6	-46.9	70.8
Mean	26.8	27.6	28.6	32.6	59.7	2804.8	2726.9	2470.9	1823.2	1065.5	0.0	0.1	104.7	104.5	3.5	24.8	1.5	8.6	43.9	-27.6	84.6
+ 1 S.D.	44.6	45.9	47.6	52.4	84.3	5402.6	5283.0	4895.8	3733.5	2131.8	0.0	0.1	131.3	113.1	5.1	42.9	2.8	18.1	78.2	-8.3	98.5
1-day max	58.8	59.4	61.6	65.9	115.3	8204.9	8089.5	7865.3	5877.4	3239.4	0.0	0.2	256.0	183.0	6.0	52.0	3.0	23.7	115.9	-6.0	106.0
CV[1]	66.6	66.5	66.6	60.6	41.1	92.6	93.7	98.1	104.8	100.1		44.4	25.3	8.3	47.5	73.1	94.5	110.7	78.2	-69.9	16.3

[1]CV=coefficient of variation (=SD*100/mean)

APPENDIX I-5A

PREDICTED IHA STATISTICS, MOD50 VS. 300MOD50 AT KINDRED (GAGE 05059000) - MONTHLY AVERAGE FLOW (CFS)

Final Aquatic Impact Analysis Report

Year	October	November	December	January	February	March	April	May	June	July	August	September
MOD50 Baseline												
2005	164.4	196.5	134.0	68.2	31.4	93.0	780.1	1301.5	685.6	1471.6	152.2	116.7
2006	198.2	261.7	231.1	94.9	66.2	113.9	4207.8	3344.2	563.5	463.0	204.6	154.7
2007	143.2	183.3	128.9	64.9	32.3	197.6	828.0	418.1	289.7	313.8	87.0	79.5
2008	120.6	169.9	152.5	69.6	33.3	121.4	181.5	45.6	104.3	53.4	38.2	84.0
2009	163.6	166.3	136.4	57.6	25.2	62.2	740.4	309.2	204.3	198.8	108.8	38.5
2010	159.9	203.5	157.2	72.6	48.2	526.9	433.3	396.6	329.0	109.8	70.1	46.1
2011	240.6	302.9	293.2	145.9	85.7	766.2	478.1	317.7	158.6	123.1	82.5	87.1
2012	158.8	232.2	199.4	98.6	57.9	252.5	508.8	174.6	213.8	93.6	72.4	166.8
2013	223.3	324.0	268.4	142.4	98.3	411.0	1100.4	298.3	363.8	155.4	123.3	289.5
2014	297.9	300.4	262.0	109.8	82.3	144.7	5450.1	4010.9	693.2	574.7	248.5	191.0
2015	336.8	376.6	328.4	147.8	143.6	773.5	3235.1	1801.7	1077.6	741.0	497.2	612.8
300MOD50												
2005	164.4	196.5	134.0	68.2	31.4	93.0	780.1	1398.0	756.5	1507.0	169.1	121.6
2006	210.5	278.6	237.8	94.9	66.2	113.9	4207.8	3444.2	681.4	529.1	262.0	176.7
2007	154.7	188.8	133.7	64.9	32.3	197.6	828.0	456.4	361.8	415.2	104.1	86.4
2008	133.2	177.2	157.9	69.7	33.5	121.4	181.5	47.5	124.1	63.2	41.2	105.7
2009	182.9	178.1	143.4	57.7	25.2	62.2	740.4	341.2	271.4	258.5	151.9	53.5
2010	171.4	220.9	167.2	72.7	48.5	526.9	433.3	408.6	372.2	118.2	71.5	47.0
2011	253.9	333.8	310.1	146.0	85.7	766.2	478.1	334.5	178.4	133.4	83.2	88.4
2012	163.6	240.3	206.4	98.7	58.2	252.5	508.8	181.3	237.1	104.3	76.9	196.1
2013	230.7	339.4	279.7	142.5	98.3	411.0	1100.4	312.8	400.5	168.0	130.4	339.3
2014	331.5	312.2	266.7	109.9	82.4	144.7	5450.1	4090.3	822.2	661.1	329.0	224.0
2015	352.4	387.2	337.3	147.9	143.6	773.5	3235.1	1889.8	1277.3	936.0	640.9	799.4

Variance Data

	October	November	December	January	February	March	April	May	June	July	August	September
MOD50 Baseline												
1-day min	120.6	166.3	128.9	57.6	25.2	62.2	181.5	45.6	104.3	53.4	38.2	38.5
- 1 S.D.	132.9	176.2	136.6	62.9	27.8	49.2	-167.8	-243.7	128.6	-31.3	23.2	5.7
Mean	200.7	247.0	208.3	97.5	64.0	314.8	1631.2	1129.0	425.8	390.7	153.2	169.7
+ 1 S.D.	268.4	317.8	280.0	132.1	100.3	580.5	3430.3	2501.6	723.0	812.7	283.1	333.7
1-day max	336.8	376.6	328.4	147.8	143.6	773.5	5450.1	4010.9	1077.6	1471.6	497.2	612.8
CV[1]	33.8	28.7	34.4	35.5	56.6	84.4	110.3	121.6	69.8	108.0	84.9	96.6
300MOD50												
1-day min	133.2	177.2	133.7	57.7	25.2	62.2	181.5	47.5	124.1	63.2	41.2	47.0
- 1 S.D.	141.0	184.8	141.5	63.0	27.9	49.2	-167.8	-231.0	149.4	-2.4	13.8	-12.2
Mean	213.6	259.4	215.8	97.6	64.1	314.8	1631.2	1173.2	498.5	444.9	187.3	203.5
+ 1 S.D.	286.1	333.9	290.2	132.1	100.3	580.5	3430.3	2577.3	847.5	892.2	360.8	419.1
1-day max	352.4	387.2	337.3	147.9	143.6	773.5	5450.1	4090.3	1277.3	1507.0	640.9	799.4
CV[1]	34.0	28.7	34.4	35.5	56.5	84.4	110.3	119.7	70.0	100.5	92.6	106.0

[1]CV=coefficient of variation (=SD*100/mean)

APPENDIX I-5B

PREDICTED IHA STATISTICS, MOD50 VS. 300MOD50 AT KINDRED (GAGE 05059000) - MAGNITUDE (CFS), FREQUENCY (PER YEAR), AND DURATION (DAYS) OF EXTREME EVENTS

Final Aquatic Impact Analysis Report

Year	1-day min	3-day min	7-day min	30-day min	90-day min	1-day max	3-day max	7-day max	30-day max	90-day max	Zero days	Base flow	Date min	Date max	Low pulse #	Low pulse duration	High pulse #	High pulse duration	Rise rate	Fall rate	Reversals
MOD50 Baseline																					
2005	21.9	22.6	25.3	28.1	57.3	4729.0	4646.5	4191.2	1799.2	1321.1	0.0	0.1	61.0	188.0	1.0	70.0	3.0	12.7	61.5	-41.8	84.0
2006	56.1	58.0	62.2	65.6	88.0	6413.1	6318.8	6008.0	4968.7	2733.2	0.0	0.1	30.0	120.0	4.0	17.8	1.0	51.0	72.0	-51.5	86.0
2007	21.0	23.6	26.3	32.1	68.7	2043.9	2003.1	1840.5	973.7	538.3	0.0	0.1	54.0	115.0	5.0	22.4	1.0	9.0	24.8	-15.0	73.0
2008	24.3	29.6	31.7	32.7	57.3	515.9	483.2	433.8	255.6	155.2	0.0	0.3	79.0	95.0	5.0	41.6	0.0	0.0	8.4	-5.2	70.0
2009	14.6	14.8	15.1	23.3	46.0	1027.0	1012.9	946.7	755.0	421.8	0.0	0.1	68.0	108.0	3.0	39.3	0.0	0.0	19.5	-11.6	87.0
2010	29.9	31.6	34.1	44.9	73.8	1438.4	1380.3	1190.3	770.3	527.7	0.0	0.2	28.0	81.0	7.0	19.3	1.0	3.0	22.9	-17.4	97.0
2011	27.0	30.6	35.8	55.5	90.1	1048.4	1028.9	974.5	864.9	527.7	0.0	0.1	259.0	76.0	6.0	14.0	0.0	0.0	19.0	-14.1	85.0
2012	51.9	53.6	53.8	56.9	89.4	1048.9	984.5	880.5	642.4	343.1	0.0	0.3	79.0	95.0	2.0	58.0	0.0	0.0	16.5	-11.4	76.0
2013	87.8	91.1	91.4	95.6	133.1	1811.6	1717.1	1580.1	1262.3	657.9	0.0	0.3	20.0	96.0	3.0	6.7	1.0	16.0	27.9	-19.5	78.0
2014	68.9	71.4	76.4	81.5	106.0	8208.9	8154.5	8033.9	6202.9	3418.1	0.0	0.1	30.0	120.0	1.0	50.0	1.0	56.0	83.4	-56.7	86.0
2015	116.6	118.6	121.0	124.7	168.1	3820.4	3794.7	3724.7	3235.1	2139.8	0.0	0.1	16.0	108.0	0.0	0.0	4.0	18.3	59.2	-37.8	78.0
300MOD50																					
2005	21.9	22.6	25.3	28.1	57.3	4764.1	4686.6	4232.8	1834.5	1384.0	0.0	0.1	61.0	188.0	1.0	70.0	3.0	13.0	61.0	-42.4	84.0
2006	56.1	58.0	62.2	65.6	89.4	6413.1	6318.8	6008.0	4968.7	2806.5	0.0	0.1	30.0	120.0	4.0	17.5	1.0	56.0	74.5	-50.8	82.0
2007	21.0	23.6	26.3	32.1	69.1	2043.9	2003.1	1840.5	981.8	598.0	0.0	0.1	54.0	115.0	4.0	25.3	1.0	9.0	25.7	-15.4	71.0
2008	24.3	29.6	31.7	32.7	58.3	515.9	483.2	433.8	255.6	168.4	0.0	0.3	79.0	95.0	6.0	31.7	0.0	0.0	8.9	-5.1	67.0
2009	14.6	14.8	15.1	23.3	46.0	1027.0	1012.9	946.7	755.0	453.7	0.0	0.1	68.0	108.0	3.0	37.3	0.0	0.0	20.6	-11.7	79.0
2010	29.9	31.6	34.1	44.9	76.1	1438.4	1380.3	1190.3	770.3	542.3	0.0	0.2	28.0	81.0	5.0	25.8	1.0	3.0	23.6	-17.5	95.0
2011	27.5	31.1	36.2	55.9	94.9	1048.4	1028.9	974.5	864.9	533.5	0.0	0.1	259.0	76.0	6.0	12.5	0.0	0.0	18.5	-14.6	87.0
2012	51.9	53.6	53.8	56.9	88.3	1048.9	984.5	880.5	642.4	349.0	0.0	0.3	79.0	95.0	2.0	56.5	0.0	0.0	16.7	-11.3	70.0
2013	87.8	91.1	91.4	95.6	133.5	1811.6	1717.1	1580.1	1262.3	669.0	0.0	0.3	20.0	96.0	2.0	8.5	1.0	16.0	28.7	-19.6	74.0
2014	68.9	71.4	76.4	81.5	107.3	8208.9	8154.5	8033.9	6202.9	3487.9	0.0	0.1	30.0	120.0	1.0	49.0	3.0	21.3	87.3	-55.5	86.0
2015	116.6	118.7	121.0	124.7	183.2	3820.4	3794.7	3724.7	3235.1	2209.0	0.0	0.1	16.0	108.0	0.0	0.0	5.0	16.6	61.2	-40.5	76.0

Variance Data

	1-day min	3-day min	7-day min	30-day min	90-day min	1-day max	3-day max	7-day max	30-day max	90-day max	Zero days	Base flow	Date min	Date max	Low pulse #	Low pulse duration	High pulse #	High pulse duration	Rise rate	Fall rate	Reversals
MOD50 Baseline																					
1-day min	14.6	14.8	15.1	23.3	46.0	515.9	483.2	433.8	255.6	155.2	0.0	0.1	16.0	76.0	0.0	0.0	0.0	0.0	8.4	-56.7	70.0
- 1 S.D.	14.7	16.8	19.3	26.6	52.8	372.8	331.7	230.8	3.9	56.7	0.0	0.1	53.6	100.3	1.1	8.4	-0.2	-5.1	11.7	-43.6	74.2
Mean	47.3	49.6	52.1	58.3	88.9	2918.7	2865.9	2709.5	1975.5	1162.2	0.0	0.2	65.8	109.3	3.4	30.8	1.1	15.1	37.7	-25.6	81.8
+ 1 S.D.	79.9	82.4	84.9	90.0	124.9	5464.6	5400.1	5188.1	3947.0	2267.6	0.0	0.3	78.1	118.2	5.6	53.2	2.4	35.3	63.7	-7.7	89.5
1-day max	116.6	118.6	121.0	124.7	168.1	8208.9	8154.5	8033.9	6202.9	3418.1	0.0	0.3	259.0	188.0	7.0	70.0	4.0	56.0	83.4	-5.2	97.0
CV[1]	69.0	66.1	62.9	54.4	40.6	87.2	88.4	91.5	99.8	95.1		62.5	18.6	8.2	67.0	72.7	119.3	133.9	69.0	-69.9	9.4
300MOD50																					
1-day min	14.6	14.8	15.1	23.3	46.0	515.9	483.2	433.8	255.6	168.4	0.0	0.1	16.0	76.0	0.0	0.0	0.0	0.0	8.9	-55.5	67.0
- 1 S.D.	14.7	16.9	19.4	26.6	51.8	373.5	332.5	232.1	8.5	71.7	0.0	0.1	53.6	100.3	1.0	9.0	-0.3	-4.3	11.9	-43.7	70.7
Mean	47.3	49.6	52.1	58.3	91.2	2921.9	2869.5	2713.3	1979.4	1200.1	0.0	0.2	65.8	109.3	3.1	30.4	1.4	12.3	38.8	-25.9	79.2
+ 1 S.D.	79.9	82.4	84.9	90.0	130.6	5470.3	5406.6	5194.4	3950.3	2328.6	0.0	0.2	78.1	118.2	5.2	51.8	3.0	28.8	65.7	-8.0	87.7
1-day max	116.6	118.7	121.0	124.7	183.2	8208.9	8154.5	8033.9	6202.9	3487.9	0.0	0.3	259.0	188.0	6.0	70.0	5.0	56.0	87.3	-5.1	95.0
CV[1]	68.9	66.0	62.8	54.4	43.2	87.2	88.4	91.4	99.6	94.0		60.0	18.6	8.2	67.0	70.5	119.9	134.6	69.4	-68.9	10.8

[1]CV=coefficient of variation (=SD*100/mean)

APPENDIX I-6A

PREDICTED IHA STATISTICS, MOD50 VS. 300MOD50 AT HALSTAD (GAGE 05064500) - MONTHLY AVERAGE FLOW (CFS)

Final Aquatic Impact Analysis Report

Year	October	November	December	January	February	March	April	May	June	July	August	September
MOD50 Baseline												
2005	621.0	782.5	488.2	363.8	424.2	713.9	11498.3	6550.2	4765.7	20724.5	1519.2	791.1
2006	604.8	1000.8	777.5	757.1	1178.5	1870.4	39697.0	16519.3	4884.1	5103.0	1700.8	1270.9
2007	390.5	535.1	343.5	244.1	197.7	1349.9	3182.3	1449.3	938.5	1313.2	383.9	709.9
2008	536.7	648.1	521.3	469.4	375.3	608.5	3096.9	804.5	687.1	263.2	199.6	212.9
2009	505.5	554.9	450.4	283.5	253.6	776.1	6204.5	1718.5	990.2	799.0	417.3	226.0
2010	1378.0	1593.4	1028.3	757.3	646.6	4897.7	5822.5	3572.5	2990.5	1263.4	968.7	573.7
2011	917.4	1154.2	1100.6	663.5	910.7	5827.6	5523.5	2060.0	1169.3	432.9	422.6	417.1
2012	958.5	1141.0	900.7	840.1	707.9	1194.3	6034.9	1609.7	1340.6	479.4	372.5	414.4
2013	1744.0	1867.5	1458.6	1388.0	1201.4	1926.4	10490.1	2818.4	2288.1	820.7	623.3	721.1
2014	739.8	1218.2	941.0	925.8	1465.3	2323.7	49352.7	20490.3	6046.4	6314.2	2102.1	1573.0
2015	2309.1	1764.6	2067.0	1073.4	969.9	7303.8	11615.1	9194.4	5234.4	4077.5	3008.8	5320.0
300MOD50												
2005	621.0	782.5	488.2	363.8	424.2	713.9	11498.3	6614.6	4863.8	20757.9	1542.0	796.3
2006	615.7	1017.1	787.5	757.4	1165.8	1870.4	39697.0	16581.1	5032.2	5161.1	1770.0	1294.0
2007	405.0	540.0	349.8	244.3	197.7	1349.9	3182.3	1476.3	984.4	1441.1	408.9	716.8
2008	550.2	654.7	528.3	469.7	376.6	608.5	3096.9	804.7	703.7	276.7	203.1	229.1
2009	526.0	568.0	459.4	284.0	253.6	776.1	6204.5	1735.0	1063.4	845.0	478.8	243.1
2010	1388.8	1611.0	1041.2	757.8	648.0	4897.7	5822.5	3578.6	3036.7	1273.5	971.1	574.6
2011	925.2	1184.5	1123.1	664.1	910.7	5827.6	5523.5	2069.6	1193.7	445.2	423.9	417.9
2012	962.8	1148.3	909.3	840.4	710.6	1194.3	6034.9	1613.7	1360.1	495.1	376.9	439.0
2013	1750.8	1881.5	1472.8	1388.4	1201.4	1926.4	10490.1	2827.6	2321.6	840.2	629.7	761.5
2014	782.4	1230.0	947.9	926.0	1449.2	2323.7	49352.7	20533.9	6201.2	6389.2	2197.2	1608.6
2015	2328.1	1774.9	2077.6	1074.0	969.9	7303.8	11615.1	9278.6	5408.8	4263.8	3140.5	5532.1

Variance Data

	October	November	December	January	February	March	April	May	June	July	August	September
MOD50 Baseline												
1-day min	390.5	535.1	343.5	244.1	197.7	608.5	3096.9	804.5	687.1	263.2	199.6	212.9
- 1 S.D.	372.4	643.2	409.2	354.1	335.1	309.4	-1733.0	-621.1	825.3	-2218.2	160.2	-344.7
Mean	973.2	1114.6	916.1	706.0	757.4	2617.5	13865.3	6071.6	2848.6	3781.0	1065.3	1111.8
+ 1 S.D.	1574.0	1585.9	1423.0	1057.9	1179.6	4925.5	29463.5	12764.3	4872.0	9780.2	1970.5	2568.4
1-day max	2309.1	1867.5	2067.0	1388.0	1465.3	7303.8	49352.7	20490.3	6046.4	20724.5	3008.8	5320.0
CV[1]	61.7	42.3	55.3	49.8	55.8	88.2	112.5	110.2	71.0	158.7	85.0	131.0
300MOD50												
1-day min	405.0	540.0	349.8	244.3	197.7	608.5	3096.9	804.7	703.7	276.7	203.1	229.1
- 1 S.D.	386.6	652.4	416.3	354.4	337.1	309.4	-1733.0	-610.4	848.7	-2167.7	160.6	-368.0
Mean	986.9	1126.6	925.9	706.4	755.2	2617.5	13865.3	6101.3	2924.5	3835.4	1103.8	1146.6
+ 1 S.D.	1587.2	1600.8	1435.5	1058.3	1173.4	4925.5	29463.5	12812.9	5000.3	9838.4	2047.1	2661.2
1-day max	2328.1	1881.5	2077.6	1388.4	1449.2	7303.8	49352.7	20533.9	6201.2	20757.9	3140.5	5532.1
CV[1]	60.8	42.1	55.0	49.8	55.4	88.2	112.5	110.0	71.0	156.5	85.5	132.1

[1]CV=coefficient of variation (=SD*100/mean)

APPENDIX I-6B

PREDICTED IHA STATISTICS, MOD50 VS. 300MOD50 AT HALSTAD (GAGE 05064500) - MAGNITUDE (CFS), FREQUENCY (PER YEAR), AND DURATION (DAYS) OF EXTREME EVENTS

Final Aquatic Impact Analysis Report

Year	1-day min	3-day min	7-day min	30-day min	90-day min	1-day max	3-day max	7-day max	30-day max	90-day max	Zero days	Base flow	Date min	Date max	Low pulse #	Low pulse duration	High pulse #	High pulse duration	Rise rate	Fall rate	Reversals
MOD50 Baseline																					
2005	235.7	243.7	287.1	352.1	413.1	41247.4	40803.3	39490.6	23499.8	12872.8	0.0	0.1	17.0	192.0	3.0	37.7	2.0	23.5	493.9	-291.7	64.0
2006	385.7	391.4	407.0	412.7	433.1	72336.2	71026.8	65369.6	44164.7	20530.5	0.0	0.1	292.0	111.0	2.0	8.5	1.0	46.0	597.8	-405.9	65.0
2007	165.5	167.4	170.4	186.4	249.0	5157.2	4763.6	4078.0	3275.3	2115.8	0.0	0.2	35.0	92.0	4.0	49.8	0.0	0.0	102.6	-53.7	63.0
2008	147.6	161.3	169.0	186.5	212.7	8844.7	8017.6	6878.8	3130.0	1571.5	0.0	0.2	274.0	97.0	7.0	31.0	0.0	0.0	74.1	-52.3	77.0
2009	184.7	188.9	203.8	226.0	300.3	9139.3	9101.2	8946.3	6287.7	3065.5	0.0	0.2	274.0	100.0	6.0	31.7	0.0	0.0	90.1	-51.3	69.0
2010	353.9	435.8	451.5	571.7	732.4	13669.6	13382.6	12717.2	8176.9	5409.8	0.0	0.2	275.0	86.0	4.0	5.0	2.0	5.0	289.5	-138.2	75.0
2011	196.4	201.2	216.5	283.9	418.6	11797.7	11759.2	11387.4	8316.4	4555.5	0.0	0.1	258.0	89.0	4.0	21.3	1.0	7.0	120.6	-93.0	90.0
2012	270.0	297.7	321.1	344.9	410.2	17422.9	15804.7	13413.1	6111.8	3088.3	0.0	0.2	274.0	97.0	3.0	27.3	1.0	6.0	139.6	-106.2	75.0
2013	479.8	474.4	506.7	575.1	644.2	29902.8	27154.7	23005.9	10558.0	5323.8	0.0	0.2	274.0	98.0	7.0	4.4	1.0	9.0	245.4	-178.6	77.0
2014	466.3	481.1	539.0	713.3	962.6	89931.0	88135.2	81076.1	55002.3	25495.8	0.0	0.1	276.0	110.0	3.0	1.3	4.0	13.8	714.1	-522.9	65.0
2015	897.3	898.2	834.7	682.7	656.7	19309.7	18946.0	18525.1	14876.6	10147.4	0.0	0.2	49.0	89.0	0.0	0.0	3.0	12.7	427.3	-241.5	53.0
300MOD50																					
2005	235.7	243.7	287.1	352.1	413.1	41287.4	40845.7	39532.0	23537.6	12934.5	0.0	0.1	17.0	192.0	3.0	36.0	2.0	23.5	494.1	-291.8	64.0
2006	396.1	402.0	418.2	428.0	442.1	72336.2	71026.8	65369.6	44164.7	20601.8	0.0	0.1	292.0	111.0	2.0	8.0	1.0	46.0	606.1	-406.1	65.0
2007	165.5	167.4	170.4	186.4	250.3	5157.2	4763.6	4078.0	3275.4	2132.0	0.0	0.2	35.0	92.0	4.0	49.5	0.0	0.0	103.5	-54.3	61.0
2008	163.3	166.3	172.4	193.7	223.4	8844.7	8017.6	6878.8	3130.0	1575.8	0.0	0.2	252.0	97.0	7.0	30.9	0.0	0.0	73.4	-52.3	77.0
2009	198.0	202.8	216.5	236.9	301.5	9139.3	9101.2	8946.3	6287.7	3089.8	0.0	0.2	274.0	100.0	6.0	30.0	0.0	0.0	92.9	-50.5	63.0
2010	366.7	436.2	451.8	572.6	738.9	13669.6	13382.6	12717.2	8176.9	5420.2	0.0	0.2	275.0	86.0	4.0	5.0	2.0	5.0	287.2	-140.0	75.0
2011	196.5	201.4	216.6	284.3	423.1	11797.7	11759.2	11387.4	8316.4	4560.9	0.0	0.1	258.0	89.0	5.0	16.6	1.0	7.0	120.6	-93.1	90.0
2012	293.8	319.6	332.2	353.3	424.5	17422.9	15804.7	13413.1	6111.8	3093.5	0.0	0.3	274.0	97.0	3.0	27.0	1.0	6.0	138.9	-105.7	75.0
2013	503.8	516.0	535.2	583.9	668.0	29902.8	27154.7	23005.9	10558.0	5334.6	0.0	0.2	202.0	98.0	7.0	3.9	1.0	9.0	247.2	-177.7	77.0
2014	512.1	527.3	593.4	756.8	983.5	89931.0	88135.2	81076.1	55002.3	25563.2	0.0	0.1	276.0	110.0	1.0	0.0	4.0	13.8	723.4	-523.2	65.0
2015	897.3	898.2	902.3	980.6	1301.0	19309.7	18946.0	18525.1	14876.6	10204.9	0.0	0.2	49.0	89.0	0.0	0.0	3.0	13.0	426.2	-243.3	53.0

Variance Data

	1-day min	3-day min	7-day min	30-day min	90-day min	1-day max	3-day max	7-day max	30-day max	90-day max	Zero days	Base flow	Date min	Date max	Low pulse #	Low pulse duration	High pulse #	High pulse duration	Rise rate	Fall rate	Reversals
MOD50 Baseline																					
1-day min	147.6	161.3	169.0	186.4	212.7	5157.2	4763.6	4078.0	3130.0	1571.5	0.0	0.1	17.0	86.0	0.0	0.0	0.0	0.0	74.1	-522.9	53.0
- 1 S.D.	125.7	140.9	170.4	218.1	264.8	925.5	446.9	373.5	-752.8	573.0	0.0	0.1	144.4	97.0	1.8	2.9	0.1	-2.4	73.9	-351.0	60.4
Mean	343.9	358.3	373.4	412.3	493.9	28978.0	28081.4	25898.9	16672.7	8561.5	0.0	0.2	208.9	105.6	3.9	19.8	1.4	11.2	299.5	-194.1	70.3
+ 1 S.D.	562.1	575.7	576.3	606.5	723.0	57030.6	55715.8	51424.3	34098.2	16550.0	0.0	0.2	273.4	114.1	6.0	36.7	2.7	24.7	525.2	-37.2	80.1
1-day max	897.3	898.2	834.7	713.3	962.6	89931.0	88135.2	81076.1	55002.3	25495.8	0.0	0.2	292.0	192.0	7.0	49.8	4.0	46.0	714.1	-51.3	90.0
CV[1]	63.5	60.7	54.3	47.1	46.4	96.8	98.4	98.6	104.5	93.3		43.8	30.9	8.1	54.2	85.4	94.9	121.3	75.3	-80.8	14.0
300MOD50																					
1-day min	163.3	166.3	170.4	186.4	223.4	5157.2	4763.6	4078.0	3130.0	1575.8	0.0	0.1	17.0	86.0	0.0	0.0	0.0	0.0	73.4	-523.2	53.0
- 1 S.D.	137.4	150.1	167.1	195.8	226.1	927.4	448.8	375.0	-750.8	578.8	0.0	0.1	140.3	97.0	1.5	2.0	0.1	-2.4	73.1	-351.4	59.3
Mean	357.2	371.0	390.6	448.0	560.9	28981.7	28085.2	25902.7	16676.1	8591.9	0.0	0.2	200.4	105.6	3.8	18.8	1.4	11.2	301.2	-194.4	69.6
+ 1 S.D.	576.9	591.8	614.0	700.3	895.6	57036.0	55721.6	51430.3	34103.1	16605.1	0.0	0.2	260.4	114.1	6.1	35.6	2.7	24.8	529.4	-37.3	79.8
1-day max	897.3	898.2	902.3	980.6	1301.0	89931.0	88135.2	81076.1	55002.3	25563.2	0.0	0.3	292.0	192.0	7.0	49.5	4.0	46.0	723.4	-50.5	90.0
CV[1]	61.5	59.5	57.2	56.3	59.7	96.8	98.4	98.6	104.5	93.3		41.2	30.0	8.1	60.5	89.3	94.9	121.1	75.7	-80.8	14.7

[1]CV=coefficient of variation (=SD*100/mean)

APPENDIX I-7A

PREDICTED IHA STATISTICS, MOD50 VS. 300MOD50 AT GRAND FORKS (GAGE 05082500) - MONTHLY AVERAGE FLOW (CFS)

Final Aquatic Impact Analysis Report

Year	October	November	December	January	February	March	April	May	June	July	August	September
MOD50 Baseline												
2005	2138.1	2200.3	1387.4	1388.6	1453.4	1764.2	19307.6	15318.5	6427.3	26138.0	3088.6	2316.6
2006	1895.0	2335.9	2283.4	1904.1	1808.7	2206.8	58222.6	26180.0	8775.1	14176.7	3408.6	2549.9
2007	1437.3	1532.3	1222.5	1136.9	1121.4	2224.1	7048.9	3061.4	2179.0	2084.6	1064.1	1259.3
2008	1329.5	1500.0	1327.3	1173.3	1158.9	1503.2	7042.9	1509.7	1228.4	592.2	383.1	643.4
2009	1821.3	1295.2	898.2	874.9	757.8	1619.9	11873.8	4287.5	2385.5	2301.3	1400.2	918.7
2010	3599.7	4493.6	2639.9	1498.2	1187.0	6689.1	13330.2	6283.4	4612.5	1947.5	1939.3	1612.9
2011	1381.6	1590.2	1474.7	993.0	1015.0	6512.8	10725.7	2747.9	1615.9	756.3	801.8	894.5
2012	2473.8	2758.7	2430.2	2168.1	2193.4	2895.6	13562.1	2934.4	2383.7	1084.6	724.4	1232.4
2013	4406.4	4615.1	4050.2	3637.2	3718.8	4591.5	23518.7	5090.7	4075.3	1852.5	1181.2	2149.5
2014	2306.2	2878.1	2809.2	2346.2	2248.4	2748.9	72278.3	32507.7	10883.9	17578.4	4212.3	3158.9
2015	4145.5	3769.3	4413.2	1992.8	1947.4	12999.4	29235.1	18649.7	11206.0	7598.4	6245.9	12897.5
300MOD50												
2005	2138.1	2200.3	1387.4	1388.6	1453.4	1764.2	19307.6	15362.3	6542.6	26171.6	3113.7	2322.9
2006	1904.6	2351.2	2295.7	1904.8	1795.1	2206.8	58222.6	26216.9	8942.1	14233.1	3482.4	2574.4
2007	1453.1	1537.5	1229.2	1137.6	1121.4	2224.1	7048.9	3081.1	2219.2	2216.9	1096.0	1266.7
2008	1343.2	1506.4	1335.0	1174.1	1159.1	1503.2	7042.9	1509.8	1242.3	606.9	387.6	655.5
2009	1842.7	1309.3	908.1	876.3	757.8	1619.9	11873.8	4297.9	2458.0	2344.2	1467.0	938.2
2010	3611.3	4510.7	2654.1	1499.4	1186.1	6689.1	13330.2	6287.4	4657.9	1959.6	1942.4	1613.9
2011	1386.8	1619.6	1500.1	994.4	1015.0	6512.8	10725.7	2753.5	1642.3	769.6	804.2	895.0
2012	2478.0	2765.3	2439.4	2168.9	2194.6	2895.6	13562.1	2937.0	2400.7	1103.0	729.5	1253.2
2013	4412.8	4628.1	4065.8	3638.3	3718.8	4591.5	23518.7	5096.9	4106.2	1876.4	1188.1	2184.4
2014	2352.9	2890.0	2817.5	2346.7	2231.1	2748.9	72278.3	32534.4	11047.3	17650.8	4312.9	3196.5
2015	4167.0	3779.4	4424.5	1994.0	1947.4	12999.4	29235.1	18729.5	11363.7	7782.0	6380.9	13114.8

Variance Data

	October	November	December	January	February	March	April	May	June	July	August	September
MOD50 Baseline												
1-day min	1329.5	1295.2	898.2	874.9	757.8	1503.2	7042.9	1509.7	1228.4	592.2	383.1	643.4
- 1 S.D.	1341.0	1433.3	1105.3	936.7	855.1	686.0	2579.9	17.7	1359.6	-1702.1	402.4	-780.9
Mean	2448.6	2633.5	2266.9	1737.6	1691.8	4159.6	24195.1	10779.2	5070.2	6919.1	2222.7	2694.0
+ 1 S.D.	3556.2	3833.7	3428.6	2538.5	2528.5	7633.2	45810.2	21540.7	8780.9	15540.4	4042.9	6168.8
1-day max	4406.4	4615.1	4413.2	3637.2	3718.8	12999.4	72278.3	32507.7	11206.0	26138.0	6245.9	12897.5
CV[1]	45.2	45.6	51.2	46.1	49.5	83.5	89.3	99.8	73.2	124.6	81.9	129.0
300MOD50												
1-day min	1343.2	1309.3	908.1	876.3	757.8	1503.2	7042.9	1509.8	1242.3	606.9	387.6	655.5
- 1 S.D.	1355.1	1444.5	1114.8	937.6	853.6	686.0	2579.9	23.9	1379.1	-1654.9	403.4	-806.8
Mean	2462.8	2645.3	2277.9	1738.4	1689.1	4159.6	24195.1	10800.6	5147.5	6974.0	2264.1	2728.7
+ 1 S.D.	3570.5	3846.0	3440.9	2539.3	2524.6	7633.2	45810.2	21577.4	8915.9	15603.0	4124.7	6264.2
1-day max	4412.8	4628.1	4424.5	3638.3	3718.8	12999.4	72278.3	32534.4	11363.7	26171.6	6380.9	13114.8
CV[1]	45.0	45.4	51.1	46.1	49.5	83.5	89.3	99.8	73.2	123.7	82.2	129.6

[1]CV=coefficient of variation (=SD*100/mean)

APPENDIX I-7B

PREDICTED IHA STATISTICS, MOD50 VS. 300MOD50 AT GRAND FORKS (GAGE 05082500) - MAGNITUDE (CFS), FREQUENCY (PER YEAR), AND DURATION (DAYS) OF EXTREME EVENTS

Final Aquatic Imapact Analysis Report

Year	1-day min	3-day min	7-day min	30-day min	90-day min	1-day max	3-day max	7-day max	30-day max	90-day max	Zero days	Base flow	Date min	Date max	Low pulse #	Low pulse duration	High pulse #	High pulse duration	Rise rate	Fall rate	Reversals
MOD50 Baseline																					
2005	1083.8	1201.1	1278.3	1376.0	1402.1	44064.1	43564.6	42413.2	29484.1	19279.5	0.0	0.2	16.0	196.0	3.0	8.0	2.0	21.5	598.1	-396.4	68.0
2006	1585.2	1605.0	1612.5	1456.5	1412.3	131190.4	119443.9	113899.5	66196.6	31569.0	0.0	0.2	291.0	109.0	0.0	0.0	4.0	15.0	1177.2	-748.7	72.0
2007	712.7	712.9	743.6	973.5	1151.4	15448.0	14722.9	12475.1	7049.0	4317.1	0.0	0.4	271.0	102.0	6.0	29.7	0.0	0.0	193.7	-99.7	71.0
2008	268.8	284.5	290.1	361.2	525.3	17657.4	17115.5	15294.4	7191.0	3361.5	0.0	0.2	253.0	97.0	8.0	29.6	1.0	2.0	149.9	-112.8	76.0
2009	709.9	711.6	712.2	747.9	840.5	16643.0	16561.0	16394.3	11939.6	6328.0	0.0	0.3	38.0	104.0	4.0	42.5	0.0	0.0	184.0	-113.7	77.0
2010	734.2	1159.9	1164.1	1178.0	1480.0	25075.9	24190.9	22206.7	14747.3	9691.0	0.0	0.3	275.0	110.0	2.0	29.0	2.0	6.5	458.2	-282.0	55.0
2011	413.2	435.2	480.4	590.3	766.7	19997.8	19816.2	18934.5	12589.9	6796.9	0.0	0.2	260.0	98.0	9.0	20.8	1.0	6.0	179.9	-163.2	113.0
2012	509.5	539.9	550.5	678.8	993.5	34060.9	33291.4	29717.7	13849.6	6499.2	0.0	0.2	253.0	97.0	3.0	26.3	1.0	9.0	272.7	-229.0	74.0
2013	890.2	914.6	930.3	1137.2	1618.8	59527.7	58231.0	51541.9	23729.7	11125.7	0.0	0.2	254.0	98.0	7.0	7.1	1.0	14.0	457.7	-413.2	70.0
2014	1755.5	1767.6	1818.9	2149.6	2426.7	162338.1	147635.1	140675.6	82329.1	39185.6	0.0	0.1	281.0	109.0	0.0	0.0	4.0	18.3	1409.7	-948.3	64.0
2015	1801.2	1803.8	1816.9	1891.2	1977.5	55594.8	54809.7	52125.1	35006.2	22411.4	0.0	0.2	41.0	92.0	0.0	0.0	3.0	16.7	952.0	-583.9	53.0
300MOD50																					
2005	1083.8	1201.1	1278.3	1376.0	1402.1	44100.7	43601.2	42451.6	29484.1	19340.8	0.0	0.2	16.0	196.0	3.0	8.0	2.0	21.5	597.7	-396.1	68.0
2006	1586.5	1611.0	1623.6	1472.9	1421.9	131190.4	119443.9	113899.5	66196.6	31640.2	0.0	0.2	37.0	109.0	0.0	0.0	4.0	15.0	1202.4	-745.4	70.0
2007	718.9	719.3	749.6	995.3	1153.3	15448.0	14722.9	12475.1	7049.0	4332.7	0.0	0.4	271.0	102.0	6.0	29.2	0.0	0.0	194.8	-100.3	67.0
2008	271.5	288.9	294.9	366.9	535.6	17657.4	17115.5	15294.4	7191.0	3364.8	0.0	0.2	253.0	97.0	8.0	29.6	1.0	2.0	153.2	-110.2	76.0
2009	709.9	711.6	712.2	747.9	843.6	16643.0	16561.0	16394.3	11939.6	6349.4	0.0	0.3	38.0	104.0	4.0	41.5	0.0	0.0	189.5	-111.7	77.0
2010	749.0	1159.9	1164.1	1178.0	1498.9	25075.9	24190.9	22206.7	14747.3	9699.7	0.0	0.3	275.0	110.0	2.0	28.5	2.0	6.5	471.7	-279.6	51.0
2011	413.4	435.4	480.6	590.8	773.5	19997.8	19816.2	18934.5	12589.9	6801.3	0.0	0.2	260.0	98.0	8.0	22.8	1.0	6.0	182.0	-161.5	117.0
2012	516.8	545.7	556.5	687.4	1007.8	34060.9	33291.4	29717.7	13849.6	6503.3	0.0	0.2	253.0	97.0	3.0	26.0	1.0	9.0	269.6	-228.9	70.0
2013	905.0	920.6	936.5	1146.4	1641.1	59527.7	58231.0	51541.9	23729.7	11134.5	0.0	0.2	226.0	98.0	6.0	7.2	1.0	14.0	460.5	-410.9	70.0
2014	1806.4	1818.9	1867.7	2149.6	2426.1	162338.1	147635.1	140675.6	82329.1	39252.9	0.0	0.1	281.0	109.0	0.0	0.0	4.0	18.5	1469.2	-931.4	66.0
2015	1801.2	1803.8	1816.9	1891.2	2360.4	55594.8	54809.7	52125.1	35006.2	22460.1	0.0	0.2	41.0	92.0	0.0	0.0	3.0	16.7	953.3	-584.1	53.0

Variance Data

	1-day min	3-day min	7-day min	30-day min	90-day min	1-day max	3-day max	7-day max	30-day max	90-day max	Zero days	Base flow	Date min	Date max	Low pulse #	Low pulse duration	High pulse #	High pulse duration	Rise rate	Fall rate	Reversals
MOD50 Baseline																					
1-day min	268.8	284.5	290.1	361.2	525.3	15448.0	14722.9	12475.1	7049.0	3361.5	0.0	0.1	16.0	92.0	0.0	0.0	0.0	0.0	149.9	-948.3	53.0
- 1 S.D.	412.3	475.6	494.6	588.3	771.0	3469.9	5460.5	4273.0	2702.6	2603.2	0.0	0.1	141.5	101.4	0.5	2.5	0.3	2.3	107.1	-655.0	56.4
Mean	951.3	1012.4	1036.2	1140.0	1326.8	52872.5	49943.8	46879.8	27646.6	14596.8	0.0	0.2	203.0	110.2	3.8	17.6	1.7	9.9	548.5	-371.9	72.1
+ 1 S.D.	1490.3	1549.2	1577.7	1691.7	1882.6	102275.2	94427.2	89486.7	52590.5	26590.4	0.0	0.3	264.5	118.9	7.1	32.6	3.2	17.5	989.9	-88.8	87.8
1-day max	1801.2	1803.8	1818.9	2149.6	2426.7	162338.1	147635.1	140675.6	82329.1	39185.6	0.0	0.4	291.0	196.0	9.0	42.5	4.0	21.5	1409.7	-99.7	113.0
CV[1]	56.7	53.0	52.3	48.4	41.9	93.4	89.1	90.9	90.2	82.2		33.3	30.3	7.9	85.9	85.6	82.1	76.9	80.5	-76.1	21.8
300MOD50																					
1-day min	271.5	288.9	294.9	366.9	535.6	15448.0	14722.9	12475.1	7049.0	3364.8	0.0	0.1	16.0	92.0	0.0	0.0	0.0	0.0	153.2	-931.4	51.0
- 1 S.D.	415.3	476.5	495.5	595.2	761.4	3473.8	5464.3	4276.9	2702.6	2606.7	0.0	0.2	121.4	101.4	0.6	2.7	0.3	2.3	102.8	-648.9	54.2
Mean	960.2	1019.7	1043.7	1145.7	1369.5	52875.9	49947.2	46883.3	27646.6	14625.4	0.0	0.2	177.4	110.2	3.6	17.5	1.7	9.9	558.5	-369.1	71.4
+ 1 S.D.	1505.1	1562.9	1591.9	1696.1	1977.6	102277.9	94430.0	89489.8	52590.5	26644.2	0.0	0.3	233.3	118.9	6.7	32.3	3.2	17.6	1014.2	-89.3	88.6
1-day max	1806.4	1818.9	1867.7	2149.6	2426.1	162338.1	147635.1	140675.6	82329.1	39252.9	0.0	0.4	281.0	196.0	8.0	41.5	4.0	21.5	1469.2	-100.3	117.0
CV[1]	56.7	53.3	52.5	48.0	44.4	93.4	89.1	90.9	90.2	82.2		28.6	31.6	7.9	83.5	84.6	82.1	77.0	81.6	-75.8	24.1

[1]CV=coefficient of variation (=SD*100/mean)

APPENDIX I-8A

PREDICTED IHA STATISTICS, MOD50 VS. 300MOD50 AT EMERSON (GAGE 05092000) - MONTHLY AVERAGE FLOW (CFS)

Final Aquatic Impact Analysis Report

Year	October	November	December	January	February	March	April	May	June	July	August	September
MOD50 Baseline												
2005	2162.2	2485.3	1513.2	1467.8	1459.8	1683.0	13278.6	28092.6	6691.1	29828.8	5808.3	2631.8
2006	2152.5	2699.5	2493.3	2094.1	2016.0	2304.8	51022.6	59029.0	11088.7	19860.9	4420.4	3050.5
2007	1792.1	1864.2	1273.2	1157.5	1122.7	2139.4	13424.1	5252.6	3123.8	2761.4	1466.9	1552.9
2008	1245.6	1727.6	1372.3	1227.9	1199.2	1310.7	8701.4	1902.0	1347.7	797.9	408.3	808.0
2009	1840.7	1460.4	968.6	923.4	776.9	1185.1	15638.4	5946.7	3007.8	2908.8	1875.0	993.3
2010	3703.9	5092.7	2837.1	1777.0	1290.0	5173.5	19742.2	8922.8	5658.9	2151.1	2134.8	1785.8
2011	1565.7	1923.3	1682.0	1145.0	1016.2	5286.1	16201.3	3326.1	2727.2	1080.5	830.2	878.0
2012	2406.8	3183.3	2507.1	2253.2	2269.3	2527.8	16754.5	3646.7	2623.8	1415.5	770.8	1546.7
2013	4540.7	5333.4	4181.0	3773.2	3844.0	4236.6	28586.2	6364.5	4483.1	2359.5	1304.6	2636.6
2014	2386.6	3341.1	3069.9	2568.6	2508.3	2876.4	64934.5	70803.4	14632.5	24680.1	5483.1	3778.9
2015	4498.7	4217.6	5389.6	2544.9	2392.3	8226.2	49343.7	24779.2	16516.8	10722.6	7413.6	14547.5
300MOD50												
2005	2162.2	2485.3	1513.2	1467.8	1459.8	1683.0	13278.6	28110.1	6824.2	29859.2	5843.3	2640.1
2006	2160.4	2713.5	2507.9	2095.6	2009.7	2304.8	51022.6	59033.4	11273.6	19919.8	4499.4	3078.8
2007	1809.2	1870.8	1279.8	1159.3	1122.7	2139.4	13424.1	5262.2	3166.5	2885.7	1511.1	1562.4
2008	1258.4	1734.9	1380.3	1229.8	1199.6	1310.7	8701.4	1902.0	1358.3	813.5	414.3	814.7
2009	1863.3	1476.0	978.9	926.5	776.9	1185.1	15638.4	5951.4	3075.0	2955.0	1942.3	1016.1
2010	3717.6	5108.6	2852.8	1779.7	1290.0	5173.5	19742.2	8924.5	5700.6	2167.6	2139.1	1787.0
2011	1568.0	1948.8	1711.2	1149.2	1016.2	5286.1	16201.3	3328.2	2753.6	1094.5	835.3	878.4
2012	2410.5	3189.3	2516.6	2255.1	2270.0	2527.8	16754.5	3647.8	2637.3	1436.5	777.3	1560.4
2013	4547.1	5344.9	4197.7	3775.6	3844.1	4236.6	28586.2	6367.3	4509.7	2389.0	1312.2	2661.6
2014	2440.2	3354.8	3079.9	2569.7	2498.8	2876.4	64934.5	70804.9	14802.6	24753.0	5591.4	3821.8
2015	4523.6	4228.0	5401.1	2547.5	2392.3	8226.2	49343.7	24819.3	16677.0	10908.9	7563.9	14757.4

Variance Data

	October	November	December	January	February	March	April	May	June	July	August	September
MOD50 Baseline												
1-day min	1245.6	1460.4	968.6	923.4	776.9	1185.1	8701.4	1902.0	1347.7	797.9	408.3	808.0
- 1 S.D.	1423.9	1679.3	1125.1	1050.7	905.7	1197.6	8008.2	-4235.9	1323.7	-1787.2	470.9	-802.9
Mean	2572.3	3029.9	2480.6	1903.0	1808.6	3359.0	27057.0	19824.1	6536.5	8960.7	2901.5	3110.0
+ 1 S.D.	3720.8	4380.4	3836.2	2755.2	2711.6	5520.5	46105.9	43884.1	11749.2	19708.5	5332.0	7022.8
1-day max	4540.7	5333.4	5389.6	3773.2	3844.0	8226.2	64934.5	70803.4	16516.8	29828.8	7413.6	14547.5
CV[1]	44.6	44.6	54.6	44.8	49.9	64.3	70.4	121.4	79.7	119.9	83.8	125.8
300MOD50												
1-day min	1258.4	1476.0	978.9	926.5	776.9	1185.1	8701.4	1902.0	1358.3	813.5	414.3	814.7
- 1 S.D.	1437.6	1690.6	1135.8	1053.0	905.2	1197.6	8008.2	-4229.3	1342.8	-1740.6	476.6	-828.4
Mean	2587.3	3041.4	2492.7	1905.1	1807.3	3359.0	27057.0	19831.9	6616.2	9016.6	2948.2	3143.5
+ 1 S.D.	3737.0	4392.1	3849.6	2757.2	2709.4	5520.5	46105.9	43893.1	11889.6	19773.8	5419.7	7115.4
1-day max	4547.1	5344.9	5401.1	3775.6	3844.1	8226.2	64934.5	70804.9	16677.0	29859.2	7563.9	14757.4
CV[1]	44.4	44.4	54.4	44.7	49.9	64.3	70.4	121.3	79.7	119.3	83.8	126.4

[1]CV=coefficient of variation (=SD*100/mean)

APPENDIX I-8B

PREDICTED IHA STATISTICS, MOD50 VS. 300MOD50 AT EMERSON (GAGE 05092000) - MAGNITUDE (CFS), FREQUENCY (PER YEAR), AND DURATION (DAYS) OF EXTREME EVENTS

Final Aquatic Impact Analysis Report

Year	1-day min	3-day min	7-day min	30-day min	90-day min	1-day max	3-day max	7-day max	30-day max	90-day max	Zero days	Base flow	Date min	Date max	Low pulse #	Low pulse duration	High pulse #	High pulse duration	Rise rate	Fall rate	Reversals
MOD50 Baseline																					
2005	1315.1	1321.4	1348.5	1423.0	1467.9	42730.0	42638.7	42096.0	34628.9	21494.2	0.0	0.2	22.0	129.0	4.0	17.0	2.0	27.5	427.3	-412.9	42.0
2006	1864.4	1867.5	1877.5	1845.5	1668.5	131772.4	130817.4	125432.3	85429.7	42103.6	0.0	0.1	34.0	118.0	0.0	0.0	2.0	34.0	1060.8	-682.6	20.0
2007	913.7	892.7	891.8	1109.1	1172.6	24411.7	23928.0	22368.0	13768.9	7421.3	0.0	0.3	274.0	107.0	4.0	39.8	1.0	5.0	227.3	-128.4	34.0
2008	342.1	344.0	349.9	406.2	643.7	17842.8	17636.4	16685.5	8708.2	3998.7	0.0	0.2	229.0	101.0	5.0	47.2	0.0	0.0	138.7	-97.0	27.0
2009	730.4	732.0	737.7	781.3	867.6	24291.4	24060.5	23053.0	15848.1	8253.6	0.0	0.2	45.0	109.0	3.0	59.3	1.0	7.0	221.8	-153.9	43.0
2010	934.2	961.3	1265.5	1285.3	1628.5	25367.3	25328.1	25126.9	19877.5	12479.8	0.0	0.3	275.0	115.0	2.0	27.5	1.0	12.0	358.4	-195.5	41.0
2011	576.5	580.5	587.7	690.1	889.2	30414.3	29459.1	27127.6	16910.3	8704.3	0.0	0.2	265.0	100.0	5.0	32.6	1.0	9.0	263.4	-180.4	52.0
2012	630.6	632.2	636.7	764.2	1219.4	29861.6	29620.7	28975.4	16755.8	7712.7	0.0	0.2	228.0	104.0	2.0	34.5	1.0	10.0	237.9	-176.3	35.0
2013	1049.8	1050.5	1055.7	1281.2	1919.4	40515.7	40382.0	39707.9	28670.0	13186.7	0.0	0.2	227.0	109.0	3.0	12.7	1.0	21.0	336.2	-265.4	39.0
2014	1978.9	1989.7	2012.3	2356.9	2638.6	182528.7	179841.4	168486.6	15696.3	52235.4	0.0	0.1	277.0	118.0	0.0	0.0	2.0	40.0	1332.2	-987.7	28.0
2015	2187.3	2190.1	2202.6	2315.1	2131.3	62268.2	62032.5	60738.6	49343.7	31003.9	0.0	0.2	30.0	103.0	0.0	0.0	3.0	20.3	792.6	-549.1	32.0
300MOD50																					
2005	1315.1	1321.4	1348.5	1423.0	1467.9	42730.0	42638.7	42096.0	34629.0	21553.7	0.0	0.2	22.0	129.0	4.0	17.0	2.0	27.5	429.2	-410.2	44.0
2006	1864.5	1867.5	1877.5	1862.9	1678.9	131772.4	130817.4	125432.3	85429.7	42173.6	0.0	0.1	34.0	118.0	0.0	0.0	2.0	34.0	1075.0	-682.1	20.0
2007	918.2	897.6	897.3	1109.1	1174.7	24411.7	23928.0	22368.0	13768.9	7436.5	0.0	0.3	274.0	107.0	4.0	39.3	1.0	5.0	227.9	-128.9	34.0
2008	347.9	349.8	355.9	412.1	653.3	17842.8	17636.4	16685.5	8708.2	4001.4	0.0	0.2	229.0	101.0	5.0	47.2	0.0	0.0	137.0	-97.1	27.0
2009	730.4	732.0	737.7	781.3	870.6	24291.4	24060.5	23053.0	15848.1	8275.6	0.0	0.2	45.0	109.0	4.0	43.3	1.0	7.0	224.9	-152.6	43.0
2010	950.4	977.5	1265.5	1285.3	1646.0	25367.3	25328.1	25126.9	19877.5	12486.4	0.0	0.3	275.0	115.0	2.0	27.0	1.0	12.0	358.6	-197.3	41.0
2011	576.8	580.8	588.0	690.6	896.3	30414.3	29459.1	27127.6	16910.3	8708.6	0.0	0.2	265.0	100.0	4.0	40.0	1.0	9.0	263.5	-180.5	52.0
2012	636.5	638.0	642.8	771.8	1232.9	29861.6	29620.7	28975.4	16755.8	7716.6	0.0	0.2	228.0	104.0	2.0	34.0	1.0	10.0	236.6	-175.4	35.0
2013	1055.8	1056.6	1062.1	1290.2	1940.5	40515.7	40382.0	39707.9	28670.0	13195.2	0.0	0.2	227.0	109.0	3.0	11.7	1.0	21.0	336.3	-265.3	39.0
2014	2031.9	2042.6	2063.7	2402.8	2639.3	182528.7	179841.4	168486.6	15696.3	52301.7	0.0	0.1	277.0	118.0	0.0	0.0	2.0	40.0	1357.2	-982.5	30.0
2015	2187.4	2190.1	2202.7	2315.2	2890.9	62268.2	62032.5	60738.6	49343.7	31052.0	0.0	0.2	30.0	103.0	0.0	0.0	3.0	20.3	792.3	-548.3	32.0

Variance Data

	1-day min	3-day min	7-day min	30-day min	90-day min	1-day max	3-day max	7-day max	30-day max	90-day max	Zero days	Base flow	Date min	Date max	Low pulse #	Low pulse duration	High pulse #	High pulse duration	Rise rate	Fall rate	Reversals
MOD50 Baseline																					
1-day min	342.1	344.0	349.9	406.2	643.7	17842.8	17636.4	16685.5	8708.2	3998.7	0.0	0.1	22.0	100.0	0.0	0.0	0.0	0.0	138.7	-987.7	20.0
- 1 S.D.	518.9	520.8	555.0	646.3	876.7	2778.4	2870.8	3601.4	4069.7	2922.6	0.0	0.1	119.7	107.6	0.6	4.3	0.6	4.1	96.8	-631.4	26.8
Mean	1138.5	1142.0	1178.7	1296.2	1477.0	55636.8	55067.7	52708.9	35967.0	18963.1	0.0	0.2	173.3	110.3	2.6	24.6	1.4	16.9	490.6	-348.1	35.7
+ 1 S.D.	1758.1	1763.2	1802.4	1946.1	2077.2	108495.2	107264.6	101816.4	67864.3	35003.6	0.0	0.2	226.8	113.0	4.5	44.9	2.2	29.7	884.4	-64.9	44.7
1-day max	2187.3	2190.1	2202.6	2356.9	2638.6	182528.7	179841.4	168486.6	105696.3	52235.4	0.0	0.3	277.0	129.0	5.0	59.3	3.0	40.0	1332.2	-97.0	52.0
CV[1]	54.4	54.4	52.9	50.1	40.6	95.0	94.8	93.2	88.7	84.6		26.3	30.9	2.4	74.9	82.6	59.6	75.5	80.3	-81.4	25.0
300MOD50																					
1-day min	347.9	349.8	355.9	412.1	653.3	17842.8	17636.4	16685.5	8708.2	4001.4	0.0	0.1	22.0	100.0	0.0	0.0	0.0	0.0	137.0	-982.5	20.0
- 1 S.D.	521.9	523.8	556.6	646.5	839.3	2778.4	2870.8	3601.4	4069.8	2926.1	0.0	0.1	119.7	107.6	0.7	5.1	0.6	4.1	93.3	-629.2	27.2
Mean	1146.8	1150.4	1185.6	1304.0	1553.8	55636.8	55067.7	52708.9	35967.0	18991.0	0.0	0.2	173.3	110.3	2.6	23.6	1.4	16.9	494.4	-347.3	36.1
+ 1 S.D.	1771.7	1776.9	1814.6	1961.5	2268.2	108495.2	107264.6	101816.4	67864.3	35056.0	0.0	0.2	226.8	113.0	4.4	42.1	2.2	29.7	895.6	-65.4	45.0
1-day max	2187.4	2190.1	2202.7	2402.8	2890.9	182528.7	179841.4	168486.6	105696.3	52301.7	0.0	0.3	277.0	129.0	5.0	47.2	3.0	40.0	1357.2	-97.1	52.0
CV[1]	54.5	54.5	53.1	50.4	46.0	95.0	94.8	93.2	88.7	84.6		26.3	30.9	2.4	72.9	78.6	59.6	75.5	81.1	-81.2	24.7

[1]CV=coefficient of variation (=SD*100/mean)

APPENDIX I-9A

PREDICTED IHA STATISTICS, MOD55 VS. 480MOD55 AT HWY 30 (CALIBRATED AT WARWICK GAGE) - MONTHLY AVERAGE FLOW (CFS)

Final Aquatic Impact Analysis Report

Year	October	November	December	January	February	March	April	May	June	July	August	September
MOD55 Baseline												
2005	9.7	15.2	8.7	5.6	5.3	31.6	210.8	26.0	43.2	6.7	25.9	50.4
2006	9.1	11.8	16.2	8.6	9.6	176.5	951.9	446.0	164.3	156.5	169.2	108.0
2007	2.9	9.2	4.4	4.6	4.5	39.9	433.5	285.3	52.1	35.0	4.9	6.2
2008	6.8	10.2	5.7	5.0	9.9	309.5	242.6	57.2	17.5	3.0	1.1	1.5
2009	9.7	15.2	8.7	5.6	5.3	31.6	211.2	26.1	43.3	6.7	26.0	50.6
2010	12.2	11.8	8.0	6.4	14.2	303.2	34.1	19.5	4.3	1.5	0.5	0.7
2011	17.1	16.4	11.1	9.0	13.7	423.3	47.7	27.3	5.9	2.1	0.7	1.0
2012	19.1	15.7	10.6	9.0	8.0	66.4	2100.7	448.1	67.5	122.4	38.9	20.3
2013	60.2	27.9	24.3	21.7	45.9	651.9	254.2	86.4	37.2	17.6	4.5	6.9
2014	10.4	8.4	6.6	6.4	5.5	103.6	840.4	218.2	74.7	40.4	24.0	9.6
2015	42.2	29.7	11.0	6.8	36.2	391.3	420.9	300.7	69.9	6.7	3.9	3.1
480MOD55												
2005	9.7	15.2	8.7	5.6	5.3	31.6	210.8	26.0	43.2	6.7	25.9	50.4
2006	9.1	11.8	16.2	8.6	9.6	176.5	951.9	446.0	164.3	156.5	169.2	108.0
2007	2.9	9.2	4.4	4.6	4.5	39.9	433.5	285.3	52.1	35.0	4.9	6.2
2008	6.8	10.2	5.7	5.0	10.6	309.5	242.6	57.2	17.5	3.0	1.1	1.5
2009	9.7	15.2	8.7	5.6	5.3	31.6	211.2	26.1	43.3	6.7	26.0	50.6
2010	12.2	11.8	8.0	6.4	9.8	303.2	34.1	19.5	4.3	1.5	0.5	0.7
2011	17.1	16.4	11.1	9.0	13.7	423.3	47.7	27.3	5.9	2.1	0.7	1.0
2012	19.1	15.7	10.6	9.0	8.0	66.4	2100.7	448.1	67.5	122.4	38.9	20.3
2013	60.2	27.9	24.3	21.7	45.9	651.9	254.2	86.4	37.2	17.6	4.5	6.9
2014	10.4	8.4	6.6	6.4	5.5	103.6	840.4	218.2	74.7	40.4	24.0	9.6
2015	42.2	29.7	11.0	6.8	36.2	391.3	420.9	300.7	69.9	6.7	3.9	3.1

Variance Data

	October	November	December	January	February	March	April	May	June	July	August	September
MOD55 Baseline												
1-day min	2.9	8.4	4.4	4.6	4.5	31.6	34.1	19.5	4.3	1.5	0.5	0.7
- 1 S.D.	0.7	8.5	4.9	3.3	0.6	26.5	-77.7	6.2	8.4	-17.0	-21.7	-10.1
Mean	18.1	15.6	10.5	8.0	14.4	229.9	522.6	176.4	52.7	36.2	27.2	23.5
+ 1 S.D.	35.5	22.7	16.1	12.8	28.1	433.2	1122.8	346.7	97.0	89.5	76.2	57.1
1-day max	60.2	29.7	24.3	21.7	45.9	651.9	2100.7	448.1	164.3	156.5	169.2	108.0
CV[1]	96.0	45.4	53.5	59.5	96.0	88.5	114.9	96.5	84.1	146.9	179.7	143.1
480MOD55												
1-day min	2.9	8.4	4.4	4.6	4.5	31.6	34.1	19.5	4.3	1.5	0.5	0.7
- 1 S.D.	0.7	8.5	4.9	3.3	0.2	26.5	-77.7	6.2	8.4	-17.0	-21.7	-10.1
Mean	18.1	15.6	10.5	8.0	14.0	229.9	522.6	176.4	52.7	36.2	27.2	23.5
+ 1 S.D.	35.5	22.7	16.1	12.8	27.9	433.2	1122.8	346.7	97.0	89.5	76.2	57.1
1-day max	60.2	29.7	24.3	21.7	45.9	651.9	2100.7	448.1	164.3	156.5	169.2	108.0
CV[1]	96.0	45.4	53.5	59.5	98.6	88.5	114.9	96.5	84.1	146.9	179.7	143.1

[1]CV=coefficient of variation (=SD*100/mean)

APPENDIX I-9B

PREDICTED IHA STATISTICS, MOD55 VS. 480MOD55 AT HWY 30 (CALIBRATED FROM WARWICK GAGE) - MAGNITUDE (CFS), FREQUENCY (PER YEAR), AND DURATION (DAYS) OF EXTREME EVENTS

Final Aquatic Impact Analysis Report

	1-day min	3-day min	7-day min	30-day min	90-day min	1-day max	3-day max	7-day max	30-day max	90-day max	Zero days	Base flow	Date min	Date max	Low pulse #	Low pulse duration	High pulse #	High pulse duration	Rise rate	Fall rate	Reversals
MOD55 Baseline																					
2005	2.8	2.8	3.0	5.0	5.8	630.3	610.3	538.2	232.0	101.8	0.0	0.1	212.0	94.0	8.0	12.5	1.0	8.0	10.9	-7.3	57.0
2006	7.2	7.4	7.8	4.7	6.0	2667.7	2380.9	2003.9	1067.7	567.7	0.0	0.0	284.0	92.0	0.0	0.0	2.0	22.0	43.4	-27.1	67.0
2007	0.6	0.7	1.1	2.8	4.5	1374.7	1302.6	1109.9	638.2	264.8	0.0	0.0	275.0	112.0	9.0	16.8	2.0	10.0	27.3	-15.0	59.0
2008	0.9	0.9	1.0	1.1	1.7	998.5	963.0	909.4	475.7	206.8	0.0	0.0	241.0	90.0	4.0	36.8	1.0	14.0	15.0	-10.1	54.0
2009	2.8	2.8	3.0	5.0	5.8	631.5	611.5	539.2	232.4	102.0	0.0	0.1	212.0	94.0	8.0	11.6	1.0	8.0	10.9	-7.3	57.0
2010	0.0	0.0	0.1	0.4	0.8	825.1	786.9	704.5	314.3	124.3	4.0	0.0	232.0	67.0	5.0	29.0	1.0	10.0	9.1	-5.9	81.0
2011	0.0	0.0	0.1	0.6	1.1	1151.9	1098.5	983.5	435.0	171.6	4.0	0.0	232.0	67.0	4.0	30.0	1.0	13.0	10.3	-8.1	85.0
2012	6.9	7.3	7.5	8.0	8.8	4549.3	4246.8	3744.8	2100.7	893.5	0.0	0.0	32.0	111.0	0.0	0.0	1.0	46.0	72.3	-48.6	84.0
2013	0.4	0.5	0.8	4.3	7.1	1200.2	1192.0	1174.4	712.4	338.7	0.0	0.0	229.0	73.0	3.0	15.7	2.0	13.5	17.0	-9.6	70.0
2014	3.0	3.3	4.2	5.4	5.7	2633.1	2515.3	2174.5	878.5	406.4	0.0	0.0	71.0	106.0	4.0	17.8	2.0	10.0	39.4	-18.7	45.0
2015	0.8	1.0	1.0	2.1	3.4	1595.3	1526.9	1421.1	678.1	377.3	0.0	0.0	244.0	88.0	4.0	19.0	3.0	7.7	24.1	-13.9	86.0
480MOD55																					
2005	2.8	2.8	3.0	5.0	5.8	630.3	610.3	538.2	232.0	101.8	0.0	0.1	212.0	94.0	8.0	11.6	1.0	8.0	10.9	-7.3	57.0
2006	7.2	7.4	7.8	4.7	6.0	2667.7	2380.9	2003.9	1067.7	567.7	0.0	0.0	284.0	92.0	0.0	0.0	2.0	22.0	44.2	-27.1	67.0
2007	0.6	0.7	1.1	2.8	4.5	1374.7	1302.6	1109.9	638.2	264.8	0.0	0.0	275.0	112.0	9.0	16.8	2.0	10.0	27.3	-15.0	59.0
2008	0.9	0.9	1.0	1.1	1.7	998.5	963.0	909.4	475.7	206.9	0.0	0.0	241.0	90.0	4.0	36.8	1.0	14.0	14.8	-10.1	54.0
2009	2.8	2.8	3.0	5.0	5.8	631.5	611.5	539.2	232.4	102.0	0.0	0.1	212.0	94.0	8.0	11.6	1.0	8.0	10.9	-7.3	57.0
2010	0.0	0.0	0.1	0.4	0.8	825.1	786.9	704.5	311.6	122.9	4.0	0.0	232.0	67.0	5.0	29.0	1.0	10.0	7.7	-5.9	81.0
2011	0.0	0.0	0.1	0.6	1.1	1151.9	1098.5	983.5	435.0	171.6	4.0	0.0	232.0	67.0	4.0	30.0	1.0	13.0	10.3	-8.1	85.0
2012	6.9	7.3	7.5	8.0	8.8	4549.3	4246.8	3744.8	2100.7	893.5	0.0	0.0	32.0	111.0	0.0	0.0	1.0	46.0	71.1	-48.6	84.0
2013	0.4	0.5	0.8	4.3	7.1	1200.2	1192.0	1174.4	712.4	338.7	0.0	0.0	229.0	73.0	3.0	15.7	2.0	13.5	17.0	-9.6	70.0
2014	3.0	3.3	4.2	5.4	5.7	2633.1	2515.3	2174.5	878.5	406.4	0.0	0.0	71.0	106.0	4.0	17.5	2.0	10.0	39.4	-18.9	45.0
2015	0.8	1.0	1.0	2.1	4.3	1595.3	1526.9	1421.1	678.1	377.3	0.0	0.0	244.0	88.0	4.0	19.0	3.0	7.7	24.1	-13.9	86.0

Variance Data

	1-day min	3-day min	7-day min	30-day min	90-day min	1-day max	3-day max	7-day max	30-day max	90-day max	Zero days	Base flow	Date min	Date max	Low pulse #	Low pulse duration	High pulse #	High pulse duration	Rise rate	Fall rate	Reversals
MOD55 Baseline																					
1-day min	0.0	0.0	0.1	0.4	0.8	630.3	610.3	538.2	232.0	101.8	0.0	0.0	32.0	67.0	0.0	0.0	1.0	7.7	9.1	-48.6	45.0
- 1 S.D.	-0.3	-0.3	-0.1	1.2	2.0	471.6	472.4	443.7	173.0	83.9	-0.9	0.0	160.8	86.4	1.5	5.6	0.9	3.6	5.9	-28.2	53.3
Mean	2.3	2.4	2.7	3.6	4.6	1659.8	1566.8	1391.2	705.9	323.2	0.7	0.0	205.8	90.4	4.5	17.2	1.6	14.7	25.4	-15.6	67.7
+ 1 S.D.	4.9	5.1	5.5	6.0	7.2	2848.0	2661.1	2338.8	1238.9	562.5	2.4	0.1	250.8	94.3	7.4	28.8	2.2	25.9	45.0	-3.0	82.2
1-day max	7.2	7.4	7.8	8.0	8.8	4549.3	4246.8	3744.8	2100.7	893.5	4.0	0.1	284.0	112.0	9.0	36.8	3.0	46.0	72.3	-5.9	86.0
CV[1]	112.6	111.1	103.7	66.7	55.8	71.6	69.8	68.1	75.5	74.0	221.9	100.0	21.8	4.4	67.0	67.2	43.9	75.6	76.8	-80.7	21.3
480MOD55																					
1-day min	0.0	0.0	0.1	0.4	0.8	630.3	610.3	538.2	232.0	101.8	0.0	0.0	32.0	67.0	0.0	0.0	1.0	7.7	7.7	-48.6	45.0
- 1 S.D.	-0.3	-0.3	-0.1	1.2	2.2	471.6	472.4	443.7	172.5	83.7	-0.9	0.0	160.8	86.4	1.5	5.5	0.9	3.6	5.8	-28.2	53.3
Mean	2.3	2.4	2.7	3.6	4.7	1659.8	1566.8	1391.2	705.7	323.1	0.7	0.0	205.8	90.4	4.5	17.1	1.6	14.7	25.2	-15.6	67.7
+ 1 S.D.	4.9	5.1	5.5	6.0	7.2	2848.0	2661.1	2338.8	1238.8	562.4	2.4	0.1	250.8	94.3	7.4	28.7	2.2	25.9	44.7	-3.0	82.2
1-day max	7.2	7.4	7.8	8.0	8.8	4549.3	4246.8	3744.8	2100.7	893.5	4.0	0.1	284.0	112.0	9.0	36.8	3.0	46.0	71.1	-5.9	86.0
CV[1]	112.6	111.1	103.7	66.7	54.4	71.6	69.8	68.1	75.5	74.1	221.9	100.0	21.8	4.4	67.0	67.8	43.9	75.6	77.1	-80.7	21.3

[1]CV=coefficient of variation (=SD*100/mean)

APPENDIX I-10A

PREDICTED IHA STATISTICS, MOD55 VS. 480MOD55 AT COOPERSTOWN (GAGE 05057000) - MONTHLY AVERAGE FLOW (CFS)

Final Aquatic Impact Analysis Report

Year	October	November	December	January	February	March	April	May	June	July	August	September
MOD55 Baseline												
2005	17.7	36.3	24.2	17.2	15.9	51.4	477.9	90.2	87.4	26.7	17.0	86.6
2006	77.1	51.3	43.5	24.0	24.9	203.4	2279.8	934.1	547.8	461.7	300.9	259.5
2007	43.1	33.5	15.2	12.1	13.5	97.5	772.2	690.1	168.2	96.4	20.3	11.5
2008	25.3	25.7	19.4	14.1	14.8	308.6	731.1	144.0	49.7	22.0	3.7	1.7
2009	17.7	36.3	24.2	17.2	15.9	51.4	478.3	90.3	87.5	26.7	17.0	86.7
2010	39.4	27.3	20.8	15.3	21.7	620.5	114.9	75.6	46.1	90.9	18.1	9.8
2011	26.5	38.0	29.0	21.4	28.5	870.0	156.3	105.2	64.3	126.8	25.2	13.7
2012	93.9	70.6	55.7	46.4	39.1	78.2	4022.9	1685.9	297.1	325.1	149.4	71.4
2013	118.6	72.4	66.8	36.9	43.2	1160.9	587.2	189.4	171.7	127.7	118.4	100.3
2014	67.7	64.9	30.6	31.3	30.4	120.1	2430.9	584.6	244.5	190.9	106.9	33.5
2015	94.3	95.7	74.5	50.0	31.1	637.5	1632.2	684.3	231.5	89.9	18.8	3.6
480MOD55												
2005	17.7	36.3	24.2	17.2	15.9	51.4	477.9	456.9	569.8	502.1	506.6	567.2
2006	547.3	532.2	157.7	24.1	24.9	203.4	2279.8	1333.6	1013.8	940.6	786.6	727.6
2007	507.7	514.3	130.8	12.2	13.5	97.5	772.2	1072.9	639.8	570.1	495.3	492.2
2008	506.0	506.4	134.0	14.2	14.9	308.6	731.2	530.0	526.4	498.0	483.5	481.9
2009	499.2	517.1	138.0	17.3	15.9	51.4	478.3	457.0	569.9	502.2	506.6	567.3
2010	510.2	509.6	133.1	15.4	20.4	620.5	114.9	441.6	523.7	570.3	498.0	489.9
2011	510.1	521.3	139.3	21.4	28.5	870.0	156.3	472.5	540.8	605.9	505.1	134.6
2012	94.1	70.6	55.7	46.4	39.2	78.2	4022.9	2093.9	757.4	815.9	614.8	547.9
2013	611.6	542.6	178.5	37.0	43.2	1160.9	587.2	570.4	642.8	601.2	597.6	580.1
2014	547.9	544.4	145.9	31.4	30.5	120.1	2430.9	976.2	705.1	671.9	580.2	511.1
2015	580.7	573.9	185.0	50.0	31.1	637.5	1632.2	1070.7	700.4	557.3	499.0	483.7

Variance Data

	October	November	December	January	February	March	April	May	June	July	August	September
MOD55 Baseline												
1-day min	17.7	25.7	15.2	12.1	13.5	51.4	114.9	75.6	46.1	22.0	3.7	1.7
- 1 S.D.	21.0	27.5	16.3	12.7	15.3	-1.0	23.2	-26.8	32.6	7.4	-18.8	-14.0
Mean	56.5	50.2	36.7	26.0	25.4	381.8	1244.0	479.4	181.4	144.1	72.3	61.7
+ 1 S.D.	92.0	72.8	57.1	39.3	35.5	764.5	2464.7	985.6	330.2	280.8	163.5	137.3
1-day max	118.6	95.7	74.5	50.0	43.2	1160.9	4022.9	1685.9	547.8	461.7	300.9	259.5
CV[1]	62.8	45.2	55.6	51.1	39.8	100.3	98.1	105.6	82.0	94.9	126.0	122.7
480MOD55												
1-day min	17.7	36.3	24.2	12.2	13.5	51.4	114.9	441.6	523.7	498.0	483.5	134.6
- 1 S.D.	250.4	249.1	81.0	12.8	15.1	-1.0	23.2	342.5	510.3	481.4	461.7	365.0
Mean	448.4	442.6	129.3	26.1	25.3	381.8	1244.0	861.4	653.6	621.4	552.1	507.6
+ 1 S.D.	646.4	636.1	177.5	39.3	35.4	764.5	2464.7	1380.4	797.0	761.4	642.6	650.2
1-day max	611.6	573.9	185.0	50.0	43.2	1160.9	4022.9	2093.9	1013.8	940.6	786.6	727.6
CV[1]	44.2	43.7	37.3	51.0	40.2	100.3	98.1	60.2	21.9	22.5	16.4	28.1

[1]CV=coefficient of variation (=SD*100/mean)

APPENDIX I-10B

PREDICTED IHA STATISTICS, MOD55 VS. 480MOD55 AT COOPERSTOWN (GAGE 05057000) - MAGNITUDE (CFS), FREQUENCY (PER YEAR), AND DURATION (DAYS) OF EXTREME EVENTS

Final Aquatic Impact Analysis Report

Year	1-day min	3-day min	7-day min	30-day min	90-day min	1-day max	3-day max	7-day max	30-day max	90-day max	Zero days	Base flow	Date min	Date max	Low pulse #	Low pulse duration	High pulse #	High pulse duration	Rise rate	Fall rate	Reversals
MOD55 Baseline																					
2005	6.2	6.4	6.9	10.3	17.9	1116.3	1067.6	934.8	489.9	226.3	0.0	0.1	225.0	101.0	5.0	30.8	1.0	5.0	10.0	-6.4	82.0
2006	22.6	22.7	23.2	23.9	25.3	4123.0	4046.5	3755.1	2317.6	1291.7	0.0	0.1	24.0	97.0	4.0	2.5	3.0	18.7	59.7	-31.0	80.0
2007	5.7	6.1	7.1	9.5	13.1	1672.6	1651.9	1573.3	1119.6	554.6	0.0	0.0	248.0	118.0	3.0	56.0	1.0	24.0	18.8	-11.0	88.0
2008	1.4	1.5	1.5	1.7	4.5	1677.9	1632.0	1524.4	890.4	400.4	0.0	0.0	247.0	93.0	6.0	33.0	1.0	15.0	15.3	-8.0	82.0
2009	6.3	6.4	6.9	10.3	18.0	1117.2	1068.5	935.7	490.3	226.5	0.0	0.1	225.0	101.0	5.0	27.6	1.0	5.0	10.1	-6.4	84.0
2010	2.0	2.5	4.4	9.0	17.7	1238.1	1224.6	1149.4	644.0	276.6	0.0	0.1	267.0	77.0	5.0	26.0	1.0	13.0	17.7	-7.6	86.0
2011	2.7	3.4	6.2	13.7	26.0	1692.5	1688.5	1590.0	902.1	385.9	0.0	0.1	267.0	77.0	6.0	12.0	1.0	15.0	20.7	-11.0	93.0
2012	37.3	26.0	24.2	39.2	42.9	7247.2	6889.2	6184.7	4289.7	2024.0	0.0	0.0	32.0	114.0	0.0	0.0	1.0	51.0	69.8	-41.2	78.0
2013	11.4	13.3	14.9	26.1	44.5	1714.3	1685.2	1647.4	1232.4	658.3	0.0	0.1	275.0	78.0	2.0	8.0	3.0	9.7	35.3	-14.7	67.0
2014	14.3	14.3	14.8	25.9	29.0	6201.1	5411.0	4642.6	2487.4	1103.6	0.0	0.1	35.0	110.0	4.0	7.0	1.0	33.0	59.1	-30.0	82.0
2015	2.7	2.9	3.0	3.5	13.1	3741.9	3594.7	3355.3	1915.9	998.3	0.0	0.0	258.0	95.0	3.0	19.7	2.0	23.0	36.2	-18.5	71.0
480MOD55																					
2005	6.7	6.9	7.7	14.4	17.9	1116.3	1067.6	934.8	575.1	550.7	0.0	0.0	277.0	101.0	4.0	24.8	1.0	5.0	12.2	-7.2	80.0
2006	22.6	22.9	23.2	24.0	26.0	4123.0	4046.5	3755.1	2317.6	1557.4	0.0	0.0	24.0	97.0	4.0	2.0	5.0	25.4	61.3	-34.1	60.0
2007	8.9	9.2	10.0	11.4	15.3	1687.8	1657.9	1573.3	1318.2	880.8	0.0	0.0	31.0	131.0	1.0	81.0	1.0	33.0	23.4	-12.5	88.0
2008	12.1	12.1	12.2	13.7	20.3	1677.9	1632.0	1524.4	890.4	627.9	0.0	0.0	51.0	93.0	1.0	70.0	1.0	15.0	16.3	-9.8	90.0
2009	13.2	13.2	13.3	14.4	18.5	1117.2	1068.5	935.7	575.2	534.7	0.0	0.0	30.0	101.0	1.0	82.0	1.0	5.0	13.1	-9.1	76.0
2010	9.3	9.3	9.4	13.2	41.8	1238.1	1224.6	1149.4	644.0	541.3	0.0	0.0	17.0	77.0	2.0	31.0	3.0	5.0	18.4	-10.2	78.0
2011	5.6	7.3	13.1	17.8	51.0	1692.5	1688.5	1590.0	902.1	566.1	0.0	0.0	272.0	77.0	3.0	11.7	2.0	9.5	23.9	-15.0	73.0
2012	37.3	38.2	38.5	39.2	42.8	7247.2	6889.2	6184.7	4311.4	2307.1	0.0	0.1	32.0	114.0	0.0	0.0	3.0	28.0	64.8	-40.9	82.0
2013	12.9	13.3	14.9	26.1	82.1	1714.3	1685.2	1647.4	1232.4	789.2	0.0	0.0	43.0	78.0	1.0	16.0	7.0	5.9	37.2	-16.8	55.0
2014	14.3	14.3	14.8	25.9	31.9	6201.1	5411.0	4642.6	2495.4	1375.1	0.0	0.0	35.0	110.0	3.0	8.3	2.0	34.5	61.0	-30.1	70.0
2015	20.0	20.0	20.1	29.3	71.5	3741.9	3594.7	3355.3	1915.9	1243.3	0.0	0.0	44.0	95.0	1.0	10.0	2.0	29.0	39.8	-20.8	76.0

Variance Data

	1-day min	3-day min	7-day min	30-day min	90-day min	1-day max	3-day max	7-day max	30-day max	90-day max	Zero days	Base flow	Date min	Date max	Low pulse #	Low pulse duration	High pulse #	High pulse duration	Rise rate	Fall rate	Reversals
MOD55 Baseline																					
1-day min	1.4	1.5	1.5	1.7	4.5	1116.3	1067.6	934.8	489.9	226.3	0.0	0.0	24.0	77.0	0.0	0.0	1.0	5.0	10.0	-41.2	67.0
- 1 S.D.	-0.8	1.2	2.4	4.2	10.6	700.1	741.1	733.1	371.7	177.0	0.0	0.0	136.6	92.6	2.1	3.6	0.6	5.9	10.4	-28.8	73.9
Mean	10.2	9.6	10.3	15.7	22.9	2867.5	2723.6	2481.1	1525.4	740.6	0.0	0.1	191.2	96.5	3.9	20.2	1.5	19.3	32.1	-16.9	81.2
+ 1 S.D.	21.2	18.0	18.1	27.2	35.3	5034.8	4706.1	4229.2	2679.1	1304.1	0.0	0.1	245.8	100.3	5.7	36.8	2.3	32.8	53.7	-5.0	88.5
1-day max	37.3	26.0	24.2	39.2	44.5	7247.2	6889.2	6184.7	4289.7	2024.0	0.0	0.1	275.0	118.0	6.0	56.0	3.0	51.0	69.8	-6.4	93.0
CV[1]	107.7	88.0	76.5	73.0	54.0	75.6	72.8	70.5	75.6	76.1		40.0	28.6	4.0	46.3	82.1	56.6	69.7	67.6	-70.7	9.0
480MOD55																					
1-day min	5.6	6.9	7.7	11.4	15.3	1116.3	1067.6	934.8	575.1	534.7	0.0	0.0	17.0	77.0	0.0	0.0	1.0	5.0	12.2	-40.9	55.0
- 1 S.D.	5.7	6.1	7.4	12.1	15.6	702.3	742.0	733.1	422.7	429.0	0.0	0.0	34.3	93.2	0.5	-1.0	0.6	5.5	13.4	-30.2	64.6
Mean	14.8	15.2	16.1	20.9	38.1	2868.8	2724.2	2481.1	1561.6	997.6	0.0	0.0	44.6	97.6	1.9	30.6	2.6	17.8	33.7	-18.8	75.3
+ 1 S.D.	23.9	24.3	24.8	29.6	60.6	5035.4	4706.3	4229.2	2700.5	1566.2	0.0	0.0	54.8	102.1	3.3	62.3	4.5	30.0	54.1	-7.4	85.9
1-day max	37.3	38.2	38.5	39.2	82.1	7247.2	6889.2	6184.7	4311.4	2307.1	0.0	0.1	277.0	131.0	4.0	82.0	7.0	34.5	64.8	-7.2	90.0
CV[1]	61.2	60.1	53.9	41.9	59.0	75.5	72.8	70.5	72.9	57.0		33.3	23.1	4.6	71.7	103.4	74.9	69.2	60.4	-60.7	14.1

[1]CV=coefficient of variation (=SD*100/mean)

APPENDIX I-11A

PREDICTED IHA STATISTICS, MOD55 VS. 480MOD55 AT BALDHILL DAM (GAGE 05058000) - MONTHLY AVERAGE FLOW (CFS)

Final Aquatic Impact Analysis Report

Year	October	November	December	January	February	March	April	May	June	July	August	September
MOD55 Baseline												
2005	155.3	155.9	130.7	24.1	20.2	117.5	260.4	99.9	115.2	36.3	51.8	117.1
2006	233.8	195.8	178.4	58.3	69.3	634.7	2620.9	1291.0	797.7	561.0	384.7	310.5
2007	184.6	144.6	119.4	16.5	16.7	105.4	686.2	765.6	235.2	128.9	27.2	19.1
2008	141.3	161.1	121.3	22.3	43.0	364.5	489.0	164.9	81.6	30.5	13.0	13.0
2009	145.9	155.9	130.7	24.1	20.2	117.5	260.8	100.0	115.3	36.3	51.8	117.2
2010	169.6	136.2	123.0	22.0	56.5	778.2	13.0	13.0	13.0	80.6	31.9	28.2
2011	163.2	150.2	131.8	30.7	63.6	1090.2	13.0	28.5	98.7	142.5	44.5	37.0
2012	229.4	211.9	194.5	52.7	55.3	273.4	5467.3	2427.5	355.3	347.0	188.7	84.1
2013	286.2	205.6	176.1	41.4	62.4	1456.4	395.7	228.8	229.0	143.1	113.2	117.9
2014	207.4	199.3	157.5	56.3	33.4	252.0	2581.5	1197.8	315.0	229.3	125.6	63.9
2015	213.2	212.0	177.2	52.3	47.2	732.7	1811.0	744.8	280.0	108.3	29.3	19.6
480MOD55												
2005	155.3	155.9	130.7	24.1	20.2	117.5	260.4	451.3	597.9	511.2	540.2	599.2
2006	703.7	676.6	308.2	58.4	70.4	634.7	2620.9	1675.5	1262.3	1041.6	870.3	778.1
2007	648.8	625.4	250.4	16.6	16.7	105.4	686.2	1133.4	706.4	602.8	501.8	499.9
2008	621.9	641.9	251.2	22.4	43.8	364.5	489.0	536.0	557.9	506.1	486.8	489.4
2009	637.2	636.9	259.8	24.2	20.2	117.5	260.8	451.4	598.0	511.2	540.3	599.3
2010	639.9	618.8	250.6	22.1	45.6	778.2	13.0	286.0	548.3	581.5	511.8	506.3
2011	648.4	633.9	257.4	30.8	63.6	1090.2	13.0	380.4	575.2	621.6	524.4	173.6
2012	229.8	211.9	194.5	52.7	56.1	273.4	5467.3	2820.6	815.2	838.0	653.9	560.7
2013	779.6	675.8	302.9	41.5	62.4	1456.4	395.7	594.5	700.0	616.4	592.3	597.5
2014	688.0	678.8	288.3	56.4	33.5	252.0	2581.5	1575.3	773.8	710.6	599.0	541.1
2015	699.5	690.9	303.0	52.4	47.2	732.7	1811.0	1116.9	748.8	574.8	508.9	499.0

Variance Data

	October	November	December	January	February	March	April	May	June	July	August	September
MOD55 Baseline												
1-day min	141.3	136.2	119.4	16.5	16.7	105.4	13.0	13.0	13.0	30.5	13.0	13.0
- 1 S.D.	148.8	145.9	121.2	20.5	25.2	93.9	-356.1	-113.1	25.3	7.1	-13.0	-1.6
Mean	193.6	175.3	149.1	36.4	44.3	538.4	1327.2	642.0	239.6	167.6	96.5	84.3
+ 1 S.D.	238.4	204.8	177.1	52.4	63.4	982.9	3010.4	1397.1	454.0	328.2	206.0	170.2
1-day max	286.2	212.0	194.5	58.3	69.3	1456.4	5467.3	2427.5	797.7	561.0	384.7	310.5
CV[1]	23.1	16.8	18.7	43.9	43.1	82.6	126.8	117.6	89.4	95.8	113.4	101.9
480MOD55												
1-day min	155.3	155.9	130.7	16.6	16.7	105.4	13.0	286.0	548.3	506.1	486.8	173.6
- 1 S.D.	386.1	376.1	201.6	20.5	24.7	93.9	-356.1	226.8	513.3	483.8	465.5	387.1
Mean	586.5	567.9	254.3	36.5	43.6	538.4	1327.2	1001.9	716.7	646.9	575.4	531.3
+ 1 S.D.	787.0	759.7	306.9	52.5	62.5	982.9	3010.4	1777.1	920.2	810.0	685.3	675.5
1-day max	779.6	690.9	308.2	58.4	70.4	1456.4	5467.3	2820.6	1262.3	1041.6	870.3	778.1
CV[1]	34.2	33.8	20.7	43.7	43.3	82.6	126.8	77.4	28.4	25.2	19.1	27.1

[1]CV=coefficient of variation (=SD*100/mean)

APPENDIX I-11B

PREDICTED IHA STATISTICS, MOD55 VS. 480MOD55 AT BALDHILL DAM (GAGE 05058000) - MAGNITUDE (CFS), FREQUENCY (PER YEAR), AND DURATION (DAYS) OF EXTREME EVENTS

Final Aquatic Impact Analysis Report

Year	1-day min	3-day min	7-day min	30-day min	90-day min	1-day max	3-day max	7-day max	30-day max	90-day max	Zero days	Base flow	Date min	Date max	Low pulse #	Low pulse duration	High pulse #	High pulse duration	Rise rate	Fall rate	Reversals
MOD55 Baseline																					
2005	13.0	13.0	13.0	18.4	36.7	662.6	608.0	506.5	299.3	202.6	0.0	0.1	108.0	102.0	12.0	9.6	0.0	0.0	32.6	-25.7	159.0
2006	23.6	23.6	24.1	47.7	76.3	3382.9	3382.5	3375.8	2861.5	1701.1	0.0	0.0	69.0	108.0	4.0	4.0	4.0	15.5	72.6	-57.3	133.0
2007	13.0	13.0	13.0	15.4	35.5	2220.4	2181.0	1968.2	1288.5	599.0	0.0	0.1	9.0	120.0	7.0	20.0	2.0	9.0	38.3	-29.3	158.0
2008	13.0	13.0	13.0	13.0	16.8	1245.2	1233.4	1096.2	715.6	348.6	0.0	0.1	24.0	89.0	11.0	12.3	2.0	4.5	42.5	-29.2	129.0
2009	13.0	13.0	13.0	18.4	36.8	663.6	608.9	507.4	299.6	181.2	0.0	0.1	275.0	102.0	13.0	8.9	0.0	0.0	33.1	-25.6	159.0
2010	13.0	13.0	13.0	13.0	13.0	1405.6	1275.7	1149.4	800.8	293.7	0.0	0.1	1.0	68.0	15.0	13.4	2.0	4.5	41.8	-25.2	82.0
2011	13.0	13.0	13.0	13.0	46.3	2045.2	1856.1	1590.0	1117.8	405.9	0.0	0.1	92.0	68.0	18.0	7.2	1.0	16.0	46.4	-35.7	113.0
2012	38.6	40.1	41.7	46.1	63.6	8604.0	8523.4	8022.6	5711.2	2827.7	0.0	0.1	82.0	108.0	0.0	0.0	2.0	26.5	96.5	-73.9	135.0
2013	23.6	25.9	26.5	36.1	94.3	2446.5	2222.8	1806.2	1513.0	708.7	0.0	0.1	232.0	68.0	9.0	3.1	1.0	26.0	50.4	-34.7	114.0
2014	13.0	19.0	20.0	29.4	63.4	6233.6	5384.5	4359.3	3318.0	1418.2	0.0	0.0	131.0	113.0	13.0	4.1	1.0	29.0	75.0	-57.2	164.0
2015	13.0	13.0	13.0	13.1	42.8	3382.0	3361.5	3338.3	2138.0	1121.7	0.0	0.0	233.0	92.0	8.0	8.6	3.0	7.0	57.9	-34.8	118.0
480MOD55																					
2005	13.0	13.0	13.8	18.4	36.7	967.3	876.3	729.5	702.8	661.9	0.0	0.1	108.0	159.0	6.0	12.7	0.0	0.0	32.4	-25.8	167.0
2006	23.6	23.6	24.1	49.3	79.6	3382.9	3382.5	3375.8	2861.5	1946.0	0.0	0.0	69.0	108.0	4.0	4.0	8.0	12.8	77.6	-57.7	126.0
2007	13.0	13.0	13.0	15.4	37.3	2220.4	2181.0	1968.2	1481.6	973.0	0.0	0.0	9.0	120.0	2.0	45.0	2.0	14.0	39.2	-29.8	146.0
2008	13.0	13.0	13.5	20.1	51.2	1245.2	1233.4	1096.2	715.6	595.7	0.0	0.0	24.0	89.0	7.0	7.1	2.0	4.5	39.1	-26.2	150.0
2009	13.0	13.0	13.8	18.4	37.6	1026.9	876.4	740.2	664.1	622.1	0.0	0.0	108.0	304.0	6.0	12.7	0.0	0.0	33.8	-26.4	163.0
2010	13.0	13.0	13.0	13.0	105.7	1405.6	1275.7	1149.4	797.6	600.6	0.0	0.0	1.0	68.0	6.0	15.2	2.0	4.5	39.7	-27.4	115.0
2011	13.0	13.0	13.0	13.0	119.0	2045.2	1856.1	1590.0	1117.8	590.9	0.0	0.0	92.0	68.0	10.0	8.3	3.0	6.0	50.8	-37.9	118.0
2012	38.6	40.1	41.7	46.1	62.7	8604.0	8523.4	8022.6	5732.9	3086.1	0.0	0.0	82.0	108.0	0.0	0.0	1.0	65.0	93.2	-71.9	135.0
2013	29.3	31.8	35.2	40.2	125.0	2446.5	2222.8	1806.2	1513.0	837.5	0.0	0.1	40.0	68.0	7.0	1.7	3.0	10.3	53.5	-35.9	106.0
2014	13.5	19.0	20.0	29.7	68.0	6233.6	5384.5	4359.3	3356.6	1683.2	0.0	0.0	92.0	113.0	10.0	3.7	5.0	7.6	78.2	-57.6	154.0
2015	20.0	23.8	24.5	40.0	103.5	3382.0	3361.5	3338.3	2138.0	1363.0	0.0	0.0	45.0	92.0	3.0	4.7	3.0	12.3	57.5	-33.9	131.0

Variance Data

	1-day min	3-day min	7-day min	30-day min	90-day min	1-day max	3-day max	7-day max	30-day max	90-day max	Zero days	Base flow	Date min	Date max	Low pulse #	Low pulse duration	High pulse #	High pulse duration	Rise rate	Fall rate	Reversals
MOD55 Baseline																					
1-day min	13.0	13.0	13.0	13.0	13.0	662.6	608.0	506.5	299.3	181.2	0.0	0.0	1.0	68.0	0.0	0.0	0.0	0.0	32.6	-73.9	82.0
- 1 S.D.	9.0	9.4	9.3	10.4	23.1	476.4	417.1	312.0	201.5	71.9	0.0	0.0	84.6	89.5	4.9	2.7	0.4	1.8	33.1	-55.3	107.5
Mean	17.3	18.1	18.5	24.0	47.8	2935.6	2785.2	2520.0	1823.9	891.7	0.0	0.1	114.2	94.4	10.0	8.3	1.6	12.6	53.4	-39.0	133.1
+ 1 S.D.	25.5	26.9	27.7	37.5	72.4	5394.8	5153.4	4728.0	3446.4	1711.5	0.0	0.1	143.7	99.3	15.1	13.9	2.8	23.3	73.6	-22.6	158.7
1-day max	38.6	40.1	41.7	47.7	94.3	8604.0	8523.4	8022.6	5711.2	2827.7	0.0	0.1	275.0	120.0	18.0	20.0	4.0	29.0	96.5	-25.2	164.0
CV[1]	47.9	48.0	49.8	56.7	51.6	83.8	85.0	87.6	89.0	91.9		37.5	25.9	5.2	51.2	67.8	73.2	85.6	37.9	-41.9	19.2
480MOD55																					
1-day min	13.0	13.0	13.0	13.0	36.7	967.3	876.3	729.5	664.1	590.9	0.0	0.0	1.0	68.0	0.0	0.0	0.0	0.0	32.4	-71.9	106.0
- 1 S.D.	9.8	10.4	10.5	13.7	41.6	595.8	513.1	393.4	357.4	386.3	0.0	0.0	54.4	96.2	2.4	-2.0	0.3	-5.6	33.5	-55.0	117.2
Mean	18.5	19.7	20.5	27.6	75.1	2996.3	2834.0	2561.4	1916.5	1178.2	0.0	0.0	60.9	117.9	5.6	10.5	2.6	12.5	54.1	-39.1	137.4
+ 1 S.D.	27.2	29.0	30.5	41.5	108.7	5396.8	5154.9	4729.5	3475.6	1970.1	0.0	0.1	67.4	139.7	8.7	22.9	4.9	30.5	74.6	-23.3	157.6
1-day max	38.6	40.1	41.7	49.3	125.0	8604.0	8523.4	8022.6	5732.9	3086.1	0.0	0.1	108.0	304.0	10.0	45.0	8.0	65.0	93.2	-25.8	167.0
CV[1]	47.2	47.3	48.8	50.3	44.7	80.1	81.9	84.6	81.3	67.2		25.0	10.7	18.4	56.0	118.9	86.7	145.1	38.0	-40.6	14.7

[1]CV=coefficient of variation (=SD*100/mean)

APPENDIX I-12A

PREDICTED IHA STATISTICS, MOD55 VS. 480MOD55 AT LISBON (GAGE 0508700) - MONTHLY AVERAGE FLOW (CFS)

Final Aquatic Impact Analysis Report

Year	October	November	December	January	February	March	April	May	June	July	August	September
MOD55 Baseline												
2005	140.4	189.7	150.0	49.5	24.8	242.3	369.9	119.5	144.5	49.8	41.5	156.2
2006	269.5	263.2	215.6	77.2	85.4	678.6	3011.4	1573.3	902.0	602.1	406.3	394.3
2007	187.8	167.1	124.4	34.9	18.7	98.3	737.3	996.4	526.4	676.8	57.0	29.4
2008	139.2	181.6	149.4	57.7	67.4	395.4	713.3	225.2	120.6	48.0	14.5	15.6
2009	116.3	189.7	150.0	49.5	24.8	242.4	370.3	119.6	144.6	49.9	41.5	156.3
2010	159.7	158.6	130.2	57.4	72.2	927.3	83.4	43.0	34.8	112.8	52.2	54.2
2011	137.6	180.6	142.0	72.8	94.7	1303.9	106.1	57.9	132.5	197.3	71.4	73.9
2012	220.1	264.5	241.8	101.0	85.1	363.9	6641.3	3570.5	685.0	562.5	223.1	168.2
2013	286.6	227.2	185.2	64.6	52.5	1493.9	530.5	265.5	293.5	215.9	73.9	160.4
2014	213.4	204.3	169.0	102.9	149.6	528.5	2712.5	1638.2	401.5	236.9	163.7	68.1
2015	221.5	226.9	193.6	102.2	61.1	842.5	2207.6	849.4	312.4	131.7	38.5	20.7
480MOD55												
2005	140.4	189.7	150.0	49.5	24.8	242.3	369.9	423.2	628.1	516.8	532.1	642.6
2006	744.8	743.4	388.6	77.5	81.8	678.6	3011.4	1924.9	1361.1	1085.5	890.2	856.8
2007	649.0	646.9	301.4	35.3	18.7	98.3	737.3	1325.5	995.8	1143.9	523.4	511.5
2008	628.2	661.7	325.6	58.0	72.6	395.4	713.3	549.1	595.9	516.1	487.7	492.3
2009	629.0	667.3	324.6	49.8	24.8	242.4	370.3	423.3	628.2	516.9	532.2	642.7
2010	636.0	636.9	304.2	57.8	67.7	927.3	83.4	255.6	572.6	622.3	528.3	529.8
2011	637.3	659.3	313.3	73.1	94.7	1303.9	106.1	359.6	609.2	678.5	547.4	262.1
2012	222.3	264.5	241.8	101.0	84.8	363.9	6641.3	3929.0	1139.7	1052.7	684.6	638.7
2013	786.7	695.1	354.7	64.8	52.5	1493.9	530.5	588.8	769.8	675.4	564.4	630.8
2014	699.8	683.7	342.5	103.2	150.3	528.5	2712.5	1980.9	851.0	721.7	627.9	547.0
2015	713.9	704.6	362.2	102.6	61.1	842.5	2207.6	1185.6	775.2	588.9	514.4	502.9

Variance Data

	October	November	December	January	February	March	April	May	June	July	August	September
MOD55 Baseline												
1-day min	166.3	158.6	124.4	34.9	18.7	98.3	83.4	43.0	34.8	48.0	14.5	15.6
- 1 S.D.	133.4	168.7	131.3	46.4	29.0	193.9	-391.6	-219.2	64.7	25.5	-9.0	8.4
Mean	190.2	204.9	168.3	70.0	66.9	647.0	1589.4	859.9	336.2	262.2	107.6	117.9
+ 1 S.D.	247.0	241.0	205.2	93.5	104.9	1100.0	3570.4	1938.9	607.6	498.8	224.2	227.4
1-day max	286.6	264.5	241.8	102.9	149.6	1493.9	6641.3	3570.5	902.0	676.8	406.3	394.3
CV[1]	29.9	17.7	22.0	33.7	56.7	70.0	124.6	125.5	80.7	90.3	108.4	92.9
480MOD55												
1-day min	140.4	189.7	150.0	35.3	18.7	98.3	83.4	255.6	572.6	516.1	487.7	262.1
- 1 S.D.	380.4	410.4	244.5	46.7	28.7	193.9	-391.6	72.6	554.6	498.3	469.1	423.2
Mean	589.8	595.7	309.9	70.2	66.7	647.0	1589.4	1176.9	811.5	738.1	584.8	568.8
+ 1 S.D.	799.1	781.1	375.3	93.8	104.7	1100.0	3570.4	2281.2	1068.4	977.8	700.5	714.5
1-day max	786.7	743.4	388.6	103.2	150.3	1493.9	6641.3	3929.0	1361.1	1143.9	890.2	856.8
CV[1]	35.5	31.1	21.1	33.5	56.9	70.0	124.6	93.8	31.7	32.5	19.8	25.6

[1]CV=coefficient of variation (=SD*100/mean)

APPENDIX I-12B

PREDICTED IHA STATISTICS, MOD55 VS. 480MOD55 AT LISBON (GAGE 05058700) - MAGNITUDE (CFS), FREQUENCY (PER YEAR), AND DURATION (DAYS) OF EXTREME EVENTS

Final Aquatic Impact Analysis Report

Year	1-day min	3-day min	7-day min	30-day min	90-day min	1-day max	3-day max	7-day max	30-day max	90-day max	Zero days	Base flow	Date min	Date max	Low pulse #	Low pulse duration	High pulse #	High pulse duration	Rise rate	Fall rate	Reversals
MOD55 Baseline																					
2005	19.9	20.8	21.8	24.7	50.3	786.9	720.0	613.0	525.8	269.5	0.0	0.2	233.0	84.0	2.0	60.0	0.0	0.0	16.6	-12.2	98.0
2006	57.8	58.3	60.5	64.7	112.8	3671.1	3642.7	3600.9	3101.5	1947.2	0.0	0.1	26.0	106.0	2.0	9.0	3.0	19.7	58.3	-41.9	79.0
2007	15.5	15.7	16.2	17.3	41.1	4854.0	4564.0	2984.4	1418.8	946.5	0.0	0.1	40.0	183.0	4.0	31.5	2.0	10.0	61.4	-37.9	98.0
2008	13.5	13.5	13.6	14.3	20.6	1370.9	1300.0	1252.3	905.0	451.9	0.0	0.1	231.0	99.0	4.0	35.0	2.0	1.5	22.3	-14.7	86.0
2009	15.4	17.8	21.9	24.7	50.4	787.0	720.1	613.1	526.1	269.6	0.0	0.2	278.0	84.0	3.0	40.0	0.0	0.0	16.7	-12.4	94.0
2010	15.8	15.9	19.5	34.6	44.5	1492.4	1356.7	1316.0	950.5	371.2	0.0	0.1	274.0	72.0	8.0	22.9	2.0	4.0	23.8	-13.5	103.0
2011	15.6	17.9	28.2	52.7	89.5	2115.7	1929.6	1854.6	1335.9	516.5	0.0	0.1	275.0	72.0	13.0	6.8	1.0	16.0	32.0	-19.9	105.0
2012	45.7	49.4	68.7	74.8	95.8	9920.0	9810.4	9548.0	7093.0	3726.9	0.0	0.1	277.0	112.0	3.0	0.7	3.0	20.3	126.7	-76.7	103.0
2013	29.3	29.6	30.9	43.8	101.7	2111.2	2010.4	1934.4	1657.1	779.4	0.0	0.1	236.0	70.0	2.0	37.5	1.0	26.0	39.0	-28.0	75.0
2014	37.8	38.8	41.0	65.7	133.1	5177.6	5085.2	4774.6	3665.1	1704.1	0.0	0.1	263.0	116.0	3.0	8.0	2.0	16.5	57.5	-42.9	90.0
2015	17.0	17.2	17.5	18.7	50.9	3924.1	3797.0	3728.5	2608.9	1336.2	0.0	0.0	265.0	89.0	4.0	22.0	1.0	21.0	49.3	-24.7	70.0
480MOD55																					
2005	20.6	20.8	21.8	24.7	50.3	964.5	933.9	800.9	737.7	710.8	0.0	0.1	69.0	247.0	1.0	70.0	0.0	0.0	19.5	-14.5	91.0
2006	57.8	58.3	60.5	64.8	116.6	3671.1	3642.7	3600.9	3101.5	2159.9	0.0	0.1	26.0	106.0	2.0	9.0	2.0	35.5	62.9	-44.3	71.0
2007	15.5	15.7	16.2	17.3	43.7	5399.2	5093.1	3472.9	1579.2	1298.8	0.0	0.0	40.0	183.0	2.0	38.0	3.0	11.7	65.5	-40.3	92.0
2008	34.2	34.4	34.9	39.8	86.3	1370.9	1300.0	1252.3	905.0	651.0	0.0	0.1	30.0	99.0	1.0	46.0	2.0	1.5	25.8	-17.5	80.0
2009	20.6	20.9	21.9	24.7	53.3	964.7	934.0	801.0	680.0	638.5	0.0	0.1	69.0	247.0	1.0	70.0	0.0	0.0	21.8	-16.0	91.0
2010	23.1	24.8	27.7	41.9	140.1	1492.4	1356.7	1316.0	950.5	613.5	0.0	0.1	19.0	72.0	3.0	25.0	2.0	4.0	29.0	-17.2	92.0
2011	27.6	30.9	33.5	55.3	159.2	2115.7	1929.6	1854.6	1335.9	632.9	0.0	0.1	274.0	72.0	7.0	7.6	1.0	16.0	37.9	-25.2	89.0
2012	54.8	58.9	68.7	74.7	94.6	9920.0	9810.4	9548.0	7114.7	3981.2	0.0	0.1	277.0	112.0	3.0	1.7	4.0	18.8	124.3	-76.1	107.0
2013	41.3	41.7	42.7	46.3	137.7	2111.2	2010.4	1934.4	1657.1	903.7	0.0	0.1	45.0	70.0	1.0	48.0	2.0	14.0	41.3	-31.3	72.0
2014	58.2	59.7	63.0	98.2	141.6	5177.6	5085.2	4774.6	3697.0	1884.6	0.0	0.1	12.0	116.0	1.0	6.0	3.0	13.0	62.5	-42.8	84.0
2015	45.7	46.1	47.9	59.0	127.6	3924.1	3797.0	3728.5	2608.9	1558.3	0.0	0.1	42.0	89.0	3.0	7.3	2.0	17.5	49.1	-28.3	79.0

Variance Data

	1-day min	3-day min	7-day min	30-day min	90-day min	1-day max	3-day max	7-day max	30-day max	90-day max	Zero days	Base flow	Date min	Date max	Low pulse #	Low pulse duration	High pulse #	High pulse duration	Rise rate	Fall rate	Reversals
MOD55 Baseline																					
1-day min	13.5	13.5	13.6	14.3	20.6	786.9	720.0	613.0	525.8	269.5	0.0	0.0	26.0	70.0	2.0	0.7	0.0	0.0	16.6	-76.7	70.0
- 1 S.D.	10.7	11.4	12.4	17.8	36.0	595.1	492.8	348.5	224.8	79.1	0.0	0.1	162.5	90.1	1.0	6.9	0.5	2.8	14.1	-49.1	78.9
Mean	25.8	26.8	30.9	39.6	71.9	3291.9	3176.0	2929.1	2162.5	1119.9	0.0	0.1	218.0	98.8	4.4	24.9	1.6	12.3	45.8	-29.5	91.0
+ 1 S.D.	40.8	42.2	49.3	61.5	107.8	5988.7	5859.2	5509.7	4100.2	2160.7	0.0	0.1	273.6	107.5	7.7	42.8	2.6	21.8	77.5	-10.0	103.1
1-day max	57.8	58.3	68.7	74.8	133.1	9920.0	9810.4	9548.0	7093.0	3726.9	0.0	0.2	278.0	183.0	13.0	60.0	3.0	26.0	126.7	-12.2	105.0
CV[1]	58.3	57.3	59.7	55.2	50.0	81.9	84.5	88.1	89.6	92.9		40.0	25.5	8.8	76.4	72.3	66.5	77.7	69.3	-66.2	13.3
480MOD55																					
1-day min	15.5	15.7	16.2	17.3	43.7	964.5	933.9	800.9	680.0	613.5	0.0	0.0	12.0	70.0	1.0	1.7	0.0	0.0	19.5	-76.1	71.0
- 1 S.D.	20.2	21.0	21.8	25.6	63.3	673.1	586.2	455.2	305.1	338.7	0.0	0.1	37.4	105.1	0.5	4.0	0.7	1.5	19.0	-50.4	75.8
Mean	36.3	37.5	39.9	49.7	104.6	3373.8	3263.0	3007.6	2215.2	1366.7	0.0	0.1	48.8	128.5	2.3	29.9	1.9	12.0	49.0	-32.1	86.2
+ 1 S.D.	52.4	54.0	58.0	73.8	146.0	6074.4	5939.8	5560.1	4125.4	2394.6	0.0	0.1	60.3	151.8	4.1	55.8	3.1	22.5	79.1	-13.9	96.6
1-day max	58.2	59.7	68.7	98.2	159.2	9920.0	9810.4	9548.0	7114.7	3981.2	0.0	0.1	277.0	247.0	7.0	70.0	4.0	35.5	124.3	-14.5	107.0
CV[1]	44.2	44.0	45.4	48.5	39.5	80.1	82.0	84.9	86.2	75.2		33.3	23.5	18.2	79.3	86.7	63.9	87.9	61.4	-56.8	12.1

[1]CV=coefficient of variation (=SD*100/mean)

APPENDIX I-13A

PREDICTED IHA STATISTICS, MOD55 VS. 480MOD55 AT KINDRED (GAGE 05059000) - MONTHLY AVERAGE FLOW (CFS)

Final Aquatic Impact Analysis Report

Year	October	November	December	January	February	March	April	May	June	July	August	September
MOD55 Baseline												
2005	168.7	232.2	199.4	98.6	57.9	230.3	520.2	182.4	211.8	98.2	70.7	166.4
2006	354.4	371.9	324.3	145.7	140.6	759.2	3166.0	1767.6	1058.1	727.1	487.6	601.5
2007	227.0	193.2	132.7	67.0	30.2	88.7	735.0	1252.9	659.3	1415.8	146.9	112.4
2008	202.2	250.0	180.3	99.6	189.5	490.9	842.4	339.0	175.2	101.7	44.4	28.7
2009	130.4	232.2	199.4	98.6	57.9	230.4	520.6	182.6	211.9	98.2	70.7	166.5
2010	163.3	175.5	133.5	66.4	77.2	947.9	175.2	52.5	65.6	128.1	82.9	83.9
2011	130.0	204.5	146.5	79.3	106.4	1340.9	227.2	68.5	167.8	230.6	111.0	115.9
2012	247.1	333.5	289.1	123.3	96.4	217.1	6799.9	4334.9	795.8	661.0	275.0	221.7
2013	296.1	251.4	213.8	89.6	56.4	1479.8	676.3	360.1	301.8	317.2	63.6	198.1
2014	267.5	259.9	188.6	114.7	158.9	671.9	2698.5	2279.5	642.7	293.8	252.0	108.7
2015	222.5	248.6	227.7	158.8	96.5	706.4	2578.7	982.6	488.2	225.5	74.8	59.1
480MOD55												
2005	168.7	232.2	199.4	98.6	57.9	230.3	520.2	440.1	698.0	556.6	561.4	658.4
2006	834.9	852.9	537.6	146.6	141.0	759.2	3166.0	2084.7	1515.1	1210.5	970.9	1060.9
2007	683.2	673.2	353.8	68.2	30.2	88.7	735.0	1545.7	1129.4	1876.4	602.7	594.6
2008	700.7	729.6	399.3	100.8	199.1	490.9	842.4	618.6	648.4	562.2	517.3	506.0
2009	657.6	712.7	417.8	99.8	57.9	230.4	520.6	440.3	698.1	556.6	561.4	658.5
2010	639.1	654.7	353.0	67.5	76.7	947.9	175.2	210.9	604.3	648.2	552.0	557.1
2011	634.7	684.1	363.4	80.4	106.4	1340.9	227.2	317.7	653.2	714.7	580.2	351.0
2012	251.7	333.5	289.1	123.3	96.6	217.1	6799.9	4660.6	1248.7	1147.8	727.3	694.2
2013	800.0	719.1	425.4	90.3	56.4	1479.8	676.3	641.0	782.5	768.7	550.0	673.5
2014	756.9	738.9	404.2	115.9	155.5	671.9	2698.5	2584.5	1088.8	778.9	710.1	582.5
2015	726.1	724.2	438.0	159.7	96.5	706.4	2578.7	1284.2	944.3	675.8	545.8	540.3

Variance Data

	October	November	December	January	February	March	April	May	June	July	August	September
MOD55 Baseline												
1-day min	130.0	175.5	132.7	66.4	30.2	88.7	175.2	52.5	65.6	98.2	44.4	28.7
- 1 S.D.	148.9	192.5	142.7	74.0	48.1	187.5	-276.1	-242.4	117.0	-12.9	17.5	14.7
Mean	219.0	250.3	203.2	103.8	97.1	651.2	1721.8	1073.0	434.4	390.7	152.7	169.4
+ 1 S.D.	289.1	308.1	263.7	133.6	146.0	1114.9	3719.7	2388.3	751.8	794.2	287.9	324.1
1-day max	354.4	371.9	324.3	158.8	189.5	1479.8	6799.9	4334.9	1058.1	1415.8	487.6	601.5
CV[1]	32.0	23.1	29.8	28.7	50.4	71.2	116.0	122.6	73.1	103.3	88.5	91.4
480MOD55												
1-day min	168.7	232.2	199.4	67.5	30.2	88.7	175.2	210.9	604.3	556.6	517.3	351.0
- 1 S.D.	408.5	455.6	293.3	74.9	47.2	187.5	-276.1	1.8	610.7	460.0	492.4	451.1
Mean	623.1	641.4	380.1	104.6	97.6	651.2	1721.8	1348.0	910.1	863.3	625.4	625.2
+ 1 S.D.	837.6	827.2	466.8	134.4	148.1	1114.9	3719.7	2694.2	1209.4	1266.6	758.3	799.3
1-day max	834.9	852.9	537.6	159.7	199.1	1479.8	6799.9	4660.6	1515.1	1876.4	970.9	1060.9
CV[1]	34.4	29.0	22.8	28.4	51.7	71.2	116.0	99.9	32.9	46.7	21.3	27.8

[1]CV=coefficient of variation (=SD*100/mean)

APPENDIX I-13B

PREDICTED IHA STATISTICS, MOD55 VS. 480MOD55 AT KINDRED (GAGE 05059000) - MAGNITUDE (CFS), FREQUENCY (PER YEAR), AND DURATION (DAYS) OF EXTREME EVENTS

Final Aquatic Impact Analysis Report

Year	1-day min	3-day min	7-day min	30-day min	90-day min	1-day max	3-day max	7-day max	30-day max	90-day max	Zero days	Base flow	Date min	Date max	Low pulse #	Low pulse duration	High pulse #	High pulse duration	Rise rate	Fall rate	Reversals
MOD55 Baseline																					
2005	51.8	53.6	53.8	56.9	88.1	965.9	908.5	832.5	626.5	351.4	0.0	0.3	80.0	96.0	3.0	40.3	0.0	0.0	15.6	-10.9	80.0
2006	114.6	116.6	118.9	122.5	177.0	3814.7	3787.6	3713.6	3166.0	2096.9	0.0	0.1	16.0	108.0	0.0	0.0	4.0	16.3	58.1	-37.8	82.0
2007	21.1	21.7	24.3	27.1	55.9	4556.3	4474.6	4028.2	1730.0	1265.9	0.0	0.1	61.0	188.0	5.0	17.6	3.0	11.0	64.5	-38.4	81.0
2008	23.3	23.9	24.3	28.7	48.0	1433.0	1397.9	1379.4	1030.7	572.7	0.0	0.1	274.0	95.0	2.0	57.0	2.0	1.5	21.1	-12.0	74.0
2009	51.9	53.6	53.8	56.9	88.1	965.9	908.5	832.5	626.8	343.0	0.0	0.3	80.0	96.0	4.0	30.3	0.0	0.0	16.4	-10.8	76.0
2010	35.9	37.1	39.0	46.7	67.8	1457.4	1430.0	1366.7	999.5	410.7	0.0	0.2	23.0	82.0	11.0	17.3	2.0	2.0	19.9	-13.0	76.0
2011	39.3	40.9	44.6	64.3	110.6	2027.5	1975.1	1911.0	1406.6	572.9	0.0	0.2	279.0	76.0	10.0	10.6	1.0	16.0	26.5	-19.0	74.0
2012	80.4	83.3	89.1	95.4	123.8	9759.6	9692.4	9641.0	7469.7	4018.6	0.0	0.1	30.0	114.0	4.0	12.3	3.0	20.7	99.6	-67.6	87.0
2013	46.0	46.8	48.0	55.9	116.2	2442.5	2369.6	2248.6	1773.2	860.9	0.0	0.1	51.0	88.0	2.0	40.5	1.0	24.0	38.2	-25.1	88.0
2014	67.1	69.0	75.7	105.3	148.4	5025.9	4974.5	4810.6	3875.3	2009.1	0.0	0.1	15.0	119.0	2.0	11.5	4.0	10.3	55.3	-39.7	81.0
2015	39.7	46.1	51.1	56.6	92.9	4521.3	4469.1	4294.6	2845.1	1494.8	0.0	0.1	242.0	93.0	3.0	28.7	1.0	22.0	39.2	-28.5	94.0
480MOD55																					
2005	51.8	53.6	53.8	56.9	88.1	965.9	908.5	832.5	827.6	795.2	0.0	0.2	80.0	96.0	1.0	67.0	0.0	0.0	18.1	-12.6	74.0
2006	114.8	116.8	119.1	122.6	187.3	3814.7	3787.6	3713.6	3166.0	2294.7	0.0	0.1	16.0	108.0	0.0	0.0	4.0	21.0	62.2	-39.5	76.0
2007	21.1	21.7	24.3	27.1	59.0	4967.6	4931.0	4525.4	2206.7	1619.5	0.0	0.0	61.0	188.0	2.0	36.5	3.0	15.0	69.3	-39.2	69.0
2008	65.2	66.8	70.1	83.3	176.6	1433.0	1397.9	1379.4	1030.7	738.7	0.0	0.1	19.0	95.0	1.0	33.0	2.0	1.5	22.2	-15.1	66.0
2009	51.9	53.6	53.8	56.9	91.6	965.9	908.5	832.5	712.7	650.9	0.0	0.1	80.0	96.0	1.0	67.0	0.0	0.0	19.7	-14.5	66.0
2010	36.0	38.1	39.7	56.5	148.2	1457.4	1430.0	1366.7	999.5	631.0	0.0	0.1	23.0	82.0	5.0	16.8	2.0	2.0	25.3	-15.9	64.0
2011	45.5	48.1	50.5	73.3	170.6	2027.5	1975.1	1911.0	1406.6	664.3	0.0	0.1	20.0	76.0	5.0	12.2	1.0	16.0	34.0	-22.8	58.0
2012	80.4	83.3	89.1	95.4	122.6	9759.6	9692.4	9641.0	7489.3	4273.2	0.0	0.1	30.0	114.0	2.0	22.5	3.0	25.7	94.5	-68.9	91.0
2013	46.0	46.8	48.4	55.9	155.0	2442.5	2369.6	2248.6	1773.2	983.1	0.0	0.1	51.0	88.0	1.0	53.0	2.0	12.5	39.2	-28.3	77.0
2014	67.3	69.3	76.0	105.5	159.8	5025.9	4974.5	4810.6	3904.8	2191.0	0.0	0.1	15.0	119.0	1.0	9.0	3.0	19.0	57.4	-40.5	78.0
2015	68.6	72.2	77.6	93.1	171.2	4521.3	4469.1	4294.6	2845.1	1713.2	0.0	0.1	49.0	93.0	1.0	25.0	2.0	17.0	44.9	-29.4	72.0

Variance Data

	1-day min	3-day min	7-day min	30-day min	90-day min	1-day max	3-day max	7-day max	30-day max	90-day max	Zero days	Base flow	Date min	Date max	Low pulse #	Low pulse duration	High pulse #	High pulse duration	Rise rate	Fall rate	Reversals
MOD55 Baseline																					
1-day min	21.1	21.7	24.3	27.1	48.0	965.9	908.5	832.5	626.5	343.0	0.0	0.1	15.0	76.0	0.0	0.0	0.0	0.0	15.6	-67.6	74.0
- 1 S.D.	24.8	26.5	28.4	34.7	62.5	750.7	703.7	604.9	308.9	158.2	0.0	0.1	51.3	96.3	0.8	7.4	0.5	2.0	15.2	-45.0	74.8
Mean	51.9	53.9	56.6	65.1	101.5	3360.9	3308.0	3187.1	2322.7	1272.5	0.0	0.2	71.4	105.0	4.2	24.2	1.9	11.2	41.3	-27.5	81.2
+ 1 S.D.	79.0	81.3	84.8	95.5	140.5	5971.1	5912.3	5769.4	4336.4	2386.8	0.0	0.2	91.5	113.7	7.6	41.0	3.4	20.5	67.4	-10.0	87.5
1-day max	114.6	116.6	118.9	122.5	177.0	9759.6	9692.4	9641.0	7469.7	4018.6	0.0	0.3	279.0	188.0	11.0	57.0	4.0	24.0	99.6	-10.8	94.0
CV[1]	52.2	50.9	49.8	46.7	38.4	77.7	78.7	81.0	86.7	87.6		60.0	28.2	8.3	81.3	69.5	75.9	82.0	63.2	-63.6	7.8
480MOD55																					
1-day min	21.1	21.7	24.3	27.1	59.0	965.9	908.5	832.5	712.7	631.0	0.0	0.0	15.0	76.0	0.0	0.0	0.0	0.0	18.1	-68.9	58.0
- 1 S.D.	34.1	35.7	37.7	47.4	96.6	766.4	721.2	629.7	408.5	392.4	0.0	0.1	37.6	96.3	0.2	8.3	0.7	2.5	19.9	-46.5	63.1
Mean	59.0	60.9	63.8	75.1	139.1	3398.3	3349.5	3232.4	2396.6	1505.0	0.0	0.1	40.4	105.0	1.8	31.1	2.0	11.8	44.3	-29.7	71.9
+ 1 S.D.	83.8	86.2	90.0	102.8	181.6	6030.2	5977.8	5835.0	4384.6	2617.5	0.0	0.1	43.1	113.7	3.5	53.9	3.3	21.1	68.6	-12.9	80.8
1-day max	114.8	116.8	119.1	122.6	187.3	9759.6	9692.4	9641.0	7489.3	4273.2	0.0	0.2	80.0	188.0	5.0	67.0	4.0	25.7	94.5	-12.6	91.0
CV[1]	42.2	41.5	40.9	36.9	30.6	77.4	78.5	80.5	83.0	73.9		44.4	6.9	8.3	91.2	73.5	63.0	78.9	54.9	-56.5	12.3

[1]CV=coefficient of variation (=SD*100/mean)

APPENDIX I-14A

PREDICTED IHA STATISTICS, MOD55 VS. 480MOD55 AT HALSTAD (GAGE 05064500) - MONTHLY AVERAGE FLOW (CFS)

Final Aquatic Impact Analysis Report

Year	October	November	December	January	February	March	April	May	June	July	August	September
MOD55 Baseline												
2005	1063.7	1141.1	900.6	840.1	707.9	1105.4	6063.2	1664.9	1341.6	498.5	370.7	418.1
2006	2165.7	1736.2	2032.6	1055.3	956.9	7172.3	11403.4	9027.8	5141.8	4005.6	2955.6	5225.7
2007	896.2	759.0	473.4	352.0	407.9	685.6	11037.2	6300.7	4578.8	19933.2	1462.1	761.1
2008	877.6	1052.7	654.3	598.3	667.9	3196.4	4885.3	1398.4	587.0	339.9	120.9	62.9
2009	1008.8	1141.1	900.6	840.1	707.9	1105.5	6063.5	1665.1	1341.7	498.5	370.7	418.2
2010	548.5	524.1	445.7	378.5	402.0	2984.3	1268.3	1062.1	1825.7	2137.7	1043.6	933.6
2011	706.5	687.5	581.3	504.7	561.9	4205.4	1730.9	1474.2	2613.6	3039.7	1452.8	1301.5
2012	800.7	1406.3	1084.3	1074.3	1699.6	2793.5	59673.6	22345.0	7071.8	7213.0	2402.1	1828.5
2013	1455.1	1090.1	749.5	460.3	386.2	3985.3	2837.0	1143.7	1644.0	3565.2	833.7	878.2
2014	1816.6	1661.7	1207.1	771.5	708.8	3348.3	13022.3	9439.2	3673.8	1270.0	832.3	490.5
2015	1468.2	1540.1	1159.2	917.2	1071.8	7323.1	19712.9	4537.3	11054.5	3369.0	1275.3	585.6
480MOD55												
2005	1063.7	1141.1	900.6	840.1	707.9	1105.4	6063.2	1831.8	1833.0	945.1	845.4	920.4
2006	2663.8	2213.8	2332.5	1058.9	953.0	7172.3	11403.4	9263.9	5601.5	4485.3	3432.1	5693.0
2007	1338.8	1237.1	785.3	359.1	408.0	685.6	11037.2	6517.9	5043.4	20390.5	1912.7	1233.4
2008	1379.0	1536.3	960.7	604.3	683.9	3196.4	4885.3	1587.7	1053.9	795.6	586.4	537.8
2009	1553.7	1622.6	1208.3	845.5	707.9	1105.5	6063.5	1832.0	1833.1	945.1	845.4	920.5
2010	1029.1	1001.2	760.5	385.0	400.6	2984.3	1268.3	1112.0	2371.5	2667.9	1504.6	1412.5
2011	1205.8	1166.5	893.8	510.2	562.0	4205.4	1730.9	1603.6	3138.5	3521.6	1908.1	1631.0
2012	811.8	1406.3	1084.3	1074.3	1719.9	2793.5	59673.6	22577.7	7539.9	7693.7	2849.6	2301.4
2013	1964.9	1556.0	1054.2	464.1	386.2	3985.3	2837.0	1329.1	2123.5	4025.5	1292.7	1371.0
2014	2313.0	2138.7	1511.8	776.8	710.5	3348.3	13022.3	9662.5	4120.0	1735.0	1298.3	954.4
2015	1985.5	2013.1	1458.4	921.4	1071.8	7323.1	19712.9	4762.5	11509.8	3810.3	1740.9	1053.3

Variance Data

	October	November	December	January	February	March	April	May	June	July	August	September
MOD55 Baseline												
1-day min	548.5	524.1	445.7	352.0	386.2	685.6	1268.3	1062.1	587.0	339.9	120.9	62.9
- 1 S.D.	662.9	758.9	474.2	446.2	369.8	1230.7	-4087.3	-977.4	584.7	-1435.5	326.7	-254.1
Mean	1164.3	1158.2	926.3	708.4	752.6	3445.9	12518.0	5459.9	3715.8	4170.0	1192.7	1173.1
+ 1 S.D.	1665.8	1557.4	1378.3	970.6	1135.5	5661.1	29123.2	11897.1	6847.0	9775.6	2058.7	2600.2
1-day max	2165.7	1736.2	2032.6	1074.3	1699.6	7323.1	59673.6	22345.0	11054.5	19933.2	2955.6	5225.7
CV[1]	43.1	34.5	48.8	37.0	50.9	64.3	132.7	117.9	84.3	134.4	72.6	121.7
480MOD55												
1-day min	811.8	1001.2	760.5	359.1	386.2	685.6	1268.3	1112.0	1053.9	795.6	586.4	537.8
- 1 S.D.	988.5	1131.2	721.1	452.1	368.1	1230.7	-4087.3	-825.8	1080.1	-967.2	792.5	217.1
Mean	1573.5	1548.4	1177.3	712.7	755.6	3445.9	12518.0	5643.7	4197.1	4637.8	1656.0	1639.0
+ 1 S.D.	2158.6	1965.7	1633.5	973.3	1143.1	5661.1	29123.2	12113.2	7314.1	10242.7	2519.5	3060.9
1-day max	2663.8	2213.8	2332.5	1074.3	1719.9	7323.1	59673.6	22577.7	11509.8	20390.5	3432.1	5693.0
CV[1]	37.2	26.9	38.8	36.6	51.3	64.3	132.7	114.6	74.3	120.9	52.1	86.8

[1]CV=coefficient of variation (=SD*100/mean)

APPENDIX I-14B

PREDICTED IHA STATISTICS, MOD55 VS. 480MOD55 AT HALSTAD (GAGE 05064500) - MAGNITUDE (CFS), FREQUENCY (PER YEAR), AND DURATION (DAYS) OF EXTREME EVENTS

Final Aquatic Impact Analysis Report

Year	1-day min	3-day min	7-day min	30-day min	90-day min	1-day max	3-day max	7-day max	30-day max	90-day max	Zero days	Base flow	Date min	Date max	Low pulse #	Low pulse duration	High pulse #	High pulse duration	Rise rate	Fall rate	Reversals
MOD55 Baseline																					
2005	293.0	313.4	321.1	344.9	402.3	17402.4	15782.5	13376.4	6096.1	3088.0	0.0	0.2	274.0	98.0	3.0	32.7	1.0	6.0	139.0	-104.8	81.0
2006	467.7	492.9	658.9	961.5	738.5	18970.6	18613.0	18198.0	14622.7	9963.8	0.0	0.2	275.0	89.0	1.0	0.0	3.0	12.3	408.7	-239.5	49.0
2007	228.8	236.2	278.1	339.5	399.0	39658.2	39231.0	37958.1	22593.8	12372.2	0.0	0.1	17.0	192.0	5.0	28.4	2.0	23.0	498.9	-277.4	61.0
2008	47.5	48.3	48.7	62.9	166.4	12478.1	12329.5	11558.3	6581.2	3197.5	0.0	0.0	274.0	91.0	3.0	62.3	1.0	8.0	134.3	-55.1	67.0
2009	293.1	244.5	314.6	344.9	387.7	17402.5	15782.5	13376.4	6096.5	3088.2	0.0	0.2	274.0	98.0	3.0	32.7	1.0	6.0	139.3	-104.7	81.0
2010	180.0	264.0	312.2	355.9	406.0	5974.8	5731.6	5114.1	3246.8	1822.6	0.0	0.3	275.0	71.0	4.0	36.3	0.0	0.0	119.6	-79.6	61.0
2011	404.8	409.6	420.6	488.3	547.6	8555.6	8244.3	7344.2	4551.1	2541.0	0.0	0.3	21.0	71.0	7.0	16.0	0.0	0.0	169.7	-113.5	69.0
2012	503.6	512.7	538.2	768.5	1092.2	106317.9	13435.4	95119.7	64541.2	29864.3	0.0	0.1	292.0	109.0	1.0	10.0	4.0	16.3	883.1	-605.0	66.0
2013	355.8	356.5	360.4	372.2	519.4	7279.1	7036.4	6258.9	4919.4	2707.4	0.0	0.2	41.0	188.0	6.0	16.7	0.0	0.0	154.7	-97.4	69.0
2014	278.4	280.9	305.0	484.8	800.5	23313.6	23000.9	22140.0	14236.9	9359.0	0.0	0.1	269.0	110.0	5.0	11.6	2.0	14.0	342.7	-179.5	64.0
2015	284.6	294.8	334.8	585.6	926.7	42836.1	42585.1	41318.3	23653.1	13024.5	0.0	0.1	274.0	94.0	2.0	11.0	2.0	18.0	616.3	-296.3	67.0
480MOD55																					
2005	615.1	617.0	624.4	707.0	776.7	17402.4	15782.5	13376.4	6096.1	3283.9	0.0	0.4	53.0	98.0	1.0	14.0	1.0	6.0	135.0	-106.6	77.0
2006	881.5	882.4	886.4	963.5	1160.8	18970.6	18613.0	18198.0	14622.7	10138.9	0.0	0.2	49.0	89.0	0.0	0.0	3.0	13.0	408.1	-244.5	47.0
2007	229.8	237.0	279.4	340.1	427.7	40127.5	39730.9	38459.8	23077.8	12690.9	0.0	0.1	17.0	192.0	1.0	90.0	2.0	23.0	528.7	-269.5	51.0
2008	517.3	520.0	525.3	537.8	631.8	12478.1	12329.5	11558.3	6581.2	3249.5	0.0	0.4	274.0	91.0	2.0	62.0	1.0	8.0	123.8	-56.8	68.0
2009	615.1	617.0	624.4	707.0	799.3	17402.5	15782.5	13376.4	6096.5	3284.1	0.0	0.4	53.0	98.0	1.0	14.0	1.0	6.0	141.2	-104.3	75.0
2010	300.5	304.1	312.7	356.3	489.1	5974.8	5731.6	5114.1	3545.4	2238.1	0.0	0.2	21.0	71.0	2.0	39.0	0.0	0.0	132.1	-77.3	61.0
2011	405.2	410.0	420.9	488.9	632.6	8555.6	8244.3	7344.2	4755.2	2930.2	0.0	0.2	21.0	71.0	1.0	59.0	0.0	0.0	185.9	-110.0	61.0
2012	509.9	519.0	544.7	780.0	1096.0	106317.9	13435.4	95119.7	64541.2	30100.5	0.0	0.1	292.0	109.0	1.0	9.0	4.0	16.8	875.5	-605.3	64.0
2013	355.8	356.5	360.4	372.3	598.9	7797.3	7549.4	6744.6	4919.4	2785.9	0.0	0.2	41.0	188.0	1.0	65.0	0.0	0.0	157.8	-98.2	67.0
2014	609.1	619.5	644.0	696.5	840.2	23313.6	23000.9	22140.0	14237.0	9522.1	0.0	0.2	62.0	110.0	3.0	6.0	2.0	14.0	345.0	-182.0	66.0
2015	674.4	682.4	710.0	798.8	1145.9	42836.1	42585.1	41318.3	23653.1	13217.9	0.0	0.2	43.0	94.0	1.0	1.0	2.0	18.0	639.1	-292.1	67.0

Variance Data

	1-day min	3-day min	7-day min	30-day min	90-day min	1-day max	3-day max	7-day max	30-day max	90-day max	Zero days	Base flow	Date min	Date max	Low pulse #	Low pulse duration	High pulse #	High pulse duration	Rise rate	Fall rate	Reversals
MOD55 Baseline																					
1-day min	47.5	48.3	48.7	62.9	166.4	5974.8	5731.6	5114.1	3246.8	1822.6	0.0	0.0	17.0	71.0	1.0	0.0	0.0	0.0	119.6	-605.0	49.0
- 1 S.D.	174.0	184.4	199.8	223.5	304.2	-1599.1	-1738.8	-1588.4	-2225.5	-58.8	0.0	0.1	141.5	97.6	1.7	6.1	0.2	1.5	76.0	-354.7	57.8
Mean	303.4	314.0	353.9	464.5	580.6	27289.9	26524.8	24705.7	15558.1	8275.3	0.0	0.2	207.8	110.1	3.6	23.4	1.5	9.4	327.9	-195.7	66.8
+ 1 S.D.	432.8	443.5	508.0	705.5	856.9	56178.9	54788.3	50999.7	33341.6	16609.4	0.0	0.3	274.2	122.6	5.6	40.7	2.8	17.3	579.8	-36.7	75.8
1-day max	503.6	512.7	658.9	961.5	1092.2	106317.9	103435.4	95119.7	64541.2	29864.3	0.0	0.3	292.0	192.0	7.0	62.3	4.0	23.0	883.1	-55.1	81.0
CV[1]	42.7	41.3	43.5	51.9	47.6	105.9	106.6	106.4	114.3	100.7		56.3	31.9	11.3	53.8	73.9	89.7	84.0	76.8	-81.2	13.4
480MOD55																					
1-day min	229.8	237.0	279.4	340.1	427.7	5974.8	5731.6	5114.1	3545.4	2238.1	0.0	0.1	17.0	71.0	0.0	0.0	0.0	0.0	123.8	-605.3	47.0
- 1 S.D.	331.5	336.5	354.9	406.3	523.3	-1494.2	-1634.5	-1490.6	-2122.4	158.1	0.0	0.1	39.4	97.6	0.5	1.1	0.2	1.5	79.9	-353.7	55.0
Mean	519.4	524.1	539.3	613.5	781.8	27379.7	26616.8	24795.4	15647.8	8494.7	0.0	0.2	50.9	110.1	1.3	32.6	1.5	9.5	333.8	-195.1	64.0
+ 1 S.D.	707.3	711.6	723.8	820.7	1040.2	56253.6	54868.2	51081.5	33417.9	16831.4	0.0	0.3	62.4	122.6	2.1	64.2	2.8	17.5	587.7	-36.6	73.0
1-day max	881.5	882.4	886.4	963.5	1160.8	106317.9	103435.4	95119.7	64541.2	30100.5	0.0	0.4	292.0	192.0	3.0	90.0	4.0	23.0	875.5	-56.8	77.0
CV[1]	36.2	35.8	34.2	33.8	33.1	105.5	106.1	106.0	113.6	98.1		54.5	22.6	11.3	62.2	96.7	89.7	83.8	76.1	-81.3	14.0

[1]CV=coefficient of variation (=SD*100/mean)

APPENDIX I-15A

PREDICTED IHA STATISTICS, MOD55 VS. 480MOD55 AT GRAND FORKS (GAGE 05082500) - MONTHLY AVERAGE FLOW (CFS)

Final Aquatic Impact Analysis Report

Year	October	November	December	January	February	March	April	May	June	July	August	September
MOD55 Baseline												
2005	2629.1	2758.9	2430.2	2168.1	2193.4	2672.8	13718.0	3009.1	2391.6	1122.0	697.5	1258.3
2006	3842.4	3707.5	4337.5	1958.9	1927.3	12763.2	28728.8	18307.3	11008.5	7464.7	6135.9	12670.2
2007	2599.1	2125.7	1338.4	1338.1	1397.3	1694.8	18539.5	14736.3	6174.4	25140.2	2972.9	2228.6
2008	2904.9	2973.9	2261.2	2106.5	2006.9	4572.3	11701.3	2995.1	1971.0	1416.6	1218.0	890.9
2009	2563.9	2758.6	2430.2	2168.1	2193.4	2672.8	13718.3	3009.2	2391.7	1122.1	697.5	1258.3
2010	744.5	724.5	631.4	622.2	596.7	4888.8	3109.7	2282.3	2263.5	3072.9	1614.1	2452.6
2011	1019.3	963.5	837.0	838.1	837.8	6890.7	4279.4	3175.7	3234.1	4324.8	2262.4	3412.2
2012	2675.8	3346.8	3271.1	2735.4	2615.1	3246.7	87108.4	36064.2	12930.6	20093.2	4835.5	3672.8
2013	4109.8	2634.6	2048.9	1747.6	1621.1	8294.2	7293.8	3162.0	5356.3	6298.9	2793.3	2737.0
2014	3474.1	2780.5	2204.3	1941.2	1792.5	4560.1	25877.5	20052.7	7468.4	3622.2	2556.7	1620.0
2015	4289.8	4090.8	3891.1	3322.6	3577.3	10025.1	32702.8	7959.3	23628.0	6643.8	3145.3	1956.5
480MOD55												
2005	2629.1	2758.9	2430.2	2168.1	2193.4	2672.8	13718.0	3124.7	2881.5	1554.6	1172.0	1764.8
2006	4360.7	4169.6	4690.3	1967.1	1913.8	12763.2	28728.8	18497.1	11468.8	7942.8	6606.6	13146.3
2007	3027.2	2603.3	1699.0	1355.8	1397.4	1694.8	18539.5	14911.3	6633.8	25600.4	3415.2	2690.6
2008	3412.7	3456.9	2616.0	2121.1	2027.3	4572.3	11701.3	3133.1	2425.4	1868.8	1674.9	1361.1
2009	3119.4	3242.6	2783.9	2181.3	2193.5	2672.8	13718.3	3124.9	2881.6	1554.7	1172.0	1764.9
2010	1228.0	1199.9	997.7	638.9	597.6	4888.8	3109.7	2297.1	2791.4	3589.0	2089.4	2927.0
2011	1516.4	1443.1	1199.8	851.6	837.8	6890.7	4279.4	3243.4	3774.1	4796.0	2728.7	3781.3
2012	2695.4	3346.8	3271.1	2735.4	2637.7	3246.7	87108.4	36205.7	13442.6	20575.0	5284.8	4138.8
2013	4633.1	3101.1	2399.2	1758.0	1621.1	8294.2	7293.8	3292.7	5837.9	6768.3	3236.6	3227.9
2014	3979.7	3255.5	2556.2	1953.2	1795.4	4560.1	25877.5	20234.4	7915.9	4069.4	3021.9	2074.9
2015	4823.0	4562.0	4237.8	3332.8	3577.3	10025.1	32702.8	8140.8	24080.5	7087.9	3601.8	2411.1

Variance Data

	October	November	December	January	February	March	April	May	June	July	August	September
MOD55 Baseline												
1-day min	744.5	724.5	631.4	622.2	596.7	1694.8	3109.7	2282.3	1971.0	1122.0	697.5	890.9
- 1 S.D.	1663.6	1592.4	1169.8	1128.9	1070.1	2192.9	-1133.1	-401.4	566.7	-664.2	950.6	-188.5
Mean	2804.8	2624.1	2334.7	1904.2	1887.2	5662.0	22434.3	10432.1	7165.3	7302.0	2629.9	3105.2
+ 1 S.D.	3946.0	3655.9	3499.5	2679.6	2704.3	9131.0	46001.8	21265.7	13763.9	15268.1	4309.2	6398.9
1-day max	4289.8	4090.8	4337.5	3322.6	3577.3	12763.2	87108.4	36064.2	23628.0	25140.2	6135.9	12670.2
CV[1]	40.7	39.3	49.9	40.7	43.3	61.3	105.1	103.8	92.1	109.1	63.9	106.1
480MOD55												
1-day min	1228.0	1199.9	997.7	638.9	597.6	1694.8	3109.7	2297.1	2425.4	1554.6	1172.0	1361.1
- 1 S.D.	2036.2	2005.2	1488.0	1142.7	1071.0	2192.9	-1133.1	-296.0	1061.5	-207.5	1415.9	280.0
Mean	3220.4	3012.7	2625.5	1914.8	1890.2	5662.0	22434.3	10564.1	7648.5	7764.3	3091.3	3571.7
+ 1 S.D.	4404.6	4020.1	3763.1	2686.9	2709.4	9131.0	46001.8	21424.2	14235.5	15736.0	4766.6	6863.4
1-day max	4823.0	4562.0	4690.3	3332.8	3577.3	12763.2	87108.4	36205.7	24080.5	25600.4	6606.6	13146.3
CV[1]	36.8	33.4	43.3	40.3	43.3	61.3	105.1	102.8	86.1	102.7	54.2	92.2

[1]CV=coefficient of variation (=SD*100/mean)

APPENDIX I-15B

PREDICTED IHA STATISTICS, MOD55 VS. 480MOD55 AT GRAND FORKS (GAGE 05082500) - MAGNITUDE (CFS), FREQUENCY (PER YEAR), AND DURATION (DAYS) OF EXTREME EVENTS

Final Aquatic Impact Analysis Report

Year	1-day min	3-day min	7-day min	30-day min	90-day min	1-day max	3-day max	7-day max	30-day max	90-day max	Zero days	Base flow	Date min	Date max	Low pulse #	Low pulse duration	High pulse #	High pulse duration	Rise rate	Fall rate	Reversals
MOD55 Baseline																					
2005	509.4	539.9	550.5	678.8	988.4	34057.8	33281.5	29703.3	13833.8	6498.9	0.0	0.2	254.0	98.0	3.0	30.7	1.0	8.0	272.8	-228.2	74.0
2006	1344.9	1382.5	1480.3	1858.3	2094.9	54617.6	53846.0	51208.4	34395.0	22012.6	0.0	0.2	275.0	92.0	2.0	6.5	3.0	16.3	895.9	-585.5	49.0
2007	1046.4	1158.8	1232.7	1327.4	1351.0	42350.1	41873.0	40772.2	28331.4	18529.3	0.0	0.2	16.0	196.0	2.0	61.0	2.0	21.0	626.9	-366.5	64.0
2008	641.8	644.2	647.4	890.9	1163.3	28693.6	28619.5	25538.0	13129.5	6465.4	0.0	0.2	274.0	95.0	3.0	33.0	1.0	8.0	265.6	-132.1	71.0
2009	509.5	539.9	550.5	678.8	705.5	34057.8	33281.5	29703.3	13834.1	6499.1	0.0	0.2	254.0	98.0	3.0	30.7	1.0	8.0	274.7	-226.7	76.0
2010	486.2	506.3	538.7	585.9	608.4	9312.5	9178.0	8542.6	5637.0	3516.9	0.0	0.3	282.0	74.0	4.0	16.5	0.0	0.0	204.2	-125.3	88.0
2011	634.3	648.3	718.1	787.3	829.6	13200.5	13018.8	12149.9	7910.6	4907.3	0.0	0.3	309.0	74.0	6.0	6.3	0.0	0.0	280.2	-183.0	86.0
2012	2157.3	2114.4	1873.4	2517.2	2835.1	189409.5	171619.9	163855.8	96526.8	45887.3	0.0	0.1	282.0	108.0	0.0	0.0	2.0	41.5	1724.9	-1094.1	65.0
2013	1417.5	1420.4	1444.1	1607.9	1773.5	15338.4	14902.2	13520.5	10508.1	6368.4	0.0	0.4	56.0	97.0	10.0	8.3	0.0	0.0	454.2	-273.8	69.0
2014	1362.5	1373.0	1388.2	1620.0	1917.6	54379.1	52782.6	47794.4	31249.1	18416.9	0.0	0.2	266.0	113.0	8.0	8.5	2.0	17.5	608.0	-400.4	86.0
2015	1298.5	1455.1	1669.6	1956.5	2448.7	65161.7	64717.6	61796.5	36533.9	22572.3	0.0	0.2	274.0	94.0	1.0	6.0	2.0	19.5	991.5	-579.5	74.0
480MOD55																					
2005	1006.7	1014.2	1021.4	1138.0	1460.8	34057.8	33281.5	29703.3	13833.8	6670.6	0.0	0.3	226.0	98.0	3.0	27.7	1.0	8.0	267.7	-231.8	76.0
2006	1771.9	1775.0	1786.9	1858.4	2344.3	54617.6	53846.0	51208.4	34395.0	22171.9	0.0	0.2	41.0	92.0	2.0	6.5	3.0	16.3	910.4	-587.2	47.0
2007	1051.7	1163.2	1236.4	1338.6	1413.3	42798.6	42321.8	41241.5	28333.3	18841.4	0.0	0.2	16.0	196.0	1.0	116.0	2.0	21.0	656.1	-356.8	60.0
2008	1117.7	1121.0	1123.0	1361.1	1622.1	28693.6	28619.5	25538.0	13129.5	6502.7	0.0	0.3	270.0	95.0	2.0	38.5	1.0	8.0	265.2	-132.5	75.0
2009	1006.7	1014.2	1021.4	1138.0	1157.9	34057.8	33281.5	29703.3	13834.1	6670.8	0.0	0.3	226.0	98.0	3.0	26.0	1.0	8.0	284.6	-222.7	72.0
2010	534.3	537.6	538.8	586.2	715.0	9312.5	9178.0	8542.6	5637.0	3538.9	0.0	0.2	32.0	74.0	5.0	11.4	0.0	0.0	219.0	-123.7	86.0
2011	743.3	748.1	754.5	813.3	933.9	13200.5	13018.8	12149.9	7910.6	4956.5	0.0	0.3	31.0	74.0	4.0	3.5	0.0	0.0	300.6	-178.5	80.0
2012	2186.2	2208.6	2244.4	2517.2	2837.2	189409.5	171619.9	163855.8	96527.1	46123.1	0.0	0.2	282.0	108.0	0.0	0.0	2.0	42.0	1728.6	-1084.6	65.0
2013	1417.5	1420.4	1444.1	1607.9	1872.3	15338.4	14902.2	13520.5	10508.1	6429.1	0.0	0.3	56.0	97.0	2.0	29.0	0.0	0.0	468.2	-269.3	67.0
2014	1423.9	1500.9	1644.3	1776.5	1981.7	54379.1	52782.6	47794.4	31249.1	18576.2	0.0	0.2	64.0	113.0	6.0	7.0	2.0	18.0	626.7	-398.9	82.0
2015	1751.7	1911.5	2130.5	2411.1	3601.5	65161.7	64717.6	61796.5	36533.9	22756.2	0.0	0.2	274.0	94.0	1.0	1.0	2.0	19.5	1047.6	-563.1	76.0

Variance Data

	1-day min	3-day min	7-day min	30-day min	90-day min	1-day max	3-day max	7-day max	30-day max	90-day max	Zero days	Base flow	Date min	Date max	Low pulse #	Low pulse duration	High pulse #	High pulse duration	Rise rate	Fall rate	Reversals
MOD55 Baseline																					
1-day min	486.2	506.3	538.7	585.9	608.4	9312.5	9178.0	8542.6	5637.0	3516.9	0.0	0.1	16.0	74.0	0.0	0.0	0.0	0.0	204.2	-1094.1	49.0
- 1 S.D.	503.5	542.2	593.8	676.3	774.4	-785.7	1977.3	799.1	788.8	2012.0	0.0	0.2	169.2	94.3	0.8	0.7	0.3	0.3	140.3	-667.0	61.4
Mean	1037.1	1071.2	1099.4	1319.0	1519.6	49143.5	47011.0	44053.2	26535.4	14697.7	0.0	0.2	231.1	103.6	3.8	18.9	1.3	12.7	599.9	-381.4	72.9
+ 1 S.D.	1570.7	1600.1	1605.0	1961.7	2264.9	99072.7	92044.7	87307.3	52282.0	27383.4	0.0	0.3	293.0	112.8	6.9	37.1	2.3	25.1	1059.5	-95.8	84.4
1-day max	2157.3	2114.4	1873.4	2517.2	2835.1	189409.5	171619.9	163855.8	96526.8	45887.3	0.0	0.4	309.0	196.0	10.0	61.0	3.0	41.5	1724.9	-125.3	88.0
CV[1]	51.5	49.4	46.0	48.7	49.0	101.6	95.8	98.2	97.0	86.3		33.3	26.8	9.0	79.3	96.4	79.5	97.4	76.6	-74.9	15.7
480MOD55																					
1-day min	534.3	537.6	538.8	586.2	715.0	9312.5	9178.0	8542.6	5637.0	3538.9	0.0	0.2	16.0	74.0	0.0	0.0	0.0	0.0	219.0	-1084.6	47.0
- 1 S.D.	784.2	802.6	812.1	896.3	958.9	-739.0	2023.0	845.1	788.9	2095.5	0.0	0.2	70.0	94.3	0.8	-8.9	0.3	0.3	152.7	-660.1	60.3
Mean	1273.8	1310.4	1358.7	1504.2	1812.7	49184.3	47051.8	44095.8	26535.6	14839.7	0.0	0.3	104.7	103.6	2.6	24.2	1.3	12.8	615.9	-377.2	71.5
+ 1 S.D.	1763.4	1818.2	1905.3	2112.1	2666.5	99107.5	92080.6	87346.6	52282.3	27584.0	0.0	0.3	139.5	112.8	4.4	57.4	2.3	25.3	1079.1	-94.3	82.6
1-day max	2186.2	2208.6	2244.4	2517.2	3601.5	189409.5	171619.9	163855.8	96527.1	46123.1	0.0	0.3	282.0	196.0	6.0	116.0	3.0	42.0	1728.6	-123.7	86.0
CV[1]	38.4	38.8	40.2	40.4	47.1	101.5	95.7	98.1	97.0	85.9		28.0	33.2	9.0	68.2	136.9	79.5	97.7	75.2	-75.0	15.6

[1]CV=coefficient of variation (=SD*100/mean)

APPENDIX I-16A

PREDICTED IHA STATISTICS, MOD55 VS. 480MOD55 AT EMERSON (GAGE 05092000) - MONTHLY AVERAGE FLOW (CFS)

Final Aquatic Impact Analysis Report

Year	October	November	December	January	February	March	April	May	June	July	August	September
MOD55 Baseline												
2005	2705.1	3183.9	2507.1	2253.2	2269.3	2479.7	16696.6	3740.3	2630.7	1464.5	769.7	1540.9
2006	3816.7	4151.2	5296.6	2502.6	2358.0	8098.1	48576.7	24251.4	16189.8	10533.1	7283.2	14290.7
2007	3495.6	2410.9	1459.5	1414.9	1403.7	1615.0	12944.7	26820.1	6438.6	28881.0	5388.0	2531.5
2008	2863.4	3358.3	2299.9	2138.9	2073.6	3481.9	19872.5	4705.7	2729.5	1885.3	1441.1	1018.0
2009	2628.8	3180.9	2507.1	2253.2	2269.3	2479.7	16696.8	3740.5	2630.7	1464.6	769.7	1541.0
2010	868.0	1116.6	769.7	688.9	649.4	7290.7	10594.3	4871.3	2694.8	3658.0	1546.2	3034.9
2011	1360.0	1494.3	1024.3	925.2	904.2	10296.2	14712.3	6773.8	3826.9	5143.9	2167.3	4240.6
2012	2963.4	3879.1	3575.3	2992.4	2927.1	3388.4	83131.4	76185.4	17483.0	28624.0	6212.2	4398.9
2013	4623.0	3098.5	2253.3	1800.4	1668.6	9461.8	12110.0	3823.3	5149.5	7501.1	2895.0	3553.0
2014	3598.7	3268.2	2349.4	2013.1	1856.1	3740.3	26594.4	37835.9	13962.8	4537.7	3057.1	1785.5
2015	3934.3	4572.1	3913.0	3378.3	3297.1	6203.7	40536.4	9397.7	23766.1	9900.1	3529.6	2087.5
480MOD55												
2005	2705.1	3183.9	2507.1	2253.2	2269.3	2479.7	16696.6	3791.7	3103.0	1877.4	1243.5	2054.4
2006	4352.9	4611.9	5712.5	2526.1	2350.3	8098.1	48576.7	24330.9	16687.6	11006.6	7748.6	14778.3
2007	3922.8	2867.6	1881.0	1465.6	1403.9	1615.0	12944.7	26928.1	6870.2	29273.0	5914.8	2992.8
2008	3366.4	3845.0	2711.1	2176.4	2076.1	3481.9	19872.5	4779.2	3161.8	2333.7	1893.8	1474.9
2009	3196.2	3669.1	2919.4	2287.7	2269.4	2479.7	16696.8	3792.0	3103.0	1877.5	1243.5	2054.4
2010	1352.9	1582.6	1196.9	747.2	647.5	7290.7	10594.3	4872.2	3139.0	4175.4	2030.6	3519.9
2011	1833.4	1973.9	1448.4	975.1	904.4	10296.2	14712.3	6789.4	4337.2	5611.2	2634.7	4671.6
2012	3006.4	3879.4	3575.3	2992.4	2939.3	3388.4	83131.4	76201.0	18028.3	29111.3	6678.8	4860.3
2013	5167.9	3564.6	2652.9	1837.9	1668.7	9461.8	12110.0	3885.4	5608.3	7989.9	3331.3	4047.4
2014	4102.0	3742.8	2759.7	2044.2	1854.0	3740.3	26594.4	37896.9	14461.7	4981.2	3526.5	2221.4
2015	4473.1	5048.1	4321.3	3405.7	3297.2	6203.7	40536.4	9507.0	24091.0	10468.6	3980.0	2538.7

Variance Data

	October	November	December	January	February	March	April	May	June	July	August	September
MOD55 Baseline												
1-day min	868.0	1116.6	769.7	688.9	649.4	1615.0	10594.3	3740.3	2630.7	1464.5	769.7	1018.0
- 1 S.D.	1879.9	2018.0	1224.8	1224.8	1175.5	2259.3	5362.1	-4097.8	1284.5	-639.0	963.2	-69.9
Mean	2987.0	3064.9	2541.4	2032.8	1970.6	5321.4	27496.9	18376.9	8863.9	9417.6	3187.2	3638.4
+ 1 S.D.	4094.1	4111.9	3857.9	2840.9	2765.7	8383.5	49631.7	40851.5	16443.3	19474.1	5411.2	7346.7
1-day max	4623.0	4572.1	5296.6	3378.3	3297.1	10296.2	83131.4	76185.4	23766.1	28881.0	7283.2	14290.7
CV[1]	37.1	34.2	51.8	39.7	40.3	57.5	80.5	122.3	85.5	106.8	69.8	101.9
480MOD55												
1-day min	1352.9	1582.6	1196.9	747.2	647.5	1615.0	10594.3	3791.7	3103.0	1877.4	1243.5	1474.9
- 1 S.D.	2255.0	2428.6	1588.2	1270.7	1174.4	2259.3	5362.1	-4035.7	1758.3	-172.1	1428.8	399.3
Mean	3407.2	3451.7	2880.5	2064.7	1970.9	5321.4	27496.9	18434.0	9326.5	9882.3	3656.9	4110.4
+ 1 S.D.	4559.4	4474.8	4172.8	2858.6	2767.5	8383.5	49631.7	40903.6	16894.6	19936.7	5885.1	7821.4
1-day max	5167.9	5048.1	5712.5	3405.7	3297.2	10296.2	83131.4	76201.0	24091.0	29273.0	7748.6	14778.3
CV[1]	33.8	29.6	44.9	38.5	40.4	57.5	80.5	121.9	81.1	101.7	60.9	90.3

[1]CV=coefficient of variation (=SD*100/mean)

APPENDIX I-16B

PREDICTED IHA STATISTICS, MOD55 VS. 480MOD55 AT EMERSON (GAGE 05092000) - MAGNITUDE (CFS), FREQUENCY (PER YEAR), AND DURATION (DAYS) OF EXTREME EVENTS

Final Aquatic Impact Analysis Report

Year	1-day min	3-day min	7-day min	30-day min	90-day min	1-day max	3-day max	7-day max	30-day max	90-day max	Zero days	Base flow	Date min	Date max	Low pulse #	Low pulse duration	High pulse #	High pulse duration	Rise rate	Fall rate	Reversals
MOD55 Baseline																					
2005	630.6	632.2	636.7	764.1	1166.2	29856.8	29613.4	28968.2	16740.1	7712.4	0.0	0.2	229.0	105.0	3.0	28.7	1.0	10.0	238.0	-172.6	40.0
2006	1063.9	1085.1	1218.0	2275.4	2547.5	61435.0	61186.8	59894.3	48576.7	30455.0	0.0	0.1	276.0	103.0	1.0	0.0	3.0	19.3	721.8	-575.6	32.0
2007	1268.5	1274.6	1300.5	1370.2	1413.5	41285.2	41197.9	40722.8	33339.0	20707.8	0.0	0.2	22.0	129.0	1.0	123.0	2.0	26.5	453.5	-390.8	38.0
2008	699.4	716.9	766.3	1018.0	1432.5	34209.4	34153.5	32943.5	19996.4	9401.8	0.0	0.2	274.0	100.0	3.0	34.0	1.0	12.0	327.0	-150.7	31.0
2009	630.6	632.2	636.7	764.1	925.1	29856.8	29613.4	28968.3	16740.4	7712.6	0.0	0.2	229.0	105.0	3.0	28.7	1.0	10.0	233.7	-174.9	42.0
2010	589.2	595.6	607.2	642.1	686.8	16143.2	16050.9	15394.3	12162.7	7828.9	0.0	0.2	46.0	96.0	3.0	14.3	0.0	0.0	225.5	-141.2	52.0
2011	842.8	850.5	863.2	888.4	934.5	22361.5	22258.8	21393.0	17007.1	10928.1	0.0	0.2	46.0	96.0	5.0	35.4	1.0	3.0	318.8	-203.0	58.0
2012	2632.8	2361.1	1938.3	2807.0	3085.7	227449.0	223507.0	208079.2	123896.3	61230.4	0.0	0.1	287.0	116.0	0.0	0.0	2.0	43.0	1806.4	-1158.7	32.0
2013	1486.1	1490.6	1512.9	1639.9	1870.2	22404.6	22130.0	20535.2	14496.3	8641.6	0.0	0.3	62.0	101.0	4.0	22.5	1.0	2.0	454.9	-222.4	33.0
2014	1478.2	1494.2	1506.0	1712.3	1973.9	59611.9	58881.1	56075.0	44304.0	26669.1	0.0	0.2	271.0	118.0	3.0	31.0	1.0	51.0	645.6	-316.9	43.0
2015	1453.7	1507.6	1772.6	2087.5	2624.4	51916.5	51552.6	50836.0	40536.4	24490.7	0.0	0.2	275.0	106.0	2.0	7.0	2.0	25.5	700.6	-390.3	27.0
480MOD55																					
2005	1087.1	1087.9	1092.4	1223.4	1635.7	29856.8	29613.4	28968.2	16740.1	7873.6	0.0	0.3	227.0	105.0	3.0	25.0	1.0	10.0	239.9	-171.8	39.0
2006	1511.2	1534.0	1678.7	2276.3	2875.1	61435.0	61186.8	59894.3	48576.7	30612.1	0.0	0.1	276.0	103.0	1.0	0.0	3.0	19.3	725.4	-577.9	30.0
2007	1275.6	1281.8	1308.2	1373.0	1470.1	41285.2	41197.9	40722.8	33343.7	20995.3	0.0	0.2	22.0	129.0	1.0	116.0	2.0	27.0	482.4	-371.7	32.0
2008	1152.7	1165.4	1208.5	1474.9	1884.1	34209.4	34153.5	32943.5	19996.4	9502.8	0.0	0.3	274.0	100.0	3.0	28.0	1.0	12.0	322.5	-151.2	27.0
2009	1087.2	1087.9	1092.4	1223.5	1390.2	29856.8	29613.4	28968.3	16740.4	7873.8	0.0	0.3	227.0	105.0	2.0	35.5	1.0	10.0	249.7	-169.2	37.0
2010	589.3	595.7	607.4	642.8	816.4	16143.2	16050.9	15394.3	12162.7	7838.6	0.0	0.2	46.0	96.0	4.0	38.5	0.0	0.0	251.6	-135.0	50.0
2011	842.9	851.0	863.2	889.0	1060.7	22361.5	22258.8	21393.0	17007.1	10962.9	0.0	0.2	46.0	96.0	3.0	48.7	1.0	3.0	345.2	-197.4	52.0
2012	2664.2	2669.5	2416.6	2807.0	3086.1	227449.0	223507.0	208079.2	123896.7	61460.9	0.0	0.1	287.0	116.0	0.0	0.0	2.0	43.5	1781.8	-1157.5	34.0
2013	1486.1	1490.6	1512.9	1640.0	1990.3	22404.6	22130.0	20535.2	14496.3	8681.2	0.0	0.3	62.0	101.0	3.0	23.0	1.0	2.0	451.8	-223.8	33.0
2014	1816.7	1820.8	1830.5	1853.3	2040.0	59611.9	58881.1	56075.0	44305.5	26827.2	0.0	0.2	34.0	118.0	2.0	33.0	1.0	51.0	658.1	-317.7	41.0
2015	1886.4	1960.1	2293.4	2538.7	3687.3	51916.5	51552.6	50836.0	40536.4	24646.1	0.0	0.2	275.0	106.0	1.0	0.0	2.0	25.5	717.0	-385.3	25.0

Variance Data

	1-day min	3-day min	7-day min	30-day min	90-day min	1-day max	3-day max	7-day max	30-day max	90-day max	Zero days	Base flow	Date min	Date max	Low pulse #	Low pulse duration	High pulse #	High pulse duration	Rise rate	Fall rate	Reversals
MOD55 Baseline																					
1-day min	589.2	595.6	607.2	642.1	686.8	16143.2	16050.9	15394.3	12162.7	7712.4	0.0	0.1	22.0	96.0	0.0	0.0	0.0	0.0	225.5	-1158.7	27.0
- 1 S.D.	554.6	604.2	675.6	735.1	905.9	-5206.2	-4679.9	-2830.6	3061.3	3348.1	0.0	0.1	127.1	103.9	1.1	-4.2	0.6	1.6	102.6	-653.0	29.4
Mean	1161.4	1149.1	1159.9	1451.7	1696.4	54230.0	53649.6	51255.4	35254.1	19616.2	0.0	0.2	183.4	106.8	2.6	29.5	1.4	18.4	556.9	-354.3	38.9
+ 1 S.D.	1768.3	1694.1	1644.1	2168.4	2486.9	113666.2	111979.0	105341.4	67446.9	35884.3	0.0	0.2	239.7	109.8	4.0	63.2	2.2	35.2	1011.2	-55.6	48.4
1-day max	2632.8	2361.1	1938.3	2807.0	3085.7	227449.0	223507.0	208079.2	123896.3	61230.4	0.0	0.3	287.0	129.0	5.0	123.0	3.0	51.0	1806.4	-141.2	58.0
CV[1]	52.3	47.4	41.8	49.4	46.6	109.6	108.7	105.5	91.3	82.9		33.3	30.7	2.8	56.5	114.0	59.6	91.2	81.6	-84.3	24.4
480MOD55																					
1-day min	589.3	595.7	607.4	642.8	816.4	16143.2	16050.9	15394.3	12162.7	7838.6	0.0	0.1	22.0	96.0	0.0	0.0	0.0	0.0	239.9	-1157.5	25.0
- 1 S.D.	828.3	835.4	877.1	951.2	1106.7	-5206.2	-4679.9	-2830.6	3061.8	3436.3	0.0	0.2	60.2	103.9	0.9	-1.0	0.6	1.6	122.3	-650.1	27.7
Mean	1399.9	1413.2	1445.8	1631.1	1994.2	54230.0	53649.6	51255.4	35254.7	19752.2	0.0	0.2	94.9	106.8	2.1	31.6	1.4	18.5	566.0	-350.8	36.4
+ 1 S.D.	1971.6	1991.0	2014.6	2311.0	2881.6	113666.2	111979.0	105341.4	67447.7	36068.2	0.0	0.3	129.6	109.8	3.3	64.2	2.2	35.4	1009.6	-51.4	45.0
1-day max	2664.2	2669.5	2416.6	2807.0	3687.3	227449.0	223507.0	208079.2	123896.7	61460.9	0.0	0.3	287.0	129.0	4.0	116.0	3.0	51.0	1781.8	-135.0	52.0
CV[1]	40.8	40.9	39.3	41.7	44.5	109.6	108.7	105.5	91.3	82.6		27.3	36.5	2.8	58.4	103.0	59.6	91.3	78.4	-85.3	23.9

[1]CV=coefficient of variation (=SD*100/mean)

APPENDIX I-17A

PREDICTED IHA STATISTICS, WET VS. WETOF AT HWY 30 (CALIBRATED FROM WARWICK GAGE) - MONTHLY AVERAGE FLOW (CFS)

Final Aquatic Impact Analysis Report

Year	October	November	December	January	February	March	April	May	June	July	August	September
WET Baseline												
2015	2.0	3.4	4.1	3.3	3.3	64.6	141.2	39.2	17.0	231.4	327.0	30.1
2016	10.8	11.6	12.0	9.2	8.6	275.4	143.0	62.0	126.9	39.9	8.8	10.0
2017	39.4	51.4	34.0	18.4	13.1	537.2	370.3	218.8	71.4	69.4	42.2	10.3
2018	12.1	10.0	8.0	7.8	6.8	111.6	898.2	233.9	80.7	44.1	26.6	11.3
2019	13.7	11.4	8.0	7.0	6.3	28.0	1382.1	319.8	48.5	81.2	27.8	15.1
2020	16.7	13.5	11.0	8.2	46.1	330.8	243.0	55.3	35.2	16.8	5.9	6.6
2021	9.1	11.5	15.5	8.7	9.6	158.9	852.7	400.1	148.0	141.1	152.4	97.6
2022	33.1	39.8	16.2	10.5	123.5	128.3	56.2	42.4	105.1	32.2	16.2	22.6
2023	20.3	16.9	12.6	5.5	4.0	119.3	469.7	104.3	71.9	123.6	33.5	9.5
2024	57.4	27.1	23.8	21.3	44.0	619.8	230.1	81.0	34.3	17.1	5.2	8.2
2025	21.7	15.6	6.4	4.3	18.7	192.7	207.3	148.4	35.3	4.3	2.9	2.5
WETOF												
2015	2.0	3.4	4.1	3.3	3.3	64.6	141.2	39.2	17.0	231.4	327.0	30.1
2016	10.8	11.6	12.0	9.2	8.6	275.4	143.0	62.0	126.9	39.9	8.8	10.0
2017	39.4	51.4	34.0	18.4	13.1	537.2	370.3	218.8	71.4	69.4	42.2	10.3
2018	12.1	10.0	8.0	7.8	6.8	111.6	898.2	233.9	80.7	44.1	26.6	11.3
2019	13.7	11.4	8.0	7.0	6.3	28.0	1382.1	319.8	48.5	81.2	27.8	15.1
2020	16.7	13.5	11.0	8.2	60.5	330.8	243.0	55.3	35.2	16.8	5.9	6.6
2021	9.1	11.5	15.5	8.7	9.6	158.9	852.7	400.1	148.0	141.1	152.4	97.6
2022	33.1	39.8	16.2	10.5	119.3	128.3	56.2	42.4	105.1	32.2	16.2	22.6
2023	20.3	16.9	12.6	5.5	4.0	119.3	469.7	104.3	71.9	123.6	33.5	9.5
2024	57.4	27.1	23.8	21.3	46.2	619.8	230.1	81.0	34.3	17.1	5.2	8.2
2025	21.7	15.6	6.4	4.3	18.7	192.7	207.3	148.4	35.3	4.3	2.9	2.5

Variance Data

	October	November	December	January	February	March	April	May	June	July	August	September
WET Baseline												
1-day min	2.0	3.4	4.1	3.3	3.3	28.0	56.2	39.2	17.0	4.3	2.9	2.5
- 1 S.D.	5.5	4.8	5.1	3.9	-9.9	41.0	37.6	32.4	28.4	4.3	-39.4	-6.4
Mean	21.5	19.3	13.8	9.5	25.8	233.3	454.0	155.0	70.4	72.8	59.0	20.3
+ 1 S.D.	37.5	33.7	22.4	15.0	61.6	425.6	870.3	277.6	112.4	141.4	157.3	47.1
1-day max	57.4	51.4	34.0	21.3	123.5	619.8	1382.1	400.1	148.0	231.4	327.0	97.6
CV[1]	74.6	75.0	62.6	58.9	138.5	82.4	91.7	79.1	59.7	94.1	166.8	131.6
WETOF												
1-day min	2.0	3.4	4.1	3.3	3.3	28.0	56.2	39.2	17.0	4.3	2.9	2.5
- 1 S.D.	5.5	4.8	5.1	3.9	-8.9	41.0	37.6	32.4	28.4	4.3	-39.4	-6.4
Mean	21.5	19.3	13.8	9.5	26.9	233.3	454.0	155.0	70.4	72.8	59.0	20.3
+ 1 S.D.	37.5	33.7	22.4	15.0	62.8	425.6	870.3	277.6	112.4	141.4	157.3	47.1
1-day max	57.4	51.4	34.0	21.3	119.3	619.8	1382.1	400.1	148.0	231.4	327.0	97.6
CV[1]	74.6	75.0	62.6	58.9	133.0	82.4	91.7	79.1	59.7	94.1	166.8	131.6

[1]CV=coefficient of variation (=SD*100/mean)

APPENDIX I-17B

PREDICTED IHA STATISTICS, WET VS. WETOF AT HWY 30 (CALIBRATED FROM WARWICK GAGE) - MAGNITUDE (CFS), FREQUENCY (PER YEAR), AND DURATION (DAYS) OF EXTREME EVENTS

Final Aquatic Impact Analysis Report

Year	1-day min	3-day min	7-day min	30-day min	90-day min	1-day max	3-day max	7-day max	30-day max	90-day max	Zero days	Base flow	Date min	Date max	Low pulse #	Low pulse duration	High pulse #	High pulse duration	Rise rate	Fall rate	Reversals
WET Baseline																					
2015	1.5	1.5	1.6	2.0	3.2	1117.5	1091.8	988.8	507.8	202.7	0.0	0.0	280.0	214.0	2.0	88.0	2.0	11.5	17.8	-12.0	67.0
2016	5.9	6.0	6.3	7.3	9.5	871.1	848.0	780.0	386.6	173.7	0.0	0.1	237.0	86.0	7.0	11.4	1.0	13.0	14.4	-9.2	72.0
2017	7.9	7.8	7.9	9.4	10.1	1464.0	1425.5	1315.5	798.4	394.6	0.0	0.1	274.0	81.0	2.0	4.5	1.0	28.0	23.9	-10.6	49.0
2018	4.2	4.5	5.4	6.8	7.1	2811.9	2686.1	2322.4	938.8	434.8	0.0	0.1	71.0	106.0	6.0	18.2	2.0	12.5	41.6	-19.7	45.0
2019	5.5	5.8	6.0	6.3	6.8	3011.7	2811.5	2479.3	1391.3	592.3	0.0	0.0	32.0	112.0	6.0	21.2	1.0	41.0	48.3	-32.5	83.0
2020	3.3	3.5	3.7	5.1	7.0	1086.7	1030.2	870.1	414.5	221.9	0.0	0.1	218.0	90.0	4.0	22.8	2.0	9.0	13.3	-10.0	75.0
2021	7.5	7.7	8.0	8.4	10.2	2388.0	2131.3	1794.0	956.3	509.0	0.0	0.1	284.0	92.0	9.0	5.0	2.0	22.5	39.6	-24.2	67.0
2022	6.9	7.4	7.8	8.9	15.2	441.4	418.6	368.3	202.2	108.8	0.0	0.2	45.0	55.0	2.0	8.0	1.0	5.0	12.3	-6.0	69.0
2023	3.0	3.0	3.0	3.6	5.8	1063.6	1035.4	950.1	540.9	246.7	0.0	0.0	38.0	95.0	3.0	32.0	1.0	21.0	19.7	-10.3	49.0
2024	1.4	1.4	1.7	5.0	8.7	1125.2	1117.5	1101.0	668.3	318.2	0.0	0.0	228.0	72.0	5.0	11.2	2.0	15.0	15.9	-9.1	70.0
2025	1.4	1.5	1.5	2.0	2.4	782.7	749.1	697.3	333.3	185.9	0.0	0.0	244.0	88.0	5.0	33.4	1.0	10.0	11.9	-6.9	86.0
WETOF																					
2015	1.5	1.5	1.6	2.0	3.2	1117.5	1091.8	988.8	507.8	202.7	0.0	0.0	280.0	214.0	3.0	8.3	2.0	11.5	17.8	-12.0	67.0
2016	5.9	6.0	6.3	7.3	9.4	871.1	848.0	780.0	386.6	173.7	0.0	0.1	237.0	86.0	7.0	11.4	1.0	13.0	14.4	-9.1	72.0
2017	7.9	7.8	7.9	9.4	10.1	1464.0	1425.5	1315.5	798.4	394.6	0.0	0.1	274.0	81.0	2.0	4.5	1.0	28.0	23.9	-10.6	49.0
2018	4.2	4.5	5.4	6.8	7.1	2811.9	2686.1	2322.4	938.8	434.8	0.0	0.1	71.0	106.0	6.0	18.0	2.0	12.5	41.6	-19.9	45.0
2019	5.5	5.8	6.0	6.3	6.8	3011.7	2811.5	2479.3	1391.3	592.3	0.0	0.0	32.0	112.0	6.0	21.2	1.0	41.0	48.3	-32.5	83.0
2020	3.3	3.5	3.7	5.1	7.0	1086.7	1030.2	870.1	414.5	226.6	0.0	0.1	218.0	90.0	4.0	22.8	2.0	9.5	13.8	-10.0	75.0
2021	7.5	7.7	8.0	8.4	10.2	2388.0	2131.3	1794.0	956.3	509.0	0.0	0.1	284.0	92.0	9.0	5.0	2.0	22.5	39.6	-24.2	67.0
2022	6.9	7.4	7.8	8.9	15.2	441.4	418.6	368.3	199.1	106.5	0.0	0.2	45.0	55.0	2.0	8.0	1.0	5.0	12.3	-5.9	69.0
2023	3.0	3.0	3.0	3.6	5.8	1063.6	1035.4	950.1	540.9	246.7	0.0	0.0	38.0	95.0	3.0	32.0	1.0	21.0	19.7	-10.3	49.0
2024	1.4	1.4	1.7	5.0	8.7	1125.2	1117.5	1101.0	668.3	318.3	0.0	0.0	228.0	72.0	5.0	11.2	2.0	15.0	15.9	-9.0	70.0
2025	1.4	1.5	1.5	2.0	3.1	782.7	749.1	697.3	333.3	185.9	0.0	0.0	244.0	88.0	5.0	33.4	1.0	10.0	11.9	-6.9	86.0

Variance Data

	1-day min	3-day min	7-day min	30-day min	90-day min	1-day max	3-day max	7-day max	30-day max	90-day max	Zero days	Base flow	Date min	Date max	Low pulse #	Low pulse duration	High pulse #	High pulse duration	Rise rate	Fall rate	Reversals
WET Baseline																					
1-day min	1.4	1.4	1.5	2.0	2.4	441.4	418.6	368.3	202.2	108.8	0.0	0.0	32.0	55.0	2.0	4.5	1.0	5.0	11.9	-32.5	45.0
- 1 S.D.	1.9	2.0	2.2	3.3	4.3	605.5	600.2	565.0	301.6	153.2	0.0	0.0	125.9	88.1	2.3	-0.4	0.9	6.8	10.3	-22.0	53.0
Mean	4.4	4.6	4.8	5.9	7.8	1469.4	1395.0	1242.4	648.9	308.1	0.0	0.1	177.4	99.2	4.6	23.2	1.5	17.1	23.5	-13.7	66.6
+ 1 S.D.	6.9	7.1	7.4	8.5	11.4	2333.4	2189.9	1919.9	996.3	462.9	0.0	0.1	228.8	110.3	6.9	46.9	2.0	27.5	36.7	-5.4	80.1
1-day max	7.9	7.8	8.0	9.4	15.2	3011.7	2811.5	2479.3	1391.3	592.3	0.0	0.2	284.0	214.0	9.0	88.0	2.0	41.0	48.3	-6.0	86.0
CV[1]	56.0	55.6	54.4	44.2	45.5	58.8	57.0	54.5	53.5	50.3		66.7	29.0	11.2	49.4	101.9	36.6	60.3	56.3	-60.5	20.4
WETOF																					
1-day min	1.4	1.4	1.5	2.0	3.1	441.4	418.6	368.3	199.1	106.5	0.0	0.0	32.0	55.0	2.0	4.5	1.0	5.0	11.9	-32.5	45.0
- 1 S.D.	1.9	2.0	2.2	3.3	4.4	605.5	600.2	565.0	300.9	153.4	0.0	0.0	125.9	88.1	2.5	5.7	0.9	6.9	10.4	-22.0	53.0
Mean	4.4	4.6	4.8	5.9	7.9	1469.4	1395.0	1242.4	648.7	308.3	0.0	0.1	177.4	99.2	4.7	16.0	1.5	17.2	23.6	-13.7	66.6
+ 1 S.D.	6.9	7.1	7.4	8.5	11.3	2333.4	2189.9	1919.9	996.5	463.2	0.0	0.1	228.8	110.3	6.9	26.3	2.0	27.5	36.8	-5.4	80.1
1-day max	7.9	7.8	8.0	9.4	15.2	3011.7	2811.5	2479.3	1391.3	592.3	0.0	0.2	284.0	214.0	9.0	33.4	2.0	41.0	48.3	-5.9	86.0
CV[1]	56.0	55.6	54.4	44.2	43.9	58.8	57.0	54.5	53.6	50.2		66.7	29.0	11.2	46.3	64.3	36.6	60.0	56.1	-60.7	20.4

[1]CV=coefficient of variation (=SD*100/mean)

APPENDIX I-18A

PREDICTED IHA STATISTICS, WET VS. WETOF AT COOPERSTOWN (GAGE 05057000) - MONTHLY AVERAGE FLOW (CFS)

Final Aquatic Impact Analysis Report

Year	October	November	December	January	February	March	April	May	June	July	August	September
WET Baseline												
2015	36.4	20.2	12.8	10.0	10.3	41.0	445.0	127.9	76.8	615.0	1062.5	229.2
2016	79.9	50.8	42.1	32.5	32.1	458.8	666.0	181.4	324.6	318.4	108.5	320.0
2017	378.6	251.5	120.1	69.2	64.3	1342.1	1269.0	534.7	232.8	203.7	124.8	52.5
2018	68.9	70.1	33.5	34.4	33.4	130.3	2591.4	622.5	260.3	204.2	114.7	36.7
2019	69.2	47.7	37.9	31.7	26.9	40.9	2559.3	1215.6	209.2	211.6	107.5	49.0
2020	49.6	50.1	42.7	31.7	108.9	416.8	775.4	206.9	119.5	75.4	27.4	18.6
2021	55.9	46.8	39.9	22.4	23.3	181.2	2037.4	835.6	492.1	413.5	269.6	233.9
2022	62.8	63.7	29.3	17.1	107.0	318.4	132.1	75.5	160.1	97.0	31.6	31.9
2023	41.9	33.7	22.8	10.3	5.7	94.7	946.4	217.4	169.3	212.6	68.8	22.4
2024	111.5	68.9	63.5	35.5	41.0	1104.4	532.2	174.7	161.0	117.8	117.4	89.2
2025	55.1	47.9	37.4	25.4	15.9	298.7	805.0	338.0	118.4	46.0	10.2	2.8
WETOF												
2015	37.7	20.2	12.8	10.0	10.3	41.1	445.4	128.1	76.8	640.7	1180.5	377.7
2016	209.9	150.8	146.9	157.8	175.7	632.7	825.4	387.6	608.8	651.1	361.9	473.8
2017	488.3	370.0	259.8	213.2	211.5	1537.4	1542.0	960.8	651.9	546.6	343.7	153.0
2018	114.4	103.5	72.9	85.5	95.3	217.8	2704.3	775.8	447.4	382.5	248.3	114.0
2019	114.1	79.2	86.1	96.3	101.6	122.6	2714.9	1546.7	694.1	693.8	572.1	360.4
2020	288.6	301.1	277.9	265.2	390.2	744.4	1131.8	663.8	567.2	426.9	222.1	110.0
2021	93.5	86.3	84.3	74.9	85.8	263.7	2179.7	1158.1	910.7	800.7	600.0	478.6
2022	233.2	215.9	161.0	152.9	261.9	485.2	303.7	234.8	296.9	212.0	92.0	58.0
2023	55.8	49.6	39.2	32.3	39.6	145.3	1008.1	290.7	264.9	330.6	151.9	48.5
2024	120.7	94.5	89.6	71.6	103.5	1175.6	627.7	285.3	234.4	155.1	123.8	89.2
2025	55.1	47.9	37.4	25.4	15.9	298.7	805.0	338.0	118.4	46.0	10.2	2.8

Variance Data

	October	November	December	January	February	March	April	May	June	July	August	September
WET Baseline												
1-day min	36.4	20.2	12.8	10.0	5.7	40.9	132.1	75.5	76.8	46.0	10.2	2.8
- 1 S.D.	-5.5	5.8	15.5	12.9	6.6	-30.7	304.7	55.0	94.4	61.4	-113.3	-10.2
Mean	91.8	68.3	43.8	29.1	42.6	402.5	1159.9	411.8	211.3	228.6	185.7	98.8
+ 1 S.D.	189.1	130.8	72.1	45.3	78.6	835.6	2015.2	768.7	328.2	395.9	484.8	207.7
1-day max	378.6	251.5	120.1	69.2	108.9	1342.1	2591.4	1215.6	492.1	615.0	1062.5	320.0
CV[1]	106.0	91.5	64.6	55.7	84.4	107.6	73.7	86.7	55.3	73.2	161.0	110.3
WETOF												
1-day min	37.7	20.2	12.8	10.0	10.3	41.1	303.7	128.1	76.8	46.0	10.2	2.8
- 1 S.D.	30.9	26.0	27.5	26.8	20.0	39.3	429.1	164.3	177.4	200.4	23.4	26.7
Mean	164.7	138.1	115.3	107.7	135.6	515.0	1298.9	615.4	442.9	444.2	355.1	206.0
+ 1 S.D.	298.4	250.2	203.0	188.7	251.2	990.6	2168.7	1066.5	708.3	688.0	686.9	385.3
1-day max	488.3	370.0	277.9	265.2	390.2	1537.4	2714.9	1546.7	910.7	800.7	1180.5	478.6
CV[1]	81.2	81.2	76.2	75.1	85.3	92.4	67.0	73.3	59.9	54.9	93.4	87.0

[1]CV=coefficient of variation (=SD*100/mean)

APPENDIX I-18B

PREDICTED IHA STATISTICS, WET VS. WETOF AT COOPERSTOWN (GAGE 05057000) - MAGNITUDE (CFS), FREQUENCY (PER YEAR), AND DURATION (DAYS) OF EXTREME EVENTS

Final Aquatic Impact Analysis Report

Year	1-day min	3-day min	7-day min	30-day min	90-day min	1-day max	3-day max	7-day max	30-day max	90-day max	Zero days	Base flow	Date min	Date max	Low pulse #	Low pulse duration	High pulse #	High pulse duration	Rise rate	Fall rate	Reversals
WET Baseline																					
2015	1.5	1.5	1.6	2.0	3.2	1117.5	1091.8	988.8	507.8	202.7	0.0	0.0	280.0	214.0	2.0	88.0	2.0	11.5	17.8	-12.0	67.0
2016	5.9	6.0	6.3	7.3	9.5	871.1	848.0	780.0	386.6	173.7	0.0	0.1	237.0	86.0	7.0	11.4	1.0	13.0	14.4	-9.2	72.0
2017	7.9	7.8	7.9	9.4	10.1	1464.0	1425.5	1315.5	798.4	394.6	0.0	0.1	274.0	81.0	2.0	4.5	1.0	28.0	23.9	-10.6	49.0
2018	4.2	4.5	5.4	6.8	7.1	2811.9	2686.1	2322.4	938.8	434.8	0.0	0.1	71.0	106.0	6.0	18.2	2.0	12.5	41.6	-19.7	45.0
2019	5.5	5.8	6.0	6.3	6.8	3011.7	2811.5	2479.3	1391.3	592.3	0.0	0.0	32.0	112.0	6.0	21.2	1.0	41.0	48.3	-32.5	83.0
2020	3.3	3.5	3.7	5.1	7.0	1086.7	1030.2	870.1	414.5	221.9	0.0	0.1	218.0	90.0	4.0	22.8	2.0	9.0	13.3	-10.0	75.0
2021	7.5	7.7	8.0	8.4	10.2	2388.0	2131.3	1794.0	956.3	509.0	0.0	0.1	284.0	92.0	9.0	5.0	2.0	22.5	39.6	-24.2	67.0
2022	6.9	7.4	7.8	8.9	15.2	441.4	418.6	368.3	202.2	108.8	0.0	0.2	45.0	55.0	2.0	8.0	1.0	5.0	12.3	-6.0	69.0
2023	3.0	3.0	3.0	3.6	5.8	1063.6	1035.4	950.1	540.9	246.7	0.0	0.0	38.0	95.0	3.0	32.0	1.0	21.0	19.7	-10.3	49.0
2024	1.4	1.4	1.7	5.0	8.7	1125.2	1117.5	1101.0	668.3	318.2	0.0	0.0	228.0	72.0	5.0	11.2	2.0	15.0	15.9	-9.1	70.0
2025	1.4	1.5	1.5	2.0	2.4	782.7	749.1	697.3	333.3	185.9	0.0	0.0	244.0	88.0	5.0	33.4	1.0	10.0	11.9	-6.9	86.0
WETOF																					
2015	1.5	1.5	1.6	2.0	3.2	1117.5	1091.8	988.8	507.8	202.7	0.0	0.0	280.0	214.0	3.0	8.3	2.0	11.5	17.8	-12.0	67.0
2016	5.9	6.0	6.3	7.3	9.4	871.1	848.0	780.0	386.6	173.7	0.0	0.1	237.0	86.0	7.0	11.4	1.0	13.0	14.4	-9.1	72.0
2017	7.9	7.8	7.9	9.4	10.1	1464.0	1425.5	1315.5	798.4	394.6	0.0	0.1	274.0	81.0	2.0	4.5	1.0	28.0	23.9	-10.6	49.0
2018	4.2	4.5	5.4	6.8	7.1	2811.9	2686.1	2322.4	938.8	434.8	0.0	0.1	71.0	106.0	6.0	18.0	2.0	12.5	41.6	-19.9	45.0
2019	5.5	5.8	6.0	6.3	6.8	3011.7	2811.5	2479.3	1391.3	592.3	0.0	0.0	32.0	112.0	6.0	21.2	1.0	41.0	48.3	-32.5	83.0
2020	3.3	3.5	3.7	5.1	7.0	1086.7	1030.2	870.1	414.5	226.6	0.0	0.1	218.0	90.0	4.0	22.8	2.0	9.5	13.8	-10.0	75.0
2021	7.5	7.7	8.0	8.4	10.2	2388.0	2131.3	1794.0	956.3	509.0	0.0	0.1	284.0	92.0	9.0	5.0	2.0	22.5	39.6	-24.2	67.0
2022	6.9	7.4	7.8	8.9	15.2	441.4	418.6	368.3	199.1	106.5	0.0	0.2	45.0	55.0	2.0	8.0	1.0	5.0	12.3	-5.9	69.0
2023	3.0	3.0	3.0	3.6	5.8	1063.6	1035.4	950.1	540.9	246.7	0.0	0.0	38.0	95.0	3.0	32.0	1.0	21.0	19.7	-10.3	49.0
2024	1.4	1.4	1.7	5.0	8.7	1125.2	1117.5	1101.0	668.3	318.3	0.0	0.0	228.0	72.0	5.0	11.2	2.0	15.0	15.9	-9.0	70.0
2025	1.4	1.5	1.5	2.0	3.1	782.7	749.1	697.3	333.3	185.9	0.0	0.0	244.0	88.0	5.0	33.4	1.0	10.0	11.9	-6.9	86.0

Variance Data

	1-day min	3-day min	7-day min	30-day min	90-day min	1-day max	3-day max	7-day max	30-day max	90-day max	Zero days	Base flow	Date min	Date max	Low pulse #	Low pulse duration	High pulse #	High pulse duration	Rise rate	Fall rate	Reversals
WET Baseline																					
1-day min	2.4	2.4	2.5	2.7	10.0	513.0	504.8	479.5	349.0	201.6	0.0	0.0	17.0	64.0	1.0	2.0	0.0	0.0	10.5	-33.2	65.0
- 1 S.D.	7.1	7.1	7.3	8.0	14.7	969.9	1008.5	949.1	672.5	361.4	0.0	0.0	80.8	93.5	1.6	-8.7	0.5	6.4	17.8	-26.4	67.7
Mean	15.4	16.1	17.0	21.4	28.6	2707.0	2555.3	2305.7	1490.6	741.4	0.0	0.1	119.2	104.0	3.7	37.0	1.5	19.9	33.3	-17.8	77.0
+ 1 S.D.	23.7	25.1	26.7	34.9	42.6	4444.0	4102.0	3662.3	2308.7	1121.4	0.0	0.1	157.6	114.5	5.9	82.7	2.4	33.4	48.7	-9.1	86.3
1-day max	28.9	31.8	35.1	51.2	57.5	6610.1	5770.1	4951.3	2839.6	1340.8	0.0	0.2	275.0	207.0	7.0	162.0	3.0	45.0	58.6	-5.3	100.0
CV[1]	54.0	56.0	57.2	62.8	48.7	64.2	60.5	58.8	54.9	51.2		57.1	32.2	10.1	57.6	123.6	64.8	67.7	46.5	-48.8	12.1
WETOF																					
1-day min	2.4	2.4	2.5	2.7	10.6	666.1	659.6	649.8	519.4	371.4	0.0	0.0	17.0	64.0	0.0	0.0	0.0	0.0	9.0	-33.8	48.0
- 1 S.D.	16.0	16.4	17.0	22.9	27.5	1099.1	1136.0	1079.8	807.8	484.2	0.0	0.1	201.4	93.5	-0.3	-27.2	0.6	7.9	16.3	-29.6	58.5
Mean	53.6	54.7	57.1	65.0	68.1	2841.0	2690.0	2444.3	1636.0	933.1	0.0	0.1	264.8	104.0	0.6	23.5	2.2	21.1	30.4	-19.7	66.8
+ 1 S.D.	91.2	93.0	97.1	107.1	108.6	4583.0	4243.9	3808.8	2464.1	1382.0	0.0	0.2	328.2	114.5	1.6	74.2	3.8	34.2	44.5	-9.9	75.2
1-day max	124.4	127.7	132.6	143.7	151.3	6733.1	5894.0	5077.9	3011.6	1663.5	0.0	0.3	347.0	207.0	2.0	162.0	5.0	44.5	59.6	-6.7	76.0
CV[1]	70.1	70.1	70.2	64.8	59.6	61.3	57.8	55.8	50.6	48.1		64.3	23.9	10.1	143.8	215.6	73.4	62.6	46.4	-49.9	12.5

[1]CV=coefficient of variation (=SD*100/mean)

APPENDIX I-19A

PREDICTED IHA STATISTICS, WET VS. WETOF AT BALDHILL DAM (GAGE 05058000) - MONTHLY AVERAGE FLOW (CFS)

Final Aquatic Impact Analysis Report

Year	October	November	December	January	February	March	April	May	June	July	August	September
WET Baseline												
2015	147.5	143.8	118.4	13.6	13.0	223.3	250.1	205.6	133.8	1008.4	1639.7	307.8
2016	213.4	193.6	152.5	40.5	36.2	704.4	548.4	204.3	408.6	495.0	146.6	420.2
2017	651.2	418.2	248.0	86.1	80.1	1635.7	1846.8	765.9	289.9	356.1	206.9	93.0
2018	210.3	206.7	162.1	60.9	36.6	270.5	2781.3	1265.3	335.3	245.0	134.6	69.0
2019	194.5	175.3	163.8	35.9	37.6	126.6	3260.8	1893.5	247.9	229.1	125.2	66.5
2020	189.3	177.8	147.8	37.3	220.4	605.9	494.3	222.2	141.6	81.7	51.5	20.0
2021	205.1	186.6	171.1	53.1	63.9	590.8	2283.4	1154.2	715.6	502.2	344.4	279.3
2022	186.4	172.1	136.0	19.4	97.0	355.9	13.0	13.0	101.2	121.0	41.2	46.0
2023	161.0	156.6	128.8	16.5	18.1	170.0	881.3	267.4	205.9	265.0	79.1	25.5
2024	274.8	200.0	172.2	39.7	59.1	1389.4	327.8	208.7	214.9	132.0	114.4	105.0
2025	165.9	156.1	139.0	26.5	23.9	385.7	691.9	367.5	142.2	55.1	17.6	13.0
WETOF												
2015	149.0	143.8	118.4	13.6	13.0	223.4	250.5	205.8	133.8	1015.0	1772.2	456.3
2016	344.6	294.0	256.9	165.0	178.9	877.5	707.7	408.2	689.0	829.3	403.4	576.7
2017	760.3	536.1	387.5	230.0	227.2	1720.1	2227.6	1189.0	710.9	701.8	430.8	196.2
2018	256.9	240.1	201.2	111.6	98.2	357.0	2880.6	1429.3	521.7	424.1	270.4	147.7
2019	240.3	206.7	211.4	100.0	112.2	207.0	3413.1	2216.4	733.5	708.9	594.3	382.4
2020	428.6	429.0	383.4	270.6	498.2	934.9	848.5	678.0	590.0	438.6	250.3	114.0
2021	242.8	226.0	215.4	105.1	126.1	662.4	2432.7	1470.5	1132.4	892.6	676.6	527.0
2022	357.5	325.4	267.8	155.2	249.3	524.2	32.2	256.2	304.7	237.8	102.9	72.9
2023	175.0	172.6	145.1	37.7	52.3	219.2	943.9	339.8	300.9	382.8	164.1	53.0
2024	283.7	225.4	198.2	75.4	119.0	1460.5	422.0	319.7	289.5	170.4	121.5	105.0
2025	165.9	156.1	139.0	26.5	23.9	385.7	691.9	367.5	142.2	55.1	17.6	13.0

Variance Data

	October	November	December	January	February	March	April	May	June	July	August	September
WET Baseline												
1-day min	147.5	143.8	118.4	13.6	13.0	126.6	13.0	13.0	101.2	55.1	17.6	13.0
- 1 S.D.	94.6	123.5	123.6	17.6	3.7	90.1	89.7	-0.3	90.9	42.1	-201.5	-7.0
Mean	236.3	198.8	158.2	39.0	62.4	587.1	1216.3	597.1	267.0	317.3	263.7	131.4
+ 1 S.D.	378.0	274.1	192.7	60.5	121.0	1084.1	2342.8	1194.4	443.0	592.6	729.0	269.8
1-day max	651.2	418.2	248.0	86.1	220.4	1635.7	3260.8	1893.5	715.6	1008.4	1639.7	420.2
CV[1]	60.0	37.9	21.8	54.9	94.0	84.7	92.6	100.0	65.9	86.7	176.4	105.4
WETOF												
1-day min	149.0	143.8	118.4	13.6	13.0	207.0	32.2	205.8	133.8	55.1	17.6	13.0
- 1 S.D.	136.9	147.4	139.6	35.2	17.4	173.2	183.4	140.3	199.9	216.3	-52.2	35.0
Mean	309.5	268.6	229.5	117.3	154.4	688.4	1350.1	807.3	504.4	532.4	436.7	240.4
+ 1 S.D.	482.2	389.9	319.4	199.5	291.3	1203.6	2516.7	1474.3	808.9	848.5	925.6	445.7
1-day max	760.3	536.1	387.5	270.6	498.2	1720.1	3413.1	2216.4	1132.4	1015.0	1772.2	576.7
CV[1]	55.8	45.1	39.2	70.0	88.7	74.8	86.4	82.6	60.4	59.4	111.9	85.4

[1] CV=coefficient of variation (=SD*100/mean)

APPENDIX I-19B

PREDICTED IHA STATISTICS, WET VS. WETOF AT BALDHILL DAM (GAGE 05058000) - MAGNITUDE (CFS), FREQUENCY (PER YEAR), AND DURATION (DAYS) OF EXTREME EVENTS

Final Aquatic Impact Analysis Report

Year	1-day min	3-day min	7-day min	30-day min	90-day min	1-day max	3-day max	7-day max	30-day max	90-day max	Zero days	Base flow	Date min	Date max	Low pulse #	Low pulse duration	High pulse #	High pulse duration	Rise rate	Fall rate	Reversals
WET Baseline																					
2015	13.0	13.0	13.0	13.0	23.7	2432.4	2412.9	2403.7	2151.6	1016.1	0.0	0.0	1.0	230.0	3.0	30.0	3.0	12.3	60.2	-55.0	119.0
2016	13.0	13.0	29.9	35.2	62.9	2201.7	1977.7	1763.5	1084.5	544.1	0.0	0.1	109.0	91.0	5.0	13.6	5.0	4.8	59.8	-52.5	159.0
2017	36.9	47.2	51.9	75.3	112.2	3367.4	3361.0	3347.8	2886.1	1482.3	0.0	0.1	269.0	101.0	7.0	1.1	6.0	8.7	71.3	-50.6	163.0
2018	16.2	21.2	22.2	32.2	67.2	5284.7	5284.7	4926.9	3537.5	1518.1	0.0	0.1	37.0	114.0	9.0	8.1	2.0	15.5	68.7	-55.6	163.0
2019	26.6	27.5	28.6	31.5	44.4	4656.7	4656.7	4495.6	3644.7	1838.2	0.0	0.1	83.0	117.0	10.0	9.7	2.0	23.5	57.4	-48.7	143.0
2020	13.6	15.5	17.2	20.0	49.7	1162.7	1090.8	935.5	694.0	486.5	0.0	0.1	272.0	58.0	3.0	36.0	2.0	2.5	34.2	-21.5	137.0
2021	22.1	22.1	22.5	45.1	72.5	3394.9	3388.1	3379.9	2520.8	1509.5	0.0	0.0	69.0	105.0	8.0	4.9	3.0	19.3	72.1	-57.8	127.0
2022	13.0	13.0	13.0	13.0	38.1	513.0	504.8	490.6	369.2	165.6	0.0	0.1	92.0	65.0	7.0	25.6	0.0	0.0	19.3	-12.6	91.0
2023	13.0	13.0	13.0	13.6	34.2	1460.3	1412.9	1262.4	935.6	482.1	0.0	0.1	7.0	91.0	4.0	28.8	2.0	6.5	38.5	-27.3	116.0
2024	13.0	23.6	25.7	34.7	91.4	2286.3	2077.0	1690.9	1428.6	656.4	0.0	0.1	111.0	67.0	4.0	21.0	1.0	27.0	47.2	-32.5	115.0
2025	13.0	13.0	13.0	13.0	26.6	1842.3	1721.4	1665.6	879.0	496.3	0.0	0.1	42.0	91.0	4.0	35.8	1.0	13.0	35.2	-19.8	104.0
WETOF																					
2015	13.0	13.0	13.0	13.0	23.7	2447.4	2440.6	2417.5	2243.6	1129.1	0.0	0.0	1.0	232.0	3.0	30.0	3.0	12.7	60.4	-54.5	119.0
2016	148.3	149.0	154.0	164.1	193.0	2370.7	2147.7	1949.7	1259.8	738.4	0.0	0.3	8.0	91.0	0.0	0.0	4.0	8.5	57.6	-53.1	155.0
2017	116.3	126.2	132.9	191.6	224.4	3393.9	3380.9	3370.6	3068.6	1810.7	0.0	0.2	269.0	105.0	0.0	0.0	4.0	22.8	70.5	-50.2	165.0
2018	74.6	80.1	87.5	97.7	123.4	5533.9	5533.9	5171.1	3660.6	1652.9	0.0	0.2	37.0	112.0	0.0	0.0	3.0	10.7	68.0	-53.5	159.0
2019	91.0	93.9	97.3	99.0	115.4	4918.7	4918.7	4758.3	3759.1	2143.0	0.0	0.1	1.0	118.0	0.0	0.0	1.0	55.0	53.3	-48.7	134.0
2020	75.9	77.3	84.9	114.0	191.0	1478.8	1431.1	1270.1	1013.5	859.0	0.0	0.2	273.0	99.0	0.0	0.0	4.0	7.0	39.2	-22.2	113.0
2021	70.4	74.3	89.5	103.9	129.6	3394.9	3393.6	3383.2	2650.7	1774.0	0.0	0.1	5.0	105.0	0.0	0.0	6.0	15.2	70.5	-58.6	127.0
2022	13.0	13.0	13.0	32.2	112.8	666.1	659.6	649.8	540.5	318.1	0.0	0.1	96.0	65.0	2.0	14.0	0.0	0.0	17.4	-15.0	105.0
2023	25.1	26.2	27.9	36.6	62.2	1537.8	1495.4	1324.7	999.8	556.9	0.0	0.1	274.0	91.0	6.0	12.8	2.0	7.0	30.4	-26.8	126.0
2024	25.3	27.4	28.5	49.6	116.2	2348.5	2140.2	1762.2	1500.1	748.8	0.0	0.1	231.0	67.0	1.0	15.0	1.0	27.0	47.9	-32.8	115.0
2025	13.0	13.0	13.0	13.0	26.6	1842.3	1721.4	1665.6	879.0	496.3	0.0	0.1	42.0	91.0	4.0	35.8	1.0	13.0	35.2	-19.8	104.0

Variance Data

	1-day min	3-day min	7-day min	30-day min	90-day min	1-day max	3-day max	7-day max	30-day max	90-day max	Zero days	Base flow	Date min	Date max	Low pulse #	Low pulse duration	High pulse #	High pulse duration	Rise rate	Fall rate	Reversals
WET Baseline																					
1-day min	13.0	13.0	13.0	13.0	23.7	513.0	504.8	490.6	369.2	165.6	0.0	0.0	1.0	58.0	3.0	1.1	0.0	0.0	19.3	-57.8	91.0
- 1 S.D.	9.7	9.8	11.1	10.8	28.8	1142.9	1047.4	941.7	657.5	360.1	0.0	0.1	74.2	89.7	3.3	6.9	0.7	3.4	33.7	-56.3	106.2
Mean	17.6	20.2	22.7	29.7	56.6	2600.2	2535.3	2396.6	1830.2	926.8	0.0	0.1	99.3	102.7	5.8	19.5	2.5	12.1	51.3	-39.4	130.6
+ 1 S.D.	25.4	30.6	34.4	48.6	84.4	4057.5	4023.1	3851.5	3002.8	1493.6	0.0	0.1	124.3	115.8	8.3	32.1	4.2	20.8	68.8	-22.6	155.1
1-day max	36.9	47.2	51.9	75.3	112.2	5284.7	5284.7	4926.9	3644.7	1838.2	0.0	0.1	272.0	230.0	10.0	36.0	6.0	27.0	72.1	-12.6	163.0
CV[1]	44.7	51.5	51.2	63.7	49.1	56.0	58.7	60.7	64.1	61.1		42.9	25.3	12.7	42.6	64.5	71.8	71.7	34.2	-42.8	18.7
WETOF																					
1-day min	13.0	13.0	13.0	13.0	23.7	666.1	659.6	649.8	540.5	318.1	0.0	0.0	1.0	65.0	0.0	0.0	0.0	0.0	17.4	-58.6	104.0
- 1 S.D.	14.1	15.0	16.6	23.3	54.4	1240.5	1152.0	1049.3	794.4	484.3	0.0	0.1	75.0	93.9	-0.6	-3.3	0.8	1.4	32.3	-55.9	107.7
Mean	60.5	63.1	67.4	83.2	119.8	2721.2	2660.3	2520.3	1961.4	1111.6	0.0	0.1	112.5	106.9	1.5	9.8	2.6	16.3	50.0	-39.6	129.3
+ 1 S.D.	107.0	111.1	118.2	143.1	185.3	4201.8	4168.5	3991.2	3128.4	1738.9	0.0	0.2	149.9	120.0	3.5	22.9	4.4	31.1	67.7	-23.3	150.9
1-day max	148.3	149.0	154.0	191.6	224.4	5533.9	5533.9	5171.1	3759.1	2143.0	0.0	0.3	274.0	232.0	6.0	35.8	6.0	55.0	70.5	-15.0	165.0
CV[1]	76.7	76.2	75.4	72.0	54.6	54.4	56.7	58.4	59.5	56.4		61.5	33.3	12.2	142.8	133.7	68.2	91.5	35.4	-41.2	16.7

[1]CV=coefficient of variation (=SD*100/mean)

APPENDIX I-20A

PREDICTED IHA STATISTICS, WET VS. WETOF AT LISBON (GAGE 05058700) - MONTHLY AVERAGE FLOW (CFS)

Final Aquatic Impact Analysis Report

Year	October	November	December	January	February	March	April	May	June	July	August	September
WET Baseline												
2015	158.2	157.7	122.7	38.0	23.4	266.2	444.4	219.9	235.9	1232.0	1961.2	375.3
2016	228.8	218.0	194.6	79.7	69.6	728.3	879.2	308.7	404.0	584.1	235.9	452.0
2017	774.0	531.0	306.4	126.5	85.3	1721.1	2308.7	885.7	350.4	388.4	226.8	116.8
2018	215.6	211.9	174.3	109.4	160.1	565.0	2936.7	1719.0	426.6	253.5	174.5	73.6
2019	197.9	210.8	195.1	73.7	56.8	157.9	4007.2	2703.4	465.0	374.6	157.4	116.1
2020	191.0	233.6	204.4	86.3	252.6	933.4	795.8	348.4	260.4	174.0	81.1	36.4
2021	242.3	246.8	204.3	71.5	74.1	609.6	2649.9	1406.4	810.5	539.0	363.8	354.8
2022	193.5	180.6	145.1	42.2	62.4	374.1	61.1	16.4	69.1	162.6	49.3	44.3
2023	151.6	174.2	137.1	38.3	17.6	133.0	1181.9	329.0	243.1	284.4	108.1	32.5
2024	258.7	220.3	180.7	62.4	49.9	1437.8	442.4	245.4	282.4	192.3	80.4	141.9
2025	182.9	163.7	147.1	60.1	30.7	403.0	911.0	423.5	161.5	69.5	21.2	15.2
WETOF												
2015	160.4	157.7	122.7	38.0	23.4	266.3	444.8	220.1	235.9	1238.7	2082.9	518.8
2016	364.4	319.5	296.3	198.7	209.7	910.0	1035.0	501.6	681.6	917.5	499.8	621.0
2017	882.3	646.3	443.6	266.5	232.6	1823.3	2664.8	1299.7	766.6	744.6	463.1	224.9
2018	268.5	245.6	211.7	157.2	221.0	651.7	3044.8	1870.7	607.2	435.5	311.9	158.2
2019	248.3	241.5	240.3	133.4	131.4	240.5	4152.2	3006.7	945.2	849.2	630.1	442.9
2020	438.1	483.5	440.3	313.7	573.2	1258.2	1144.3	795.6	709.9	538.6	292.3	140.1
2021	280.5	285.7	247.5	121.0	135.3	688.3	2787.6	1709.1	1219.6	936.0	699.0	606.8
2022	367.6	336.3	276.5	171.8	217.7	550.4	86.0	238.7	291.2	280.1	115.0	76.1
2023	167.0	189.8	153.2	56.6	47.7	184.1	1247.3	397.1	335.9	402.0	195.0	66.0
2024	269.3	244.2	206.5	94.8	103.3	1513.3	531.1	356.0	362.1	232.3	91.5	141.9
2025	182.9	163.7	147.1	60.1	30.7	403.0	911.0	423.5	161.5	69.5	21.2	15.2

Variance Data

	October	November	December	January	February	March	April	May	June	July	August	September
WET Baseline												
1-day min	151.6	157.7	122.7	38.0	17.6	133.0	61.1	16.4	69.1	69.5	21.2	15.2
- 1 S.D.	78.5	128.2	132.9	43.3	11.2	151.1	247.5	-48.7	141.3	64.4	-240.5	2.7
Mean	254.1	231.7	182.9	71.6	80.2	666.3	1510.8	782.3	337.2	386.8	314.5	159.9
+ 1 S.D.	429.6	335.1	232.9	100.0	149.3	1181.5	2774.0	1613.4	533.1	709.1	869.5	317.1
1-day max	774.0	531.0	306.4	126.5	252.6	1721.1	4007.2	2703.4	810.5	1232.0	1961.2	452.0
CV[1]	69.1	44.6	27.3	39.6	86.1	77.3	83.6	106.2	58.1	83.3	176.5	98.3
WETOF												
1-day min	160.4	157.7	122.7	38.0	23.4	184.1	86.0	220.1	161.5	69.5	21.2	15.2
- 1 S.D.	126.7	154.3	145.5	59.0	21.6	223.9	336.1	91.2	244.3	244.3	-81.5	45.7
Mean	329.9	301.2	253.3	146.5	175.1	771.7	1640.8	983.5	574.2	604.0	491.1	273.8
+ 1 S.D.	533.1	448.2	361.0	234.1	328.6	1319.5	2945.5	1875.9	904.2	963.7	1063.6	501.9
1-day max	882.3	646.3	443.6	313.7	573.2	1823.3	4152.2	3006.7	1219.6	1238.7	2082.9	621.0
CV[1]	61.6	48.8	42.5	59.8	87.7	71.0	79.5	90.7	57.5	59.5	116.6	83.3

[1]CV=coefficient of variation (=SD*100/mean)

APPENDIX I-20B

PREDICTED IHA STATISTICS, WET VS. WET AT LISBON (GAGE 05058700) - MAGNITUDE (CFS), FREQUENCY (PER YEAR), AND DURATION (DAYS) OF EXTREME EVENTS

Final Aquatic Impact Analysis Report

Year	1-day min	3-day min	7-day min	30-day min	90-day min	1-day max	3-day max	7-day max	30-day max	90-day max	Zero days	Base flow	Date min	Date max	Low pulse #	Low pulse duration	High pulse #	High pulse duration	Rise rate	Fall rate	Reversals
WET Baseline																					
2015	17.2	17.2	17.3	22.9	48.1	3394.0	3188.4	2916.8	2485.0	1228.5	0.0	0.0	50.0	201.0	3.0	26.7	2.0	20.5	55.9	-42.7	81.0
2016	44.3	47.9	54.4	62.2	89.1	2258.8	2185.7	2038.5	1395.8	702.0	0.0	0.2	62.0	93.0	2.0	32.5	1.0	18.0	38.1	-31.2	92.0
2017	67.0	68.0	69.2	84.9	142.7	3999.3	3988.4	3906.4	3243.9	1712.6	0.0	0.1	272.0	98.0	3.0	11.0	4.0	13.0	56.2	-40.6	88.0
2018	41.0	42.0	44.2	70.9	140.9	5421.6	5351.3	5223.5	3897.8	1822.5	0.0	0.1	263.0	115.0	3.0	12.0	2.0	18.5	62.3	-45.3	90.0
2019	43.7	44.6	45.9	50.3	67.0	5379.8	5321.3	5229.0	4571.5	2433.1	0.0	0.1	54.0	117.0	3.0	29.3	2.0	25.5	81.0	-51.8	106.0
2020	20.5	20.5	20.8	36.4	78.7	1704.3	1486.1	1310.3	1067.8	745.3	0.0	0.1	269.0	59.0	5.0	19.2	3.0	6.0	39.0	-28.2	90.0
2021	52.6	53.0	55.0	58.9	104.4	3619.0	3595.0	3559.6	2734.6	1728.5	0.0	0.1	26.0	105.0	1.0	53.0	3.0	19.7	57.2	-41.8	77.0
2022	13.6	13.6	13.8	16.2	45.2	506.1	503.7	490.0	376.6	173.9	0.0	0.1	143.0	69.0	5.0	38.6	0.0	0.0	11.3	-6.7	79.0
2023	13.5	14.2	15.9	17.7	46.7	1828.8	1743.6	1616.1	1182.7	596.0	0.0	0.1	55.0	93.0	3.0	39.0	2.0	7.5	36.8	-23.4	79.0
2024	18.0	24.0	29.9	42.1	99.1	1969.7	1874.5	1810.0	1560.0	723.2	0.0	0.1	275.0	69.0	4.0	22.0	1.0	27.0	36.2	-26.3	74.0
2025	14.3	14.4	14.4	15.2	34.1	1930.4	1921.0	1864.0	1112.6	601.4	0.0	0.1	274.0	91.0	2.0	72.0	1.0	15.0	29.1	-11.1	62.0
WETOF																					
2015	17.2	17.2	17.3	22.9	48.1	3402.1	3196.8	2916.8	2491.1	1323.4	0.0	0.0	50.0	201.0	3.0	26.7	2.0	21.5	55.6	-43.2	83.0
2016	172.1	173.3	174.4	193.1	219.1	2430.2	2357.6	2241.3	1571.9	895.4	0.0	0.3	14.0	93.0	0.0	0.0	3.0	9.7	37.2	-34.2	94.0
2017	146.9	149.0	152.5	209.6	236.3	3999.3	3988.4	3910.2	3386.6	2038.0	0.0	0.2	272.0	98.0	0.0	0.0	4.0	19.8	55.9	-41.4	88.0
2018	107.3	108.1	112.8	153.5	192.4	5670.8	5594.9	5427.4	4014.1	1954.6	0.0	0.2	10.0	115.0	0.0	0.0	3.0	13.7	63.8	-47.4	92.0
2019	112.4	115.3	116.4	126.9	136.3	5720.5	5656.9	5519.2	4688.3	2734.3	0.0	0.1	26.0	117.0	0.0	0.0	3.0	21.0	80.6	-51.9	108.0
2020	91.5	93.7	96.9	138.5	228.3	2057.4	1935.5	1705.5	1389.1	1126.4	0.0	0.2	274.0	59.0	0.0	0.0	4.0	9.3	42.1	-31.3	83.0
2021	97.7	99.1	103.2	111.2	159.6	3652.7	3607.0	3572.6	2865.3	1970.3	0.0	0.1	9.0	106.0	0.0	0.0	2.0	37.5	56.7	-42.1	81.0
2022	15.0	16.4	19.9	52.3	117.5	662.5	661.5	655.3	552.6	328.0	0.0	0.1	114.0	67.0	4.0	13.8	0.0	0.0	11.4	-9.2	77.0
2023	34.7	35.1	37.8	41.6	72.4	1922.7	1817.7	1678.8	1249.6	670.9	0.0	0.1	274.0	93.0	2.0	46.5	2.0	8.0	35.2	-24.8	71.0
2024	33.1	33.7	36.3	57.6	128.9	2035.8	1942.5	1880.8	1633.3	814.9	0.0	0.1	235.0	69.0	6.0	10.8	1.0	27.0	36.5	-26.9	70.0
2025	14.3	14.4	14.4	15.2	34.1	1930.4	1921.0	1864.0	1112.6	601.4	0.0	0.1	274.0	91.0	2.0	72.0	1.0	15.0	29.1	-11.1	62.0

Variance Data

	1-day min	3-day min	7-day min	30-day min	90-day min	1-day max	3-day max	7-day max	30-day max	90-day max	Zero days	Base flow	Date min	Date max	Low pulse #	Low pulse duration	High pulse #	High pulse duration	Rise rate	Fall rate	Reversals
WET Baseline																					
1-day min	13.5	13.6	13.8	15.2	34.1	506.1	503.7	490.0	376.6	173.9	0.0	0.0	26.0	59.0	1.0	11.0	0.0	0.0	11.3	-51.8	62.0
- 1 S.D.	12.6	13.6	14.8	19.4	43.7	1329.0	1246.1	1145.5	813.3	436.2	0.0	0.1	110.4	90.4	1.9	14.2	0.8	7.2	26.8	-46.1	71.9
Mean	31.4	32.7	34.6	43.4	81.5	2910.2	2832.6	2724.0	2148.0	1133.3	0.0	0.1	158.5	100.9	3.1	32.3	1.9	15.5	45.7	-31.7	83.5
+ 1 S.D.	50.3	51.7	54.4	67.5	119.2	4491.3	4419.2	4302.5	3482.7	1830.5	0.0	0.1	206.6	111.4	4.3	50.4	3.1	23.8	64.7	-17.4	95.0
1-day max	67.0	68.0	69.2	84.9	142.7	5421.6	5351.3	5229.0	4571.5	2433.1	0.0	0.2	275.0	201.0	5.0	72.0	4.0	27.0	81.0	-6.7	106.0
CV[1]	60.0	58.2	57.3	55.4	46.4	54.3	56.0	57.9	62.1	61.5		33.3	30.4	10.4	39.5	56.0	59.7	53.5	41.4	-45.2	13.8
WETOF																					
1-day min	14.3	14.4	14.4	15.2	34.1	662.5	661.5	655.3	552.6	328.0	0.0	0.0	9.0	59.0	0.0	0.0	0.0	0.0	11.4	-51.9	62.0
- 1 S.D.	20.2	20.8	22.8	33.9	71.4	1431.3	1362.7	1264.6	944.2	557.0	0.0	0.1	93.6	90.3	-0.5	-8.5	1.0	6.3	26.9	-47.1	69.8
Mean	76.6	77.7	80.2	102.0	143.0	3044.1	2970.9	2852.0	2268.6	1314.3	0.0	0.1	141.1	100.8	1.6	15.4	2.3	16.6	45.8	-33.0	82.6
+ 1 S.D.	133.0	134.7	137.6	170.2	214.6	4656.8	4579.1	4439.4	3593.0	2071.7	0.0	0.2	188.6	111.4	3.6	39.4	3.5	26.9	64.8	-19.0	95.5
1-day max	172.1	173.3	174.4	209.6	236.3	5720.5	5656.9	5519.2	4688.3	2734.3	0.0	0.3	274.0	201.0	6.0	72.0	4.0	37.5	80.6	-9.2	108.0
CV[1]	73.6	73.3	71.6	66.8	50.1	53.0	54.1	55.7	58.4	57.6		50.0	33.7	10.5	132.9	155.3	55.9	62.1	41.4	-42.6	15.5

[1]CV=coefficient of variation (=SD*100/mean)

APPENDIX I-21A

PREDICTED IHA STATISTICS, WET VS. WETOF AT KINDRED (GAGE 05059000) - MONTHLY AVERAGE FLOW (CFS)

Final Aquatic Impact Analysis Report

Year	October	November	December	January	February	March	April	May	June	July	August	September
WET Baseline												
2015	189.5	177.2	132.3	54.6	31.3	162.7	677.3	262.7	294.3	1196.5	2253.3	482.1
2016	270.5	260.4	233.5	123.6	92.8	690.1	1101.7	430.2	407.3	702.9	244.4	428.8
2017	770.2	619.0	363.9	152.1	104.2	1534.4	2728.4	1139.6	512.2	513.2	273.2	187.9
2018	268.9	271.0	195.0	121.2	170.0	718.1	2930.9	2392.7	682.8	314.0	268.0	116.4
2019	221.1	256.7	227.1	93.4	64.7	110.1	4036.3	3215.2	543.6	446.4	198.4	149.9
2020	218.3	261.6	212.6	130.4	201.5	1184.0	948.1	593.5	540.8	386.0	137.8	105.2
2021	321.6	343.7	301.6	134.3	126.9	674.4	2791.9	1580.1	951.3	650.7	436.5	540.2
2022	205.8	196.2	164.1	76.0	58.6	404.7	134.0	46.3	55.6	217.4	74.5	55.3
2023	154.4	195.4	152.8	65.5	31.6	102.2	1213.0	427.6	288.8	291.0	145.0	54.0
2024	252.6	243.0	207.4	86.9	53.6	1433.1	574.0	332.6	292.8	284.5	63.9	183.0
2025	197.7	174.5	164.1	95.7	48.7	315.6	1104.7	489.3	251.9	117.6	39.5	34.8
WETOF												
2015	192.3	177.2	132.3	54.6	31.3	162.7	677.6	263.0	294.3	1203.1	2364.4	621.9
2016	408.7	364.0	333.3	237.1	232.6	876.9	1257.9	611.4	679.2	1039.2	513.6	609.9
2017	878.1	731.9	498.8	289.2	250.0	1654.2	3060.5	1542.7	927.6	879.6	520.2	299.7
2018	328.3	305.2	230.6	168.0	225.2	802.9	3043.5	2534.3	860.7	498.0	407.6	204.4
2019	277.7	287.9	269.5	149.8	137.6	192.6	4176.6	3502.9	1020.3	914.5	670.7	489.6
2020	472.4	510.6	448.9	353.1	515.1	1507.0	1293.5	1031.6	993.9	754.7	363.6	213.9
2021	360.4	382.5	344.0	180.6	187.9	755.3	2922.9	1868.5	1354.3	1052.6	775.8	796.6
2022	382.4	354.2	295.8	200.0	210.3	592.4	174.0	235.1	294.8	340.9	142.6	91.9
2023	172.1	210.7	168.9	80.9	57.2	153.6	1282.9	491.8	379.6	409.0	233.1	92.0
2024	265.9	265.3	233.6	115.7	101.3	1513.2	658.0	442.6	378.0	326.1	78.3	183.3
2025	197.7	174.5	164.1	95.7	48.7	315.6	1104.7	489.3	251.9	117.6	39.5	34.8

Variance Data

	October	November	December	January	February	March	April	May	June	July	August	September
WET Baseline												
1-day min	154.4	174.5	132.3	54.6	31.3	102.2	134.0	46.3	55.6	117.6	39.5	34.8
- 1 S.D.	109.9	147.3	145.8	71.8	33.0	148.1	413.8	-17.1	194.1	165.0	-257.5	29.6
Mean	279.1	272.6	214.0	103.1	89.5	666.3	1658.2	991.8	438.3	465.5	375.9	212.5
+ 1 S.D.	448.4	397.9	282.2	134.3	145.9	1184.5	2902.6	2000.7	682.5	765.9	1009.2	395.4
1-day max	770.2	619.0	363.9	152.1	201.5	1534.4	4036.3	3215.2	951.3	1196.5	2253.3	540.2
CV[1]	60.6	46.0	31.9	30.3	63.2	77.8	75.0	101.7	55.7	64.6	168.5	86.1
WETOF												
1-day min	172.1	174.5	132.3	54.6	31.3	153.6	174.0	235.1	251.9	117.6	39.5	34.8
- 1 S.D.	160.3	179.3	167.1	83.8	45.4	208.6	500.0	114.9	298.4	323.8	-89.9	74.0
Mean	357.8	342.2	283.6	175.0	181.6	775.1	1786.5	1183.0	675.9	685.0	555.4	330.7
+ 1 S.D.	555.4	505.1	400.1	266.1	317.7	1341.7	3073.1	2251.1	1053.3	1046.2	1200.7	587.4
1-day max	878.1	731.9	498.8	353.1	515.1	1654.2	4176.6	3502.9	1354.3	1203.1	2364.4	796.6
CV[1]	55.2	47.6	41.1	52.1	75.0	73.1	72.0	90.3	55.8	52.7	116.2	77.6

[1]CV=coefficient of variation (=SD*100/mean)

APPENDIX I-21B

PREDICTED IHA STATISTICS, WET VS. WETOF AT KINDRED (GAGE 05059000) - MAGNITUDE (CFS), FREQUENCY (PER YEAR), AND DURATION (DAYS) OF EXTREME EVENTS

Final Aquatic Impact Analysis Report

Year	1-day min	3-day min	7-day min	30-day min	90-day min	1-day max	3-day max	7-day max	30-day max	90-day max	Zero days	Base flow	Date min	Date max	Low pulse #	Low pulse duration	High pulse #	High pulse duration	Rise rate	Fall rate	Reversals
WET Baseline																					
2015	20.1	20.6	22.1	27.5	55.7	3334.2	3292.3	3136.1	2593.7	1349.9	0.0	0.0	65.0	224.0	2.0	42.0	2.0	21.0	49.8	-33.0	66.0
2016	62.4	66.5	72.5	90.4	126.8	2388.5	2351.3	2235.0	1532.5	797.0	0.0	0.2	49.0	89.0	1.0	61.0	1.0	19.0	32.7	-24.9	66.0
2017	87.6	90.4	92.7	103.5	161.4	4212.0	4168.9	4034.9	3316.8	1907.6	0.0	0.1	48.0	103.0	3.0	17.0	3.0	18.7	53.9	-38.6	75.0
2018	71.5	73.5	80.0	112.5	157.0	5317.4	5299.2	5148.2	4122.7	2147.2	0.0	0.1	15.0	117.0	4.0	8.3	3.0	17.0	58.3	-41.6	83.0
2019	55.0	56.8	60.8	64.1	87.4	5773.8	5713.8	5511.9	4791.9	2625.3	0.0	0.1	30.0	120.0	3.0	30.0	1.0	53.0	67.4	-48.1	85.0
2020	79.2	81.0	93.4	102.2	152.4	1684.8	1648.0	1528.5	1231.4	934.0	0.0	0.2	273.0	89.0	5.0	15.6	4.0	5.5	42.3	-29.1	83.0
2021	104.1	105.9	107.9	110.7	164.2	3692.1	3660.2	3596.0	2791.9	1861.5	0.0	0.2	16.0	107.0	2.0	16.0	4.0	16.3	56.2	-38.3	84.0
2022	25.3	28.1	32.0	40.3	72.7	538.5	534.5	523.0	423.0	205.0	0.0	0.2	162.0	72.0	3.0	64.0	0.0	0.0	9.6	-6.6	92.0
2023	24.7	24.8	25.6	30.7	58.9	1692.0	1673.2	1566.7	1224.7	649.4	0.0	0.1	36.0	108.0	3.0	39.0	2.0	7.5	28.7	-16.9	83.0
2024	41.8	43.4	45.9	53.3	113.6	2285.2	2217.0	2103.8	1667.9	799.3	0.0	0.1	275.0	87.0	5.0	20.0	1.0	25.0	37.3	-23.2	89.0
2025	22.4	25.5	28.4	32.8	62.0	2334.2	2291.0	2159.5	1236.3	678.8	0.0	0.1	242.0	94.0	2.0	71.5	1.0	14.0	23.1	-13.8	93.0
WETOF																					
2015	20.1	20.6	22.1	27.5	55.7	3334.2	3292.3	3136.1	2606.3	1428.2	0.0	0.0	65.0	224.0	2.0	42.0	2.0	22.0	50.0	-33.4	66.0
2016	207.8	207.9	208.8	223.8	252.8	2628.3	2588.0	2455.3	1715.3	990.2	0.0	0.4	22.0	89.0	0.0	0.0	2.0	15.0	33.9	-26.4	60.0
2017	206.6	208.8	217.3	247.6	290.2	4288.3	4262.7	4181.0	3495.9	2232.7	0.0	0.2	272.0	104.0	0.0	0.0	2.0	43.5	52.7	-40.0	71.0
2018	113.7	114.6	121.1	160.9	206.7	5553.4	5510.2	5343.5	4232.1	2278.9	0.0	0.2	14.0	117.0	1.0	5.0	2.0	29.0	59.3	-43.3	74.0
2019	120.1	121.3	124.2	130.5	154.9	6080.2	6019.2	5794.8	4910.3	2927.4	0.0	0.1	24.0	120.0	2.0	1.5	3.0	21.3	69.2	-48.0	77.0
2020	151.2	153.0	167.6	210.4	306.1	2008.9	1990.2	1878.0	1552.9	1309.2	0.0	0.2	273.0	89.0	0.0	0.0	4.0	14.3	47.2	-31.4	85.0
2021	150.9	151.2	153.2	162.5	217.8	3722.8	3696.0	3632.7	2922.9	2093.8	0.0	0.2	16.0	108.0	0.0	0.0	3.0	29.0	56.7	-37.9	80.0
2022	50.3	53.3	58.0	91.3	134.5	697.8	696.4	690.1	599.6	351.5	0.0	0.2	118.0	69.0	2.0	32.5	0.0	0.0	9.9	-8.6	77.0
2023	46.3	46.7	47.7	52.7	84.4	1755.6	1736.7	1630.0	1290.8	723.5	0.0	0.2	28.0	108.0	4.0	25.0	2.0	9.0	28.0	-17.7	73.0
2024	51.3	52.4	54.4	73.1	148.0	2359.6	2291.5	2178.3	1742.0	891.2	0.0	0.1	239.0	87.0	5.0	18.0	1.0	27.0	34.4	-24.9	89.0
2025	22.4	25.5	28.4	32.8	62.0	2334.2	2291.0	2159.5	1236.3	678.8	0.0	0.1	242.0	94.0	2.0	71.5	1.0	14.0	23.1	-13.8	93.0

Variance Data

	1-day min	3-day min	7-day min	30-day min	90-day min	1-day max	3-day max	7-day max	30-day max	90-day max	Zero days	Base flow	Date min	Date max	Low pulse #	Low pulse duration	High pulse #	High pulse duration	Rise rate	Fall rate	Reversals
WET Baseline																					
1-day min	20.1	20.6	22.1	27.5	55.7	538.5	534.5	523.0	423.0	205.0	0.0	0.0	15.0	72.0	1.0	8.3	0.0	0.0	9.6	-48.1	66.0
- 1 S.D.	24.6	26.4	29.1	35.2	65.9	1412.2	1381.9	1298.3	894.7	507.3	0.0	0.1	78.1	97.9	1.7	12.7	0.7	4.1	24.4	-41.4	72.5
Mean	54.0	56.0	60.1	69.8	110.2	3023.0	2986.3	2867.6	2266.6	1268.6	0.0	0.1	110.1	110.0	3.0	34.9	2.0	17.9	41.7	-28.5	81.7
+ 1 S.D.	83.4	85.7	91.2	104.4	154.5	4633.7	4590.7	4436.9	3638.6	2029.9	0.0	0.2	142.1	122.1	4.3	57.2	3.3	31.7	59.1	-15.7	90.9
1-day max	104.1	105.9	107.9	112.5	164.2	5773.8	5713.8	5511.9	4791.9	2625.3	0.0	0.2	275.0	224.0	5.0	71.5	4.0	53.0	67.4	-6.6	93.0
CV[1]	54.4	53.0	51.7	49.5	40.2	53.3	53.7	54.7	60.5	60.0		46.2	29.1	11.0	42.0	63.6	67.0	76.9	41.5	-45.0	11.3
WETOF																					
1-day min	20.1	20.6	22.1	27.5	55.7	697.8	696.4	690.1	599.6	351.5	0.0	0.0	14.0	69.0	0.0	0.0	0.0	0.0	9.9	-48.0	60.0
- 1 S.D.	33.9	35.4	38.0	49.9	86.0	1522.0	1496.9	1417.7	1026.8	623.2	0.0	0.1	82.5	97.7	-0.1	-5.5	0.9	8.6	24.4	-42.2	67.1
Mean	103.7	105.0	109.3	128.5	173.9	3160.3	3124.9	3007.2	2391.3	1446.0	0.0	0.2	119.4	109.9	1.6	17.8	2.0	20.4	42.2	-29.6	76.8
+ 1 S.D.	173.5	174.6	180.6	207.1	261.8	4798.6	4753.0	4596.7	3755.9	2268.8	0.0	0.3	156.3	122.1	3.3	41.1	3.1	32.1	60.0	-17.0	86.5
1-day max	207.8	208.8	217.3	247.6	306.1	6080.2	6019.2	5794.8	4910.3	2927.4	0.0	0.4	273.0	224.0	5.0	71.5	4.0	43.5	69.2	-8.6	93.0
CV[1]	67.4	66.3	65.2	61.2	50.6	51.8	52.1	52.9	57.1	56.9		47.1	30.9	11.1	103.0	131.2	55.0	57.7	42.2	-42.6	12.6

[1]CV=coefficient of variation (=SD*100/mean)

APPENDIX I-22A

PREDICTED IHA STATISTICS, WET VS. WETOF AT HALSTAD (GAGE 05064500) - MONTHLY AVERAGE FLOW (CFS)

Final Aquatic Impact Analysis Report

Year	October	November	December	January	February	March	April	May	June	July	August	September
WET Baseline												
2015	729.0	508.8	526.1	415.0	412.2	1255.6	8011.5	2147.4	3102.6	10691.0	11492.3	3359.5
2016	2177.0	1524.7	1123.1	876.1	820.3	4491.3	8510.9	4528.3	2979.5	6001.4	1764.5	2095.2
2017	2824.0	1833.4	1042.0	867.6	794.0	9604.3	11960.5	5931.5	3031.9	4415.3	1323.3	759.4
2018	1906.9	1761.2	1278.7	818.5	755.1	3573.0	13906.5	10018.2	3899.4	1350.0	885.9	521.5
2019	584.7	967.6	752.3	730.9	1122.0	1798.9	38194.2	15846.5	4700.0	4909.9	1637.7	1223.1
2020	1547.7	1281.0	1174.9	910.3	1915.2	8518.2	5755.9	8543.2	6036.0	8124.5	1769.2	1046.3
2021	2046.8	1562.0	1828.3	947.8	853.0	6385.5	10157.3	8057.5	4600.1	3579.4	2643.6	4667.8
2022	557.2	417.7	315.8	204.3	211.8	869.0	679.9	883.3	513.0	717.5	577.0	310.8
2023	603.2	750.6	601.1	379.4	359.0	1122.3	9026.7	2438.4	1411.7	1145.4	583.7	316.8
2024	1311.0	1027.0	708.2	435.1	362.0	3880.4	2505.5	1051.0	1622.8	3266.0	766.0	812.8
2025	866.1	806.1	618.5	477.1	523.0	3483.1	9507.3	2217.3	5388.1	1684.2	632.5	297.2
WETOF												
2015	733.9	508.9	526.1	415.0	412.2	1255.6	8011.8	2147.8	3102.6	10695.1	11574.9	3506.3
2016	2315.3	1632.0	1222.1	984.5	960.1	4669.6	8668.3	4708.0	3224.2	6349.6	2040.0	2298.1
2017	2931.1	1941.6	1173.1	1003.9	937.4	9755.2	12241.3	6307.1	3448.3	4802.8	1582.5	896.5
2018	1976.6	1796.7	1312.9	862.9	813.0	3651.8	14009.6	10157.3	4075.4	1527.7	1040.4	615.6
2019	650.7	1001.2	791.3	783.9	1192.9	1876.3	38306.8	16118.8	5151.5	5370.9	2121.0	1589.5
2020	1810.5	1528.6	1414.4	1131.7	2671.3	8848.3	6083.0	8974.5	6487.2	8518.6	2018.4	1170.9
2021	2086.4	1599.9	1869.7	992.5	911.3	6464.1	10273.9	8312.0	4992.3	3990.3	2985.5	4945.7
2022	736.2	582.3	450.2	326.3	346.9	1062.9	759.0	1022.8	741.1	882.2	653.0	352.5
2023	624.7	765.3	617.0	394.1	382.1	1168.2	9098.7	2496.9	1499.5	1258.3	680.9	364.4
2024	1327.7	1045.4	734.6	460.6	407.2	3960.4	2581.7	1160.0	1715.4	3317.1	784.4	814.7
2025	866.1	806.1	618.5	477.1	523.0	3483.1	9507.3	2217.3	5388.1	1684.2	632.5	297.2

Variance Data

	October	November	December	January	February	March	April	May	June	July	August	September
WET Baseline												
1-day min	557.2	417.7	315.8	204.3	211.8	869.0	679.9	883.3	513.0	717.5	577.0	297.2
- 1 S.D.	598.1	637.2	475.2	378.9	262.3	1112.8	866.1	949.8	1653.8	1033.1	-965.5	-22.5
Mean	1377.6	1130.9	906.3	642.0	738.9	4089.2	10746.9	5605.7	3389.6	4171.3	2188.7	1400.9
+ 1 S.D.	2157.1	1624.6	1337.4	905.2	1215.4	7065.7	20627.8	10261.5	5125.3	7309.6	5342.9	2824.3
1-day max	2824.0	1833.4	1828.3	947.8	1915.2	9604.3	38194.2	15846.5	6036.0	10691.0	11492.3	4667.8
CV[1]	56.6	43.7	47.6	41.0	64.5	72.8	91.9	83.1	51.2	75.2	144.1	101.6
WETOF												
1-day min	624.7	508.9	450.2	326.3	346.9	1062.9	759.0	1022.8	741.1	882.2	632.5	297.2
- 1 S.D.	656.7	688.2	524.7	412.3	203.8	1169.9	984.5	1043.2	1813.6	1226.3	-774.5	38.3
Mean	1459.9	1200.7	975.5	712.1	868.9	4199.6	10867.4	5783.9	3620.5	4399.7	2374.0	1531.9
+ 1 S.D.	2263.2	1713.3	1426.2	1011.9	1533.9	7229.2	20750.3	10524.5	5427.4	7573.1	5522.4	3025.6
1-day max	2931.1	1941.6	1869.7	1131.7	2671.3	9755.2	38306.8	16118.8	6487.2	10695.1	11574.9	4945.7
CV[1]	55.0	42.7	46.2	42.1	76.5	72.1	90.9	82.0	49.9	72.1	132.6	97.5

[1]CV=coefficient of variation (=SD*100/mean)

APPENDIX I-22B

PREDICTED IHA STATISTICS, WET VS. WETOF AT HALSTAD (GAGE 05064500) - MAGNITUDE (CFS), FREQUENCY (PER YEAR), AND DURATION (DAYS) OF EXTREME EVENTS

Final Aquatic Impact Analysis Report

Year	1-day min	3-day min	7-day min	30-day min	90-day min	1-day max	3-day max	7-day max	30-day max	90-day max	Zero days	Base flow	Date min	Date max	Low pulse #	Low pulse duration	High pulse #	High pulse duration	Rise rate	Fall rate	Reversals
WET Baseline																					
2015	301.1	301.7	306.4	376.5	423.3	21597.2	21454.3	20747.2	16842.2	8811.9	0.0	0.1	66.0	216.0	2.0	83.0	2.0	23.5	301.6	-173.4	56.0
2016	725.9	751.0	758.9	803.9	913.6	16658.8	16396.2	15884.0	10656.4	6250.2	0.0	0.3	252.0	92.0	0.0	0.0	2.0	13.0	346.3	-159.0	60.0
2017	384.8	391.0	434.9	751.0	874.6	23542.5	23276.5	22405.5	17087.6	9686.8	0.0	0.1	271.0	91.0	2.0	8.0	1.0	37.0	368.3	-159.6	59.0
2018	294.8	297.4	322.7	463.4	648.9	24790.7	24456.7	23533.4	15182.2	9966.8	0.0	0.1	269.0	110.0	4.0	11.3	3.0	13.7	364.7	-190.6	62.0
2019	405.7	411.7	428.4	564.1	765.1	69539.0	68280.5	62841.8	42444.3	19737.6	0.0	0.1	292.0	111.0	4.0	5.0	3.0	17.3	563.5	-399.0	69.0
2020	700.1	746.3	810.3	885.8	1036.7	18942.1	18715.1	17591.2	10858.7	7801.0	0.0	0.2	270.0	140.0	0.0	0.0	5.0	10.6	417.6	-265.9	65.0
2021	788.1	788.9	792.5	625.3	456.3	16936.5	16615.8	16238.6	13093.7	8883.4	0.0	0.2	49.0	89.0	0.0	0.0	3.0	14.7	387.4	-206.0	51.0
2022	143.4	145.2	147.3	156.7	241.0	3728.9	3288.1	2371.2	1060.3	827.3	0.0	0.3	39.0	146.0	7.0	41.4	0.0	0.0	48.2	-39.8	77.0
2023	192.1	201.4	260.9	304.0	413.0	13112.8	13079.5	12916.4	9149.8	4431.1	0.0	0.2	275.0	100.0	6.0	28.3	1.0	19.0	129.0	-74.3	67.0
2024	266.3	275.1	313.2	349.6	495.3	6785.7	6563.7	5846.4	4591.6	2524.6	0.0	0.2	275.0	187.0	5.0	22.6	0.0	0.0	142.2	-91.3	68.0
2025	154.9	161.2	179.4	297.2	501.1	20943.7	20813.5	20122.4	11367.0	6289.3	0.0	0.1	274.0	94.0	2.0	65.5	2.0	12.0	311.7	-140.3	65.0
WETOF																					
2015	301.1	301.7	306.4	376.5	423.3	21614.8	21473.8	20764.1	16849.0	8875.1	0.0	0.1	66.0	215.0	2.0	83.0	2.0	23.5	308.4	-170.6	54.0
2016	874.8	886.7	893.5	926.6	1031.1	16907.4	16643.9	16120.6	10845.9	6440.8	0.0	0.3	38.0	92.0	0.0	0.0	2.0	14.0	339.2	-160.2	62.0
2017	476.5	483.8	528.7	877.3	1014.1	23547.8	23279.3	22410.3	17165.8	9998.8	0.0	0.1	272.0	91.0	1.0	9.0	1.0	39.0	381.3	-158.8	63.0
2018	364.8	367.4	392.7	537.7	737.1	24870.0	24534.3	23605.2	15287.2	10095.5	0.0	0.1	269.0	110.0	4.0	6.5	3.0	14.0	375.9	-188.5	60.0
2019	467.5	473.5	489.6	630.9	811.5	69658.1	68399.1	62958.4	42589.9	20024.9	0.0	0.1	292.0	111.0	3.0	4.0	4.0	13.8	556.9	-402.4	65.0
2020	805.3	845.8	909.8	1062.6	1271.0	19428.3	19203.0	18083.2	11305.8	8274.2	0.0	0.2	270.0	140.0	0.0	0.0	5.0	11.2	452.3	-270.2	59.0
2021	849.2	849.8	853.2	806.3	617.1	17040.8	16719.9	16338.1	13186.0	9100.0	0.0	0.2	48.0	89.0	0.0	0.0	3.0	15.0	374.3	-210.7	53.0
2022	216.3	217.0	222.4	284.5	375.2	4000.5	3556.2	2628.2	1226.0	964.6	0.0	0.3	272.0	146.0	7.0	34.6	0.0	0.0	45.0	-43.8	78.0
2023	218.5	227.3	286.8	343.1	435.3	13211.6	13181.7	13011.8	9222.4	4499.7	0.0	0.2	275.0	100.0	5.0	32.2	1.0	19.0	123.4	-77.2	65.0
2024	289.4	298.3	336.3	383.7	522.2	6869.3	6644.1	5916.8	4673.7	2614.4	0.0	0.2	275.0	187.0	5.0	21.8	0.0	0.0	139.3	-92.5	68.0
2025	154.9	161.2	179.4	297.2	530.7	20943.7	20813.5	20122.4	11367.0	6289.3	0.0	0.1	274.0	94.0	2.0	65.5	2.0	12.0	311.7	-140.3	65.0

Variance Data

	1-day min	3-day min	7-day min	30-day min	90-day min	1-day max	3-day max	7-day max	30-day max	90-day max	Zero days	Base flow	Date min	Date max	Low pulse #	Low pulse duration	High pulse #	High pulse duration	Rise rate	Fall rate	Reversals
WET Baseline																					
1-day min	143.4	145.2	147.3	156.7	241.0	3728.9	3288.1	2371.2	1060.3	827.3	0.0	0.1	39.0	89.0	0.0	0.0	0.0	0.0	48.2	-399.0	51.0
- 1 S.D.	160.6	163.3	188.1	270.4	364.8	4254.4	4197.1	4385.1	3189.6	2792.5	0.0	0.1	151.9	110.5	0.4	-4.3	0.5	4.3	159.3	-271.0	56.5
Mean	396.1	406.4	432.3	507.1	615.4	21507.1	21176.4	20045.3	13848.5	7746.4	0.0	0.2	212.0	125.1	2.9	24.1	2.0	14.6	307.3	-172.7	63.6
+ 1 S.D.	631.6	649.6	676.4	743.7	866.0	38759.7	38155.7	35705.4	24507.4	12700.3	0.0	0.2	272.1	139.7	5.4	52.5	3.5	24.9	455.3	-74.3	70.6
1-day max	788.1	788.9	810.3	885.8	1036.7	69539.0	68280.5	62841.8	42444.3	19737.6	0.0	0.3	292.0	216.0	7.0	83.0	5.0	37.0	563.5	-39.8	77.0
CV[1]	59.5	59.8	56.5	46.7	40.7	80.2	80.2	78.1	77.0	64.0		43.8	28.4	11.7	84.9	117.6	74.0	70.4	48.2	-57.0	11.1
WETOF																					
1-day min	154.9	161.2	179.4	284.5	375.2	4000.5	3556.2	2628.2	1226.0	964.6	0.0	0.1	38.0	89.0	0.0	0.0	0.0	0.0	45.0	-402.4	53.0
- 1 S.D.	188.4	191.7	217.2	310.7	411.8	4413.7	4356.0	4539.8	3321.0	2914.4	0.0	0.1	152.4	110.5	0.3	-5.0	0.5	4.0	158.2	-272.8	56.1
Mean	456.2	464.8	490.8	593.3	706.2	21644.7	21313.5	20178.1	13974.4	7925.2	0.0	0.2	213.7	125.0	2.6	23.3	2.1	14.7	309.8	-174.1	62.9
+ 1 S.D.	724.0	737.9	764.4	875.9	1000.7	38875.8	38271.0	35816.4	24627.9	12936.1	0.0	0.3	275.1	139.6	5.0	51.7	3.7	25.4	461.4	-75.4	69.8
1-day max	874.8	886.7	909.8	1062.6	1271.0	69658.1	68399.1	62958.4	42589.9	20024.9	0.0	0.3	292.0	215.0	7.0	83.0	5.0	39.0	556.9	-43.8	78.0
CV[1]	58.7	58.8	55.7	47.6	41.7	79.6	79.6	77.5	76.2	63.2		52.9	28.7	11.6	89.8	121.6	75.6	72.7	48.9	-56.7	10.9

[1]CV=coefficient of variation (=SD*100/mean)

APPENDIX I-23A

PREDICTED IHA STATISTICS, WET VS. WETOF AT GRAND FORKS (GAGE 05082500) - MONTHLY AVERAGE FLOW (CFS)

Final Aquatic Impact Analysis Report

Year	October	November	December	January	February	March	April	May	June	July	August	September
WET Baseline												
2015	1565.7	887.6	998.1	837.3	1025.4	2115.5	13697.8	3407.4	4493.6	11996.5	16761.7	6256.7
2016	3724.2	2175.1	2018.7	1564.3	1436.0	6863.2	12078.3	6279.3	5895.1	12858.6	3494.6	3879.3
2017	4928.5	3596.9	2507.2	1819.2	1693.7	15463.5	18393.4	9977.7	4203.2	7362.6	2661.6	2038.6
2018	3640.4	2951.3	2338.6	2061.4	1908.2	4866.8	27552.6	21345.0	7928.6	3848.7	2719.6	1722.6
2019	1795.6	2252.1	2200.3	1834.3	1726.4	2121.8	55982.4	25158.6	8442.8	13633.6	3281.0	2453.0
2020	3142.8	2849.8	2676.4	1881.4	3490.3	13552.3	8589.4	13209.6	9499.3	12172.6	2986.1	2035.6
2021	3634.7	3326.3	3885.3	1757.0	1712.1	11348.6	25681.7	16311.5	9839.4	6668.0	5482.1	11313.9
2022	952.4	490.2	440.3	370.6	411.2	1155.7	995.0	1302.7	1254.9	2438.5	1506.9	1820.5
2023	2460.2	1806.3	1239.5	1217.5	1078.4	2337.5	17139.3	6102.7	3397.2	3290.1	1980.3	1306.0
2024	3774.9	2471.2	1923.1	1639.8	1516.1	7990.0	6625.7	2914.8	5145.4	5767.8	2642.3	2492.1
2025	2300.9	2052.9	1957.3	1658.0	1738.9	4745.0	15891.3	3874.9	11526.2	3290.6	1556.9	971.0
WETOF												
2015	1571.6	887.9	998.1	837.3	1025.4	2115.5	13698.1	3407.8	4493.6	11999.0	16812.0	6424.9
2016	3861.2	2286.2	2116.6	1668.9	1576.3	7037.7	12243.5	6455.4	6129.4	13204.9	3773.7	4092.3
2017	5035.3	3704.1	2634.1	1954.2	1836.0	15631.9	18637.9	10347.9	4620.6	7756.8	2931.0	2187.4
2018	3718.4	2988.2	2372.0	2103.2	1966.3	4944.8	27646.7	21488.0	8102.5	4020.9	2879.3	1821.3
2019	1867.1	2288.1	2237.3	1885.3	1796.5	2199.4	56093.9	25399.5	8882.7	14101.1	3759.2	2836.5
2020	3411.8	3096.3	2918.9	2100.4	4413.4	13886.9	8912.5	13634.7	9943.5	12581.9	3242.6	2173.0
2021	3675.0	3363.1	3926.3	1800.1	1768.5	11427.4	25787.0	16552.0	10223.9	7081.3	5826.7	11606.1
2022	1128.9	656.7	575.9	491.8	530.2	1355.0	1093.3	1419.2	1473.8	2620.9	1589.6	1865.4
2023	2485.0	1820.7	1255.2	1231.9	1100.3	2380.5	17212.6	6159.2	3481.8	3399.6	2079.4	1361.2
2024	3795.7	2487.2	1949.0	1664.0	1551.9	8069.9	6700.7	3017.6	5243.8	5824.2	2662.9	2495.3
2025	2300.9	2052.9	1957.3	1658.0	1738.9	4745.0	15891.3	3874.9	11526.2	3290.6	1556.9	971.0

Variance Data

	October	November	December	January	February	March	April	May	June	July	August	September
WET Baseline												
1-day min	952.4	490.2	440.3	370.6	411.2	1155.7	995.0	1302.7	1254.9	2438.5	1506.9	971.0
- 1 S.D.	1716.4	1307.8	1097.9	1004.7	852.6	1637.9	3733.9	1961.5	3351.3	3257.5	-241.7	266.9
Mean	2901.9	2260.0	2016.8	1512.8	1612.4	6596.4	18420.6	9989.5	6511.4	7575.2	4097.6	3299.0
+ 1 S.D.	4087.3	3212.1	2935.7	2020.9	2372.2	11554.8	33107.3	18017.4	9671.6	11893.0	8436.8	6331.1
1-day max	4928.5	3596.9	3885.3	2061.4	3490.3	15463.5	55982.4	25158.6	11526.2	13633.6	16761.7	11313.9
CV[1]	40.8	42.1	45.6	33.6	47.1	75.2	79.7	80.4	48.5	57.0	105.9	91.9
WETOF												
1-day min	1128.9	656.7	575.9	491.8	530.2	1355.0	1093.3	1419.2	1473.8	2620.9	1556.9	971.0
- 1 S.D.	1793.3	1369.9	1154.1	1061.3	772.3	1696.9	3858.5	2061.7	3540.6	3395.6	-40.6	341.6
Mean	2986.4	2330.1	2085.5	1581.4	1754.9	6708.6	18537.9	10159.7	6738.3	7807.4	4283.0	3439.5
+ 1 S.D.	4179.6	3290.4	3017.0	2101.4	2737.5	11720.3	33217.4	18257.6	9936.1	12219.2	8606.7	6537.4
1-day max	5035.3	3704.1	3926.3	2103.2	4413.4	15631.9	56093.9	25399.5	11526.2	14101.1	16812.0	11606.1
CV[1]	40.0	41.2	44.7	32.9	56.0	74.7	79.2	79.7	47.5	56.5	100.9	90.1

[1]CV=coefficient of variation (=SD*100/mean)

APPENDIX I-23B

PREDICTED IHA STATISTICS, WET VS. WETOF AT GRAND FORKS (GAGE 05082500) - MAGNITUDE (CFS), FREQUENCY (PER YEAR), AND DURATION (DAYS) OF EXTREME EVENTS

Final Aquatic Impact Analysis Report

Year	1-day min	3-day min	7-day min	30-day min	90-day min	1-day max	3-day max	7-day max	30-day max	90-day max	Zero days	Base flow	Date min	Date max	Low pulse #	Low pulse duration	High pulse #	High pulse duration	Rise rate	Fall rate	Reversals
WET Baseline																					
2015	667.3	693.6	790.5	833.4	906.0	25446.5	25416.5	25257.7	21242.1	11939.0	0.0	0.2	334.0	217.0	1.0	168.0	2.0	23.0	427.9	-235.4	62.0
2016	1323.6	1324.2	1347.7	1430.1	1638.1	26405.4	25707.2	23752.6	15428.3	8956.5	0.0	0.3	40.0	193.0	4.0	16.0	2.0	14.5	581.6	-284.0	58.0
2017	1203.0	1219.0	1283.6	1674.4	1840.5	35406.9	34995.8	33462.3	26818.1	15303.8	0.0	0.2	272.0	92.0	7.0	5.4	3.0	11.3	551.0	-276.7	75.0
2018	1449.4	1459.3	1474.7	1550.6	1904.0	57832.2	56130.6	50815.8	33291.8	19603.0	0.0	0.2	266.0	113.0	5.0	3.6	2.0	22.5	641.3	-431.0	84.0
2019	1454.1	1465.5	1489.0	1665.4	1885.0	126137.2	114884.3	19536.4	63623.0	30351.8	0.0	0.2	282.0	109.0	5.0	4.6	4.0	17.0	1115.5	-731.6	70.0
2020	1586.0	1601.8	1679.4	1872.1	2291.1	29419.8	28926.2	27052.1	15940.6	11970.1	0.0	0.3	272.0	141.0	2.0	3.0	4.0	11.0	551.2	-384.4	81.0
2021	1593.8	1594.0	1604.4	1154.8	698.6	48753.6	48061.6	45703.6	30726.1	19640.6	0.0	0.2	43.0	92.0	1.0	23.0	3.0	18.3	826.5	-512.0	59.0
2022	256.2	256.9	258.9	302.0	383.7	6522.7	5756.0	4358.0	2583.3	2065.5	0.0	0.2	42.0	183.0	7.0	43.4	0.0	0.0	161.9	-107.5	73.0
2023	905.3	1005.9	1007.6	1061.4	1174.8	23778.6	23638.3	23399.6	17234.0	9095.9	0.0	0.3	275.0	104.0	3.0	53.7	1.0	20.0	271.4	-161.0	75.0
2024	1321.5	1327.3	1349.8	1509.5	1674.7	14337.5	13930.5	12642.5	9812.1	5945.9	0.0	0.4	275.0	96.0	7.0	11.0	1.0	1.0	417.8	-257.6	65.0
2025	652.7	728.4	831.1	971.0	1148.7	31225.9	30961.6	29667.4	17648.4	10938.2	0.0	0.2	274.0	94.0	3.0	31.3	2.0	12.5	518.3	-261.0	74.0
WETOF																					
2015	667.3	693.6	790.5	833.4	906.1	25466.0	25435.5	25274.4	21248.9	12002.7	0.0	0.2	334.0	217.0	1.0	167.0	2.0	23.0	427.6	-234.7	62.0
2016	1454.4	1455.4	1477.0	1560.3	1752.2	26806.4	26110.2	24152.5	15627.1	9147.0	0.0	0.3	38.0	193.0	3.0	17.7	2.0	14.5	548.2	-292.2	64.0
2017	1296.5	1313.4	1384.3	1817.6	1979.1	35430.0	35020.9	33496.4	26915.5	15601.4	0.0	0.2	272.0	92.0	2.0	6.0	2.0	18.0	545.2	-277.3	73.0
2018	1524.5	1536.5	1548.8	1629.7	1976.2	57900.7	56198.6	50882.7	33399.1	19730.6	0.0	0.2	270.0	113.0	3.0	3.7	2.0	22.5	649.3	-431.8	84.0
2019	1538.4	1549.6	1572.5	1728.6	1947.2	126302.6	115042.4	19670.3	63773.1	30637.1	0.0	0.2	282.0	109.0	3.0	8.3	3.0	23.7	1133.1	-725.2	66.0
2020	1691.9	1707.3	1783.9	1990.7	2525.3	29965.7	29462.3	27561.3	16393.7	12447.2	0.0	0.3	272.0	141.0	1.0	1.0	4.0	11.8	604.2	-392.4	81.0
2021	1646.5	1647.9	1657.7	1333.9	859.9	48855.0	48163.1	45802.7	30820.2	19845.3	0.0	0.2	41.0	92.0	1.0	13.0	4.0	14.0	834.2	-510.0	55.0
2022	389.3	389.4	389.9	426.6	515.6	6756.5	5990.9	4614.7	2774.1	2161.8	0.0	0.3	40.0	183.0	10.0	28.4	0.0	0.0	156.5	-112.1	79.0
2023	938.6	1024.3	1027.0	1080.5	1192.6	23865.7	23725.4	23482.1	17307.5	9163.0	0.0	0.3	275.0	104.0	3.0	52.7	1.0	20.0	264.3	-164.3	75.0
2024	1353.2	1372.0	1394.2	1544.7	1693.2	14412.5	14005.4	12716.9	9895.3	6034.0	0.0	0.4	275.0	96.0	7.0	10.6	1.0	1.0	418.2	-255.7	69.0
2025	652.7	728.4	831.1	971.0	1718.7	31225.9	30961.6	29667.4	17648.4	10938.2	0.0	0.2	274.0	94.0	3.0	31.3	2.0	12.5	518.3	-261.0	74.0

Variance Data

	1-day min	3-day min	7-day min	30-day min	90-day min	1-day max	3-day max	7-day max	30-day max	90-day max	Zero days	Base flow	Date min	Date max	Low pulse #	Low pulse duration	High pulse #	High pulse duration	Rise rate	Fall rate	Reversals
WET Baseline																					
1-day min	256.2	256.9	258.9	302.0	383.7	6522.7	5756.0	4358.0	2583.3	2065.5	0.0	0.2	40.0	92.0	1.0	3.0	0.0	0.0	161.9	-731.6	58.0
- 1 S.D.	685.1	720.2	764.7	814.8	822.4	6344.1	7788.0	7114.2	7019.2	5504.8	0.0	0.2	149.0	114.0	1.8	-14.9	0.9	6.0	293.0	-507.1	61.9
Mean	1128.4	1152.4	1192.4	1275.0	1413.2	38660.6	37128.1	35058.9	23122.5	13255.5	0.0	0.2	215.9	130.4	4.1	33.0	2.2	13.7	551.3	-331.1	70.6
+ 1 S.D.	1571.8	1584.5	1620.1	1735.2	2004.0	70977.1	66468.2	63003.7	39225.8	21006.1	0.0	0.3	282.8	146.8	6.4	80.9	3.4	21.5	809.6	-155.2	79.2
1-day max	1593.8	1601.8	1679.4	1872.1	2291.1	126137.2	114884.3	109536.4	63623.0	30351.8	0.0	0.4	334.0	217.0	7.0	168.0	4.0	23.0	1115.5	-107.5	84.0
CV[1]	39.3	37.5	35.9	36.1	41.8	83.6	79.0	79.7	69.6	58.5		26.1	31.0	12.6	56.2	145.2	57.3	56.4	46.9	-53.1	12.2
WETOF																					
1-day min	389.3	389.4	389.9	426.6	515.6	6756.5	5990.9	4614.7	2774.1	2161.8	0.0	0.2	38.0	92.0	1.0	1.0	0.0	0.0	156.5	-725.2	55.0
- 1 S.D.	741.1	776.7	822.7	879.8	947.1	6512.8	7959.3	7291.7	7163.5	5623.6	0.0	0.2	148.3	114.0	0.6	-16.7	0.9	6.5	289.3	-506.0	62.3
Mean	1195.8	1219.8	1259.7	1356.1	1551.5	38817.0	37283.3	35211.0	23254.8	13428.0	0.0	0.2	215.7	130.4	3.4	30.9	2.1	14.6	554.4	-332.4	71.1
+ 1 S.D.	1650.5	1662.9	1696.8	1832.4	2155.9	71121.2	66607.4	63130.3	39346.1	21232.4	0.0	0.3	283.2	146.8	6.1	78.5	3.3	22.8	819.6	-158.8	79.9
1-day max	1691.9	1707.3	1783.9	1990.7	2525.3	126302.6	115042.4	109670.3	63773.1	30637.1	0.0	0.4	334.0	217.0	10.0	167.0	4.0	23.7	1133.1	-112.1	84.0
CV[1]	38.0	36.3	34.7	35.1	39.0	83.2	78.7	79.3	69.2	58.1		29.2	31.3	12.6	82.4	154.2	58.4	55.8	47.8	-52.2	12.4

[1]CV=coefficient of variation (=SD*100/mean)

APPENDIX I-24A

PREDICTED IHA STATISTICS, WET VS. WETOF AT EMERSON (GAGE 05092000) - MONTHLY AVERAGE FLOW (CFS)

Final Aquatic Impact Analysis Report

Year	October	November	December	January	February	March	April	May	June	July	August	September
WET Baseline												
2015	2523.0	1021.4	1116.9	928.3	1046.3	1311.3	15728.8	4093.7	4577.8	10289.0	25555.3	9548.4
2016	4284.3	3074.4	2258.9	1639.5	1472.8	6178.7	17295.3	7341.4	6433.7	14177.0	4571.8	4642.8
2017	5465.5	5116.1	2997.7	2024.9	1755.6	14827.9	32141.1	13740.8	6018.4	8414.3	3842.8	2718.3
2018	3571.2	3469.3	2493.2	2131.6	1976.1	3993.4	27887.9	40427.5	15103.0	4822.0	3251.2	1893.9
2019	1929.0	2604.4	2401.5	2020.3	1932.6	2214.1	48968.8	56893.7	10610.0	19092.1	4253.6	2934.6
2020	3806.3	3490.7	3143.8	2247.1	2753.2	20326.6	17438.0	14589.2	11058.1	16273.1	3622.4	2389.8
2021	3834.0	3721.0	4740.9	2253.5	2097.2	7316.8	43789.6	21254.6	14316.0	9403.8	6503.3	12760.1
2022	2086.2	711.8	507.8	403.0	348.1	1495.4	1773.9	1242.4	1729.5	2971.4	1628.1	2235.4
2023	2472.6	2017.5	1334.8	1278.3	1100.0	1745.2	22331.5	8682.5	4269.6	4163.9	2624.5	1404.0
2024	4227.5	2906.5	2117.6	1690.1	1561.2	9109.9	11122.3	3522.8	5055.2	6805.8	2782.6	3197.1
2025	2299.0	2303.2	1962.8	1702.6	1600.3	3079.7	19689.8	4378.4	12475.8	4028.5	1780.5	1042.7
WETOF												
2015	2530.8	1022.2	1116.9	928.3	1046.3	1311.3	15729.0	4094.1	4577.9	10289.6	25569.0	9733.6
2016	4423.4	3187.4	2355.4	1740.8	1601.4	6332.6	17490.9	7508.1	6656.2	14509.6	4863.6	4864.0
2017	5569.7	5224.9	3120.5	2153.8	1896.8	14968.6	32325.7	14158.5	6442.5	8811.7	4130.8	2886.4
2018	3662.2	3508.5	2525.9	2169.7	2027.8	4065.6	27962.9	40542.4	15312.1	4996.1	3416.7	1999.6
2019	2005.0	2645.1	2436.2	2067.2	1998.9	2293.3	49062.3	57057.8	11074.7	19569.9	4728.6	3342.7
2020	4091.0	3732.7	3389.7	2467.1	3339.4	20659.3	17765.2	14956.8	11500.0	16734.7	3896.9	2544.1
2021	3875.6	3758.0	4781.5	2293.4	2151.9	7383.6	43877.9	21459.6	14710.4	9816.9	6857.7	13070.4
2022	2261.0	878.2	649.6	526.0	465.4	1706.3	1896.6	1316.1	1951.2	3174.0	1723.2	2284.5
2023	2503.5	2031.5	1350.3	1293.2	1119.1	1784.1	22400.5	8742.1	4348.7	4267.9	2727.0	1469.5
2024	4254.9	2919.3	2142.1	1714.5	1591.2	9187.4	11196.4	3620.4	5155.6	6872.1	2806.7	3202.6
2025	2299.0	2303.2	1962.8	1702.6	1600.3	3079.7	19689.8	4378.4	12475.8	4028.5	1780.5	1042.7

Variance Data

	October	November	December	January	February	March	April	May	June	July	August	September
WET Baseline												
1-day min	1929.0	711.8	507.8	403.0	348.1	1311.3	1773.9	1242.4	1729.5	2971.4	1628.1	1042.7
- 1 S.D.	2187.9	1516.6	1144.2	1078.4	971.9	352.4	9573.7	-1541.9	3800.2	3743.5	-1300.6	369.3
Mean	3318.1	2766.9	2279.6	1665.4	1604.0	6509.0	23469.7	16015.2	8331.6	9131.0	5492.4	4069.7
+ 1 S.D.	4448.2	4017.3	3415.1	2252.4	2236.0	12665.6	37365.7	33572.3	12862.9	14518.5	12285.4	7770.2
1-day max	5465.5	5116.1	4740.9	2253.5	2753.2	20326.6	48968.8	56893.7	15103.0	19092.1	25555.3	12760.1
CV[1]	34.1	45.2	49.8	35.2	39.4	94.6	59.2	109.6	54.4	59.0	123.7	90.9
WETOF												
1-day min	2005.0	878.2	649.6	526.0	465.4	1311.3	1896.6	1316.1	1951.2	3174.0	1723.2	1042.7
- 1 S.D.	2254.9	1571.1	1198.1	1129.8	974.6	390.3	9690.5	-1418.8	3974.0	3853.1	-1078.8	455.2
Mean	3406.9	2837.4	2348.3	1732.4	1712.6	6615.6	23581.6	16166.7	8564.1	9370.1	5681.9	4221.8
+ 1 S.D.	4559.0	4103.6	3498.5	2335.0	2450.6	12841.0	37472.7	33752.3	13154.2	14887.1	12442.6	7988.4
1-day max	5569.7	5224.9	4781.5	2467.1	3339.4	20659.3	49062.3	57057.8	15312.1	19569.9	25569.0	13070.4
CV[1]	33.8	44.6	49.0	34.8	43.1	94.1	58.9	108.8	53.6	58.9	119.0	89.2

[1]CV=coefficient of variation (=SD*100/mean)

APPENDIX I-24B

PREDICTED IHA STATISTICS, WET VS. WETOF AT EMERSON (GAGE 05092000) - MAGNITUDE (CFS), FREQUENCY (PER YEAR), AND DURATION (DAYS) OF EXTREME EVENTS

Final Aquatic Impact Analysis Report

Year	1-day min	3-day min	7-day min	30-day min	90-day min	1-day max	3-day max	7-day max	30-day max	90-day max	Zero days	Base flow	Date min	Date max	Low pulse #	Low pulse duration	High pulse #	High pulse duration	Rise rate	Fall rate	Reversals
WET Baseline																					
2015	865.8	867.1	871.1	917.3	1007.5	30091.7	30026.5	29828.9	26739.3	15408.9	0.0	0.1	29.0	228.0	1.0	165.0	2.0	23.0	374.0	-263.2	34.0
2016	1422.0	1425.0	1430.6	1474.8	1685.9	25631.5	25483.0	25088.6	19678.5	10928.3	0.0	0.2	44.0	99.0	1.0	71.0	2.0	15.0	486.4	-239.7	38.0
2017	1612.0	1574.5	1618.7	1708.1	1992.7	40753.8	40434.9	39831.0	36436.1	21376.3	0.0	0.2	274.0	93.0	2.0	26.0	1.0	40.0	680.2	-255.5	36.0
2018	1540.5	1563.0	1628.1	1759.9	2097.5	62499.3	61711.8	58695.2	47087.9	28382.1	0.0	0.2	276.0	118.0	2.0	6.5	1.0	55.0	635.4	-318.6	43.0
2019	1758.1	1760.9	1774.0	1878.3	2050.53 1	25061.20 1	24157.40 1	19294.9	82240.3	40488.1	0.0	0.1	286.0	117.0	3.0	10.0	2.0	37.5	982.6	-664.7	21.0
2020	1869.9	1930.0	1970.3	2143.2	2599.0	26940.3	26870.7	26443.9	21116.7	17492.8	0.0	0.2	274.0	71.0	1.0	1.0	4.0	16.0	608.0	-342.3	40.0
2021	1935.2	1937.1	1949.7	2037.7	1192.7	56196.5	55973.1	54805.3	43950.0	27180.5	0.0	0.2	31.0	103.0	0.0	0.0	3.0	20.7	704.9	-513.9	34.0
2022	271.2	271.8	274.8	319.1	417.9	6647.1	6350.5	5197.1	3018.7	2333.8	0.0	0.2	47.0	275.0	7.0	39.9	0.0	0.0	136.6	-89.1	36.0
2023	958.5	964.1	1039.9	1107.8	1213.4	32697.7	32541.6	31749.1	22788.0	11849.2	0.0	0.2	277.0	109.0	3.0	52.3	1.0	21.0	308.3	-210.5	44.0
2024	1361.4	1379.1	1427.7	1539.5	1765.5	21040.1	20786.3	19264.7	13556.5	8068.5	0.0	0.3	275.0	100.0	4.0	21.5	1.0	5.0	425.8	-208.5	31.0
2025	952.1	966.1	986.4	1042.7	1544.9	29802.3	29682.2	29098.2	19899.1	12146.9	0.0	0.2	274.0	102.0	4.0	29.0	2.0	14.0	512.6	-207.0	22.0
WETOF																					
2015	865.8	867.1	871.1	917.3	1007.5	30099.7	30033.4	29837.1	26746.1	15471.5	0.0	0.1	29.0	228.0	1.0	165.0	2.0	23.0	374.7	-263.1	34.0
2016	1550.1	1552.1	1556.0	1598.4	1795.6	25874.7	25720.6	25324.9	19879.1	11113.3	0.0	0.3	43.0	99.0	1.0	66.0	2.0	15.5	472.5	-242.3	40.0
2017	1724.9	1683.6	1728.6	1851.6	2129.4	40891.3	40571.1	39958.7	36529.6	21668.6	0.0	0.2	274.0	93.0	3.0	9.0	1.0	41.0	666.1	-257.2	38.0
2018	1646.0	1668.8	1716.9	1845.4	2147.6	62550.7	61762.6	58744.3	47185.6	28509.8	0.0	0.2	276.0	118.0	2.0	5.5	1.0	55.0	633.4	-320.4	45.0
2019	1840.8	1843.6	1856.4	1935.5	2112.13 1	25204.70 1	24309.20 1	19455.6	82358.7	40763.9	0.0	0.1	286.0	117.0	3.0	4.0	2.0	38.0	982.5	-663.6	21.0
2020	1974.5	2033.8	2059.0	2216.3	2833.1	27282.7	27212.1	26783.4	21460.8	17840.6	0.0	0.2	274.0	71.0	0.0	0.0	4.0	17.3	626.9	-346.7	38.0
2021	1979.3	1981.5	1992.4	2084.2	1355.8	56260.4	56037.0	54869.5	44031.6	27384.1	0.0	0.2	30.0	103.0	0.0	0.0	3.0	21.0	699.0	-514.3	32.0
2022	397.9	398.4	400.5	439.2	549.2	6899.8	6595.5	5423.7	3230.0	2462.6	0.0	0.3	46.0	275.0	7.0	37.0	0.0	0.0	136.9	-92.2	36.0
2023	995.1	1000.1	1058.6	1126.9	1231.2	32733.3	32578.4	31797.7	22860.4	11916.8	0.0	0.2	277.0	109.0	3.0	51.7	1.0	21.0	304.4	-212.6	42.0
2024	1402.6	1418.8	1458.3	1571.8	1783.8	21106.9	20852.5	19333.6	13636.6	8154.6	0.0	0.3	275.0	100.0	4.0	21.5	1.0	5.0	422.6	-208.1	31.0
2025	952.1	966.1	986.4	1042.7	1760.4	29802.3	29682.2	29098.2	19899.1	12146.9	0.0	0.2	274.0	102.0	4.0	29.0	2.0	14.0	512.6	-207.0	22.0

Variance Data

	1-day min	3-day min	7-day min	30-day min	90-day min	1-day max	3-day max	7-day max	30-day max	90-day max	Zero days	Base flow	Date min	Date max	Low pulse #	Low pulse duration	High pulse #	High pulse duration	Rise rate	Fall rate	Reversals
WET Baseline																					
1-day min	271.2	271.8	274.8	319.1	417.9	6647.1	6350.5	5197.1	3018.7	2333.8	0.0	0.1	29.0	71.0	0.0	0.0	0.0	0.0	136.6	-664.7	21.0
- 1 S.D.	813.4	817.0	841.6	897.9	988.4	9826.9	9750.6	9614.4	9140.3	6915.7	0.0	0.2	127.2	106.5	0.6	-9.1	0.6	6.4	305.0	-461.6	27.0
Mean	1322.4	1330.8	1361.0	1448.0	1597.1	41578.3	41274.4	39936.1	30591.9	17786.9	0.0	0.2	189.7	128.6	2.6	38.4	1.7	22.5	532.2	-301.2	34.5
+ 1 S.D.	1831.5	1844.6	1880.5	1998.2	2205.7	73329.7	72798.1	70257.8	52043.5	28658.0	0.0	0.3	252.3	150.8	4.5	85.8	2.8	38.5	759.5	-140.7	41.9
1-day max	1935.2	1937.1	1970.3	2143.2	2599.0	125061.2	124157.4	119294.9	82240.3	40488.1	0.0	0.3	286.0	275.0	7.0	165.0	4.0	55.0	982.6	-89.1	44.0
CV[1]	38.5	38.6	38.2	38.0	38.1	76.4	76.4	75.9	70.1	61.1		25.0	33.0	17.2	76.9	123.6	63.6	71.4	42.7	-53.3	21.7
WETOF																					
1-day min	397.9	398.4	400.5	439.2	549.2	6899.8	6595.5	5423.7	3230.0	2462.6	0.0	0.1	29.0	71.0	0.0	0.0	0.0	0.0	136.9	-663.6	21.0
- 1 S.D.	873.7	877.0	897.8	953.8	1068.0	9966.7	9886.3	9745.8	9276.9	7023.2	0.0	0.2	126.8	106.5	0.5	-13.0	0.6	6.7	302.8	-462.2	26.8
Mean	1393.6	1401.3	1425.9	1511.8	1700.5	41700.6	41395.9	40057.0	30710.7	17948.4	0.0	0.2	189.5	128.6	2.6	35.3	1.7	22.8	530.2	-302.5	34.5
+ 1 S.D.	1913.4	1925.5	1953.9	2069.7	2333.0	73434.5	72905.4	70368.1	52144.5	28873.6	0.0	0.3	252.1	150.8	4.6	83.6	2.8	38.9	757.5	-142.8	42.1
1-day max	1979.3	2033.8	2059.0	2216.3	2833.1	125204.7	124309.2	119455.6	82358.7	40763.9	0.0	0.3	286.0	275.0	7.0	165.0	4.0	55.0	982.5	-92.2	45.0
CV[1]	37.3	37.4	37.0	36.9	37.2	76.1	76.1	75.7	69.8	60.9		28.6	33.1	17.2	80.8	136.7	63.6	70.7	42.9	-52.8	22.1

[1]CV=coefficient of variation (=SD*100/mean)

APPENDIX J

RANGE OF VARIABILITY SCORE CARD FOR THE COMPARISON OF BASELINE AND PUMPING/OVERFLOW IHA STATISTICS

APPENDIX J-1
RANGE OF VARIABILITY SCORE CARD FOR COMPARISON OF MOD50 AND 300MOD50 IHA STATISTICS AT COOPERSTOWN
Final Aquatic Impact Analysis Report

	MOD50				300MOD50				RVA Targets		
	Means	SD % of mean	1-day min Low	1-day max High	Means	SD % of mean	1-day min Low	1-day max High	-1 SD Low	+1 SD High	Hydrologic Alternation
Parameter	Group #1										
October	47.2	0.8	12.6	111.9	58.2	0.7	14.4	131.5	17.8	83.9	0.14
November	47.9	0.6	19.1	125.3	60.7	0.6	27.3	157.1	22.9	77.6	0.13
December	34.3	0.8	12.8	102.6	38.7	0.7	15.8	112.2	15.3	60.5	0.25
January	20.8	0.6	6.5	40.7	20.8	0.6	6.5	40.7	7.9	33.8	0.00
February	19.1	0.7	3.3	40.9	19.1	0.6	3.3	40.9	6.7	31.5	0.00
March	131.0	1.0	33.7	392.8	131.0	1.0	33.7	392.8	41.5	261.3	0.00
April	1199.5	0.9	245.4	3315.2	1199.5	0.9	245.4	3315.2	446.9	2254.5	0.00
May	499.3	1.1	47.8	1559.8	561.2	1.0	57.5	1678.6	148.6	1034.8	-0.14
June	184.4	0.8	45.7	558.4	250.8	0.8	64.0	768.2	87.1	325.1	0.00
July	140.1	1.0	13.5	470.9	193.8	1.0	18.9	664.5	25.5	279.7	-0.25
August	68.0	1.3	9.8	307.3	100.1	1.4	14.1	475.8	19.1	157.4	-0.13
September	66.2	1.2	6.2	264.8	98.6	1.2	7.3	423.6	12.0	144.5	0.00
Parameter	Group #2										
1-day minimum	10.8	1.0	1.9	31.9	11.8	0.9	2.5	31.9	2.9	21.6	0.17
3-day minimum	11.1	1.0	1.9	32.7	12.1	0.9	2.5	32.7	3.4	22.1	0.00
7-day minimum	11.4	0.9	2.0	32.9	12.6	0.8	2.6	32.9	3.6	22.2	0.00
30-day minimum	12.4	0.7	3.4	33.5	15.0	0.7	3.4	33.5	5.4	21.6	-0.25
90-day minimum	17.3	0.6	6.3	36.5	18.4	0.5	6.4	36.6	7.8	26.9	0.00
1-day maximum	2365.7	0.8	589.3	6059.0	2365.7	0.8	589.3	6059.0	962.6	4202.7	0.00
3-day maximum	2283.3	0.8	562.3	5802.4	2283.3	0.8	562.3	5802.4	946.7	4053.3	0.00
7-day maximum	2076.4	0.8	489.9	5268.3	2076.4	0.8	489.9	5268.3	917.8	3698.5	0.00
30-day maximum	1325.8	0.9	256.0	3666.5	1330.2	0.9	256.0	3666.5	539.7	2464.3	0.00
90-day maximum	658.7	0.8	119.0	1729.8	700.1	0.8	127.4	1802.4	321.1	1208.2	0.00
Number of zero days	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00
Base flow	0.1	0.5	0.0	0.1	0.1	0.6	0.0	0.1	0.0	0.1	-0.17
Parameter	Group #3										
Date of minimum	149.3	0.3	24.0	275.0	148.4	0.3	24.0	275.0	104.3	194.2	0.00
Date of maximum	104.1	0.0	90.0	118.0	104.1	0.0	90.0	118.0	101.6	106.6	0.00
Parameter	Group #4										
Low pulse count	3.2	0.8	0.0	7.0	2.2	0.9	0.0	6.0	0.5	5.8	0.40
Low pulse duration	21.3	0.9	0.0	55.7	27.3	1.0	0.0	79.5	3.1	39.6	-0.33
High pulse count	1.2	0.6	0.0	3.0	1.4	0.9	0.0	5.0	0.4	1.9	0.00
High pulse duration	18.5	0.9	0.0	50.0	20.1	1.0	0.0	58.0	2.2	34.9	0.00
Parameter	Group #5										
Rise rate	27.0	0.8	5.9	64.9	28.8	0.8	5.9	73.4	6.4	47.6	-0.13
Fall rate	-15.1	-0.7	-33.2	-3.4	-15.2	-0.7	-33.6	-3.7	-25.6	-4.5	0.00
Number of reversals	85.6	0.1	73.0	97.0	79.1	0.1	63.0	93.0	77.9	93.4	0.00

COMPARISON STATISTISTICS OF OBSERVED (300MOD50) VALUES ABOVE AND BELOW EXPECTED (MOD50)

	Within RVA range			Above RVA Range			Above RVA Range		
	Expected (E)	Observed (O)	O-E/E	Expected (E)	Observed (O)	O-E/E	Expected (E)	Observed (O)	O-E/E
Parameter	Group #1								
October	7	8	0.14	2	2	0.00	2	1	-0.50
November	8	9	0.13	1	2	1.00	2	0	-1.00
December	8	10	0.25	1	1	0.00	2	0	-1.00
January	8	8	0.00	2	2	0.00	1	1	0.00
February	7	7	0.00	2	2	0.00	2	2	0.00
March	7	7	0.00	2	2	0.00	2	2	0.00
April	6	6	0.00	3	3	0.00	2	2	0.00
May	7	6	-0.14	2	3	0.50	2	2	0.00
June	8	8	0.00	1	2	1.00	2	1	-0.50
July	8	6	-0.25	1	3	2.00	2	2	0.00
August	8	7	-0.13	1	2	1.00	2	2	0.00
September	7	7	0.00	2	2	0.00	2	2	0.00
Parameter	Group #2								
1-day minimum	6	7	0.17	3	3	0.00	2	1	-0.50
3-day minimum	6	6	0.00	3	3	0.00	2	2	0.00
7-day minimum	6	6	0.00	3	3	0.00	2	2	0.00
30-day minimum	8	6	-0.25	1	4	3.00	2	1	-0.50
90-day minimum	8	8	0.00	2	2	0.00	1	1	0.00
1-day maximum	6	6	0.00	3	3	0.00	2	2	0.00
3-day maximum	6	6	0.00	3	3	0.00	2	2	0.00
7-day maximum	6	6	0.00	3	3	0.00	2	2	0.00
30-day maximum	7	7	0.00	2	2	0.00	2	2	0.00
90-day maximum	6	6	0.00	3	3	0.00	2	2	0.00
Number of zero days	11	11	0.00	0	0	0.00	0	0	0.00
Base flow	6	5	-0.17	3	3	0.00	2	3	0.50
Parameter	Group #3								
Date of minimum	0	0	0.00	6	6	0.00	5	5	0.00
Date of maximum	1	1	0.00	4	4	0.00	6	6	0.00
Parameter	Group #4								
Low pulse count	5	7	0.40	3	1	-0.67	3	3	0.00
Low pulse duration	6	4	-0.33	2	4	1.00	3	3	0.00
High pulse count	8	8	0.00	2	2	0.00	1	1	0.00
High pulse duration	8	8	0.00	2	2	0.00	1	1	0.00
Parameter	Group #5								
Rise rate	8	7	-0.13	2	3	0.50	1	1	0.00
Fall rate	7	7	0.00	1	1	0.00	3	3	0.00
Number of reversals	7	7	0.00	3	0	-1.00	1	4	3.00

APPENDIX J-2
RANGE OF VARIABILITY SCORE CARD FOR COMPARISON OF MOD50 AND 300MOD50 IHA STATISTICS AT BALDHILL DAM
Final Aquatic Impact Analysis Report

	MOD50				300MOD50				RVA Targets		
	Means	SD % of mean	1-day min Low	1-day max High	Means	SD % of mean	1-day min Low	1-day max High	-1 SD Low	+1 SD High	Hydrologic Alternation
Parameter	Group #1										
October	179.4	0.2	133.4	246.5	190.6	0.2	141.1	267.8	139.7	219.0	0.14
November	171.4	0.2	129.7	246.5	184.2	0.2	137.8	278.4	136.5	206.4	-0.22
December	151.2	0.3	116.4	247.8	155.9	0.3	119.4	258.3	119.6	191.6	0.13
January	31.5	0.6	13.0	62.7	31.5	0.6	13.0	62.8	14.5	50.0	0.00
February	31.0	0.7	13.0	71.7	31.0	0.7	13.0	71.7	13.0	51.9	0.00
March	233.7	0.8	69.3	640.9	233.7	0.8	69.3	640.9	109.8	428.4	0.00
April	1270.4	1.2	13.0	4459.5	1270.4	1.2	13.0	4459.5	239.7	2790.5	0.00
May	688.7	1.2	20.6	2289.4	747.8	1.1	30.0	2401.7	164.4	1491.6	0.00
June	240.4	0.9	61.5	812.7	308.1	0.8	79.6	1022.5	117.2	444.8	0.00
July	165.5	1.0	17.9	572.0	219.4	1.0	23.3	768.1	32.9	328.5	0.00
August	97.6	1.1	24.8	392.6	129.8	1.2	26.2	556.4	33.3	204.3	0.00
September	89.4	1.0	15.7	316.6	122.2	1.1	16.6	480.7	19.9	181.5	0.14
Parameter	Group #2										
1-day minimum	17.1	0.4	13.0	33.0	17.1	0.4	13.0	33.0	13.0	24.3	0.00
3-day minimum	17.3	0.4	13.0	34.3	17.5	0.4	13.0	34.3	13.0	24.9	0.00
7-day minimum	17.6	0.5	13.0	35.7	18.0	0.4	13.0	35.7	13.0	25.7	0.00
30-day minimum	23.1	0.6	13.0	50.3	23.2	0.6	13.0	50.3	13.0	36.1	0.00
90-day minimum	42.8	0.4	23.7	79.2	43.4	0.4	25.0	79.5	25.9	59.7	-0.11
1-day maximum	2368.1	0.9	367.4	7283.7	2368.1	0.9	367.4	7283.7	719.9	4578.1	0.00
3-day maximum	2267.3	0.9	294.5	6903.1	2267.3	0.9	294.5	6903.1	711.2	4405.1	0.00
7-day maximum	2101.6	1.0	197.0	6485.0	2101.6	1.0	197.0	6485.0	643.5	4141.5	0.00
30-day maximum	1484.6	1.0	143.7	4662.1	1491.7	1.0	159.2	4669.4	493.8	3042.7	0.00
90-day maximum	800.7	1.0	134.4	2401.4	841.7	1.0	146.0	2471.4	305.4	1607.6	0.00
Number of zero days	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00
Base flow	0.1	0.6	0.0	0.2	0.1	0.6	0.0	0.2	0.1	0.1	-0.13
Parameter	Group #3										
Date of minimum	54.7	0.1	1.0	111.0	54.7	0.1	1.0	111.0	47.9	61.6	0.00
Date of maximum	101.8	0.0	89.0	120.0	101.8	0.0	89.0	120.0	98.5	105.1	0.00
Parameter	Group #4										
Low pulse count	8.6	0.4	3.0	15.0	8.1	0.5	3.0	15.0	4.8	12.5	-0.13
Low pulse duration	11.8	0.9	1.2	39.0	11.9	0.8	1.2	32.7	4.8	22.6	0.00
High pulse count	1.5	0.9	0.0	4.0	1.4	0.9	0.0	4.0	0.2	2.8	0.17
High pulse duration	10.6	1.4	0.0	47.0	13.3	1.4	0.0	54.0	0.0	25.1	-0.20
Parameter	Group #5										
Rise rate	47.0	0.4	21.3	76.7	48.2	0.4	21.9	83.4	28.8	65.3	0.00
Fall rate	-36.4	-0.4	-58.1	-16.3	-36.0	-0.4	-58.4	-16.2	-51.5	-21.3	0.00
Number of reversals	142.0	0.2	96.0	187.0	139.7	0.2	96.0	189.0	115.1	168.9	0.00

COMPARISON STATISTISTICS OF OBSERVED (300MOD50) VALUES ABOVE AND BELOW EXPECTED (MOD50)

	Within RVA range			Above RVA Range			Above RVA Range		
	Expected (E)	Observed (O)	O-E/E	Expected (E)	Observed (O)	O-E/E	Expected (E)	Observed (O)	O-E/E
Parameter	Group #1								
October	7	8	0.14	3	3	0.00	1	0	-1.00
November	9	7	-0.22	1	4	3.00	1	0	-1.00
December	8	9	0.13	1	1	0.00	2	1	-0.50
January	7	7	0.00	2	2	0.00	2	2	0.00
February	7	7	0.00	2	2	0.00	2	2	0.00
March	6	6	0.00	3	3	0.00	2	2	0.00
April	7	7	0.00	2	2	0.00	2	2	0.00
May	7	7	0.00	2	2	0.00	2	2	0.00
June	8	8	0.00	1	1	0.00	2	2	0.00
July	8	8	0.00	1	2	1.00	2	1	-0.50
August	8	8	0.00	1	2	1.00	2	1	-0.50
September	7	8	0.14	2	2	0.00	2	1	-0.50
Parameter	Group #2								
1-day minimum	9	9	0.00	2	2	0.00	0	0	0.00
3-day minimum	9	9	0.00	2	2	0.00	0	0	0.00
7-day minimum	9	9	0.00	2	2	0.00	0	0	0.00
30-day minimum	7	7	0.00	2	2	0.00	2	2	0.00
90-day minimum	9	8	-0.11	1	2	1.00	1	1	0.00
1-day maximum	7	7	0.00	2	2	0.00	2	2	0.00
3-day maximum	7	7	0.00	2	2	0.00	2	2	0.00
7-day maximum	7	7	0.00	2	2	0.00	2	2	0.00
30-day maximum	7	7	0.00	2	2	0.00	2	2	0.00
90-day maximum	6	6	0.00	3	3	0.00	2	2	0.00
Number of zero days	11	11	0.00	0	0	0.00	0	0	0.00
Base flow	8	7	-0.13	1	1	0.00	2	3	0.50
Parameter	Group #3								
Date of minimum	0	0	0.00	6	6	0.00	5	5	0.00
Date of maximum	1	1	0.00	5	5	0.00	5	5	0.00
Parameter	Group #4								
Low pulse count	8	7	-0.13	2	3	0.50	1	1	0.00
Low pulse duration	8	8	0.00	1	1	0.00	2	2	0.00
High pulse count	6	7	0.17	2	1	-0.50	3	3	0.00
High pulse duration	10	8	-0.20	1	3	2.00	0	0	0.00
Parameter	Group #5								
Rise rate	7	7	0.00	3	3	0.00	1	1	0.00
Fall rate	6	6	0.00	2	2	0.00	3	3	0.00
Number of reversals	8	8	0.00	1	1	0.00	2	2	0.00

APPENDIX J-3
RANGE OF VARIABILITY SCORE CARD FOR COMPARISON OF MOD50 AND 300MOD50 IHA STATISTICS AT LISBON
Final Aquatic Impact Analysis Report

	MOD50				300MOD50				RVA Targets		
		SD	1-day min	1-day max		SD	1-day min	1-day max	-1 SD	+1 SD	Hydrologic
	Means	% of mean	Low	High	Means	% of mean	Low	High	Low	High	Alternation
Parameter	Group #1										
October	172.4	0.3	115.9	257.3	184.5	0.3	126.2	285.2	123.1	221.6	0.00
November	201.5	0.2	147.8	266.1	214.0	0.2	155.5	290.7	155.4	247.5	0.17
December	170.6	0.3	120.0	263.7	176.8	0.3	123.9	277.4	121.5	219.7	0.00
January	58.2	0.4	31.9	98.6	58.3	0.4	31.9	98.6	33.7	82.8	0.00
February	43.3	0.7	15.5	91.1	43.3	0.7	15.5	91.1	19.4	71.4	0.00
March	296.9	0.7	82.4	689.4	296.9	0.7	82.4	689.4	87.0	506.8	0.00
April	1543.2	1.2	87.1	5420.3	1543.2	1.2	87.1	5420.3	355.5	3364.5	0.00
May	923.5	1.3	20.6	3337.4	974.9	1.2	26.9	3433.3	193.1	2087.1	0.00
June	340.9	0.8	74.1	918.7	411.3	0.8	92.7	1124.8	79.7	602.2	-0.11
July	263.6	0.9	27.2	703.6	317.6	0.9	34.4	811.2	47.4	509.3	0.00
August	109.4	1.0	22.3	414.6	142.4	1.1	26.0	566.9	44.9	224.1	-0.13
September	122.4	1.0	17.9	402.0	155.9	1.1	18.9	577.8	30.6	242.0	0.14
Parameter	Group #2										
1-day minimum	26.3	0.7	13.1	58.8	26.8	0.7	13.1	58.8	13.4	44.1	0.17
3-day minimum	27.3	0.7	13.4	59.4	27.6	0.7	13.4	59.4	13.5	45.6	0.14
7-day minimum	28.5	0.7	13.5	61.6	28.6	0.7	13.8	61.6	14.0	47.6	0.00
30-day minimum	32.4	0.6	15.2	65.9	32.6	0.6	15.2	65.9	15.7	52.2	0.00
90-day minimum	58.9	0.4	30.5	114.7	59.7	0.4	33.2	115.3	34.6	83.2	0.00
1-day maximum	2800.5	0.9	372.9	8204.9	2804.8	0.9	372.9	8204.9	787.0	5394.1	0.00
3-day maximum	2722.8	0.9	341.9	8089.5	2726.9	0.9	341.9	8089.5	754.4	5275.3	0.00
7-day maximum	2467.2	1.0	298.6	7865.3	2470.9	1.0	298.6	7865.3	715.0	4891.0	0.00
30-day maximum	1819.7	1.1	201.0	5877.4	1823.2	1.0	201.0	5877.4	597.6	3730.9	0.00
90-day maximum	1026.6	1.0	142.1	3169.4	1065.5	1.0	154.5	3239.4	375.0	2069.5	0.00
Number of zero days	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00
Base flow	0.1	0.5	0.1	0.2	0.1	0.5	0.1	0.2	0.1	0.1	-0.17
Parameter	Group #3										
Date of minimum	133.4	0.3	26.0	256.0	104.7	0.3	26.0	256.0	96.3	170.5	0.00
Date of maximum	104.5	0.1	74.0	183.0	104.5	0.1	74.0	183.0	95.8	113.1	0.00
Parameter	Group #4										
Low pulse count	4.3	0.6	0.0	8.0	3.5	0.5	0.0	6.0	1.9	6.7	0.25
Low pulse duration	22.5	0.8	0.0	56.5	24.8	0.7	0.0	52.0	4.5	40.5	0.00
High pulse count	1.5	1.0	0.0	4.0	1.5	0.9	0.0	3.0	0.0	2.9	-0.25
High pulse duration	8.2	1.1	0.0	25.5	8.6	1.1	0.0	23.7	0.0	17.6	-0.11
Parameter	Group #5										
Rise rate	42.6	0.8	8.1	110.3	43.9	0.8	8.1	115.9	10.1	75.0	0.00
Fall rate	-27.4	-0.7	-65.2	-5.8	-27.6	-0.7	-64.6	-6.0	-47.0	-7.8	0.00
Number of reversals	87.8	0.2	66.0	106.0	84.6	0.2	68.0	106.0	74.2	101.4	-0.14

COMPARISON STATISTISTICS OF OBSERVED (300MOD50) VALUES ABOVE AND BELOW EXPECTED (MOD50)

	Within RVA range			Above RVA Range			Above RVA Range		
	Expected (E)	Observed (O)	O-E/E	Expected (E)	Observed (O)	O-E/E	Expected (E)	Observed (O)	O-E/E
Parameter	Group #1								
October	8	8	0.00	2	3	0.50	1	0	-1.00
November	6	7	0.17	3	4	0.33	2	0	-1.00
December	8	8	0.00	2	3	0.50	1	0	-1.00
January	8	8	0.00	2	2	0.00	1	1	0.00
February	6	6	0.00	3	3	0.00	2	2	0.00
March	7	7	0.00	3	3	0.00	1	1	0.00
April	7	7	0.00	2	2	0.00	2	2	0.00
May	7	7	0.00	2	2	0.00	2	2	0.00
June	9	8	-0.11	1	3	2.00	1	0	-1.00
July	7	7	0.00	2	3	0.50	2	1	-0.50
August	8	7	-0.13	1	2	1.00	2	2	0.00
September	7	8	0.14	2	2	0.00	2	1	-0.50
Parameter	Group #2								
1-day minimum	6	7	0.17	3	3	0.00	2	1	-0.50
3-day minimum	7	8	0.14	2	2	0.00	2	1	-0.50
7-day minimum	7	7	0.00	2	2	0.00	2	2	0.00
30-day minimum	7	7	0.00	2	2	0.00	2	2	0.00
90-day minimum	9	9	0.00	1	1	0.00	1	1	0.00
1-day maximum	7	7	0.00	2	2	0.00	2	2	0.00
3-day maximum	7	7	0.00	2	2	0.00	2	2	0.00
7-day maximum	7	7	0.00	2	2	0.00	2	2	0.00
30-day maximum	7	7	0.00	2	2	0.00	2	2	0.00
90-day maximum	7	7	0.00	2	2	0.00	2	2	0.00
Number of zero days	11	11	0.00	0	0	0.00	0	0	0.00
Base flow	6	5	-0.17	3	3	0.00	2	3	0.50
Parameter	Group #3								
Date of minimum	0	0	0.00	5	3	-0.40	6	8	0.33
Date of maximum	3	3	0.00	3	3	0.00	5	5	0.00
Parameter	Group #4								
Low pulse count	8	10	0.25	2	0	-1.00	1	1	0.00
Low pulse duration	8	8	0.00	1	1	0.00	2	2	0.00
High pulse count	4	3	-0.25	3	4	0.33	4	4	0.00
High pulse duration	9	8	-0.11	2	3	0.50	0	0	0.00
Parameter	Group #5								
Rise rate	8	8	0.00	2	2	0.00	1	1	0.00
Fall rate	8	8	0.00	1	1	0.00	2	2	0.00
Number of reversals	7	6	-0.14	2	1	-0.50	2	4	1.00

APPENDIX J-4
RANGE OF VARIABILITY SCORE CARD FOR COMPARISON OF MOD50 AND 300MOD50 IHA STATISTICS AT KINDRED
Final Aquatic Impact Analysis Report

	MOD50				300MOD50				RVA Targets		
	Means	SD % of mean	1-day min Low	1-day max High	Means	SD % of mean	1-day min Low	1-day max High	-1 SD Low	+1 SD High	Hydrologic Alternation
Parameter	Group #1										
October	200.7	0.3	120.6	336.8	213.6	0.3	133.2	352.4	132.9	268.4	0.13
November	247.0	0.3	166.3	376.6	259.4	0.3	177.1	387.2	176.2	317.8	0.14
December	208.3	0.3	128.9	328.4	215.8	0.3	133.7	337.3	136.6	280.0	0.17
January	97.5	0.4	57.6	147.8	97.6	0.4	57.7	147.9	62.9	132.1	0.00
February	64.0	0.6	25.2	143.6	64.1	0.6	25.2	143.6	27.8	100.3	0.00
March	314.8	0.8	62.2	773.5	314.8	0.8	62.2	773.5	113.9	580.5	0.00
April	1631.2	1.1	181.5	5450.0	1631.2	1.1	181.5	5450.0	478.1	3430.3	0.00
May	1129.0	1.2	45.6	4010.9	1173.2	1.2	47.5	4090.3	298.3	2501.6	0.00
June	425.8	0.7	104.3	1077.6	498.5	0.7	124.1	1277.3	128.6	723.0	-0.22
July	390.7	1.1	53.4	1471.6	444.9	1.0	63.2	1507.0	109.8	812.7	-0.13
August	153.2	0.8	38.2	497.2	187.3	0.9	41.2	640.9	72.4	283.1	-0.13
September	169.7	1.0	38.5	612.8	203.5	1.1	47.0	799.4	79.5	333.7	-0.13
Parameter	Group #2										
1-day minimum	47.3	0.7	14.6	116.6	47.3	0.7	14.6	116.6	14.7	79.9	0.00
3-day minimum	49.6	0.7	14.8	118.6	49.6	0.7	14.8	118.7	16.8	82.4	0.00
7-day minimum	52.1	0.6	15.0	121.0	52.1	0.6	15.0	121.0	19.3	84.9	0.00
30-day minimum	58.3	0.5	23.3	124.7	58.3	0.5	23.3	124.7	26.6	90.0	0.00
90-day minimum	88.9	0.4	46.0	168.1	91.2	0.4	46.0	183.2	52.8	124.9	0.00
1-day maximum	2918.7	0.9	515.9	8208.9	2921.9	0.9	515.9	8208.9	1048.4	5464.6	0.00
3-day maximum	2865.9	0.9	483.2	8154.5	2869.5	0.9	483.2	8154.5	1012.9	5400.1	0.00
7-day maximum	2709.5	0.9	433.8	8033.9	2713.3	0.9	433.8	8033.9	946.7	5188.1	0.00
30-day maximum	1975.4	1.0	255.6	6202.9	1979.4	1.0	255.6	6202.9	755.0	3947.0	0.00
90-day maximum	1162.2	1.0	155.2	3418.1	1200.1	0.9	168.4	3487.9	421.8	2267.6	0.00
Number of zero days	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00
Base flow	0.2	0.6	0.1	0.3	0.2	0.6	0.1	0.3	0.1	0.3	0.00
Parameter	Group #3										
Date of minimum	65.8	0.2	16.0	259.0	65.8	0.2	16.0	259.0	53.6	78.1	0.00
Date of maximum	109.3	0.1	76.0	188.0	109.3	0.1	76.0	188.0	100.3	118.2	0.00
Parameter	Group #4										
Low pulse count	3.4	0.7	0.0	7.0	3.1	0.7	0.0	6.0	1.1	5.6	0.00
Low pulse duration	30.8	0.7	0.0	70.0	30.4	0.7	0.0	70.0	8.4	53.2	0.14
High pulse count	1.1	1.2	0.0	4.0	1.4	1.2	0.0	5.0	0.0	2.4	-0.11
High pulse duration	15.1	1.3	0.0	56.0	12.3	1.3	0.0	56.0	0.0	35.3	0.11
Parameter	Group #5										
Rise rate	37.7	0.7	8.4	83.4	38.8	0.7	8.9	87.3	11.7	63.7	0.00
Fall rate	-25.6	-0.7	-56.7	-5.2	-25.8	-0.7	-55.5	-5.1	-43.6	-7.7	0.00
Number of reversals	81.8	0.1	70.0	97.0	79.2	0.1	67.0	95.0	74.2	89.5	-0.25

COMPARISON STATISTISTICS OF OBSERVED (300MOD50) VALUES ABOVE AND BELOW EXPECTED (MOD50)

	Within RVA range			Above RVA Range			Above RVA Range		
	Expected (E)	Observed (O)	O-E/E	Expected (E)	Observed (O)	O-E/E	Expected (E)	Observed (O)	O-E/E
Parameter	Group #1								
October	8	9	0.13	2	2	0.00	1	0	-1.00
November	7	8	0.14	2	3	0.50	2	0	-1.00
December	6	7	0.17	2	2	0.00	3	2	-0.33
January	7	7	0.00	3	3	0.00	1	1	0.00
February	9	9	0.00	1	1	0.00	1	1	0.00
March	7	7	0.00	2	2	0.00	2	2	0.00
April	7	7	0.00	2	2	0.00	2	2	0.00
May	7	7	0.00	2	2	0.00	2	2	0.00
June	9	7	-0.22	1	3	2.00	1	1	0.00
July	8	7	-0.13	1	2	1.00	2	2	0.00
August	8	7	-0.13	1	2	1.00	2	2	0.00
September	8	7	-0.13	1	2	1.00	2	2	0.00
Parameter	Group #2								
1-day minimum	8	8	0.00	2	2	0.00	1	1	0.00
3-day minimum	8	8	0.00	2	2	0.00	1	1	0.00
7-day minimum	8	8	0.00	2	2	0.00	1	1	0.00
30-day minimum	8	8	0.00	2	2	0.00	1	1	0.00
90-day minimum	8	8	0.00	2	2	0.00	1	1	0.00
1-day maximum	7	7	0.00	2	2	0.00	2	2	0.00
3-day maximum	7	7	0.00	2	2	0.00	2	2	0.00
7-day maximum	7	7	0.00	2	2	0.00	2	2	0.00
30-day maximum	7	7	0.00	2	2	0.00	2	2	0.00
90-day maximum	7	7	0.00	2	2	0.00	2	2	0.00
Number of zero days	11	11	0.00	0	0	0.00	0	0	0.00
Base flow	7	7	0.00	3	3	0.00	1	1	0.00
Parameter	Group #3								
Date of minimum	3	3	0.00	3	3	0.00	5	5	0.00
Date of maximum	3	3	0.00	3	3	0.00	5	5	0.00
Parameter	Group #4								
Low pulse count	6	6	0.00	2	2	0.00	3	3	0.00
Low pulse duration	7	8	0.14	2	2	0.00	2	1	-0.50
High pulse count	9	8	-0.11	2	3	0.50	0	0	0.00
High pulse duration	9	10	0.11	2	1	-0.50	0	0	0.00
Parameter	Group #5								
Rise rate	8	8	0.00	2	2	0.00	1	1	0.00
Fall rate	8	8	0.00	1	1	0.00	2	2	0.00
Number of reversals	8	6	-0.25	1	1	0.00	2	4	1.00

APPENDIX J-5
RANGE OF VARIABILITY SCORE CARD FOR COMPARISON OF MOD50 AND 300MOD50 IHA STATISTICS AT HALSTAD
Final Aquatic Impact Analysis Report

	MOD50				300MOD50				RVA Targets		
	Means	SD % of mean	1-day min Low	1-day max High	Means	SD % of mean	1-day min Low	1-day max High	-1 SD Low	+1 SD High	Hydrologic Alternation
Parameter	Group #1										
October	973.2	0.6	390.5	2309.1	986.9	0.6	405.0	2328.1	536.7	1574.0	0.00
November	1114.6	0.4	535.1	1867.5	1126.6	0.4	540.0	1881.4	643.2	1585.9	0.00
December	916.1	0.6	343.5	2067.0	925.9	0.6	349.8	2077.6	409.2	1423.0	0.00
January	706.0	0.5	244.1	1388.0	706.4	0.5	244.3	1388.4	354.1	1057.9	0.00
February	757.4	0.6	197.7	1465.3	755.2	0.6	197.7	1449.2	335.1	1179.6	0.00
March	2617.5	0.9	608.5	7303.8	2617.5	0.9	608.5	7303.8	776.1	4925.5	0.00
April	13865.3	1.1	3096.9	49352.7	13865.3	1.1	3096.9	49352.7	5523.5	29463.5	0.00
May	6071.6	1.1	804.5	20490.3	6101.2	1.1	804.7	20533.9	1609.7	12764.3	0.00
June	2848.6	0.7	687.1	6046.4	2924.5	0.7	703.6	6201.2	825.3	4872.0	0.00
July	3781.0	1.6	263.2	20724.5	3835.3	1.6	276.7	20757.9	479.4	9780.2	0.00
August	1065.3	0.8	199.6	3008.8	1103.8	0.9	203.1	3140.5	383.9	1970.5	0.00
September	1111.8	1.3	212.9	5320.0	1146.6	1.3	229.1	5532.1	414.4	2568.4	0.00
Parameter	Group #2										
1-day minimum	343.9	0.6	147.6	897.3	357.2	0.6	163.3	897.3	184.7	562.1	0.00
3-day minimum	358.3	0.6	161.3	898.2	371.0	0.6	166.3	898.2	188.9	575.7	0.00
7-day minimum	373.3	0.5	169.0	834.7	390.6	0.6	170.4	902.3	170.4	576.3	0.00
30-day minimum	412.3	0.5	186.4	713.3	448.0	0.6	186.4	980.6	218.1	606.5	0.00
90-day minimum	493.9	0.5	212.7	962.6	560.9	0.6	223.4	1301.0	264.8	723.0	-0.14
1-day maximum	28978.0	1.0	5157.1	89931.0	28981.7	1.0	5157.2	89931.0	9139.3	57030.6	0.00
3-day maximum	28081.3	1.0	4763.6	88135.2	28085.2	1.0	4763.6	88135.2	9101.2	55715.8	0.00
7-day maximum	25898.9	1.0	4078.0	81076.1	25902.7	1.0	4078.0	81076.1	8946.3	51424.3	0.00
30-day maximum	16672.7	1.0	3130.0	55002.3	16676.1	1.0	3130.0	55002.3	6111.8	34098.2	0.00
90-day maximum	8561.5	0.9	1571.5	25495.8	8591.9	0.9	1575.8	25563.2	3065.5	16550.0	0.00
Number of zero days	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00
Base flow	0.2	0.4	0.1	0.2	0.2	0.4	0.1	0.2	0.1	0.2	-0.17
Parameter	Group #3										
Date of minimum	208.9	0.3	17.0	292.0	200.4	0.3	17.0	292.0	144.4	273.4	2.00
Date of maximum	105.5	0.1	86.0	192.0	105.5	0.1	86.0	192.0	97.0	114.1	0.00
Parameter	Group #4										
Low pulse count	3.9	0.5	0.0	7.0	3.8	0.6	0.0	7.0	1.8	6.0	-0.13
Low pulse duration	19.8	0.9	0.0	49.8	18.8	0.9	0.0	49.5	2.9	36.7	0.14
High pulse count	1.4	0.9	0.0	4.0	1.4	0.9	0.0	4.0	0.1	2.7	0.00
High pulse duration	11.2	1.2	0.0	46.0	11.2	1.2	0.0	46.0	0.0	24.7	0.00
Parameter	Group #5										
Rise rate	299.5	0.8	74.1	714.1	301.2	0.8	73.4	723.4	102.6	525.2	0.00
Fall rate	-194.1	-0.8	-522.9	-51.3	-194.3	-0.8	-523.2	-50.5	-351.0	-53.7	0.00
Number of reversals	70.3	0.1	53.0	90.0	69.5	0.1	53.0	90.0	60.4	80.1	0.00

COMPARISON STATISTISTICS OF OBSERVED (300MOD50) VALUES ABOVE AND BELOW EXPECTED (MOD50)

	Within RVA range			Above RVA Range			Above RVA Range		
	Expected (E)	Observed (O)	O-E/E	Expected (E)	Observed (O)	O-E/E	Expected (E)	Observed (O)	O-E/E
Parameter	Group #1								
October	7	7	0.00	2	2	0.00	2	2	0.00
November	6	6	0.00	3	3	0.00	2	2	0.00
December	8	8	0.00	2	2	0.00	1	1	0.00
January	7	7	0.00	2	2	0.00	2	2	0.00
February	7	7	0.00	2	2	0.00	2	2	0.00
March	7	7	0.00	2	2	0.00	2	2	0.00
April	7	7	0.00	2	2	0.00	2	2	0.00
May	7	7	0.00	2	2	0.00	2	2	0.00
June	7	7	0.00	3	3	0.00	1	1	0.00
July	8	8	0.00	1	1	0.00	2	2	0.00
August	7	7	0.00	2	2	0.00	2	2	0.00
September	8	8	0.00	1	1	0.00	2	2	0.00
Parameter	Group #2								
1-day minimum	8	8	0.00	1	1	0.00	2	2	0.00
3-day minimum	8	8	0.00	1	1	0.00	2	2	0.00
7-day minimum	9	9	0.00	1	2	1.00	1	0	-1.00
30-day minimum	7	7	0.00	2	2	0.00	2	2	0.00
90-day minimum	7	6	-0.14	2	3	0.50	2	2	0.00
1-day maximum	7	7	0.00	2	2	0.00	2	2	0.00
3-day maximum	7	7	0.00	2	2	0.00	2	2	0.00
7-day maximum	7	7	0.00	2	2	0.00	2	2	0.00
30-day maximum	7	7	0.00	2	2	0.00	2	2	0.00
90-day maximum	7	7	0.00	2	2	0.00	2	2	0.00
Number of zero days	11	11	0.00	0	0	0.00	0	0	0.00
Base flow	6	5	-0.17	2	3	0.50	3	3	0.00
Parameter	Group #3								
Date of minimum	1	3	2.00	7	5	-0.29	3	3	0.00
Date of maximum	6	6	0.00	1	1	0.00	4	4	0.00
Parameter	Group #4								
Low pulse count	8	7	-0.13	2	2	0.00	1	2	1.00
Low pulse duration	7	8	0.14	2	1	-0.50	2	2	0.00
High pulse count	6	6	0.00	2	2	0.00	3	3	0.00
High pulse duration	10	10	0.00	1	1	0.00	0	0	0.00
Parameter	Group #5								
Rise rate	7	7	0.00	2	2	0.00	2	2	0.00
Fall rate	7	7	0.00	2	2	0.00	2	2	0.00
Number of reversals	9	9	0.00	1	1	0.00	1	1	0.00

APPENDIX J-6
RANGE OF VARIABILITY SCORE CARD FOR COMPARISON OF MOD50 AND 300MOD50 IHA STATISTICS AT GRAND FORKS
Final Aquatic Impact Analysis Report

	MOD50				300MOD50				RVA Targets		
	Means	SD % of mean	1-day min Low	1-day max High	Means	SD % of mean	1-day min Low	1-day max High	-1 SD Low	+1 SD High	Hydrologic Alternation
Parameter	Group #1										
October	2448.6	0.5	1329.5	4406.4	2462.8	0.4	1343.2	4412.8	1341.0	3556.2	0.14
November	2633.5	0.5	1295.2	4615.1	2645.3	0.5	1309.3	4628.1	1433.3	3833.7	0.00
December	2266.9	0.5	898.2	4413.2	2277.9	0.5	908.1	4424.5	1105.3	3428.6	0.00
January	1737.6	0.5	874.9	3637.2	1738.4	0.5	876.3	3638.3	936.7	2538.5	0.00
February	1691.8	0.5	757.8	3718.8	1689.1	0.5	757.8	3718.8	855.1	2528.5	0.00
March	4159.6	0.8	1503.2	12999.4	4159.6	0.8	1503.2	12999.4	1764.2	7633.2	0.00
April	24195.1	0.9	7042.9	72278.3	24195.1	0.9	7042.9	72278.3	1725.7	45810.2	0.00
May	10779.2	1.0	1509.7	32507.7	10800.6	1.0	1509.8	32534.4	2934.4	21540.7	0.00
June	5070.2	0.7	1228.3	11206.0	5147.5	0.7	1242.3	11363.7	1359.6	8780.9	-0.13
July	6919.1	1.2	592.2	26137.9	6974.0	1.2	606.9	26171.6	1084.6	15540.4	0.00
August	2222.7	0.8	383.1	6245.9	2264.1	0.8	387.6	6380.9	402.4	4042.9	0.00
September	2694.0	1.3	643.4	12897.5	2728.7	1.3	655.5	13114.8	918.7	6168.8	0.00
Parameter	Group #2										
1-day minimum	951.3	0.6	268.8	1801.1	960.2	0.6	271.5	1806.3	412.3	1490.3	0.00
3-day minimum	1012.4	0.5	284.5	1803.8	1019.7	0.5	288.9	1818.9	475.6	1549.2	0.00
7-day minimum	1036.1	0.5	290.1	1818.8	1043.7	0.5	294.9	1867.7	494.6	1577.7	0.00
30-day minimum	1140.0	0.5	361.2	2149.6	1145.7	0.5	366.9	2149.6	588.3	1691.7	0.00
90-day minimum	1326.8	0.4	525.3	2426.7	1369.5	0.4	535.6	2426.1	771.0	1882.6	0.14
1-day maximum	52872.5	0.9	15448.0	162338.1	52875.9	0.9	15448.0	162338.1	17657.4	12275.2	0.00
3-day maximum	49943.8	0.9	14722.9	147635.1	49947.2	0.9	14722.9	147635.1	17115.5	94427.2	0.00
7-day maximum	46879.8	0.9	12475.1	140675.6	46883.3	0.9	12475.1	140675.6	16394.3	89486.7	0.00
30-day maximum	27646.6	0.9	7049.0	82329.1	27646.6	0.9	7049.0	82329.1	11939.6	52590.5	0.00
90-day maximum	14596.8	0.8	3361.5	39185.6	14625.4	0.8	3364.8	39252.9	6328.0	26590.4	0.00
Number of zero days	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00
Base flow	0.2	0.3	0.1	0.4	0.2	0.3	0.1	0.4	0.1	0.3	0.00
Parameter	Group #3										
Date of minimum	203.0	0.3	16.0	291.0	177.4	0.3	16.0	281.0	141.5	264.5	0.00
Date of maximum	110.2	0.1	92.0	196.0	110.2	0.1	92.0	196.0	101.4	118.9	0.00
Parameter	Group #4										
Low pulse count	3.8	0.9	0.0	9.0	3.6	0.8	0.0	8.0	0.5	7.1	0.00
Low pulse duration	17.5	0.9	0.0	42.5	17.5	0.8	0.0	41.5	2.5	32.6	0.00
High pulse count	1.7	0.8	0.0	4.0	1.7	0.8	0.0	4.0	0.3	3.2	0.00
High pulse duration	9.9	0.8	0.0	21.5	9.9	0.8	0.0	21.5	2.3	17.5	0.00
Parameter	Group #5										
Rise rate	548.5	0.8	149.9	1409.7	558.5	0.8	153.2	1469.2	184.0	989.9	0.00
Fall rate	-371.9	-0.8	-948.3	-99.7	-369.1	-0.8	-931.4	-100.3	-655.0	-113.7	-0.14
Number of reversals	72.1	0.2	53.0	113.0	71.4	0.2	51.0	117.0	56.4	87.8	0.00

COMPARISON STATISTISTICS OF OBSERVED (300MOD50) VALUES ABOVE AND BELOW EXPECTED (MOD50)

	Within RVA range			Above RVA Range			Above RVA Range		
	Expected (E)	Observed (O)	O-E/E	Expected (E)	Observed (O)	O-E/E	Expected (E)	Observed (O)	O-E/E
Parameter	Group #1								
October	7	8	0.14	3	3	0.00	1	0	-1.00
November	8	8	0.00	2	2	0.00	1	1	0.00
December	8	8	0.00	2	2	0.00	1	1	0.00
January	9	9	0.00	1	1	0.00	1	1	0.00
February	9	9	0.00	1	1	0.00	1	1	0.00
March	8	8	0.00	1	1	0.00	2	2	0.00
April	7	7	0.00	2	2	0.00	2	2	0.00
May	7	7	0.00	2	2	0.00	2	2	0.00
June	8	7	-0.13	2	3	0.50	1	1	0.00
July	7	7	0.00	2	2	0.00	2	2	0.00
August	8	8	0.00	2	2	0.00	1	1	0.00
September	8	8	0.00	1	1	0.00	2	2	0.00
Parameter	Group #2								
1-day minimum	7	7	0.00	3	3	0.00	1	1	0.00
3-day minimum	6	6	0.00	3	3	0.00	2	2	0.00
7-day minimum	6	6	0.00	3	3	0.00	2	2	0.00
30-day minimum	8	8	0.00	2	2	0.00	1	1	0.00
90-day minimum	7	8	0.14	2	2	0.00	2	1	-0.50
1-day maximum	7	7	0.00	2	2	0.00	2	2	0.00
3-day maximum	7	7	0.00	2	2	0.00	2	2	0.00
7-day maximum	7	7	0.00	2	2	0.00	2	2	0.00
30-day maximum	7	7	0.00	2	2	0.00	2	2	0.00
90-day maximum	7	7	0.00	2	2	0.00	2	2	0.00
Number of zero days	11	11	0.00	0	0	0.00	0	0	0.00
Base flow	7	7	0.00	3	3	0.00	1	1	0.00
Parameter	Group #3								
Date of minimum	4	4	0.00	4	3	-0.25	3	4	0.33
Date of maximum	5	5	0.00	1	1	0.00	5	5	0.00
Parameter	Group #4								
Low pulse count	6	6	0.00	2	2	0.00	3	3	0.00
Low pulse duration	7	7	0.00	1	1	0.00	3	3	0.00
High pulse count	7	7	0.00	2	2	0.00	2	2	0.00
High pulse duration	6	6	0.00	2	2	0.00	3	3	0.00
Parameter	Group #5								
Rise rate	7	7	0.00	2	2	0.00	2	2	0.00
Fall rate	7	6	-0.14	2	3	0.50	2	2	0.00
Number of reversals	8	8	0.00	1	1	0.00	2	2	0.00

APPENDIX J-7
RANGE OF VARIABILITY SCORE CARD FOR COMPARISON OF MOD50 AND 300MOD50 IHA STATISTICS AT EMERSON
Final Aquatic Impact Analysis Report

	MOD50				300MOD50				RVA Targets		
		SD	1-day min	1-day max		SD	1-day min	1-day max	-1 SD	+1 SD	Hydrologic
	Means	% of mean	Low	High	Means	% of mean	Low	High	Low	High	Alternation
Parameter	Group #1										
October	2572.3	0.4	1245.6	4540.7	2587.3	0.4	1258.4	4547.1	1423.9	3720.8	0.00
November	3029.8	0.4	1460.4	5333.4	3041.3	0.4	1476.0	5344.9	1679.3	4380.4	0.00
December	2480.6	0.5	968.6	5389.6	2492.7	0.5	978.9	5401.1	1125.1	3836.2	0.00
January	1902.9	0.4	923.4	3773.2	1905.1	0.4	926.5	3775.6	1050.7	2755.2	0.00
February	1808.6	0.5	776.9	3844.0	1807.3	0.5	776.9	3844.0	905.7	2711.6	0.00
March	3359.0	0.6	1185.1	8226.2	3359.0	0.6	1185.1	8226.2	1197.6	5520.5	0.00
April	27057.0	0.7	8701.4	64934.5	27057.0	0.7	8701.4	64934.5	13424.1	46105.9	0.00
May	19824.1	1.2	1902.0	70803.4	19831.9	1.2	1902.0	70804.9	3646.7	43884.1	0.00
June	6536.5	0.8	1347.7	16516.8	6616.2	0.8	1358.3	16677.0	2727.2	11749.2	0.00
July	8960.7	1.2	797.9	29828.8	9016.6	1.2	813.5	29859.2	1415.5	19708.5	0.00
August	2901.5	0.8	408.3	7413.6	2948.1	0.8	414.3	7563.9	470.9	5332.0	0.00
September	3110.0	1.3	808.0	14547.5	3143.5	1.3	814.7	14757.4	993.3	7022.8	0.00
Parameter	Group #2										
1-day minimum	1138.5	0.5	342.1	2187.3	1146.8	0.5	347.9	2187.4	518.9	1758.1	0.00
3-day minimum	1142.0	0.5	344.0	2190.1	1150.4	0.5	349.8	2190.1	520.8	1763.2	0.00
7-day minimum	1178.7	0.5	349.9	2202.6	1185.6	0.5	355.9	2202.7	555.0	1802.4	0.00
30-day minimum	1296.2	0.5	406.2	2356.9	1304.0	0.5	412.1	2402.8	646.3	1946.1	0.00
90-day minimum	1477.0	0.4	643.7	2638.6	1553.8	0.5	653.3	2890.9	876.7	2077.2	0.00
1-day maximum	55636.8	1.0	17842.8	182528.7	55636.8	1.0	17842.8	182528.7	24411.74 1	8495.2	0.00
3-day maximum	55067.7	0.9	17636.4	179841.4	55067.7	0.9	17636.4	179841.4	24060.49 1	7264.6	0.00
7-day maximum	52708.9	0.9	16685.5	168486.6	52708.9	0.9	16685.5	168486.6	23052.95 1	1816.4	0.00
30-day maximum	35967.0	0.9	8708.2	105696.3	35967.0	0.9	8708.2	105696.3	15848.1	67864.3	0.00
90-day maximum	18963.1	0.8	3998.7	52235.4	18991.0	0.8	4001.4	52301.7	7712.7	35003.6	0.00
Number of zero days	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00
Base flow	0.2	0.3	0.1	0.3	0.2	0.3	0.1	0.3	0.1	0.2	0.00
Parameter	Group #3										
Date of minimum	173.3	0.3	22.0	277.0	173.3	0.3	22.0	277.0	119.7	226.8	0.00
Date of maximum	110.3	0.0	100.0	129.0	110.3	0.0	100.0	129.0	107.6	113.0	0.00
Parameter	Group #4										
Low pulse count	2.5	0.8	0.0	5.0	2.5	0.7	0.0	5.0	0.6	4.5	0.17
Low pulse duration	24.6	0.8	0.0	59.3	23.6	0.8	0.0	47.2	4.3	44.9	0.17
High pulse count	1.4	0.6	0.0	3.0	1.4	0.6	0.0	3.0	0.6	2.2	0.00
High pulse duration	16.9	0.8	0.0	40.0	16.9	0.8	0.0	40.0	4.1	29.7	0.00
Parameter	Group #5										
Rise rate	490.6	0.8	138.7	1332.2	494.4	0.8	137.0	1357.2	227.3	884.4	0.00
Fall rate	-348.1	-0.8	-987.7	-97.0	-347.3	-0.8	-982.5	-97.1	-631.4	-153.9	-0.14
Number of reversals	35.7	0.2	20.0	52.0	36.1	0.2	20.0	52.0	26.8	44.7	0.00

COMPARISON STATISTISTICS OF OBSERVED (300MOD50) VALUES ABOVE AND BELOW EXPECTED (MOD50)

	Within RVA range			Above RVA Range			Above RVA Range		
	Expected (E)	Observed (O)	O-E/E	Expected (E)	Observed (O)	O-E/E	Expected (E)	Observed (O)	O-E/E
Parameter	Group #1								
October	8	8	0.00	2	2	0.00	1	1	0.00
November	8	8	0.00	2	2	0.00	1	1	0.00
December	8	8	0.00	2	2	0.00	1	1	0.00
January	9	9	0.00	1	1	0.00	1	1	0.00
February	9	9	0.00	1	1	0.00	1	1	0.00
March	9	9	0.00	1	1	0.00	1	1	0.00
April	6	6	0.00	3	3	0.00	2	2	0.00
May	7	7	0.00	2	2	0.00	2	2	0.00
June	7	7	0.00	2	2	0.00	2	2	0.00
July	6	6	0.00	3	3	0.00	2	2	0.00
August	7	7	0.00	3	3	0.00	1	1	0.00
September	8	8	0.00	1	1	0.00	2	2	0.00
Parameter	Group #2								
1-day minimum	7	7	0.00	3	3	0.00	1	1	0.00
3-day minimum	7	7	0.00	3	3	0.00	1	1	0.00
7-day minimum	7	7	0.00	3	3	0.00	1	1	0.00
30-day minimum	8	8	0.00	2	2	0.00	1	1	0.00
90-day minimum	7	7	0.00	2	2	0.00	2	2	0.00
1-day maximum	7	7	0.00	2	2	0.00	2	2	0.00
3-day maximum	7	7	0.00	2	2	0.00	2	2	0.00
7-day maximum	7	7	0.00	2	2	0.00	2	2	0.00
30-day maximum	7	7	0.00	2	2	0.00	2	2	0.00
90-day maximum	7	7	0.00	2	2	0.00	2	2	0.00
Number of zero days	11	11	0.00	0	0	0.00	0	0	0.00
Base flow	7	7	0.00	2	2	0.00	2	2	0.00
Parameter	Group #3								
Date of minimum	0	0	0.00	7	7	0.00	4	4	0.00
Date of maximum	2	2	0.00	4	4	0.00	5	5	0.00
Parameter	Group #4								
Low pulse count	6	7	0.17	2	1	-0.50	3	3	0.00
Low pulse duration	6	7	0.17	2	1	-0.50	3	3	0.00
High pulse count	9	9	0.00	1	1	0.00	1	1	0.00
High pulse duration	8	8	0.00	2	2	0.00	1	1	0.00
Parameter	Group #5								
Rise rate	7	7	0.00	2	2	0.00	2	2	0.00
Fall rate	7	6	-0.14	2	3	0.50	2	2	0.00
Number of reversals	9	9	0.00	1	1	0.00	1	1	0.00

APPENDIX J-8
RANGE OF VARIABILITY SCORE CARD FOR COMPARISON OF MOD55 AND 480MOD55 IHA STATISTICS AT COOPERSTOWN
Final Aquatic Impact Analysis Report

	MOD55				480MOD55				RVA Targets		
	Means	SD % of mean	1-day min Low	1-day max High	Means	SD % of mean	1-day min Low	1-day max High	-1 SD Low	+1 SD High	Hydrologic Alternation
Parameter	Group #1										
October	56.5	0.6	17.7	118.6	448.4	0.4	17.7	611.6	21.0	92.0	-1.00
November	50.2	0.5	25.7	95.7	442.6	0.4	36.3	573.9	27.5	72.8	-0.75
December	36.7	0.6	15.2	74.5	129.3	0.4	24.2	185.0	16.3	57.1	-0.75
January	26.0	0.5	12.1	50.0	26.1	0.5	12.1	50.0	12.7	39.3	0.00
February	25.4	0.4	13.5	43.2	25.3	0.4	13.5	43.2	15.3	35.5	0.00
March	381.8	1.0	51.4	1160.9	381.8	1.0	51.4	1160.9	78.2	764.5	0.00
April	1244.0	1.0	114.9	4022.9	1244.0	1.0	114.9	4022.9	477.9	2464.7	0.00
May	479.4	1.1	75.6	1685.9	861.4	0.6	441.6	2093.9	90.3	985.6	-0.13
June	181.4	0.8	46.1	547.8	653.6	0.2	523.7	1013.8	64.3	330.2	-1.00
July	144.1	0.9	22.0	461.7	621.4	0.2	498.0	940.6	26.7	280.8	-1.00
August	72.3	1.3	3.7	300.9	552.1	0.2	483.5	786.6	17.0	163.5	-1.00
September	61.7	1.2	1.7	259.5	507.6	0.3	134.6	727.6	9.8	137.3	-0.88
Parameter	Group #2										
1-day minimum	10.2	1.1	1.4	37.3	14.8	0.6	5.6	37.3	2.7	21.2	0.29
3-day minimum	9.6	0.9	1.4	26.0	15.2	0.6	6.9	38.2	2.9	18.0	0.14
7-day minimum	10.3	0.8	1.5	24.2	16.1	0.5	7.7	38.5	2.4	18.1	0.00
30-day minimum	15.7	0.7	1.7	39.2	20.8	0.4	11.4	39.2	4.2	27.2	0.13
90-day minimum	22.9	0.5	4.5	44.5	38.1	0.6	15.3	82.1	10.6	35.3	-0.25
1-day maximum	2867.5	0.8	1116.3	7247.2	2868.8	0.8	1116.3	7247.2	1238.1	5034.8	0.00
3-day maximum	2723.6	0.7	1067.6	6889.2	2724.2	0.7	1067.6	6889.2	1224.6	4706.1	0.00
7-day maximum	2481.1	0.7	934.8	6184.7	2481.1	0.7	934.8	6184.7	1149.4	4229.2	0.00
30-day maximum	1525.4	0.8	489.9	4289.7	1561.6	0.7	575.1	4311.4	644.0	2679.1	0.00
90-day maximum	740.6	0.8	226.3	2024.0	997.6	0.6	534.7	2307.1	276.6	1304.1	0.00
Number of zero days	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00
Base flow	0.0	0.5	0.0	0.1	0.0	0.2	0.0	0.1	0.0	0.1	0.29
Parameter	Group #3										
Date of minimum	191.2	0.3	24.0	275.0	44.5	0.2	17.0	277.0	136.6	245.8	-1.00
Date of maximum	96.5	0.0	77.0	118.0	97.6	0.0	77.0	131.0	92.6	100.3	0.00
Parameter	Group #4										
Low pulse count	3.9	0.5	0.0	6.0	1.9	0.7	0.0	4.0	2.1	5.7	-0.43
Low pulse duration	20.2	0.8	0.0	56.0	30.6	1.0	0.0	82.0	3.6	36.8	-0.25
High pulse count	1.5	0.6	1.0	3.0	2.5	0.8	1.0	7.0	1.0	2.3	-0.22
High pulse duration	19.3	0.7	5.0	51.0	17.8	0.7	5.0	34.5	5.9	32.8	-0.29
Parameter	Group #5										
Rise rate	32.0	0.7	10.0	69.8	33.7	0.6	12.2	64.7	10.4	53.7	0.33
Fall rate	-16.9	-0.7	-41.2	-6.4	-18.8	-0.6	-40.9	-7.2	-28.8	-7.6	0.17
Number of reversals	81.2	0.1	67.0	93.0	75.3	0.1	55.0	90.0	73.9	88.5	-0.25

COMPARISON STATISTISTICS OF OBSERVED (480MOD55) VALUES ABOVE AND BELOW EXPECTED (MOD55)

	Within RVA range			Above RVA Range			Above RVA Range		
	Expected (E)	Observed (O)	O-E/E	Expected (E)	Observed (O)	O-E/E	Expected (E)	Observed (O)	O-E/E
Parameter	Group #1								
October	6	0	-1.00	3	10	2.33	2	1	-0.50
November	8	2	-0.75	1	9	8.00	2	0	-1.00
December	8	2	-0.75	2	9	3.50	1	0	-1.00
January	8	8	0.00	2	2	0.00	1	1	0.00
February	7	7	0.00	2	2	0.00	2	2	0.00
March	7	7	0.00	2	2	0.00	2	2	0.00
April	8	8	0.00	1	1	0.00	2	2	0.00
May	8	7	-0.13	1	4	3.00	2	0	-1.00
June	8	0	-1.00	1	11	10.00	2	0	-1.00
July	7	0	-1.00	2	11	4.50	2	0	-1.00
August	8	0	-1.00	1	11	10.00	2	0	-1.00
September	8	1	-0.88	1	10	9.00	2	0	-1.00
Parameter	Group #2								
1-day minimum	7	9	0.29	2	2	0.00	2	0	-1.00
3-day minimum	7	8	0.14	2	3	0.50	2	0	-1.00
7-day minimum	8	8	0.00	2	3	0.50	1	0	-1.00
30-day minimum	8	9	0.13	1	2	1.00	2	0	-1.00
90-day minimum	8	6	-0.25	2	5	1.50	1	0	-1.00
1-day maximum	7	7	0.00	2	2	0.00	2	2	0.00
3-day maximum	7	7	0.00	2	2	0.00	2	2	0.00
7-day maximum	7	7	0.00	2	2	0.00	2	2	0.00
30-day maximum	8	8	0.00	1	1	0.00	2	2	0.00
90-day maximum	8	8	0.00	1	3	2.00	2	0	-1.00
Number of zero days	11	11	0.00	0	0	0.00	0	0	0.00
Base flow	7	9	0.29	2	0	-1.00	2	2	0.00
Parameter	Group #3								
Date of minimum	2	0	-1.00	6	2	-0.67	3	9	2.00
Date of maximum	3	3	0.00	5	5	0.00	3	3	0.00
Parameter	Group #4								
Low pulse count	7	4	-0.43	2	0	-1.00	2	7	2.50
Low pulse duration	8	6	-0.25	1	3	2.00	2	2	0.00
High pulse count	9	7	-0.22	2	4	1.00	0	0	0.00
High pulse duration	7	5	-0.29	2	2	0.00	2	4	1.00
Parameter	Group #5								
Rise rate	6	8	0.33	3	3	0.00	2	0	-1.00
Fall rate	6	7	0.17	2	1	-0.50	3	3	0.00
Number of reversals	8	6	-0.25	1	1	0.00	2	4	1.00

APPENDIX J-9
RANGE OF VARIABILITY SCORE CARD FOR COMPARISON OF MOD55 AND 480MOD55 IHA STATISTICS AT BALDHILL DAM
Final Aquatic Impact Analysis Report

	MOD55				480MOD55				RVA Targets		
	Means	SD % of mean	1-day min Low	1-day max High	Means	SD % of mean	1-day min Low	1-day max High	-1 SD Low	+1 SD High	Hydrologic Alternation
Parameter	Group #1										
October	193.6	0.2	141.3	286.2	586.5	0.3	155.3	779.6	148.8	238.4	-0.75
November	175.3	0.2	136.1	212.0	567.9	0.3	155.9	690.9	145.9	204.8	-0.83
December	149.1	0.2	119.4	194.5	254.3	0.2	130.7	308.2	121.2	177.1	-0.86
January	36.4	0.4	16.5	58.3	36.5	0.4	16.6	58.4	20.5	52.4	0.00
February	44.3	0.4	16.7	69.3	43.6	0.4	16.7	70.4	25.2	63.4	0.00
March	538.4	0.8	105.3	1456.4	538.4	0.8	105.3	1456.4	117.5	982.9	0.00
April	1327.2	1.3	13.0	5467.3	1327.2	1.3	13.0	5467.3	260.4	3010.4	0.00
May	642.0	1.2	13.0	2427.5	1001.9	0.8	286.0	2820.6	99.9	1397.1	0.00
June	239.6	0.9	13.0	797.7	716.7	0.3	548.3	1262.3	25.3	454.0	-1.00
July	167.6	1.0	30.5	561.0	646.9	0.3	506.1	1041.6	36.3	328.2	-1.00
August	96.5	1.1	13.0	384.7	575.4	0.2	486.8	870.3	29.3	206.0	-1.00
September	84.3	1.0	13.0	310.5	531.3	0.3	173.6	778.1	19.6	170.2	-1.00
Parameter	Group #2										
1-day minimum	17.3	0.5	13.0	38.6	18.5	0.5	13.0	38.6	13.0	25.5	-0.10
3-day minimum	18.1	0.5	13.0	40.1	19.7	0.5	13.0	40.1	13.0	26.9	-0.10
7-day minimum	18.5	0.5	13.0	41.7	20.5	0.5	13.0	41.7	13.0	27.7	-0.10
30-day minimum	24.0	0.6	13.0	47.7	27.6	0.5	13.0	49.3	13.0	37.5	-0.22
90-day minimum	47.8	0.5	13.0	94.3	75.1	0.4	36.7	125.0	23.1	72.4	-0.14
1-day maximum	2935.6	0.8	662.6	8604.0	2996.3	0.8	967.3	8604.0	1245.2	5394.8	0.00
3-day maximum	2785.2	0.9	608.0	8523.4	2834.0	0.8	876.3	8523.4	1233.4	5153.4	0.00
7-day maximum	2520.0	0.9	506.5	8022.6	2561.4	0.8	729.5	8022.6	1096.2	4728.0	0.00
30-day maximum	1823.9	0.9	299.3	5711.2	1916.5	0.8	664.1	5732.9	715.6	3446.4	0.00
90-day maximum	891.7	0.9	181.2	2827.7	1178.2	0.7	590.9	3086.1	293.7	1711.5	0.13
Number of zero days	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00
Base flow	0.1	0.4	0.0	0.1	0.0	0.3	0.0	0.1	0.0	0.1	-0.67
Parameter	Group #3										
Date of minimum	114.2	0.3	1.0	275.0	60.9	0.1	1.0	108.0	84.6	143.7	0.33
Date of maximum	94.4	0.1	68.0	120.0	117.9	0.2	68.0	304.0	89.5	99.3	0.00
Parameter	Group #4										
Low pulse count	10.0	0.5	0.0	18.0	5.5	0.6	0.0	10.0	4.9	15.1	-0.13
Low pulse duration	8.3	0.7	0.0	20.0	10.5	1.2	0.0	45.0	2.7	13.9	-0.22
High pulse count	1.6	0.7	0.0	4.0	2.6	0.9	0.0	8.0	0.4	2.8	-0.43
High pulse duration	12.5	0.9	0.0	29.0	12.5	1.5	0.0	65.0	1.8	23.3	0.33
Parameter	Group #5										
Rise rate	53.4	0.4	32.6	96.5	54.1	0.4	32.4	93.2	33.1	73.6	0.00
Fall rate	-39.0	-0.4	-73.8	-25.1	-39.1	-0.4	-71.8	-25.8	-55.3	-25.7	0.33
Number of reversals	133.1	0.2	82.0	164.0	137.4	0.1	106.0	167.0	107.5	158.7	0.14

COMPARISON STATISTISTICS OF OBSERVED (480MOD55) VALUES ABOVE AND BELOW EXPECTED (MOD55)

	Within RVA range			Above RVA Range			Above RVA Range		
	Expected (E)	Observed (O)	O-E/E	Expected (E)	Observed (O)	O-E/E	Expected (E)	Observed (O)	O-E/E
Parameter	Group #1								
October	8	2	-0.75	1	9	8.00	2	0	-1.00
November	6	1	-0.83	3	10	2.33	2	0	-1.00
December	7	1	-0.86	3	10	2.33	1	0	-1.00
January	7	7	0.00	3	3	0.00	1	1	0.00
February	6	6	0.00	2	2	0.00	3	3	0.00
March	7	7	0.00	2	2	0.00	2	2	0.00
April	8	8	0.00	1	1	0.00	2	2	0.00
May	8	8	0.00	1	3	2.00	2	0	-1.00
June	9	0	-1.00	1	11	10.00	1	0	-1.00
July	7	0	-1.00	2	11	4.50	2	0	-1.00
August	8	0	-1.00	1	11	10.00	2	0	-1.00
September	8	0	-1.00	1	11	10.00	2	0	-1.00
Parameter	Group #2								
1-day minimum	10	9	-0.10	1	2	1.00	0	0	0.00
3-day minimum	10	9	-0.10	1	2	1.00	0	0	0.00
7-day minimum	10	9	-0.10	1	2	1.00	0	0	0.00
30-day minimum	9	7	-0.22	2	4	1.00	0	0	0.00
90-day minimum	7	6	-0.14	2	5	1.50	2	0	-1.00
1-day maximum	7	7	0.00	2	2	0.00	2	2	0.00
3-day maximum	7	7	0.00	2	2	0.00	2	2	0.00
7-day maximum	8	8	0.00	1	1	0.00	2	2	0.00
30-day maximum	8	8	0.00	1	1	0.00	2	2	0.00
90-day maximum	8	9	0.13	1	2	1.00	2	0	-1.00
Number of zero days	11	11	0.00	0	0	0.00	0	0	0.00
Base flow	6	2	-0.67	2	0	-1.00	3	9	2.00
Parameter	Group #3								
Date of minimum	3	4	0.33	3	0	-1.00	5	7	0.40
Date of maximum	1	1	0.00	6	6	0.00	4	4	0.00
Parameter	Group #4								
Low pulse count	8	7	-0.13	1	0	-1.00	2	4	1.00
Low pulse duration	9	7	-0.22	1	2	1.00	1	2	1.00
High pulse count	7	4	-0.43	2	5	1.50	2	2	0.00
High pulse duration	6	8	0.33	3	1	-0.67	2	2	0.00
Parameter	Group #5								
Rise rate	7	7	0.00	2	3	0.50	2	1	-0.50
Fall rate	6	8	0.33	2	0	-1.00	3	3	0.00
Number of reversals	7	8	0.14	3	2	-0.33	1	1	0.00

APPENDIX J-10
RANGE OF VARIABILITY SCORE CARD FOR COMPARISON OF MOD55 AND 480MOD55 IHA STATISTICS AT LISBON
Final Aquatic Impact Analysis Report

	MOD55				480MOD55				RVA Targets		
		SD	1-day min	1-day max		SD	1-day min	1-day max	-1 SD	+1 SD	Hydrologic
	Means	% of mean	Low	High	Means	% of mean	Low	High	Low	High	Alternation
Parameter	Group #1										
October	190.2	0.3	116.3	286.6	589.8	0.4	140.4	786.7	133.4	247.0	-0.75
November	204.9	0.2	158.6	264.5	595.7	0.3	189.7	743.4	168.7	241.0	-0.86
December	168.3	0.2	124.4	241.8	309.9	0.2	150.0	388.6	131.3	205.2	-0.86
January	70.0	0.3	34.9	102.9	70.2	0.3	35.3	103.2	46.4	93.5	0.00
February	66.9	0.6	18.7	149.6	66.7	0.6	18.7	150.3	29.0	104.9	0.00
March	647.0	0.7	98.3	1493.9	647.0	0.7	98.3	1493.9	193.9	1100.0	0.00
April	1589.4	1.2	83.4	6641.3	1589.4	1.2	83.4	6641.3	369.9	3570.4	0.00
May	859.9	1.3	43.0	3570.5	1176.9	0.9	255.6	3929.0	119.5	1938.9	0.13
June	336.2	0.8	34.8	902.0	811.5	0.3	572.6	1361.1	64.7	607.6	-0.75
July	262.2	0.9	48.0	676.8	738.1	0.3	516.1	1143.9	49.9	498.8	-1.00
August	107.6	1.1	14.5	406.3	584.8	0.2	487.7	890.2	41.5	224.2	-1.00
September	117.9	0.9	15.6	394.3	568.8	0.3	262.1	856.8	29.4	227.4	-1.00
Parameter	Group #2										
1-day minimum	25.8	0.6	13.5	57.7	36.3	0.4	15.5	58.2	15.5	40.8	-0.14
3-day minimum	26.8	0.6	13.5	58.3	37.5	0.4	15.7	59.7	15.9	42.2	-0.14
7-day minimum	30.9	0.6	13.5	68.7	39.9	0.5	16.2	68.7	17.5	49.3	0.00
30-day minimum	39.6	0.6	14.3	74.8	49.7	0.5	17.3	98.2	17.8	61.5	0.17
90-day minimum	71.9	0.5	20.6	133.1	104.6	0.4	43.7	159.2	36.0	107.8	-0.38
1-day maximum	3291.9	0.8	786.9	9920.0	3373.8	0.8	964.5	9920.0	1370.9	5988.7	0.00
3-day maximum	3176.0	0.8	720.0	9810.4	3263.0	0.8	933.9	9810.4	1300.0	5859.2	0.00
7-day maximum	2929.1	0.9	613.0	9548.0	3007.6	0.8	800.9	9548.0	1252.3	5509.7	0.00
30-day maximum	2162.5	0.9	525.8	7093.0	2215.2	0.9	680.0	7114.7	905.0	4100.2	0.00
90-day maximum	1119.9	0.9	269.5	3726.9	1366.7	0.8	613.5	3981.2	371.2	2160.7	0.25
Number of zero days	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00
Base flow	0.1	0.4	0.0	0.2	0.1	0.2	0.0	0.1	0.1	0.1	0.14
Parameter	Group #3										
Date of minimum	218.0	0.3	26.0	278.0	48.8	0.2	12.0	277.0	162.5	273.6	-1.00
Date of maximum	98.8	0.1	70.0	183.0	128.5	0.2	70.0	247.0	90.1	107.5	0.00
Parameter	Group #4										
Low pulse count	4.4	0.8	2.0	13.0	2.3	0.8	1.0	7.0	2.0	7.7	-0.33
Low pulse duration	24.8	0.7	0.7	60.0	29.9	0.9	1.7	70.0	6.9	42.8	-0.38
High pulse count	1.5	0.7	0.0	3.0	1.9	0.6	0.0	4.0	0.5	2.6	-0.14
High pulse duration	12.3	0.8	0.0	26.0	12.0	0.9	0.0	35.5	2.8	21.8	0.00
Parameter	Group #5										
Rise rate	45.8	0.7	16.6	126.7	49.0	0.6	19.5	124.3	22.3	77.5	0.00
Fall rate	-29.5	-0.7	-76.7	-12.2	-32.1	-0.6	-76.1	-14.5	-49.1	-13.5	0.25
Number of reversals	91.0	0.1	70.0	105.0	86.2	0.1	71.0	107.0	78.9	103.1	0.00

COMPARISON STATISTISTICS OF OBSERVED (480MOD55) VALUES ABOVE AND BELOW EXPECTED (MOD55)

	Within RVA range			Above RVA Range			Above RVA Range		
	Expected (E)	Observed (O)	O-E/E	Expected (E)	Observed (O)	O-E/E	Expected (E)	Observed (O)	O-E/E
Parameter	Group #1								
October	8	2	-0.75	2	9	3.50	1	0	-1.00
November	7	1	-0.86	2	10	4.00	2	0	-1.00
December	7	1	-0.86	2	10	4.00	2	0	-1.00
January	7	7	0.00	3	3	0.00	1	1	0.00
February	7	7	0.00	1	1	0.00	3	3	0.00
March	8	8	0.00	2	2	0.00	1	1	0.00
April	8	8	0.00	1	1	0.00	2	2	0.00
May	8	9	0.13	1	2	1.00	2	0	-1.00
June	8	2	-0.75	2	9	3.50	1	0	-1.00
July	6	0	-1.00	3	11	2.67	2	0	-1.00
August	8	0	-1.00	1	11	10.00	2	0	-1.00
September	8	0	-1.00	1	11	10.00	2	0	-1.00
Parameter	Group #2								
1-day minimum	7	6	-0.14	2	5	1.50	2	0	-1.00
3-day minimum	7	6	-0.14	2	4	1.00	2	1	-0.50
7-day minimum	7	7	0.00	2	3	0.50	2	1	-0.50
30-day minimum	6	7	0.17	3	3	0.00	2	1	-0.50
90-day minimum	8	5	-0.38	2	6	2.00	1	0	-1.00
1-day maximum	8	8	0.00	1	1	0.00	2	2	0.00
3-day maximum	8	8	0.00	1	1	0.00	2	2	0.00
7-day maximum	8	8	0.00	1	1	0.00	2	2	0.00
30-day maximum	8	8	0.00	1	1	0.00	2	2	0.00
90-day maximum	8	10	0.25	1	1	0.00	2	0	-1.00
Number of zero days	11	11	0.00	0	0	0.00	0	0	0.00
Base flow	7	8	0.14	2	0	-1.00	2	3	0.50
Parameter	Group #3								
Date of minimum	5	0	-1.00	4	2	-0.50	2	9	3.50
Date of maximum	2	2	0.00	3	5	0.67	6	4	-0.33
Parameter	Group #4								
Low pulse count	9	6	-0.33	2	0	-1.00	0	5	0.00
Low pulse duration	8	5	-0.38	1	4	3.00	2	2	0.00
High pulse count	7	6	-0.14	2	3	0.50	2	2	0.00
High pulse duration	7	7	0.00	1	1	0.00	3	3	0.00
Parameter	Group #5								
Rise rate	8	8	0.00	1	1	0.00	2	2	0.00
Fall rate	8	10	0.25	2	0	-1.00	1	1	0.00
Number of reversals	8	8	0.00	1	1	0.00	2	2	0.00

APPENDIX J-11
RANGE OF VARIABILITY SCORE CARD FOR COMPARISON OF MOD55 AND 480MOD55 IHA STATISTICS AT KINDRED
Final Aquatic Impact Analysis Report

	MOD55				480MOD55				RVA Targets		
		SD	1-day min	1-day max		SD	1-day min	1-day max	-1 SD	+1 SD	Hydrologic
	Means	% of mean	Low	High	Means	% of mean	Low	High	Low	High	Alternation
Parameter	Group #1										
October	219.0	0.3	129.9	354.4	623.0	0.3	168.7	834.9	148.9	289.1	-0.71
November	250.3	0.2	175.5	371.9	641.4	0.3	232.2	852.9	192.5	308.1	-0.88
December	203.2	0.3	132.7	324.3	380.1	0.2	199.4	537.6	142.7	263.7	-0.86
January	103.8	0.3	66.4	158.8	104.6	0.3	67.5	159.7	74.0	133.6	0.00
February	97.1	0.5	30.2	189.5	97.6	0.5	30.2	199.1	48.1	146.0	0.00
March	651.2	0.7	88.7	1479.8	651.2	0.7	88.7	1479.8	187.5	1114.9	0.00
April	1721.8	1.2	175.2	6799.9	1721.8	1.2	175.2	6799.9	520.2	3719.7	0.00
May	1073.0	1.2	52.5	4334.9	1348.0	1.0	210.9	4660.6	182.4	2388.3	0.13
June	434.4	0.7	65.6	1058.1	910.1	0.3	604.3	1515.1	117.0	751.8	-0.38
July	390.6	1.0	98.1	1415.8	863.3	0.5	556.6	1876.4	101.7	794.2	0.00
August	152.7	0.9	44.4	487.6	625.4	0.2	517.3	970.9	70.7	287.9	-1.00
September	169.4	0.9	28.7	601.5	625.2	0.3	351.0	1060.9	83.9	324.1	-1.00
Parameter	Group #2										
1-day minimum	51.9	0.5	21.1	114.6	59.0	0.4	21.1	114.8	24.8	79.0	0.14
3-day minimum	53.9	0.5	21.7	116.6	60.9	0.4	21.7	116.8	26.5	81.3	0.14
7-day minimum	56.6	0.5	24.3	118.9	63.8	0.4	24.3	119.1	28.4	84.8	0.14
30-day minimum	65.1	0.5	27.1	122.5	75.1	0.4	27.1	122.6	34.7	95.5	0.14
90-day minimum	101.5	0.4	48.0	177.0	139.1	0.3	59.0	187.3	62.5	140.5	-0.57
1-day maximum	3360.9	0.8	965.9	9759.6	3398.3	0.8	965.9	9759.6	1433.0	5971.1	0.00
3-day maximum	3308.0	0.8	908.5	9692.4	3349.5	0.8	908.5	9692.4	1397.9	5912.3	0.00
7-day maximum	3187.1	0.8	832.5	9641.0	3232.3	0.8	832.5	9641.0	1366.7	5769.4	0.00
30-day maximum	2322.7	0.9	626.5	7469.7	2396.6	0.8	712.7	7489.3	999.5	4336.4	0.00
90-day maximum	1272.5	0.9	343.0	4018.6	1505.0	0.7	631.0	4273.2	410.7	2386.8	0.25
Number of zero days	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00
Base flow	0.2	0.5	0.1	0.3	0.1	0.3	0.0	0.1	0.1	0.2	0.13
Parameter	Group #3										
Date of minimum	71.4	0.3	15.0	279.0	40.4	0.1	15.0	80.0	51.3	91.5	0.00
Date of maximum	105.0	0.1	76.0	188.0	105.0	0.1	76.0	188.0	96.3	113.7	0.00
Parameter	Group #4										
Low pulse count	4.2	0.8	0.0	11.0	1.8	0.9	0.0	5.0	0.8	7.6	0.25
Low pulse duration	24.2	0.7	0.0	57.0	31.1	0.7	0.0	67.0	7.4	41.0	-0.22
High pulse count	1.9	0.8	0.0	4.0	2.0	0.6	0.0	4.0	0.5	3.4	0.14
High pulse duration	11.2	0.8	0.0	24.0	11.8	0.8	0.0	25.7	2.0	20.5	0.25
Parameter	Group #5										
Rise rate	41.3	0.6	15.6	99.6	44.3	0.5	18.1	94.5	19.9	67.4	-0.13
Fall rate	-27.5	-0.6	-67.6	-10.8	-29.7	-0.6	-68.9	-12.6	-45.0	-12.0	0.25
Number of reversals	81.2	0.1	74.0	94.0	71.9	0.1	58.0	91.0	74.8	87.5	-0.57

COMPARISON STATISTISTICS OF OBSERVED (480MOD55) VALUES ABOVE AND BELOW EXPECTED (MOD55)

	Within RVA range			Above RVA Range			Above RVA Range		
	Expected (E)	Observed (O)	O-E/E	Expected (E)	Observed (O)	O-E/E	Expected (E)	Observed (O)	O-E/E
Parameter	Group #1								
October	7	2	-0.71	2	9	3.50	2	0	-1.00
November	8	1	-0.88	2	10	4.00	1	0	-1.00
December	7	1	-0.86	2	10	4.00	2	0	-1.00
January	7	7	0.00	2	2	0.00	2	2	0.00
February	8	8	0.00	2	2	0.00	1	1	0.00
March	8	8	0.00	2	2	0.00	1	1	0.00
April	8	8	0.00	1	1	0.00	2	2	0.00
May	8	9	0.13	1	2	1.00	2	0	-1.00
June	8	5	-0.38	2	6	2.00	1	0	-1.00
July	8	8	0.00	1	3	2.00	2	0	-1.00
August	8	0	-1.00	1	11	10.00	2	0	-1.00
September	8	0	-1.00	1	11	10.00	2	0	-1.00
Parameter	Group #2								
1-day minimum	7	8	0.14	2	2	0.00	2	1	-0.50
3-day minimum	7	8	0.14	2	2	0.00	2	1	-0.50
7-day minimum	7	8	0.14	2	2	0.00	2	1	-0.50
30-day minimum	7	8	0.14	2	2	0.00	2	1	-0.50
90-day minimum	7	3	-0.57	2	7	2.50	2	1	-0.50
1-day maximum	8	8	0.00	1	1	0.00	2	2	0.00
3-day maximum	8	8	0.00	1	1	0.00	2	2	0.00
7-day maximum	8	8	0.00	1	1	0.00	2	2	0.00
30-day maximum	8	8	0.00	1	1	0.00	2	2	0.00
90-day maximum	8	10	0.25	1	1	0.00	2	0	-1.00
Number of zero days	11	11	0.00	0	0	0.00	0	0	0.00
Base flow	8	9	0.13	2	0	-1.00	1	2	1.00
Parameter	Group #3								
Date of minimum	3	3	0.00	3	0	-1.00	5	8	0.60
Date of maximum	1	1	0.00	3	3	0.00	7	7	0.00
Parameter	Group #4								
Low pulse count	8	10	0.25	2	0	-1.00	1	1	0.00
Low pulse duration	9	7	-0.22	1	3	2.00	1	1	0.00
High pulse count	7	8	0.14	2	1	-0.50	2	2	0.00
High pulse duration	4	5	0.25	3	2	-0.33	4	4	0.00
Parameter	Group #5								
Rise rate	8	7	-0.13	1	2	1.00	2	2	0.00
Fall rate	8	10	0.25	2	0	-1.00	1	1	0.00
Number of reversals	7	3	-0.57	2	1	-0.50	2	7	2.50

APPENDIX J-12
RANGE OF VARIABILITY SCORE CARD FOR COMPARISON OF MOD55 AND 480MOD55 IHA STATISTICS AT HALSTAD
Final Aquatic Impact Analysis Report

	MOD55				480MOD55				RVA Targets		
		SD	1-day min	1-day max		SD	1-day min	1-day max	-1 SD	+1 SD	Hydrologic
	Means	% of mean	Low	High	Means	% of mean	Low	High	Low	High	Alternation
Parameter	Group #1										
October	1164.3	0.4	548.4	2165.7	1573.5	0.4	811.8	2663.8	662.9	1665.8	-0.13
November	1158.2	0.3	524.1	1736.2	1548.4	0.3	1001.2	2213.8	758.9	1557.4	0.00
December	926.2	0.5	445.7	2032.6	1177.3	0.4	760.4	2332.5	474.2	1378.3	0.00
January	708.4	0.4	352.0	1074.3	712.7	0.4	359.1	1074.3	446.2	970.6	0.00
February	752.6	0.5	386.2	1699.6	755.6	0.5	386.2	1719.8	407.9	1135.5	0.00
March	3445.9	0.6	685.6	7323.1	3445.9	0.6	685.6	7323.1	1230.7	5661.1	0.00
April	12518.0	1.3	1268.3	59673.6	12518.0	1.3	1268.3	59673.6	2837.0	29123.2	0.00
May	5459.8	1.2	1062.1	22345.0	5643.7	1.1	1112.0	22577.7	1398.4	11897.1	0.00
June	3715.8	0.8	587.0	11054.5	4197.1	0.7	1053.9	11509.8	1341.7	6847.0	0.14
July	4170.0	1.3	339.9	19933.2	4637.8	1.2	795.6	20390.5	498.5	9775.6	0.25
August	1192.7	0.7	120.9	2955.6	1656.0	0.5	586.4	3432.1	326.7	2058.7	0.13
September	1173.1	1.2	62.9	5225.7	1639.0	0.9	537.8	5693.0	418.2	2600.2	0.25
Parameter	Group #2										
1-day minimum	303.4	0.4	47.5	503.6	519.4	0.4	229.8	881.5	174.0	432.8	-0.50
3-day minimum	314.0	0.4	48.3	512.7	524.1	0.4	237.0	882.4	184.4	443.5	-0.50
7-day minimum	353.9	0.4	48.7	658.9	539.3	0.3	279.4	886.4	199.8	508.0	-0.50
30-day minimum	464.5	0.5	62.9	961.5	613.5	0.3	340.1	963.5	223.5	705.5	-0.25
90-day minimum	580.6	0.5	166.4	1092.2	781.8	0.3	427.7	1160.8	304.2	856.9	0.00
1-day maximum	27289.9	1.1	5974.8	106317.9	27379.7	1.1	5974.8	106317.9	8555.6	56178.9	0.00
3-day maximum	26524.8	1.1	5731.6	103435.4	26616.8	1.1	5731.6	103435.4	8244.3	54788.3	0.00
7-day maximum	24705.7	1.1	5114.1	95119.7	24795.4	1.1	5114.1	95119.7	7344.2	50999.7	0.00
30-day maximum	15558.1	1.1	3246.8	64541.2	15647.8	1.1	3545.4	64541.2	4919.4	33341.6	0.00
90-day maximum	8275.3	1.0	1822.6	29864.3	8494.7	1.0	2238.1	30100.5	2707.4	16609.4	0.13
Number of zero days	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00
Base flow	0.2	0.6	0.0	0.3	0.2	0.5	0.1	0.4	0.1	0.3	0.00
Parameter	Group #3										
Date of minimum	207.8	0.3	17.0	292.0	50.9	0.2	17.0	292.0	141.5	274.2	-0.80
Date of maximum	110.1	0.1	71.0	192.0	110.1	0.1	71.0	192.0	97.6	122.6	0.00
Parameter	Group #4										
Low pulse count	3.6	0.5	1.0	7.0	1.3	0.6	0.0	3.0	1.7	5.6	-0.57
Low pulse duration	23.4	0.7	0.0	62.3	32.6	1.0	0.0	90.0	6.1	40.7	-0.56
High pulse count	1.5	0.9	0.0	4.0	1.5	0.9	0.0	4.0	0.2	2.8	0.00
High pulse duration	9.4	0.8	0.0	23.0	9.5	0.8	0.0	23.0	1.5	17.3	0.00
Parameter	Group #5										
Rise rate	327.9	0.8	119.6	883.1	333.8	0.8	123.8	875.5	139.0	579.8	-0.14
Fall rate	-195.7	-0.8	-605.0	-55.1	-195.1	-0.8	-605.3	-56.8	-354.7	-97.4	0.00
Number of reversals	66.8	0.1	49.0	81.0	64.0	0.1	47.0	77.0	57.8	75.8	0.00

COMPARISON STATISTISTICS OF OBSERVED (480MOD55) VALUES ABOVE AND BELOW EXPECTED (MOD55)

	Within RVA range			Above RVA Range			Above RVA Range		
	Expected (E)	Observed (O)	O-E/E	Expected (E)	Observed (O)	O-E/E	Expected (E)	Observed (O)	O-E/E
Parameter	Group #1								
October	8	7	-0.13	2	4	1.00	1	0	-1.00
November	7	7	0.00	2	4	1.00	2	0	-1.00
December	8	8	0.00	1	3	2.00	2	0	-1.00
January	7	7	0.00	2	2	0.00	2	2	0.00
February	8	8	0.00	1	1	0.00	2	2	0.00
March	6	6	0.00	2	2	0.00	3	3	0.00
April	8	8	0.00	1	1	0.00	2	2	0.00
May	8	8	0.00	1	1	0.00	2	2	0.00
June	7	8	0.14	2	2	0.00	2	1	-0.50
July	8	10	0.25	1	1	0.00	2	0	-1.00
August	8	9	0.13	2	2	0.00	1	0	-1.00
September	8	10	0.25	1	1	0.00	2	0	-1.00
Parameter	Group #2								
1-day minimum	8	4	-0.50	2	7	2.50	1	0	-1.00
3-day minimum	8	4	-0.50	2	7	2.50	1	0	-1.00
7-day minimum	8	4	-0.50	2	7	2.50	1	0	-1.00
30-day minimum	8	6	-0.25	2	5	1.50	1	0	-1.00
90-day minimum	8	8	0.00	2	3	0.50	1	0	-1.00
1-day maximum	8	8	0.00	1	1	0.00	2	2	0.00
3-day maximum	8	8	0.00	1	1	0.00	2	2	0.00
7-day maximum	8	8	0.00	1	1	0.00	2	2	0.00
30-day maximum	8	8	0.00	1	1	0.00	2	2	0.00
90-day maximum	8	9	0.13	1	1	0.00	2	1	-0.50
Number of zero days	11	11	0.00	0	0	0.00	0	0	0.00
Base flow	7	7	0.00	2	3	0.50	2	1	-0.50
Parameter	Group #3								
Date of minimum	5	1	-0.80	3	1	-0.67	3	9	2.00
Date of maximum	4	4	0.00	2	2	0.00	5	5	0.00
Parameter	Group #4								
Low pulse count	7	3	-0.57	2	0	-1.00	2	8	3.00
Low pulse duration	9	4	-0.56	1	4	3.00	1	3	2.00
High pulse count	6	6	0.00	2	2	0.00	3	3	0.00
High pulse duration	6	6	0.00	2	2	0.00	3	3	0.00
Parameter	Group #5								
Rise rate	7	6	-0.14	2	2	0.00	2	3	0.50
Fall rate	8	8	0.00	2	2	0.00	1	1	0.00
Number of reversals	8	8	0.00	2	1	-0.50	1	2	1.00

APPENDIX J-13
RANGE OF VARIABILITY SCORE CARD FOR COMPARISON OF MOD55 AND 480MOD55 IHA STATISTICS AT GRAND FORKS
Final Aquatic Impact Analysis Report

	MOD55				480MOD55				RVA Targets		
	Means	SD % of mean	1-day min Low	1-day max High	Means	SD % of mean	1-day min Low	1-day max High	-1 SD Low	+1 SD High	Hydrologic Alternation
Parameter	Group #1										
October	2804.8	0.4	744.5	4289.7	3220.4	0.4	1228.0	4823.0	1663.6	3946.0	-0.29
November	2624.1	0.4	724.5	4090.8	3012.7	0.3	1199.8	4562.0	1592.4	3655.9	0.00
December	2334.7	0.5	631.4	4337.5	2625.5	0.4	997.7	4690.3	1169.8	3499.5	0.14
January	1904.2	0.4	622.2	3322.6	1914.8	0.4	638.9	3332.8	1128.9	2679.6	0.00
February	1887.2	0.4	596.6	3577.3	1890.2	0.4	597.6	3577.3	1070.1	2704.3	0.00
March	5662.0	0.6	1694.8	12763.2	5662.0	0.6	1694.8	12763.2	2192.9	9131.0	0.00
April	22434.3	1.1	3109.7	87108.4	22434.3	1.1	3109.7	87108.4	7293.8	46001.8	0.00
May	10432.1	1.0	2282.3	36064.2	10564.1	1.0	2297.1	36205.7	3009.1	21265.7	0.13
June	7165.3	0.9	1971.0	23628.0	7648.5	0.9	2425.4	24080.5	2391.6	13763.9	0.25
July	7302.0	1.1	1122.0	25140.2	7764.3	1.0	1554.6	25600.4	1416.6	15268.1	0.29
August	2629.9	0.6	697.5	6135.9	3091.3	0.5	1172.0	6606.6	950.6	4309.2	0.29
September	3105.2	1.1	890.9	12670.2	3571.7	0.9	1361.1	13146.3	1258.3	6398.9	0.25
Parameter	Group #2										
1-day minimum	1037.1	0.5	486.2	2157.3	1273.8	0.4	534.3	2186.2	503.5	1570.7	-0.11
3-day minimum	1071.2	0.5	506.3	2114.4	1310.4	0.4	537.6	2208.5	542.2	1600.1	0.00
7-day minimum	1099.4	0.5	538.6	1873.4	1358.7	0.4	538.8	2244.3	593.8	1605.0	0.00
30-day minimum	1319.0	0.5	585.9	2517.2	1504.2	0.4	586.2	2517.2	676.3	1961.7	-0.11
90-day minimum	1519.6	0.5	608.4	2835.1	1812.7	0.5	715.0	3601.5	774.4	2264.9	0.00
1-day maximum	49143.5	1.0	9312.5	189409.5	49184.3	1.0	9312.5	189409.5	15338.4	99072.7	0.00
3-day maximum	47011.0	1.0	9178.0	171619.9	47051.8	1.0	9178.0	171619.9	14902.2	92044.7	0.00
7-day maximum	44053.2	1.0	8542.6	163855.8	44095.8	1.0	8542.6	163855.8	13520.5	87307.3	0.00
30-day maximum	26535.4	1.0	5637.0	96526.8	26535.6	1.0	5637.0	96527.1	10508.1	52282.0	0.00
90-day maximum	14697.7	0.9	3516.9	45887.3	14839.7	0.9	3538.9	46123.1	6368.4	27383.4	0.00
Number of zero days	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00
Base flow	0.2	0.3	0.1	0.4	0.3	0.3	0.1	0.3	0.2	0.3	-0.25
Parameter	Group #3										
Date of minimum	231.1	0.3	16.0	309.0	104.7	0.3	16.0	282.0	169.2	293.0	-0.38
Date of maximum	103.5	0.1	74.0	196.0	103.5	0.1	74.0	196.0	94.3	112.8	0.00
Parameter	Group #4										
Low pulse count	3.8	0.8	0.0	10.0	2.6	0.7	0.0	6.0	0.8	6.9	0.25
Low pulse duration	18.9	1.0	0.0	61.0	24.2	1.4	0.0	116.0	0.7	37.1	-0.11
High pulse count	1.3	0.8	0.0	3.0	1.3	0.8	0.0	3.0	0.3	2.3	0.00
High pulse duration	12.7	1.0	0.0	41.5	12.8	1.0	0.0	42.0	0.3	25.1	0.00
Parameter	Group #5										
Rise rate	599.9	0.8	204.2	1724.9	615.9	0.8	219.0	1728.6	272.8	1059.5	-0.13
Fall rate	-381.4	-0.7	-1094.1	-125.3	-377.2	-0.7	-1084.6	-123.7	-667.0	-183.0	-0.13
Number of reversals	72.9	0.2	49.0	88.0	71.5	0.2	47.0	86.0	61.4	84.4	0.14

COMPARISON STATISTISTICS OF OBSERVED (480MOD55) VALUES ABOVE AND BELOW EXPECTED (MOD55)

	Within RVA range			Above RVA Range			Above RVA Range		
	Expected (E)	Observed (O)	O-E/E	Expected (E)	Observed (O)	O-E/E	Expected (E)	Observed (O)	O-E/E
Parameter	Group #1								
October	7	5	-0.29	2	4	1.00	2	2	0.00
November	7	7	0.00	2	2	0.00	2	2	0.00
December	7	8	0.14	2	2	0.00	2	1	-0.50
January	7	7	0.00	2	2	0.00	2	2	0.00
February	8	8	0.00	1	1	0.00	2	2	0.00
March	8	8	0.00	2	2	0.00	1	1	0.00
April	8	8	0.00	1	1	0.00	2	2	0.00
May	8	9	0.13	1	1	0.00	2	1	-0.50
June	8	10	0.25	1	1	0.00	2	0	-1.00
July	7	9	0.29	2	2	0.00	2	0	-1.00
August	7	9	0.29	2	2	0.00	2	0	-1.00
September	8	10	0.25	1	1	0.00	2	0	-1.00
Parameter	Group #2								
1-day minimum	9	8	-0.11	1	3	2.00	1	0	-1.00
3-day minimum	7	7	0.00	1	3	2.00	3	1	-0.67
7-day minimum	6	6	0.00	2	4	1.00	3	1	-0.67
30-day minimum	9	8	-0.11	1	2	1.00	1	1	0.00
90-day minimum	7	7	0.00	2	3	0.50	2	1	-0.50
1-day maximum	8	8	0.00	1	1	0.00	2	2	0.00
3-day maximum	8	8	0.00	1	1	0.00	2	2	0.00
7-day maximum	8	8	0.00	1	1	0.00	2	2	0.00
30-day maximum	8	8	0.00	1	1	0.00	2	2	0.00
90-day maximum	8	8	0.00	1	1	0.00	2	2	0.00
Number of zero days	11	11	0.00	0	0	0.00	0	0	0.00
Base flow	8	6	-0.25	2	4	1.00	1	1	0.00
Parameter	Group #3								
Date of minimum	8	5	-0.38	1	0	-1.00	2	6	2.00
Date of maximum	5	5	0.00	2	2	0.00	4	4	0.00
Parameter	Group #4								
Low pulse count	8	10	0.25	2	0	-1.00	1	1	0.00
Low pulse duration	9	8	-0.11	1	2	1.00	1	1	0.00
High pulse count	7	7	0.00	1	1	0.00	3	3	0.00
High pulse duration	7	7	0.00	1	1	0.00	3	3	0.00
Parameter	Group #5								
Rise rate	8	7	-0.13	1	1	0.00	2	3	0.50
Fall rate	8	7	-0.13	2	3	0.50	1	1	0.00
Number of reversals	7	8	0.14	3	1	-0.67	1	2	1.00

APPENDIX J-14
RANGE OF VARIABILITY SCORE CARD FOR COMPARISON OF MOD55 AND 480MOD55 IHA STATISTICS AT EMERSON
Final Aquatic Impact Analysis Report

	MOD55				480MOD55				RVA Targets		
	Means	SD % of mean	1-day min Low	1-day max High	Means	SD % of mean	1-day min Low	1-day max High	-1 SD Low	+1 SD High	Hydrologic Alternation
Parameter	Group #1										
October	2987.0	0.4	868.0	4623.0	3407.2	0.3	1352.9	5167.9	1879.9	4094.1	-0.38
November	3064.9	0.3	1116.6	4572.1	3451.7	0.3	1582.6	5048.1	2018.0	4111.9	0.00
December	2541.4	0.5	769.7	5296.6	2880.5	0.4	1196.9	5712.5	1224.8	3857.9	0.14
January	2032.8	0.4	688.9	3378.3	2064.7	0.4	747.2	3405.7	1224.8	2840.9	0.00
February	1970.6	0.4	649.4	3297.1	1970.9	0.4	647.5	3297.2	1175.5	2765.7	0.00
March	5321.4	0.6	1615.0	10296.2	5321.4	0.6	1615.0	10296.2	2259.3	8383.5	0.00
April	27496.9	0.8	10594.3	83131.4	27496.9	0.8	10594.3	83131.4	12944.7	49631.7	0.00
May	18376.9	1.2	3740.3	76185.4	18434.0	1.2	3791.7	76201.0	3823.3	40851.5	0.00
June	8863.9	0.9	2630.6	23766.1	9326.4	0.8	3103.0	24091.0	2694.8	16443.3	0.14
July	9417.6	1.1	1464.5	28881.0	9882.3	1.0	1877.4	29273.0	1885.3	19474.1	0.00
August	3187.2	0.7	769.7	7283.2	3656.9	0.6	1243.5	7748.6	963.2	5411.2	0.14
September	3638.4	1.0	1018.0	14290.7	4110.4	0.9	1474.9	14778.3	1541.0	7346.7	0.13
Parameter	Group #2										
1-day minimum	1161.4	0.5	589.2	2632.8	1399.9	0.4	589.3	2664.2	630.6	1768.3	-0.13
3-day minimum	1149.1	0.5	595.6	2361.0	1413.2	0.4	595.7	2669.5	604.2	1694.1	-0.22
7-day minimum	1159.9	0.4	607.2	1938.3	1445.8	0.4	607.4	2416.6	675.6	1644.1	0.00
30-day minimum	1451.7	0.5	642.1	2807.0	1631.1	0.4	642.8	2807.0	735.1	2168.4	-0.13
90-day minimum	1696.4	0.5	686.8	3085.7	1994.2	0.4	816.4	3687.3	905.9	2486.9	0.00
1-day maximum	54230.0	1.1	16143.2	227449.0	54230.0	1.1	16143.2	227449.0	22404.6	113666.2	0.00
3-day maximum	53649.6	1.1	16050.9	223507.0	53649.6	1.1	16050.9	223507.0	22258.8	111979.0	0.00
7-day maximum	51255.4	1.1	15394.3	208079.2	51255.4	1.1	15394.3	208079.2	21393.0	105341.4	0.00
30-day maximum	35254.1	0.9	12162.7	123896.3	35254.7	0.9	12162.7	123896.7	16740.1	67446.9	0.00
90-day maximum	19616.2	0.8	7712.4	61230.4	19752.2	0.8	7838.6	61460.9	7828.9	35884.3	0.25
Number of zero days	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00
Base flow	0.2	0.3	0.1	0.3	0.2	0.3	0.1	0.3	0.1	0.2	-0.25
Parameter	Group #3										
Date of minimum	183.4	0.3	22.0	287.0	94.9	0.4	22.0	287.0	127.1	239.7	0.00
Date of maximum	106.8	0.0	96.0	129.0	106.8	0.0	96.0	129.0	103.9	109.8	0.00
Parameter	Group #4										
Low pulse count	2.5	0.6	0.0	5.0	2.1	0.6	0.0	4.0	1.1	4.0	0.00
Low pulse duration	29.5	1.1	0.0	123.0	31.6	1.0	0.0	116.0	7.0	63.2	-0.13
High pulse count	1.4	0.6	0.0	3.0	1.4	0.6	0.0	3.0	0.6	2.2	0.00
High pulse duration	18.4	0.9	0.0	51.0	18.5	0.9	0.0	51.0	1.6	35.2	0.00
Parameter	Group #5										
Rise rate	556.9	0.8	225.5	1806.4	566.0	0.8	239.9	1781.8	238.0	1011.2	0.25
Fall rate	-354.3	-0.8	-1158.7	-141.2	-350.8	-0.9	-1157.5	-135.0	-653.0	-172.6	-0.25
Number of reversals	38.9	0.2	27.0	58.0	36.4	0.2	25.0	52.0	29.4	48.4	-0.13

COMPARISON STATISTISTICS OF OBSERVED (480MOD55) VALUES ABOVE AND BELOW EXPECTED (MOD55)

	Within RVA range			Above RVA Range			Above RVA Range		
	Expected (E)	Observed (O)	O-E/E	Expected (E)	Observed (O)	O-E/E	Expected (E)	Observed (O)	O-E/E
Parameter	Group #1								
October	8	5	-0.38	1	4	3.00	2	2	0.00
November	7	7	0.00	2	2	0.00	2	2	0.00
December	7	8	0.14	2	2	0.00	2	1	-0.50
January	7	7	0.00	2	2	0.00	2	2	0.00
February	7	7	0.00	2	2	0.00	2	2	0.00
March	8	8	0.00	2	2	0.00	1	1	0.00
April	8	8	0.00	1	1	0.00	2	2	0.00
May	8	8	0.00	1	1	0.00	2	2	0.00
June	7	8	0.14	2	3	0.50	2	0	-1.00
July	7	7	0.00	2	2	0.00	2	2	0.00
August	7	8	0.14	2	3	0.50	2	0	-1.00
September	8	9	0.13	1	1	0.00	2	1	-0.50
Parameter	Group #2								
1-day minimum	8	7	-0.13	1	3	2.00	2	1	-0.50
3-day minimum	9	7	-0.22	1	3	2.00	1	1	0.00
7-day minimum	6	6	0.00	2	4	1.00	3	1	-0.67
30-day minimum	8	7	-0.13	2	3	0.50	1	1	0.00
90-day minimum	7	7	0.00	3	3	0.00	1	1	0.00
1-day maximum	8	8	0.00	1	1	0.00	2	2	0.00
3-day maximum	8	8	0.00	1	1	0.00	2	2	0.00
7-day maximum	8	8	0.00	1	1	0.00	2	2	0.00
30-day maximum	8	8	0.00	1	1	0.00	2	2	0.00
90-day maximum	8	10	0.25	1	1	0.00	2	0	-1.00
Number of zero days	11	11	0.00	0	0	0.00	0	0	0.00
Base flow	8	6	-0.25	1	4	3.00	2	1	-0.50
Parameter	Group #3								
Date of minimum	2	2	0.00	5	4	-0.20	4	5	0.25
Date of maximum	3	3	0.00	3	3	0.00	5	5	0.00
Parameter	Group #4								
Low pulse count	6	6	0.00	2	1	-0.50	3	4	0.33
Low pulse duration	8	7	-0.13	1	1	0.00	2	3	0.50
High pulse count	9	9	0.00	1	1	0.00	1	1	0.00
High pulse duration	8	8	0.00	2	2	0.00	1	1	0.00
Parameter	Group #5								
Rise rate	8	10	0.25	1	1	0.00	2	0	-1.00
Fall rate	8	6	-0.25	2	4	1.00	1	1	0.00
Number of reversals	8	7	-0.13	2	2	0.00	1	2	1.00

APPENDIX J-15
RANGE OF VARIABILITY SCORE CARD FOR COMPARISON OF WET AND WETOF IHA STATISTICS AT COOPERSTOWN
Final Aquatic Impact Analysis Report

	WET				WETOF				RVA Targets		
		SD	1-day min	1-day max		SD	1-day min	1-day max	-1 SD	+1 SD	Hydrologic
	Means	% of mean	Low	High	Means	% of mean	Low	High	Low	High	Alternation
Parameter	Group #1										
October	91.8	1.1	36.4	378.6	164.7	0.8	37.7	488.3	49.6	189.1	-0.25
November	68.3	0.9	20.2	251.5	138.1	0.8	20.2	370.0	46.8	130.8	-0.25
December	43.8	0.6	12.8	120.1	115.3	0.8	12.8	277.9	15.5	72.1	-0.78
January	29.1	0.6	10.0	69.2	107.7	0.8	10.0	265.2	12.9	45.3	-0.75
February	42.6	0.8	5.7	108.9	135.6	0.9	10.3	390.2	6.6	78.6	-0.63
March	402.5	1.1	40.9	1342.1	515.0	0.9	41.1	1537.4	94.7	835.6	0.14
April	1159.9	0.7	132.1	2591.4	1298.9	0.7	303.7	2714.9	304.7	2015.2	0.00
May	411.8	0.9	75.5	1215.6	615.4	0.7	128.1	1546.7	174.7	768.7	-0.14
June	211.3	0.6	76.8	492.1	442.9	0.6	76.8	910.7	94.4	328.2	-0.56
July	228.6	0.7	46.0	615.0	444.2	0.5	46.0	800.7	61.4	395.9	-0.50
August	185.7	1.6	10.2	1062.4	355.1	0.9	10.2	1180.5	31.6	484.8	-0.13
September	98.7	1.1	2.8	320.0	206.0	0.9	2.8	478.6	22.4	207.7	0.00
Parameter	Group #2										
1-day minimum	15.4	0.5	2.3	28.9	53.6	0.7	2.3	124.4	7.1	23.7	-0.71
3-day minimum	16.1	0.6	2.4	31.8	54.7	0.7	2.4	127.7	7.1	25.1	-0.71
7-day minimum	17.0	0.6	2.5	35.1	57.0	0.7	2.5	132.5	7.3	26.7	-0.75
30-day minimum	21.4	0.6	2.7	51.2	65.0	0.6	2.7	143.7	8.0	34.9	-0.75
90-day minimum	28.6	0.5	10.0	57.5	68.1	0.6	10.5	151.3	14.7	42.6	-0.71
1-day maximum	2707.0	0.6	513.0	6610.1	2841.0	0.6	666.1	6733.1	969.9	4444.0	0.00
3-day maximum	2555.3	0.6	504.8	5770.1	2689.9	0.6	659.6	5894.0	1008.5	4102.0	0.00
7-day maximum	2305.7	0.6	479.5	4951.3	2444.3	0.6	649.8	5077.9	949.1	3662.3	0.00
30-day maximum	1490.6	0.5	349.0	2839.6	1636.0	0.5	519.4	3011.6	672.5	2308.7	-0.13
90-day maximum	741.4	0.5	201.6	1340.8	933.1	0.5	371.4	1663.5	361.4	1121.4	0.00
Number of zero days	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00
Base flow	0.1	0.6	0.0	0.2	0.1	0.6	0.0	0.3	0.0	0.1	-0.75
Parameter	Group #3										
Date of minimum	119.2	0.3	17.0	275.0	264.8	0.2	17.0	347.0	80.8	157.6	0.00
Date of maximum	104.0	0.1	64.0	207.0	104.0	0.1	64.0	207.0	93.5	114.5	0.00
Parameter	Group #4										
Low pulse count	3.7	0.6	1.0	7.0	0.6	1.5	0.0	2.0	1.6	5.9	-0.57
Low pulse duration	37.0	1.2	2.0	162.0	23.5	2.2	0.0	162.0	10.7	82.7	-0.75
High pulse count	1.5	0.6	0.0	3.0	2.2	0.7	0.0	5.0	0.5	2.4	-0.13
High pulse duration	19.9	0.7	0.0	45.0	21.1	0.6	0.0	44.5	6.4	33.4	0.00
Parameter	Group #5										
Rise rate	33.3	0.5	10.5	58.6	30.4	0.5	9.0	59.6	17.8	48.7	0.00
Fall rate	-17.7	-0.5	-33.2	-5.2	-19.7	-0.5	-33.8	-6.7	-26.4	-9.1	-0.14
Number of reversals	77.0	0.1	65.0	100.0	66.8	0.1	48.0	76.0	67.7	86.3	-0.33

COMPARISON STATISTISTICS OF OBSERVED (WETOF) VALUES ABOVE AND BELOW EXPECTED (WET)

	Within RVA range			Above RVA Range			Above RVA Range		
	Expected (E)	Observed (O)	O-E/E	Expected (E)	Observed (O)	O-E/E	Expected (E)	Observed (O)	O-E/E
Parameter	Group #1								
October	8	6	-0.25	1	4	3.00	2	1	-0.50
November	8	6	-0.25	1	4	3.00	2	1	-0.50
December	9	2	-0.78	1	8	7.00	1	1	0.00
January	8	2	-0.75	1	8	7.00	2	1	-0.50
February	8	3	-0.63	2	8	3.00	1	0	-1.00
March	7	8	0.14	2	2	0.00	2	1	-0.50
April	7	7	0.00	3	3	0.00	1	1	0.00
May	7	6	-0.14	2	4	1.00	2	1	-0.50
June	9	4	-0.56	1	6	5.00	1	1	0.00
July	8	4	-0.50	2	6	2.00	1	1	0.00
August	8	7	-0.13	1	3	2.00	2	1	-0.50
September	6	6	0.00	3	4	0.33	2	1	-0.50
Parameter	Group #2								
1-day minimum	7	2	-0.71	2	8	3.00	2	1	-0.50
3-day minimum	7	2	-0.71	2	8	3.00	2	1	-0.50
7-day minimum	8	2	-0.75	1	8	7.00	2	1	-0.50
30-day minimum	8	2	-0.75	1	8	7.00	2	1	-0.50
90-day minimum	7	2	-0.71	2	8	3.00	2	1	-0.50
1-day maximum	8	8	0.00	2	2	0.00	1	1	0.00
3-day maximum	8	8	0.00	2	2	0.00	1	1	0.00
7-day maximum	8	8	0.00	2	2	0.00	1	1	0.00
30-day maximum	8	7	-0.13	2	3	0.50	1	1	0.00
90-day maximum	7	7	0.00	3	4	0.33	1	0	-1.00
Number of zero days	11	11	0.00	0	0	0.00	0	0	0.00
Base flow	8	2	-0.75	2	8	3.00	1	1	0.00
Parameter	Group #3								
Date of minimum	0	0	0.00	4	10	1.50	7	1	-0.86
Date of maximum	5	5	0.00	2	2	0.00	4	4	0.00
Parameter	Group #4								
Low pulse count	7	3	-0.57	2	0	-1.00	2	8	3.00
Low pulse duration	8	2	-0.75	1	1	0.00	2	8	3.00
High pulse count	8	7	-0.13	2	3	0.50	1	1	0.00
High pulse duration	7	7	0.00	3	3	0.00	1	1	0.00
Parameter	Group #5								
Rise rate	8	8	0.00	2	1	-0.50	1	2	1.00
Fall rate	7	6	-0.14	2	2	0.00	2	3	0.50
Number of reversals	9	6	-0.33	1	0	-1.00	1	5	4.00

APPENDIX J-16
RANGE OF VARIABILITY SCORE CARD FOR COMPARISON OF WET AND WETOF IHA STATISTICS AT BALDHILL DAM
Final Aquatic Impact Analysis Report

	WET				WETOF				RVA Targets		
	Means	SD % of mean	1-day min Low	1-day max High	Means	SD % of mean	1-day min Low	1-day max High	-1 SD Low	+1 SD High	Hydrologic Alternation
Parameter	Group #1										
October	236.3	0.6	147.5	651.2	309.5	0.6	149.0	760.3	165.9	378.0	0.00
November	198.8	0.4	143.8	418.1	268.6	0.5	143.8	536.1	156.6	274.1	-0.38
December	158.1	0.2	118.4	248.0	229.5	0.4	118.4	387.5	123.6	192.7	-0.78
January	39.0	0.5	13.6	86.1	117.3	0.7	13.6	270.5	17.6	60.5	-0.71
February	62.3	0.9	13.0	220.4	154.4	0.9	13.0	498.2	23.9	121.0	-0.38
March	587.1	0.8	126.6	1635.7	688.4	0.7	207.0	1720.1	223.3	1084.1	0.00
April	1216.3	0.9	13.0	3260.8	1350.1	0.9	32.2	3413.1	89.7	2342.8	-0.13
May	597.0	1.0	13.0	1893.5	807.3	0.8	205.8	2216.4	205.6	1194.4	0.14
June	267.0	0.7	101.1	715.6	504.4	0.6	133.8	1132.4	141.6	443.0	-0.50
July	317.3	0.9	55.1	1008.4	532.4	0.6	55.1	1015.0	121.0	592.6	-0.38
August	263.7	1.8	17.6	1639.7	436.7	1.1	17.6	1772.2	51.5	729.0	0.13
September	131.4	1.1	13.0	420.2	240.4	0.9	13.0	576.7	25.5	269.8	0.00
Parameter	Group #2										
1-day minimum	17.6	0.4	13.0	36.9	60.5	0.8	13.0	148.3	13.0	25.4	-0.44
3-day minimum	20.2	0.5	13.0	47.2	63.0	0.8	13.0	149.0	13.0	30.6	-0.50
7-day minimum	22.7	0.5	13.0	51.9	67.4	0.8	13.0	154.0	13.0	34.4	-0.50
30-day minimum	29.7	0.6	13.0	75.3	83.2	0.7	13.0	191.6	13.0	48.6	-0.60
90-day minimum	56.6	0.5	23.7	112.2	119.8	0.5	23.7	224.4	28.8	84.4	-0.86
1-day maximum	2600.2	0.6	513.0	5284.7	2721.2	0.5	666.1	5533.9	1142.9	4057.5	0.00
3-day maximum	2535.3	0.6	504.8	5284.7	2660.3	0.6	659.6	5533.9	1047.4	4023.1	0.00
7-day maximum	2396.6	0.6	490.6	4926.9	2520.2	0.6	649.8	5171.1	941.7	3851.5	0.14
30-day maximum	1830.2	0.6	369.2	3644.7	1961.4	0.6	540.5	3759.1	657.5	3002.8	-0.13
90-day maximum	926.8	0.6	165.6	1838.2	1111.6	0.6	318.1	2143.0	360.1	1493.6	-0.14
Number of zero days	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00
Base flow	0.1	0.4	0.0	0.1	0.1	0.6	0.0	0.3	0.1	0.1	-0.63
Parameter	Group #3										
Date of minimum	99.3	0.3	1.0	272.0	112.5	0.3	1.0	274.0	74.2	124.3	-0.75
Date of maximum	102.7	0.1	58.0	230.0	106.9	0.1	65.0	232.0	89.7	115.8	0.17
Parameter	Group #4										
Low pulse count	5.8	0.4	3.0	10.0	1.5	1.4	0.0	6.0	3.3	8.3	-0.71
Low pulse duration	19.5	0.6	1.1	36.0	9.8	1.3	0.0	35.8	6.9	32.1	-0.43
High pulse count	2.5	0.7	0.0	6.0	2.6	0.7	0.0	6.0	0.7	4.2	0.13
High pulse duration	12.1	0.7	0.0	27.0	16.3	0.9	0.0	55.0	3.4	20.8	0.00
Parameter	Group #5										
Rise rate	51.2	0.3	19.3	72.1	50.0	0.4	17.4	70.5	33.7	68.8	-0.13
Fall rate	-39.4	-0.4	-57.8	-12.6	-39.6	-0.4	-58.6	-15.0	-56.3	-22.6	0.00
Number of reversals	130.6	0.2	91.0	163.0	129.3	0.2	104.0	165.0	106.2	155.1	0.17

COMPARISON STATISTISTICS OF OBSERVED (WETOF) VALUES ABOVE AND BELOW EXPECTED (WET)

	Within RVA range			Above RVA Range			Above RVA Range		
	Expected (E)	Observed (O)	O-E/E	Expected (E)	Observed (O)	O-E/E	Expected (E)	Observed (O)	O-E/E
Parameter	Group #1								
October	8	8	0.00	1	2	1.00	2	1	-0.50
November	8	5	-0.38	1	4	3.00	2	2	0.00
December	9	2	-0.78	1	8	7.00	1	1	0.00
January	7	2	-0.71	2	8	3.00	2	1	-0.50
February	8	5	-0.38	1	5	4.00	2	1	-0.50
March	7	7	0.00	2	2	0.00	2	2	0.00
April	8	7	-0.13	2	3	0.50	1	1	0.00
May	7	8	0.14	2	3	0.50	2	0	-1.00
June	8	4	-0.50	1	6	5.00	2	1	-0.50
July	8	5	-0.38	1	5	4.00	2	1	-0.50
August	8	9	0.13	1	1	0.00	2	1	-0.50
September	6	6	0.00	3	4	0.33	2	1	-0.50
Parameter	Group #2								
1-day minimum	9	5	-0.44	2	6	2.00	0	0	0.00
3-day minimum	10	5	-0.50	1	6	5.00	0	0	0.00
7-day minimum	10	5	-0.50	1	6	5.00	0	0	0.00
30-day minimum	10	4	-0.60	1	7	6.00	0	0	0.00
90-day minimum	7	1	-0.86	2	8	3.00	2	2	0.00
1-day maximum	8	8	0.00	2	2	0.00	1	1	0.00
3-day maximum	8	8	0.00	2	2	0.00	1	1	0.00
7-day maximum	7	8	0.14	2	2	0.00	2	1	-0.50
30-day maximum	8	7	-0.13	2	3	0.50	1	1	0.00
90-day maximum	7	6	-0.14	3	4	0.33	1	1	0.00
Number of zero days	11	11	0.00	0	0	0.00	0	0	0.00
Base flow	8	3	-0.63	1	7	6.00	2	1	-0.50
Parameter	Group #3								
Date of minimum	4	1	-0.75	2	4	1.00	5	6	0.20
Date of maximum	6	7	0.17	2	2	0.00	3	2	-0.33
Parameter	Group #4								
Low pulse count	7	2	-0.71	2	0	-1.00	2	9	3.50
Low pulse duration	7	4	-0.43	2	1	-0.50	2	6	2.00
High pulse count	8	9	0.13	2	1	-0.50	1	1	0.00
High pulse duration	7	7	0.00	2	3	0.50	2	1	-0.50
Parameter	Group #5								
Rise rate	8	7	-0.13	2	2	0.00	1	2	1.00
Fall rate	7	7	0.00	3	3	0.00	1	1	0.00
Number of reversals	6	7	0.17	3	2	-0.33	2	2	0.00

APPENDIX J-17
RANGE OF VARIABILITY SCORE CARD FOR COMPARISON OF WET AND WETOF IHA STATISTICS AT LISBON
Final Aquatic Impact Analysis Report

	WET				WETOF				RVA Targets		
	Means	SD % of mean	1-day min Low	1-day max High	Means	SD % of mean	1-day min Low	1-day max High	-1 SD Low	+1 SD High	Hydrologic Alternation
Parameter	Group #1										
October	254.0	0.7	151.6	774.0	329.9	0.6	160.4	882.3	182.9	429.6	-0.13
November	231.7	0.4	157.7	531.0	301.2	0.5	157.7	646.3	174.2	335.1	-0.25
December	182.9	0.3	122.7	306.4	253.3	0.4	122.7	443.6	132.9	232.9	-0.56
January	71.6	0.4	38.0	126.5	146.5	0.6	38.0	313.7	43.3	100.0	-0.50
February	80.2	0.9	17.6	252.6	175.1	0.9	23.4	573.2	30.7	149.3	-0.29
March	666.3	0.8	133.0	1721.1	771.7	0.7	184.1	1823.3	151.1	1181.5	0.00
April	1510.7	0.8	61.1	4007.2	1640.8	0.8	86.0	4152.2	247.5	2774.0	-0.13
May	782.3	1.1	16.4	2703.3	983.5	0.9	220.1	3006.7	245.4	1613.4	-0.14
June	337.2	0.6	69.1	810.5	574.2	0.6	161.5	1219.6	141.3	533.1	-0.44
July	386.8	0.8	69.5	1232.0	604.0	0.6	69.5	1238.7	174.0	709.1	-0.38
August	314.5	1.8	21.2	1961.2	491.1	1.2	21.2	2082.9	80.4	869.5	0.13
September	159.9	1.0	15.2	452.0	273.8	0.8	15.2	621.0	36.4	317.1	0.00
Parameter	Group #2										
1-day minimum	31.4	0.6	13.5	67.0	76.6	0.7	14.3	172.1	14.3	50.3	-0.29
3-day minimum	32.7	0.6	13.6	68.0	77.7	0.7	14.4	173.3	13.6	51.7	-0.38
7-day minimum	34.6	0.6	13.8	69.2	80.2	0.7	14.4	174.4	14.8	54.4	-0.33
30-day minimum	43.4	0.6	15.2	84.9	102.0	0.7	15.2	209.6	19.4	67.5	-0.33
90-day minimum	81.5	0.5	34.1	142.7	143.0	0.5	34.1	236.3	43.7	119.2	-0.63
1-day maximum	2910.2	0.5	506.1	5421.6	3044.1	0.5	662.5	5720.5	1329.0	4491.3	0.00
3-day maximum	2832.6	0.6	503.7	5351.2	2970.9	0.5	661.5	5656.9	1246.1	4419.2	0.00
7-day maximum	2724.0	0.6	490.0	5229.0	2852.0	0.6	655.3	5519.2	1145.5	4302.5	0.00
30-day maximum	2148.0	0.6	376.6	4571.5	2268.6	0.6	552.5	4688.3	813.3	3482.7	0.00
90-day maximum	1133.3	0.6	173.9	2433.1	1314.3	0.6	328.0	2734.3	436.2	1830.5	-0.33
Number of zero days	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00
Base flow	0.1	0.4	0.0	0.1	0.1	0.5	0.0	0.3	0.1	0.1	-0.63
Parameter	Group #3										
Date of minimum	158.5	0.3	26.0	275.0	141.1	0.3	9.0	274.0	110.4	206.6	0.00
Date of maximum	100.9	0.1	59.0	201.0	100.8	0.1	59.0	201.0	90.4	111.4	0.00
Parameter	Group #4										
Low pulse count	3.1	0.4	1.0	5.0	1.5	1.3	0.0	6.0	1.9	4.3	-0.50
Low pulse duration	32.3	0.6	11.0	72.0	15.4	1.6	0.0	72.0	14.2	50.4	-0.71
High pulse count	1.9	0.6	0.0	4.0	2.3	0.6	0.0	4.0	0.8	3.1	-0.11
High pulse duration	15.5	0.5	0.0	27.0	16.6	0.6	0.0	37.5	7.2	23.8	0.14
Parameter	Group #5										
Rise rate	45.7	0.4	11.3	80.9	45.8	0.4	11.4	80.6	26.8	64.7	0.00
Fall rate	-31.7	-0.5	-51.8	-6.6	-33.0	-0.4	-51.9	-9.2	-46.1	-17.4	-0.13
Number of reversals	83.5	0.1	62.0	106.0	82.6	0.2	62.0	108.0	71.9	95.0	-0.22

COMPARISON STATISTISTICS OF OBSERVED (WETOF) VALUES ABOVE AND BELOW EXPECTED (WET)

	Within RVA range			Above RVA Range			Above RVA Range		
	Expected (E)	Observed (O)	O-E/E	Expected (E)	Observed (O)	O-E/E	Expected (E)	Observed (O)	O-E/E
Parameter	Group #1								
October	8	7	-0.13	1	2	1.00	2	2	0.00
November	8	6	-0.25	1	3	2.00	2	2	0.00
December	9	4	-0.56	1	6	5.00	1	1	0.00
January	6	3	-0.50	2	7	2.50	3	1	-0.67
February	7	5	-0.29	2	5	1.50	2	1	-0.50
March	8	8	0.00	2	3	0.50	1	0	-1.00
April	8	7	-0.13	2	3	0.50	1	1	0.00
May	7	6	-0.14	2	3	0.50	2	2	0.00
June	9	5	-0.44	1	6	5.00	1	0	-1.00
July	8	5	-0.38	1	5	4.00	2	1	-0.50
August	8	9	0.13	1	1	0.00	2	1	-0.50
September	6	6	0.00	3	4	0.33	2	1	-0.50
Parameter	Group #2								
1-day minimum	7	5	-0.29	2	6	2.00	2	0	-1.00
3-day minimum	8	5	-0.38	2	6	2.00	1	0	-1.00
7-day minimum	6	4	-0.33	3	6	1.00	2	1	-0.50
30-day minimum	6	4	-0.33	2	6	2.00	3	1	-0.67
90-day minimum	8	3	-0.63	2	7	2.50	1	1	0.00
1-day maximum	8	8	0.00	2	2	0.00	1	1	0.00
3-day maximum	8	8	0.00	2	2	0.00	1	1	0.00
7-day maximum	8	8	0.00	2	2	0.00	1	1	0.00
30-day maximum	8	8	0.00	2	2	0.00	1	1	0.00
90-day maximum	9	6	-0.33	1	4	3.00	1	1	0.00
Number of zero days	11	11	0.00	0	0	0.00	0	0	0.00
Base flow	8	3	-0.63	2	7	2.50	1	1	0.00
Parameter	Group #3								
Date of minimum	1	1	0.00	5	5	0.00	5	5	0.00
Date of maximum	5	5	0.00	3	3	0.00	3	3	0.00
Parameter	Group #4								
Low pulse count	8	4	-0.50	2	1	-0.50	1	6	5.00
Low pulse duration	7	2	-0.71	2	1	-0.50	2	8	3.00
High pulse count	9	8	-0.11	1	2	1.00	1	1	0.00
High pulse duration	7	8	0.14	2	2	0.00	2	1	-0.50
Parameter	Group #5								
Rise rate	9	9	0.00	1	1	0.00	1	1	0.00
Fall rate	8	7	-0.13	2	2	0.00	1	2	1.00
Number of reversals	9	7	-0.22	1	1	0.00	1	3	2.00

APPENDIX J-18
RANGE OF VARIABILITY SCORE CARD FOR COMPARISON OF WET AND WETOF IHA STATISTICS AT KINDRED
Final Aquatic Impact Analysis Report

	WET				WETOF				RVA Targets		
		SD	1-day min	1-day max		SD	1-day min	1-day max	-1 SD	+1 SD	Hydrologic
	Means	% of mean	Low	High	Means	% of mean	Low	High	Low	High	Alternation
Parameter	Group #1										
October	279.1	0.6	154.4	770.2	357.8	0.6	172.1	878.1	197.7	448.4	-0.13
November	272.6	0.5	174.5	619.0	342.2	0.5	174.5	731.9	195.4	397.9	-0.13
December	214.0	0.3	132.2	363.9	283.6	0.4	132.2	498.8	145.8	282.2	-0.38
January	103.1	0.3	54.6	152.1	175.0	0.5	54.6	353.1	71.8	134.3	-0.63
February	89.5	0.6	31.3	201.5	181.6	0.7	31.3	515.1	33.0	145.9	-0.43
March	666.3	0.8	102.2	1534.4	775.1	0.7	153.6	1654.2	148.1	1184.5	0.14
April	1658.2	0.8	134.0	4036.3	1786.5	0.7	174.0	4176.5	413.8	2902.6	-0.25
May	991.8	1.0	46.3	3215.2	1183.0	0.9	235.1	3502.9	332.6	2000.7	0.00
June	438.3	0.6	55.6	951.3	675.9	0.6	251.9	1354.3	194.1	682.5	-0.25
July	465.5	0.6	117.6	1196.5	685.0	0.5	117.6	1203.1	165.0	765.9	-0.44
August	375.8	1.7	39.5	2253.3	555.4	1.2	39.5	2364.4	74.5	1009.2	0.13
September	212.5	0.9	34.8	540.2	330.7	0.8	34.8	796.6	55.3	395.4	0.00
Parameter	Group #2										
1-day minimum	54.0	0.5	20.1	104.1	103.7	0.7	20.1	207.8	24.6	83.4	-0.57
3-day minimum	56.0	0.5	20.6	105.9	105.0	0.7	20.6	208.8	26.4	85.7	-0.50
7-day minimum	60.1	0.5	22.1	107.9	109.3	0.7	22.1	217.3	29.1	91.2	-0.40
30-day minimum	69.8	0.5	27.5	112.5	128.5	0.6	27.5	247.6	35.2	104.4	-0.50
90-day minimum	110.2	0.4	55.7	164.2	173.9	0.5	55.7	306.1	65.9	154.5	-0.40
1-day maximum	3023.0	0.5	538.5	5773.8	3160.3	0.5	697.8	6080.2	1412.2	4633.7	0.00
3-day maximum	2986.3	0.5	534.5	5713.8	3124.9	0.5	696.4	6019.2	1381.9	4590.7	0.00
7-day maximum	2867.6	0.5	523.0	5511.9	3007.2	0.5	690.1	5794.8	1298.3	4436.9	0.00
30-day maximum	2266.6	0.6	423.0	4791.9	2391.3	0.6	599.6	4910.3	894.7	3638.6	0.00
90-day maximum	1268.6	0.6	205.0	2625.3	1446.0	0.6	351.5	2927.4	507.3	2029.9	-0.25
Number of zero days	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00
Base flow	0.1	0.4	0.0	0.2	0.2	0.5	0.0	0.3	0.1	0.2	-0.14
Parameter	Group #3										
Date of minimum	110.1	0.3	15.0	275.0	119.4	0.3	14.0	273.0	78.1	142.1	0.00
Date of maximum	110.0	0.1	72.0	224.0	109.9	0.1	69.0	224.0	97.9	122.1	0.00
Parameter	Group #4										
Low pulse count	3.0	0.4	1.0	5.0	1.6	1.0	0.0	5.0	1.7	4.3	-0.38
Low pulse duration	34.9	0.6	8.3	71.5	17.8	1.3	0.0	71.5	12.7	57.2	-0.43
High pulse count	2.0	0.7	0.0	4.0	2.0	0.5	0.0	4.0	0.7	3.3	0.13
High pulse duration	17.9	0.8	0.0	53.0	20.4	0.6	0.0	43.5	4.1	31.7	0.00
Parameter	Group #5										
Rise rate	41.7	0.4	9.6	67.4	42.2	0.4	9.9	69.2	24.4	59.1	-0.13
Fall rate	-28.5	-0.5	-48.1	-6.6	-29.6	-0.4	-48.0	-8.6	-41.4	-15.7	0.00
Number of reversals	81.7	0.1	66.0	93.0	76.8	0.1	60.0	93.0	72.5	90.9	0.00

COMPARISON STATISTISTICS OF OBSERVED (WETOF) VALUES ABOVE AND BELOW EXPECTED (WET)

	Within RVA range			Above RVA Range			Above RVA Range		
	Expected (E)	Observed (O)	O-E/E	Expected (E)	Observed (O)	O-E/E	Expected (E)	Observed (O)	O-E/E
Parameter	Group #1								
October	8	7	-0.13	1	2	1.00	2	2	0.00
November	8	7	-0.13	1	2	1.00	2	2	0.00
December	8	5	-0.38	2	5	1.50	1	1	0.00
January	8	3	-0.63	1	7	6.00	2	1	-0.50
February	7	4	-0.43	2	6	2.00	2	1	-0.50
March	7	8	0.14	2	3	0.50	2	0	-1.00
April	8	6	-0.25	2	4	1.00	1	1	0.00
May	7	7	0.00	2	2	0.00	2	2	0.00
June	8	6	-0.25	2	5	1.50	1	0	-1.00
July	9	5	-0.44	1	5	4.00	1	1	0.00
August	8	9	0.13	1	1	0.00	2	1	-0.50
September	6	6	0.00	3	4	0.33	2	1	-0.50
Parameter	Group #2								
1-day minimum	7	3	-0.57	2	6	2.00	2	2	0.00
3-day minimum	6	3	-0.50	2	6	2.00	3	2	-0.33
7-day minimum	5	3	-0.40	3	6	1.00	3	2	-0.33
30-day minimum	6	3	-0.50	2	6	2.00	3	2	-0.33
90-day minimum	5	3	-0.40	3	6	1.00	3	2	-0.33
1-day maximum	8	8	0.00	2	2	0.00	1	1	0.00
3-day maximum	8	8	0.00	2	2	0.00	1	1	0.00
7-day maximum	8	8	0.00	2	2	0.00	1	1	0.00
30-day maximum	8	8	0.00	2	2	0.00	1	1	0.00
90-day maximum	8	6	-0.25	2	4	1.00	1	1	0.00
Number of zero days	11	11	0.00	0	0	0.00	0	0	0.00
Base flow	7	6	-0.14	2	4	1.00	2	1	-0.50
Parameter	Group #3								
Date of minimum	0	1	0.00	4	4	0.00	7	6	-0.14
Date of maximum	5	5	0.00	1	1	0.00	5	5	0.00
Parameter	Group #4								
Low pulse count	8	5	-0.38	2	1	-0.50	1	5	4.00
Low pulse duration	7	4	-0.43	3	1	-0.67	1	6	5.00
High pulse count	8	9	0.13	2	1	-0.50	1	1	0.00
High pulse duration	9	9	0.00	1	1	0.00	1	1	0.00
Parameter	Group #5								
Rise rate	8	7	-0.13	1	2	1.00	2	2	0.00
Fall rate	7	7	0.00	2	2	0.00	2	2	0.00
Number of reversals	7	7	0.00	2	1	-0.50	2	3	0.50

APPENDIX J-19
RANGE OF VARIABILITY SCORE CARD FOR COMPARISON OF WET AND WETOF IHA STATISTICS AT HALSTAD
Final Aquatic Impact Analysis Report

	WET				WETOF				RVA Targets		
	Means	SD % of mean	1-day min Low	1-day max High	Means	SD % of mean	1-day min Low	1-day max High	-1 SD Low	+1 SD High	Hydrologic Alternation
Parameter	Group #1										
October	1377.6	0.6	557.2	2824.0	1459.9	0.6	624.7	2931.1	598.1	2157.1	0.29
November	1130.9	0.4	417.7	1833.4	1200.7	0.4	508.9	1941.5	637.2	1624.6	-0.14
December	906.3	0.5	315.8	1828.3	975.5	0.5	450.2	1869.7	475.2	1337.4	-0.11
January	642.0	0.4	204.3	947.8	712.1	0.4	326.3	1131.7	378.9	905.2	-0.25
February	738.9	0.6	211.8	1915.2	868.9	0.8	346.9	2671.3	262.3	1215.4	0.11
March	4089.2	0.7	869.0	9604.3	4199.6	0.7	1062.9	9755.2	1112.8	7065.7	0.00
April	10746.9	0.9	679.9	38194.2	10867.4	0.9	759.0	38306.8	866.1	20627.8	0.00
May	5605.7	0.8	883.3	15846.5	5783.9	0.8	1022.8	16118.8	949.8	10261.5	0.11
June	3389.6	0.5	513.0	6036.0	3620.5	0.5	741.1	6487.1	1653.8	5125.3	0.00
July	4171.3	0.8	717.5	10690.9	4399.7	0.7	882.2	10695.1	1033.1	7309.6	0.00
August	2188.7	1.4	577.0	11492.3	2373.9	1.3	632.5	11574.9	632.5	5342.9	0.25
September	1400.9	1.0	297.2	4667.8	1531.9	1.0	297.2	4945.7	316.8	2824.3	0.14
Parameter	Group #2										
1-day minimum	396.1	0.6	143.4	788.1	456.2	0.6	154.9	874.8	160.6	631.6	0.17
3-day minimum	406.4	0.6	145.2	788.9	464.8	0.6	161.2	886.7	163.3	649.6	0.17
7-day minimum	432.3	0.6	147.3	810.3	490.8	0.6	179.4	909.8	188.1	676.4	0.17
30-day minimum	507.1	0.5	156.7	885.8	593.3	0.5	284.5	1062.6	270.4	743.7	0.00
90-day minimum	615.4	0.4	241.0	1036.7	706.2	0.4	375.2	1271.0	364.8	866.0	0.14
1-day maximum	21507.1	0.8	3728.9	69539.0	21644.7	0.8	4000.5	69658.1	4254.4	38759.7	0.00
3-day maximum	21176.4	0.8	3288.1	68280.5	21313.5	0.8	3556.2	68399.1	4197.1	38155.7	0.00
7-day maximum	20045.3	0.8	2371.2	62841.8	20178.1	0.8	2628.2	62958.4	4385.1	35705.5	0.00
30-day maximum	13848.5	0.8	1060.3	42444.3	13974.4	0.8	1226.0	42589.9	3189.6	24507.4	0.00
90-day maximum	7746.4	0.6	827.3	19737.6	7925.2	0.6	964.6	20024.9	2792.5	12700.3	0.00
Number of zero days	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00
Base flow	0.2	0.5	0.1	0.3	0.2	0.5	0.1	0.3	0.1	0.2	0.00
Parameter	Group #3										
Date of minimum	212.0	0.3	39.0	292.0	213.7	0.3	38.0	292.0	151.9	272.1	0.00
Date of maximum	125.1	0.1	89.0	216.0	125.0	0.1	89.0	215.0	110.5	139.7	0.00
Parameter	Group #4										
Low pulse count	2.9	0.8	0.0	7.0	2.6	0.9	0.0	7.0	0.4	5.4	0.17
Low pulse duration	24.1	1.2	0.0	83.0	23.3	1.2	0.0	83.0	0.0	52.5	0.00
High pulse count	2.0	0.7	0.0	5.0	2.1	0.8	0.0	5.0	0.5	3.5	-0.13
High pulse duration	14.6	0.7	0.0	37.0	14.7	0.7	0.0	39.0	4.3	24.9	0.00
Parameter	Group #5										
Rise rate	307.3	0.5	48.2	563.5	309.8	0.5	45.0	556.9	159.3	455.3	0.00
Fall rate	-172.7	-0.6	-399.0	-39.8	-174.1	-0.6	-402.3	-43.8	-271.0	-74.3	0.13
Number of reversals	63.5	0.1	51.0	77.0	62.9	0.1	53.0	78.0	56.5	70.6	0.00

COMPARISON STATISTISTICS OF OBSERVED (WETOF) VALUES ABOVE AND BELOW EXPECTED (WET)

	Within RVA range			Above RVA Range			Above RVA Range		
	Expected (E)	Observed (O)	O-E/E	Expected (E)	Observed (O)	O-E/E	Expected (E)	Observed (O)	O-E/E
Parameter	Group #1								
October	7	9	0.29	2	2	0.00	2	0	-1.00
November	7	6	-0.14	2	3	0.50	2	2	0.00
December	9	8	-0.11	1	2	1.00	1	1	0.00
January	8	6	-0.25	2	4	1.00	1	1	0.00
February	9	10	0.11	1	1	0.00	1	0	-1.00
March	8	8	0.00	2	2	0.00	1	1	0.00
April	9	9	0.00	1	1	0.00	1	1	0.00
May	9	10	0.11	1	1	0.00	1	0	-1.00
June	6	6	0.00	2	3	0.50	3	2	-0.33
July	8	8	0.00	2	2	0.00	1	1	0.00
August	8	10	0.25	1	1	0.00	2	0	-1.00
September	7	8	0.14	2	2	0.00	2	1	-0.50
Parameter	Group #2								
1-day minimum	6	7	0.17	3	3	0.00	2	1	-0.50
3-day minimum	6	7	0.17	3	3	0.00	2	1	-0.50
7-day minimum	6	7	0.17	3	3	0.00	2	1	-0.50
30-day minimum	7	7	0.00	3	4	0.33	1	0	-1.00
90-day minimum	7	8	0.14	3	3	0.00	1	0	-1.00
1-day maximum	9	9	0.00	1	1	0.00	1	1	0.00
3-day maximum	9	9	0.00	1	1	0.00	1	1	0.00
7-day maximum	9	9	0.00	1	1	0.00	1	1	0.00
30-day maximum	9	9	0.00	1	1	0.00	1	1	0.00
90-day maximum	8	8	0.00	1	1	0.00	2	2	0.00
Number of zero days	11	11	0.00	0	0	0.00	0	0	0.00
Base flow	6	6	0.00	2	2	0.00	3	3	0.00
Parameter	Group #3								
Date of minimum	4	4	0.00	4	4	0.00	3	3	0.00
Date of maximum	1	1	0.00	4	4	0.00	6	6	0.00
Parameter	Group #4								
Low pulse count	6	7	0.17	2	1	-0.50	3	3	0.00
Low pulse duration	9	9	0.00	2	2	0.00	0	0	0.00
High pulse count	8	7	-0.13	1	2	1.00	2	2	0.00
High pulse duration	8	8	0.00	1	1	0.00	2	2	0.00
Parameter	Group #5								
Rise rate	7	7	0.00	1	1	0.00	3	3	0.00
Fall rate	8	9	0.13	2	1	-0.50	1	1	0.00
Number of reversals	8	8	0.00	1	1	0.00	2	2	0.00

APPENDIX J-20
RANGE OF VARIABILITY SCORE CARD FOR COMPARISON OF WET AND WETOF IHA STATISTICS AT GRAND FORKS
Final Aquatic Impact Analysis Report

	WET				WETOF				RVA Targets		
		SD	1-day min	1-day max		SD	1-day min	1-day max	-1 SD	+1 SD	Hydrologic
	Means	% of mean	Low	High	Means	% of mean	Low	High	Low	High	Alternation
Parameter	Group #1										
October	2901.8	0.4	952.4	4928.5	2986.4	0.4	1128.9	5035.3	1716.4	4087.3	0.00
November	2260.0	0.4	490.2	3596.9	2330.1	0.4	656.7	3704.1	1307.8	3212.1	0.00
December	2016.8	0.5	440.3	3885.2	2085.5	0.4	575.9	3926.3	1097.9	2935.7	0.00
January	1512.8	0.3	370.6	2061.4	1581.4	0.3	491.8	2103.1	1004.7	2020.9	-0.13
February	1612.4	0.5	411.2	3490.2	1754.9	0.6	530.2	4413.4	852.6	2372.2	0.00
March	6596.4	0.8	1155.7	15463.5	6708.6	0.7	1355.0	15631.9	1637.9	11554.8	0.00
April	18420.6	0.8	995.0	55982.4	18537.9	0.8	1093.3	56093.9	3733.9	33107.3	0.00
May	9989.5	0.8	1302.7	25158.6	10159.7	0.8	1419.2	25399.5	1961.5	18017.4	0.00
June	6511.4	0.5	1254.9	11526.2	6738.3	0.5	1473.8	11526.2	3351.3	9671.6	-0.13
July	7575.2	0.6	2438.5	13633.6	7807.4	0.6	2620.9	14101.1	3257.5	11893.0	0.00
August	4097.6	1.1	1506.9	16761.7	4283.0	1.0	1556.9	16812.0	1980.3	8436.8	0.00
September	3299.0	0.9	971.0	11313.9	3439.5	0.9	971.0	11606.1	1722.6	6331.1	-0.13
								XX			
Parameter	Group #2										
1-day minimum	1128.4	0.4	256.2	1593.8	1195.8	0.4	389.3	1691.9	685.1	1571.8	0.00
3-day minimum	1152.4	0.4	256.9	1601.8	1219.8	0.4	389.4	1707.3	720.2	1584.5	0.00
7-day minimum	1192.4	0.4	258.9	1679.4	1259.7	0.3	389.9	1783.9	764.7	1620.1	-0.11
30-day minimum	1275.0	0.4	302.0	1872.1	1356.1	0.4	426.6	1990.7	814.8	1735.2	-0.11
90-day minimum	1413.2	0.4	383.6	2291.1	1551.5	0.4	515.6	2525.3	822.4	2004.0	0.13
1-day maximum	38660.6	0.8	6522.7	126137.2	38817.0	0.8	6756.5	126302.6	23778.6	70977.1	0.00
3-day maximum	37128.1	0.8	5756.0	114884.3	37283.3	0.8	5990.8	115042.4	7788.0	66468.2	0.00
7-day maximum	35058.9	0.8	4358.0	109536.4	35211.0	0.8	4614.7	109670.3	7114.2	63003.7	0.00
30-day maximum	23122.5	0.7	2583.3	63623.0	23254.8	0.7	2774.1	63773.1	7019.2	39225.8	0.00
90-day maximum	13255.5	0.6	2065.5	30351.8	13428.0	0.6	2161.8	30637.1	5504.8	21006.1	0.00
Number of zero days	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00
Base flow	0.2	0.3	0.1	0.4	0.2	0.3	0.1	0.4	0.2	0.3	-0.13
Parameter	Group #3										
Date of minimum	215.9	0.3	40.0	334.0	215.7	0.3	38.0	334.0	149.0	282.8	0.00
Date of maximum	130.4	0.1	92.0	217.0	130.4	0.1	92.0	217.0	114.0	146.8	0.00
Parameter	Group #4										
Low pulse count	4.1	0.6	1.0	7.0	3.4	0.8	1.0	10.0	1.8	6.4	0.00
Low pulse duration	33.0	1.5	3.0	168.0	30.9	1.5	1.0	167.0	4.6	80.9	0.00
High pulse count	2.2	0.6	0.0	4.0	2.1	0.6	0.0	4.0	0.9	3.4	0.00
High pulse duration	13.7	0.6	0.0	23.0	14.6	0.6	0.0	23.7	6.0	21.5	-0.14
Parameter	Group #5										
Rise rate	551.3	0.5	161.8	1115.5	554.4	0.5	156.5	1133.1	293.0	809.6	0.00
Fall rate	-331.1	-0.5	-731.6	-107.5	-332.4	-0.5	-725.2	-112.1	-507.1	-155.2	0.00
Number of reversals	70.5	0.1	58.0	84.0	71.1	0.1	55.0	84.0	61.9	79.2	0.14

COMPARISON STATISTISTICS OF OBSERVED (WETOF) VALUES ABOVE AND BELOW EXPECTED (WET)

	Within RVA range			Above RVA Range			Above RVA Range		
	Expected (E)	Observed (O)	O-E/E	Expected (E)	Observed (O)	O-E/E	Expected (E)	Observed (O)	O-E/E
Parameter	Group #1								
October	8	8	0.00	1	1	0.00	2	2	0.00
November	7	7	0.00	2	2	0.00	2	2	0.00
December	8	8	0.00	1	1	0.00	2	2	0.00
January	8	7	-0.13	1	2	1.00	2	2	0.00
February	9	9	0.00	1	1	0.00	1	1	0.00
March	8	8	0.00	2	2	0.00	1	1	0.00
April	9	9	0.00	1	1	0.00	1	1	0.00
May	8	8	0.00	2	2	0.00	1	1	0.00
June	8	7	-0.13	2	3	0.50	1	1	0.00
July	6	6	0.00	4	4	0.00	1	1	0.00
August	8	8	0.00	1	1	0.00	2	2	0.00
September	8	7	-0.13	1	2	1.00	2	2	0.00
Parameter	Group #2								
1-day minimum	6	6	0.00	2	2	0.00	3	3	0.00
3-day minimum	7	7	0.00	2	2	0.00	2	2	0.00
7-day minimum	9	8	-0.11	1	2	1.00	1	1	0.00
30-day minimum	9	8	-0.11	1	2	1.00	1	1	0.00
90-day minimum	8	9	0.13	1	1	0.00	2	1	-0.50
1-day maximum	8	8	0.00	1	1	0.00	2	2	0.00
3-day maximum	9	9	0.00	1	1	0.00	1	1	0.00
7-day maximum	9	9	0.00	1	1	0.00	1	1	0.00
30-day maximum	9	9	0.00	1	1	0.00	1	1	0.00
90-day maximum	9	9	0.00	1	1	0.00	1	1	0.00
Number of zero days	11	11	0.00	0	0	0.00	0	0	0.00
Base flow	8	7	-0.13	1	2	1.00	2	2	0.00
Parameter	Group #3								
Date of minimum	7	7	0.00	1	1	0.00	3	3	0.00
Date of maximum	1	1	0.00	3	3	0.00	7	7	0.00
Parameter	Group #4								
Low pulse count	6	6	0.00	3	2	-0.33	2	3	0.50
Low pulse duration	8	8	0.00	1	1	0.00	2	2	0.00
High pulse count	8	8	0.00	2	2	0.00	1	1	0.00
High pulse duration	7	6	-0.14	2	3	0.50	2	2	0.00
Parameter	Group #5								
Rise rate	7	7	0.00	2	2	0.00	2	2	0.00
Fall rate	8	8	0.00	1	1	0.00	2	2	0.00
Number of reversals	7	8	0.14	2	2	0.00	2	1	-0.50

APPENDIX J-21
RANGE OF VARIABILITY SCORE CARD FOR COMPARISON OF WET AND WETOF IHA STATISTICS AT EMERSON
Final Aquatic Impact Analysis Report

	WET				WETOF				RVA Targets		
	Means	SD % of mean	1-day min Low	1-day max High	Means	SD % of mean	1-day min Low	1-day max High	-1 SD Low	+1 SD High	Hydrologic Alternation
Parameter	Group #1										
October	3318.0	0.3	1928.9	5465.5	3406.9	0.3	2005.0	5569.7	2187.9	4448.2	0.13
November	2766.9	0.5	711.8	5116.1	2837.4	0.4	878.2	5224.9	1516.6	4017.3	0.00
December	2279.6	0.5	507.8	4740.9	2348.3	0.5	649.6	4781.4	1144.2	3415.1	0.00
January	1665.4	0.4	403.0	2253.5	1732.4	0.3	526.0	2467.1	1078.4	2252.4	-0.13
February	1603.9	0.4	348.1	2753.2	1712.6	0.4	465.4	3339.4	971.9	2236.0	0.00
March	6509.0	0.9	1311.3	20326.6	6615.6	0.9	1311.3	20659.3	1745.2	12665.6	0.00
April	23469.7	0.6	1773.9	48968.8	23581.6	0.6	1896.6	49062.3	9573.7	37365.7	0.00
May	16015.2	1.1	1242.4	56893.7	16166.7	1.1	1316.1	57057.8	4093.7	33572.3	0.00
June	8331.6	0.5	1729.5	15103.0	8564.1	0.5	1951.2	15312.1	3800.2	12862.9	0.00
July	9131.0	0.6	2971.4	19092.1	9370.1	0.6	3174.0	19569.9	3743.5	14518.5	0.00
August	5492.4	1.2	1628.1	25555.3	5681.9	1.2	1723.2	25569.0	2624.5	12285.4	0.00
September	4069.7	0.9	1042.7	12760.1	4221.8	0.9	1042.7	13070.4	1893.9	7770.2	0.00
Parameter	Group #2										
1-day minimum	1322.4	0.4	271.2	1935.2	1393.5	0.4	397.8	1979.3	813.4	1831.5	-0.13
3-day minimum	1330.8	0.4	271.8	1937.1	1401.3	0.4	398.4	2033.8	817.0	1844.6	0.00
7-day minimum	1361.0	0.4	274.8	1970.3	1425.8	0.4	400.5	2059.0	841.6	1880.5	0.00
30-day minimum	1448.0	0.4	319.0	2143.2	1511.7	0.4	439.2	2216.3	897.9	1998.2	0.00
90-day minimum	1597.1	0.4	417.9	2599.0	1700.5	0.4	549.2	2833.1	988.4	2205.7	0.00
1-day maximum	41578.3	0.8	6647.1	125061.2	41700.6	0.8	6899.8	125204.7	9826.9	73329.7	0.00
3-day maximum	41274.4	0.8	6350.5	124157.4	41395.9	0.8	6595.5	124309.2	9750.6	72798.1	0.00
7-day maximum	39936.1	0.8	5197.1	119294.9	40057.0	0.8	5423.7	119455.6	9614.4	70257.8	0.00
30-day maximum	30591.9	0.7	3018.7	82240.3	30710.7	0.7	3230.0	82358.7	9140.3	52043.5	0.00
90-day maximum	17786.9	0.6	2333.8	40488.1	17948.4	0.6	2462.6	40763.9	6915.7	28658.0	0.00
Number of zero days	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00
Base flow	0.2	0.3	0.1	0.3	0.2	0.3	0.1	0.3	0.2	0.3	0.00
Parameter	Group #3										
Date of minimum	189.7	0.3	29.0	286.0	189.5	0.3	29.0	286.0	127.2	252.3	0.00
Date of maximum	128.6	0.2	71.0	275.0	128.6	0.2	71.0	275.0	106.5	150.8	0.00
Parameter	Group #4										
Low pulse count	2.5	0.8	0.0	7.0	2.5	0.8	0.0	7.0	0.6	4.5	-0.11
Low pulse duration	38.4	1.2	0.0	165.0	35.3	1.4	0.0	165.0	6.5	85.8	-0.25
High pulse count	1.7	0.6	0.0	4.0	1.7	0.6	0.0	4.0	0.6	2.8	0.00
High pulse duration	22.5	0.7	0.0	55.0	22.8	0.7	0.0	55.0	6.4	38.5	0.00
Parameter	Group #5										
Rise rate	532.2	0.4	136.6	982.5	530.1	0.4	136.9	982.5	305.0	759.5	-0.11
Fall rate	-301.2	-0.5	-664.7	-89.1	-302.5	-0.5	-663.6	-92.2	-461.6	-140.7	0.00
Number of reversals	34.5	0.2	21.0	44.0	34.5	0.2	21.0	45.0	27.0	41.9	0.00

COMPARISON STATISTISTICS OF OBSERVED (WETOF) VALUES ABOVE AND BELOW EXPECTED (WET)

	Within RVA range				Above RVA Range			Above RVA Range	
	Expected (E)	Observed (O)	O-E/E		Expected (E)	Observed (O)	O-E/E	Expected (E)	Observed (O)	O-E/E
Parameter	Group #1									
October	8	9	0.13	1	1	0.00	2	1	-0.50
November	8	8	0.00	1	1	0.00	2	2	0.00
December	8	8	0.00	1	1	0.00	2	2	0.00
January	8	7	-0.13	1	2	1.00	2	2	0.00
February	9	9	0.00	1	1	0.00	1	1	0.00
March	7	7	0.00	2	2	0.00	2	2	0.00
April	8	8	0.00	2	2	0.00	1	1	0.00
May	7	7	0.00	2	2	0.00	2	2	0.00
June	8	8	0.00	2	2	0.00	1	1	0.00
July	8	8	0.00	2	2	0.00	1	1	0.00
August	8	8	0.00	1	1	0.00	2	2	0.00
September	7	7	0.00	2	2	0.00	2	2	0.00
Parameter	Group #2								
1-day minimum	8	7	-0.13	2	3	0.50	1	1	0.00
3-day minimum	8	8	0.00	2	2	0.00	1	1	0.00
7-day minimum	8	8	0.00	2	2	0.00	1	1	0.00
30-day minimum	8	8	0.00	2	2	0.00	1	1	0.00
90-day minimum	9	9	0.00	1	1	0.00	1	1	0.00
1-day maximum	9	9	0.00	1	1	0.00	1	1	0.00
3-day maximum	9	9	0.00	1	1	0.00	1	1	0.00
7-day maximum	9	9	0.00	1	1	0.00	1	1	0.00
30-day maximum	9	9	0.00	1	1	0.00	1	1	0.00
90-day maximum	9	9	0.00	1	1	0.00	1	1	0.00
Number of zero days	11	11	0.00	0	0	0.00	0	0	0.00
Base flow	8	8	0.00	1	1	0.00	2	2	0.00
Parameter	Group #3								
Date of minimum	0	0	0.00	7	7	0.00	4	4	0.00
Date of maximum	3	3	0.00	2	2	0.00	6	6	0.00
Parameter	Group #4								
Low pulse count	9	8	-0.11	1	1	0.00	1	2	1.00
Low pulse duration	8	6	-0.25	1	1	0.00	2	4	1.00
High pulse count	8	8	0.00	2	2	0.00	1	1	0.00
High pulse duration	7	7	0.00	2	2	0.00	2	2	0.00
Parameter	Group #5								
Rise rate	9	8	-0.11	1	1	0.00	1	2	1.00
Fall rate	8	8	0.00	1	1	0.00	2	2	0.00
Number of reversals	7	7	0.00	2	2	0.00	2	2	0.00

APPENDIX K

HABITAT DURATION TABLES

APPENDIX K- HABITAT DURATION TABLES

Habitat duration tables are presented below for each habitat reach and season. Each table contains percent maximum WUA duration data for each of the six scenarios in one reach, guild, and season. A brief discussion of how to interpret these tables is presented below.

The percent exceedence column indicates the percent of time the corresponding percent maximum WUA is met or exceeded. The 20 percent exceedence habitat value, for example, represents a habitat value that is rarely exceeded (i.e., only 20 percent of the time). Similarly, the 80 percent exceedence habitat value represents a habitat value that is met or exceeded often (i.e., 80 percent of the time). When considering differences between the with-project scenario and the corresponding baseline scenario, an increase in the percent of maximum habitat at a given percent exceedence level means that as a result of the flow alteration, more habitat events have shifted closer to maximum habitat values. Conversely, a decrease means that more habitat events have shifted further from the maximum habitat value. Increases or decreases in the percent maximum habitat have different meanings depending upon the percent exceedence level. At the 20 percent exceedence level, changes in the percent of maximum habitat must be tempered by the knowledge that this level represents a small fraction of all the habitat events.

The data presented in these tables is used to develop the habitat duration curves presented in Appendix L.

HABITAT REACH L

APPENDIX K-1
PERCENT EXCEEDENCE FOR MAXIMUM WUA, HABITAT REACH L, SHALLOW POOL GUILD, SPRING
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	MOD55	WET
100	5.48	5.47	5.50
98	5.82	6.28	6.39
96	8.19	8.67	9.35
94	10.19	9.57	10.01
92	10.96	10.32	10.84
90	11.27	10.79	11.29
88	11.69	11.31	11.58
86	12.42	11.63	11.95
84	14.91	12.00	12.93
82	16.66	13.35	14.17
80	18.04	14.71	15.78
78	19.97	15.77	17.02
76	23.53	16.72	17.93
74	26.74	17.40	18.65
72	29.71	18.38	19.24
70	31.93	19.01	21.82
68	33.63	22.05	24.20
66	35.17	24.86	26.38
64	37.20	26.91	27.69
62	38.59	28.75	28.87
60	40.68	31.41	29.92
58	44.68	33.20	30.97
56	46.70	34.78	32.34
54	50.59	36.83	33.26
52	51.86	37.94	34.20
50	52.44	39.25	35.61
48	53.02	41.94	37.12
46	53.55	45.97	38.22
44	54.28	48.94	40.02
42	56.07	51.52	42.62
40	60.05	52.87	44.38
38	62.05	53.70	46.89
36	64.04	54.39	50.47
34	65.72	56.94	52.00
32	68.96	62.89	52.40
30	71.74	65.55	53.08
28	74.06	68.57	53.56
26	76.70	72.49	54.04
24	80.82	77.08	54.62
22	83.58	79.44	57.94
20	86.84	83.13	63.00
18	89.71	86.23	66.82
16	91.48	89.50	71.99
14	92.88	91.64	78.95
12	94.42	92.72	83.66
10	96.03	95.04	90.85
8	96.59	96.03	92.69
6	97.83	97.13	96.37
4	98.61	98.92	98.61
2	99.30	99.46	99.19
0	100.00	100.00	100.00

APPENDIX K-2
PERCENT EXCEEDENCE FOR MAXIMUM WUA, HABITAT REACH L, SLOW RIFFLE GUILD, SPRING
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	MOD55	WET
100	9.39	9.33	10.33
98	10.99	12.34	13.14
96	13.25	17.53	18.83
94	14.99	18.92	21.77
92	17.15	23.24	29.91
90	19.13	26.56	31.54
88	20.65	28.80	32.71
86	28.54	29.93	35.13
84	29.93	31.74	39.55
82	31.86	34.97	43.03
80	33.78	37.37	46.36
78	35.80	39.70	49.81
76	37.85	42.15	51.29
74	39.37	43.90	55.40
72	40.99	47.60	62.31
70	43.94	49.62	65.33
68	46.16	53.36	67.17
66	48.71	57.32	69.91
64	50.75	60.71	73.14
62	54.36	63.26	74.72
60	59.34	65.35	75.50
58	62.49	66.78	76.09
56	64.33	68.16	76.90
54	66.24	70.60	77.61
52	68.37	72.90	78.27
50	70.55	74.08	79.14
48	72.52	74.45	79.70
46	73.91	75.28	80.46
44	74.83	76.11	81.23
42	75.62	76.72	82.02
40	76.30	77.40	82.58
38	77.16	78.02	83.29
36	78.12	79.36	84.24
34	78.89	80.37	84.97
32	79.77	81.47	85.44
30	81.02	82.58	85.96
28	81.46	83.29	86.51
26	82.81	84.21	87.08
24	83.56	85.13	87.82
22	84.52	85.95	88.17
20	85.35	86.68	88.68
18	86.60	87.37	89.56
16	87.37	88.23	90.33
14	88.32	89.37	90.98
12	89.31	90.53	91.68
10	90.42	91.25	92.89
8	91.40	92.69	93.35
6	92.61	94.12	94.60
4	94.01	95.80	96.49
2	96.24	97.90	98.49
0	100.00	100.00	100.00

APPENDIX K-3
PERCENT EXCEEDENCE FOR MAXIMUM WUA, HABITAT REACH L, FAST RIFFLE GUILD, SPRING
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	MOD55	WET
100	0.89	1.40	1.96
98	1.21	2.18	3.33
96	1.49	2.80	3.80
94	1.73	3.27	4.81
92	2.80	4.64	6.88
90	3.21	5.75	7.47
88	3.98	6.42	8.15
86	4.61	7.02	8.95
84	5.66	7.75	9.42
82	6.27	8.62	9.75
80	6.69	8.99	9.94
78	7.24	9.73	10.04
76	8.29	9.85	10.14
74	8.87	10.04	10.29
72	9.40	10.18	10.37
70	9.79	10.32	10.50
68	9.94	10.45	10.61
66	10.10	10.57	10.75
64	10.22	10.70	10.92
62	10.30	10.88	11.04
60	10.42	11.01	11.23
58	10.52	11.20	11.52
56	10.64	11.39	11.81
54	10.75	11.63	12.27
52	10.84	11.81	15.09
50	11.00	12.00	20.68
48	11.13	12.32	25.89
46	11.31	15.63	29.40
44	11.51	22.15	32.49
42	11.72	28.11	36.76
40	11.91	33.23	40.22
38	12.13	41.91	43.69
36	14.35	46.21	46.39
34	21.31	52.61	50.35
32	27.57	58.55	54.65
30	32.16	64.93	62.23
28	36.95	69.77	66.16
26	43.07	73.70	72.50
24	50.32	78.71	76.28
22	57.59	81.82	80.89
20	65.30	83.05	82.44
18	72.24	84.49	83.87
16	79.87	86.38	84.98
14	83.35	87.53	87.14
12	86.39	89.38	88.89
10	88.43	91.27	90.81
8	90.52	92.64	92.83
6	92.12	94.38	94.63
4	95.28	96.24	96.30
2	97.57	98.19	98.39
0	100.00	100.00	100.00

APPENDIX K-4
PERCENT EXCEEDENCE FOR MAXIMUM WUA, HABITAT REACH L, RACEWAY GUILD, SPRING
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	MOD55	WET
100	0.00	0.00	0.00
98	0.00	0.00	0.07
96	0.00	0.03	0.10
94	0.00	0.06	0.17
92	0.03	0.15	0.44
90	0.06	0.23	0.51
88	0.11	0.29	2.63
86	0.15	0.42	4.45
84	0.22	0.53	7.15
82	0.28	0.65	9.15
80	0.36	2.45	10.62
78	0.44	3.67	12.58
76	0.53	4.54	15.00
74	0.64	6.40	16.90
72	1.89	7.98	18.44
70	3.47	9.11	19.99
68	4.51	10.47	22.18
66	6.20	12.89	23.48
64	7.67	15.09	26.98
62	8.76	17.31	31.20
60	10.21	20.02	34.16
58	11.29	24.41	36.24
56	12.70	28.59	39.30
54	15.18	32.10	42.95
52	17.63	36.86	45.55
50	19.36	40.23	49.07
48	21.40	43.29	52.36
46	24.36	45.90	54.57
44	28.16	50.72	56.71
42	32.63	54.24	59.73
40	38.24	57.87	61.78
38	41.31	62.88	63.92
36	45.11	65.42	65.60
34	49.89	69.22	68.21
32	53.50	73.02	70.77
30	57.05	77.39	75.47
28	60.37	80.55	78.47
26	63.95	83.41	82.69
24	67.78	86.08	84.71
22	73.04	87.72	87.25
20	77.51	88.79	88.23
18	82.24	89.89	89.23
16	87.25	90.87	90.13
14	89.08	91.84	91.32
12	91.02	93.11	92.92
10	92.58	94.07	94.19
8	93.74	95.28	95.51
6	95.01	96.41	96.56
4	96.91	97.60	97.56
2	98.43	98.82	98.93
0	100.00	100.00	100.00

APPENDIX K-5
PERCENT EXCEEDENCE FOR MAXIMUM WUA, HABITAT REACH L, MEDIUM POOL GUILD, SPRING
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	MOD55	WET
100	3.45	3.35	5.06
98	6.62	6.73	6.73
96	6.81	6.76	6.77
94	7.29	6.82	6.94
92	8.54	7.52	8.31
90	8.98	8.29	9.04
88	9.42	9.15	9.52
86	10.00	9.68	10.13
84	10.65	10.30	11.30
82	12.29	11.84	12.72
80	13.11	13.13	14.54
78	14.33	14.21	15.94
76	15.17	15.39	16.97
74	16.35	16.24	17.75
72	17.80	17.23	18.43
70	22.07	17.94	22.69
68	23.14	18.83	24.75
66	25.48	21.60	25.90
64	27.30	22.29	28.65
62	30.02	24.56	35.73
60	32.29	29.10	39.33
58	34.87	31.42	42.97
56	38.26	33.64	46.38
54	41.54	36.90	50.63
52	44.46	41.82	54.80
50	47.29	44.69	57.12
48	51.40	48.02	59.54
46	55.28	51.29	62.35
44	58.15	54.67	64.75
42	61.11	57.16	67.26
40	63.11	60.50	69.90
38	66.12	63.21	72.41
36	68.53	65.65	74.54
34	72.07	68.72	78.03
32	74.24	71.63	79.88
30	76.46	73.92	82.00
28	79.00	76.08	85.49
26	80.81	78.51	87.54
24	82.94	80.78	89.65
22	84.78	84.06	91.64
20	87.98	87.35	92.82
18	90.91	90.32	93.66
16	92.14	91.62	94.83
14	93.91	92.74	95.69
12	94.92	94.12	96.85
10	96.12	95.66	97.32
8	96.91	96.95	97.66
6	97.73	97.71	98.05
4	98.51	98.61	98.69
2	99.45	99.15	99.22
0	100.00	100.00	100.00

APPENDIX K-6
PERCENT EXCEEDENCE FOR MAXIMUM WUA, HABITAT REACH L, DEEP POOL GUILD, SPRING
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	MOD55	WET
100	0.00	0.00	0.00
98	0.00	0.00	0.00
96	0.00	0.00	0.00
94	0.00	0.00	0.00
92	0.00	0.00	0.00
90	0.00	0.00	0.00
88	0.00	0.00	0.00
86	0.00	0.00	0.00
84	0.00	0.00	0.00
82	0.00	0.00	0.00
80	0.00	0.00	0.00
78	0.00	0.00	0.00
76	0.00	0.00	0.00
74	0.00	0.00	0.00
72	0.00	0.00	0.00
70	0.00	0.00	0.00
68	0.00	0.00	0.00
66	0.00	0.00	0.00
64	0.00	0.00	0.48
62	0.00	0.00	4.06
60	0.00	0.00	6.88
58	0.00	0.00	11.25
56	0.00	1.75	13.64
54	0.00	5.74	20.25
52	0.00	9.82	24.99
50	0.00	16.03	27.81
48	0.00	18.07	33.84
46	0.00	23.44	38.48
44	3.11	28.49	42.89
42	10.45	33.36	45.67
40	16.06	36.58	48.29
38	21.23	40.30	51.85
36	27.60	45.23	55.05
34	33.98	47.89	58.83
32	40.89	52.00	62.75
30	47.93	57.57	65.00
28	53.60	64.37	66.22
26	59.28	65.44	67.10
24	64.08	66.53	68.10
22	65.67	67.74	68.95
20	67.20	68.94	70.17
18	68.30	70.49	72.06
16	69.60	72.36	73.99
14	71.48	74.86	75.27
12	74.91	77.32	78.27
10	78.91	79.36	80.67
8	82.58	84.23	83.48
6	87.65	88.18	88.04
4	90.32	91.49	91.74
2	94.94	95.23	94.83
0	100.00	100.00	100.00

APPENDIX K-7
PERCENT EXCEEDENCE FOR MAXIMUM WUA, HABITAT REACH L, LOW GRADIENT GROUP, SPRING
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	MOD55	WET
100	12.07	12.02	12.81
98	13.53	14.89	15.96
96	20.59	21.83	23.49
94	29.15	24.13	26.51
92	38.64	30.91	36.94
90	41.99	36.79	42.49
88	44.85	43.30	46.12
86	48.66	47.31	50.75
84	51.20	52.03	56.63
82	58.02	58.71	62.88
80	61.76	63.95	70.95
78	68.65	69.35	77.16
76	72.84	74.12	81.61
74	78.72	78.45	84.92
72	85.20	82.04	88.04
70	88.25	85.98	88.32
68	88.63	87.52	88.78
66	88.84	88.40	88.99
64	89.24	88.76	89.36
62	89.49	89.17	89.69
60	89.73	89.41	90.08
58	89.96	89.64	90.46
56	90.26	89.88	90.72
54	90.62	90.28	91.05
52	91.01	90.53	91.34
50	91.25	90.88	91.60
48	91.55	91.13	91.82
46	91.84	91.33	92.15
44	92.14	91.52	92.41
42	92.35	91.82	92.55
40	92.49	92.15	92.65
38	92.67	92.31	92.80
36	92.79	92.46	93.10
34	92.90	92.65	93.29
32	93.09	92.81	93.37
30	93.15	93.00	93.43
28	93.26	93.11	93.53
26	93.36	93.29	93.85
24	93.43	93.43	94.12
22	93.48	93.47	94.44
20	93.66	93.53	94.88
18	94.20	94.13	95.31
16	94.67	94.70	95.85
14	95.18	95.39	96.25
12	95.70	95.93	96.66
10	96.38	96.34	97.09
8	96.82	96.82	97.61
6	97.39	97.72	98.11
4	98.47	98.52	98.68
2	99.38	99.13	99.15
0	100.00	100.00	100.00

APPENDIX K-8
PERCENT EXCEEDENCE FOR MAXIMUM WUA, HABITAT REACH L, TRICHOPTERA GROUP, SPRING
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	MOD55	WET
100	8.76	8.63	10.92
98	12.99	14.37	15.23
96	17.74	19.89	21.22
94	20.06	21.72	23.51
92	22.36	25.46	31.08
90	24.68	29.77	34.96
88	27.48	33.21	37.52
86	31.10	35.68	39.78
84	33.81	38.20	41.14
82	36.94	39.52	41.95
80	39.62	40.27	43.04
78	40.34	41.33	46.00
76	41.28	43.20	50.78
74	42.97	45.86	54.08
72	44.33	47.90	56.57
70	46.36	49.49	61.47
68	48.10	52.90	65.54
66	50.94	54.86	67.31
64	53.65	57.90	69.09
62	55.52	60.56	70.90
60	58.52	62.82	73.54
58	61.48	65.10	75.37
56	64.19	66.61	76.27
54	65.69	68.05	77.62
52	67.53	68.91	78.98
50	68.81	70.21	80.72
48	70.44	71.56	81.63
46	72.03	73.34	83.16
44	73.56	74.75	84.22
42	74.80	75.98	85.19
40	76.18	76.78	85.92
38	77.73	78.50	86.84
36	78.72	80.19	87.71
34	80.52	81.68	88.46
32	82.36	83.36	89.37
30	83.74	84.28	90.05
28	85.28	85.61	90.40
26	86.51	86.96	91.13
24	87.45	88.11	92.00
22	88.84	89.32	92.87
20	90.02	90.35	93.74
18	91.29	92.36	94.23
16	92.73	93.69	94.81
14	93.82	94.57	95.55
12	94.63	95.45	96.34
10	95.50	96.30	96.90
8	96.47	97.08	97.64
6	97.49	98.01	98.22
4	98.73	98.66	98.71
2	99.35	99.51	99.25
0	100.00	100.00	100.00

APPENDIX K-9
PERCENT EXCEEDENCE FOR MAXIMUM WUA, HABITAT REACH L, SHALLOW POOL GUILD, SUMMER
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	MOD55	WET
100	0.00	0.00	17.18
98	10.01	6.00	24.28
96	14.01	10.00	28.49
94	16.01	12.00	30.00
92	18.43	14.00	32.87
90	22.03	16.00	34.93
88	25.22	18.00	36.34
86	27.75	20.00	38.00
84	30.02	20.00	39.57
82	32.02	22.00	41.90
80	33.23	24.00	44.00
78	34.35	25.98	45.95
76	36.04	28.00	49.58
74	37.47	30.00	50.99
72	38.49	32.63	51.57
70	40.03	34.00	52.20
68	42.03	34.89	53.11
66	45.54	36.98	53.83
64	48.04	38.53	54.53
62	50.04	42.00	55.37
60	51.99	47.74	58.84
58	53.12	48.66	62.00
56	54.04	51.26	64.00
54	54.43	52.67	67.29
52	57.30	53.63	69.98
50	61.92	54.44	71.71
48	64.04	56.00	74.00
46	68.00	58.00	76.86
44	70.42	62.00	77.18
42	72.21	64.00	78.65
40	74.12	66.45	80.33
38	76.81	69.41	82.12
36	78.79	72.00	83.80
34	81.23	74.28	85.48
32	83.41	78.00	88.05
30	85.62	80.07	88.77
28	86.54	82.12	90.01
26	88.53	85.70	90.55
24	89.69	88.06	91.79
22	90.93	89.19	92.33
20	92.05	90.60	92.95
18	93.18	91.97	94.00
16	93.88	92.50	94.74
14	95.01	93.96	94.74
12	96.06	95.51	95.90
10	96.51	96.12	95.97
8	97.29	97.52	97.14
6	98.06	98.30	97.69
4	98.76	98.84	98.53
2	99.30	99.46	99.07
0	100.00	100.00	100.00

APPENDIX K-10
PERCENT EXCEEDENCE FOR MAXIMUM WUA, HABITAT REACH L, SLOW RIFFLE GUILD, SUMMER
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	MOD55	WET
100	0.56	0.55	7.80
98	3.09	2.21	9.47
96	3.92	2.77	11.14
94	5.04	3.32	13.37
92	6.20	4.43	17.82
90	7.28	4.43	21.72
88	8.96	5.53	23.95
86	11.76	5.53	28.08
84	14.00	6.09	30.80
82	15.68	6.64	32.30
80	18.03	7.75	34.95
78	22.40	8.30	36.27
76	26.32	9.41	39.69
74	28.23	11.62	41.51
72	30.35	13.28	43.33
70	32.58	15.50	43.33
68	34.63	17.16	46.75
66	37.32	18.26	48.57
64	38.76	21.58	51.99
62	41.74	24.62	53.81
60	46.50	27.90	57.23
58	48.38	29.25	59.05
56	52.05	31.07	62.22
54	55.25	32.88	63.85
52	59.83	34.91	64.92
50	62.64	39.67	65.98
48	64.06	42.38	67.61
46	64.99	46.23	69.31
44	66.60	50.53	69.31
42	68.63	54.53	71.43
40	69.91	58.91	73.06
38	71.48	61.76	74.41
36	73.32	63.31	75.37
34	74.73	65.89	76.51
32	75.73	67.98	77.82
30	76.53	70.52	78.54
28	77.27	72.54	79.49
26	78.31	74.44	80.40
24	78.96	75.46	81.28
22	80.02	76.89	82.60
20	81.53	78.26	83.41
18	82.62	79.51	84.67
16	83.79	80.86	86.00
14	85.03	82.29	86.96
12	85.97	83.86	88.02
10	87.53	85.96	89.43
8	89.26	87.43	91.58
6	91.02	89.02	92.34
4	92.90	91.40	93.57
2	94.59	93.42	94.39
0	100.00	100.00	100.00

APPENDIX K-11
PERCENT EXCEEDENCE FOR MAXIMUM WUA, HABITAT REACH L, FAST RIFFLE GUILD, SUMMER
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	MOD55	WET
100	0.05	0.05	0.75
98	0.29	0.21	0.92
96	0.36	0.26	1.08
94	0.47	0.31	1.29
92	0.57	0.42	1.72
90	0.67	0.42	2.10
88	0.83	0.52	2.32
86	1.09	0.52	2.77
84	1.30	0.57	3.69
82	1.45	0.63	4.21
80	1.67	0.73	5.10
78	2.07	0.78	5.55
76	2.44	0.89	6.71
74	2.67	1.10	7.33
72	3.36	1.25	7.60
70	4.08	1.46	7.94
68	4.74	1.62	8.43
66	5.62	1.72	8.91
64	6.09	2.04	9.40
62	6.90	2.32	9.75
60	7.48	2.69	10.34
58	8.04	3.13	10.88
56	8.83	3.73	11.27
54	9.35	4.33	11.42
52	10.10	5.01	11.50
50	10.40	6.58	11.62
48	10.90	7.24	11.74
46	11.03	8.75	11.90
44	11.31	9.59	12.06
42	11.44	10.67	12.19
40	11.60	11.03	12.40
38	11.74	11.13	12.52
36	11.96	11.39	12.66
34	12.10	11.54	12.69
32	12.25	11.69	12.76
30	12.39	11.89	12.85
28	12.48	12.04	12.99
26	12.64	12.29	13.15
24	12.86	12.41	13.23
22	13.00	12.57	13.32
20	13.19	12.72	13.54
18	13.37	12.96	13.71
16	13.51	13.17	13.86
14	13.69	13.40	14.01
12	16.44	13.62	14.17
10	23.09	13.83	18.77
8	29.06	22.71	24.83
6	35.85	28.41	36.45
4	49.49	39.61	50.35
2	69.34	67.18	72.04
0	100.00	100.00	100.00

APPENDIX K-12
PERCENT EXCEEDENCE FOR MAXIMUM WUA, HABITAT REACH L, RACEWAY GUILD, SUMMER
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	MOD55	WET
100	0.00	0.00	0.00
98	0.00	0.00	0.00
96	0.00	0.00	0.00
94	0.00	0.00	0.00
92	0.00	0.00	0.00
90	0.00	0.00	0.00
88	0.00	0.00	0.00
86	0.00	0.00	0.01
84	0.00	0.00	0.06
82	0.00	0.00	0.10
80	0.00	0.00	0.15
78	0.00	0.00	0.18
76	0.00	0.00	0.26
74	0.00	0.00	0.29
72	0.05	0.00	0.33
70	0.10	0.00	0.33
68	0.14	0.00	0.41
66	0.19	0.00	0.45
64	0.23	0.00	0.52
62	0.29	0.00	0.56
60	0.39	0.00	0.63
58	0.43	0.03	0.67
56	0.50	0.07	0.88
54	0.57	0.11	1.98
52	0.67	0.15	2.70
50	0.91	0.26	3.42
48	1.84	0.31	4.52
46	2.45	0.39	5.66
44	3.50	0.49	5.66
42	4.83	0.57	7.10
40	5.66	0.66	8.20
38	6.70	0.82	9.35
36	7.90	1.85	11.16
34	9.02	3.56	12.44
32	10.75	4.95	13.74
30	12.29	6.64	15.25
28	16.05	7.99	17.07
26	19.10	9.44	19.85
24	23.47	11.31	22.24
22	28.67	13.70	25.77
20	33.77	16.09	28.13
18	38.06	19.28	30.59
16	41.65	22.87	36.62
14	45.14	27.78	40.35
12	48.68	35.79	45.11
10	52.72	47.03	50.91
8	56.36	52.64	54.56
6	60.49	56.10	61.54
4	68.80	62.91	69.89
2	80.89	79.65	82.92
0	100.00	100.00	100.00

APPENDIX K-13
PERCENT EXCEEDENCE FOR MAXIMUM WUA, HABITAT REACH L, MEDIUM POOL GUILD, SUMMER
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	MOD55	WET
100	0.41	0.41	5.73
98	2.26	1.64	6.96
96	2.87	2.05	8.19
94	3.68	2.46	9.83
92	4.54	3.28	13.10
90	5.32	3.28	15.97
88	6.55	4.09	17.20
86	8.60	4.09	18.57
84	10.23	4.50	22.29
82	11.46	4.91	23.88
80	13.18	5.73	25.52
78	16.29	6.14	28.20
76	17.70	6.96	30.70
74	19.65	8.60	32.29
72	22.06	9.83	34.11
70	23.87	11.47	35.93
68	25.73	12.69	37.60
66	27.73	13.51	39.33
64	29.78	15.67	41.15
62	31.54	17.32	42.97
60	34.09	19.00	44.56
58	38.98	21.53	48.20
56	40.68	22.75	49.79
54	43.63	25.47	53.42
52	46.46	27.06	54.92
50	49.09	29.79	57.69
48	52.49	33.43	59.49
46	55.14	35.34	60.74
44	56.97	39.11	62.93
42	58.99	43.42	65.03
40	60.99	46.38	66.95
38	64.04	50.24	67.80
36	66.08	52.97	70.57
34	67.92	56.48	73.03
32	69.94	59.36	75.26
30	71.98	62.63	77.27
28	73.79	65.51	80.80
26	75.95	68.66	82.72
24	77.50	71.81	85.04
22	80.77	74.18	87.30
20	83.33	76.80	90.06
18	86.27	78.39	91.34
16	89.43	81.80	92.80
14	91.71	85.07	93.96
12	93.47	88.25	95.39
10	95.20	91.16	96.90
8	96.85	93.36	97.64
6	97.35	94.78	98.07
4	98.45	96.91	98.78
2	99.13	99.13	99.66
0	100.00	100.00	100.00

APPENDIX K-14
PERCENT EXCEEDENCE FOR MAXIMUM WUA, HABITAT REACH L, DEEP POOL GUILD, SUMMER
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	MOD55	WET
100	0.00	0.00	0.00
98	0.00	0.00	0.00
96	0.00	0.00	0.00
94	0.00	0.00	0.00
92	0.00	0.00	0.00
90	0.00	0.00	0.00
88	0.00	0.00	0.00
86	0.00	0.00	0.00
84	0.00	0.00	0.00
82	0.00	0.00	0.00
80	0.00	0.00	0.00
78	0.00	0.00	0.00
76	0.00	0.00	0.00
74	0.00	0.00	0.00
72	0.00	0.00	0.00
70	0.00	0.00	0.00
68	0.00	0.00	0.00
66	0.00	0.00	0.00
64	0.00	0.00	0.00
62	0.00	0.00	0.00
60	0.00	0.00	0.00
58	0.00	0.00	0.00
56	0.00	0.00	0.00
54	0.00	0.00	0.00
52	0.00	0.00	0.00
50	0.00	0.00	0.00
48	0.00	0.00	0.00
46	0.00	0.00	0.00
44	0.00	0.00	0.00
42	0.00	0.00	0.00
40	0.00	0.00	0.00
38	0.00	0.00	0.00
36	0.00	0.00	0.00
34	0.00	0.00	0.00
32	0.00	0.00	0.00
30	0.00	0.00	0.00
28	0.00	0.00	0.00
26	0.00	0.00	0.00
24	0.00	0.00	0.00
22	3.45	0.00	0.00
20	14.51	0.00	0.00
18	29.55	0.00	6.01
16	43.20	0.00	16.69
14	57.40	0.00	35.60
12	65.20	17.24	50.57
10	72.87	34.86	58.52
8	78.00	60.17	70.61
6	83.38	73.93	79.47
4	89.99	80.70	85.44
2	95.00	90.73	93.32
0	100.00	100.00	100.00

APPENDIX K-15
PERCENT EXCEEDENCE FOR MAXIMUM WUA, HABITAT REACH L, LOW GRADIENT GROUP, SUMMER
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	MOD55	WET
100	1.87	1.87	26.20
98	10.33	7.49	31.81
96	13.09	9.36	37.43
94	16.83	11.23	44.91
92	20.73	14.97	59.89
90	24.32	14.97	72.99
88	29.93	18.71	79.95
86	39.28	18.71	86.15
84	46.76	20.59	88.10
82	52.37	22.46	88.46
80	60.23	26.20	88.82
78	74.82	28.07	89.11
76	82.42	31.81	89.53
74	88.05	39.30	89.76
72	88.86	44.91	89.98
70	89.19	52.40	90.31
68	89.41	58.01	90.62
66	89.77	61.76	90.73
64	89.88	72.99	90.95
62	90.19	80.47	91.07
60	90.48	87.99	91.28
58	90.70	88.53	91.52
56	91.01	89.01	91.81
54	91.30	89.43	92.04
52	91.59	89.77	92.16
50	91.78	89.99	92.30
48	92.01	90.40	92.37
46	92.15	90.79	92.51
44	92.28	91.21	92.59
42	92.42	91.52	92.65
40	92.55	91.76	92.77
38	92.67	91.98	92.87
36	92.77	92.27	92.94
34	92.92	92.37	92.94
32	93.05	92.51	93.01
30	93.14	92.67	93.09
28	93.23	92.81	93.23
26	93.29	92.97	93.27
24	93.37	93.08	93.37
22	93.43	93.27	93.43
20	93.51	93.33	93.50
18	93.98	93.41	94.05
16	94.54	93.49	94.78
14	95.29	93.54	95.51
12	95.73	94.10	96.20
10	96.28	94.73	96.68
8	96.69	95.18	97.41
6	97.42	95.95	97.93
4	98.35	96.74	98.78
2	99.16	99.14	99.61
0	100.00	100.00	100.00

APPENDIX K-16
PERCENT EXCEEDENCE FOR MAXIMUM WUA, HABITAT REACH L, TRICHOPTERA GROUP, SUMMER
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	MOD55	WET
100	0.77	3.86	10.80
98	4.26	5.40	13.11
96	5.40	6.95	15.43
94	6.94	10.81	18.52
92	8.54	13.12	24.69
90	10.03	17.91	30.09
88	12.34	23.16	33.17
86	16.19	24.76	38.75
84	19.28	27.01	40.77
82	21.59	30.87	41.89
80	24.83	37.82	43.86
78	30.85	38.93	44.84
76	36.25	40.17	47.39
74	38.73	40.80	48.74
72	40.30	41.81	50.10
70	41.95	42.49	50.10
68	43.47	43.18	52.64
66	45.45	43.68	54.00
64	46.52	44.02	56.54
62	48.72	44.70	57.90
60	52.25	44.87	60.44
58	53.64	45.63	61.79
56	56.35	46.22	64.17
54	58.72	46.43	65.51
52	62.11	47.34	66.38
50	63.97	47.92	67.25
48	65.23	48.43	68.59
46	66.12	49.45	69.98
44	67.40	49.62	69.98
42	68.98	50.97	71.72
40	70.01	52.50	73.06
38	71.41	53.01	74.16
36	72.72	54.53	76.13
34	73.80	55.22	77.59
32	75.91	56.91	79.34
30	77.80	57.75	80.67
28	80.98	59.62	82.32
26	82.89	60.03	83.85
24	85.57	62.39	85.76
22	87.63	64.56	87.26
20	89.96	65.95	89.19
18	92.20	69.44	91.06
16	93.75	72.07	91.47
14	94.50	74.43	93.35
12	95.20	77.17	94.17
10	96.27	82.23	95.33
8	97.15	85.36	96.55
6	97.82	87.91	97.29
4	98.67	91.39	98.19
2	99.22	95.05	99.18
0	100.00	100.00	100.00

APPENDIX K-17
PERCENT EXCEEDENCE FOR MAXIMUM WUA, HABITAT REACH L, SHALLOW POOL GUILD, FALL
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	MOD55	WET
100	16.01	20.95	34.00
98	28.02	21.67	45.41
96	38.97	23.06	51.11
94	42.18	24.70	52.20
92	46.04	25.90	53.40
90	51.86	27.05	54.20
88	53.90	28.31	55.37
86	54.04	29.12	59.62
84	58.59	29.43	61.41
82	67.76	30.92	64.85
80	71.92	34.62	70.93
78	74.06	36.00	73.50
76	77.06	37.29	76.07
74	78.61	37.92	78.65
72	80.05	38.54	82.12
70	82.06	39.55	84.65
68	83.41	40.23	85.48
66	84.68	40.70	86.75
64	86.03	41.28	87.27
62	87.49	41.79	88.77
60	88.98	42.35	89.83
58	90.00	42.82	90.01
56	90.99	43.41	91.10
54	91.48	44.04	91.17
52	91.94	44.72	91.79
50	92.25	45.28	92.33
48	92.41	45.73	92.95
46	93.02	46.29	92.95
44	93.18	46.78	93.57
42	93.72	47.28	93.57
40	93.96	47.86	94.12
38	93.96	48.54	94.19
36	94.65	49.86	94.74
34	94.73	51.17	94.74
32	95.12	53.11	95.26
30	95.51	53.62	95.35
28	95.74	54.43	95.35
26	96.07	56.43	95.97
24	96.28	58.72	95.97
22	96.44	59.43	95.97
20	96.51	60.68	96.30
18	96.90	61.50	96.52
16	97.21	63.93	96.52
14	97.44	65.53	97.14
12	97.78	67.48	97.24
10	98.06	71.28	97.44
8	98.22	73.41	97.52
6	98.53	79.55	97.91
4	98.76	87.22	98.06
2	99.39	95.91	99.07
0	100.00	100.00	100.00

APPENDIX K-18
PERCENT EXCEEDENCE FOR MAXIMUM WUA, HABITAT REACH L, SLOW RIFFLE GUILD, FALL
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	MOD55	WET
100	4.72	10.00	9.99
98	8.26	14.00	17.49
96	12.40	18.00	25.79
94	14.73	28.00	30.42
92	15.94	34.00	33.23
90	21.84	42.00	35.87
88	28.12	48.00	36.35
86	30.72	51.39	37.32
84	33.62	52.46	37.68
82	34.34	53.27	38.28
80	34.92	54.24	40.20
78	35.55	56.94	40.20
76	36.27	61.58	40.20
74	37.24	64.00	41.88
72	38.20	67.79	41.88
70	39.07	70.00	41.88
68	39.91	71.94	43.80
66	40.86	75.11	43.80
64	40.86	79.33	43.80
62	41.83	84.00	45.73
60	43.03	86.13	45.73
58	43.93	88.00	45.73
56	44.96	89.47	47.41
54	46.17	90.32	47.65
52	46.41	90.40	49.33
50	48.58	91.25	51.26
48	48.58	91.64	51.26
46	50.16	92.49	53.18
44	51.00	92.72	54.86
42	52.09	93.42	56.78
40	53.41	93.73	56.83
38	53.90	94.35	60.39
36	55.16	94.97	60.63
34	56.31	95.04	64.24
32	58.23	95.51	66.19
30	60.99	95.80	66.78
28	64.28	96.05	67.38
26	66.87	96.44	68.50
24	67.60	96.52	70.82
22	68.66	96.83	72.55
20	69.56	97.14	74.99
18	70.93	97.22	77.10
16	71.80	97.52	80.56
14	72.94	97.68	83.46
12	75.37	97.91	84.65
10	76.84	98.22	87.27
8	79.83	98.53	89.23
6	84.04	98.99	91.77
4	89.72	99.23	94.19
2	94.74	99.81	97.97
0	100.00	100.00	100.00

APPENDIX K-19
PERCENT EXCEEDENCE FOR MAXIMUM WUA, HABITAT REACH L, FAST RIFFLE GUILD, FALL
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	MOD55	WET
100	2.80	1.89	6.43
98	4.89	2.65	11.25
96	7.34	3.41	16.59
94	8.73	5.30	21.25
92	9.44	6.43	27.58
90	12.94	8.78	33.54
88	16.66	11.35	34.62
86	19.99	12.14	36.79
84	26.00	13.24	37.62
82	27.51	15.13	38.96
80	28.71	18.54	43.30
78	30.01	20.00	43.30
76	31.52	23.95	43.30
74	33.52	25.97	47.09
72	35.53	29.22	47.09
70	37.33	31.39	47.09
68	39.08	33.59	51.43
66	41.04	35.19	51.43
64	41.04	36.28	51.43
62	43.05	38.45	55.77
60	45.55	38.99	55.77
58	47.06	41.42	55.77
56	48.56	43.33	59.56
54	52.07	44.00	60.10
52	52.35	46.89	63.90
50	56.58	48.75	63.90
48	57.08	50.38	68.23
46	58.59	53.64	68.23
44	62.09	54.18	72.57
42	62.09	58.39	78.91
40	64.60	62.86	79.81
38	67.11	64.05	80.70
36	68.11	67.74	80.75
34	70.12	69.91	81.82
32	73.10	73.71	82.65
30	74.33	78.26	83.73
28	76.13	80.22	84.77
26	77.97	81.19	85.64
24	80.64	82.95	88.27
22	82.61	84.25	88.83
20	82.88	85.32	89.34
18	84.20	86.18	90.13
16	85.79	86.73	91.80
14	87.14	88.11	93.14
12	87.71	89.76	95.06
10	88.97	91.02	96.55
8	89.56	92.01	97.50
6	90.01	94.31	98.35
4	91.02	97.07	98.35
2	91.65	98.85	99.50
0	100.00	100.00	100.00

APPENDIX K-20
PERCENT EXCEEDENCE FOR MAXIMUM WUA, HABITAT REACH L, RACEWAY GUILD, FALL
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	MOD55	WET
100	0.00	0.00	0.00
98	0.00	0.00	0.00
96	0.00	0.00	0.00
94	0.00	0.00	0.05
92	0.00	0.00	0.18
90	0.00	0.00	0.30
88	0.00	0.00	0.32
86	0.05	0.00	0.37
84	0.17	0.00	0.38
82	0.20	0.00	0.41
80	0.23	0.00	0.50
78	0.25	0.02	0.50
76	0.28	0.10	0.50
74	0.32	0.13	0.58
72	0.36	0.19	0.58
70	0.40	0.24	0.58
68	0.43	0.28	0.67
66	0.47	0.31	0.67
64	0.47	0.33	0.67
62	0.51	0.37	0.76
60	0.56	0.38	0.76
58	0.60	0.42	0.76
56	0.64	0.46	0.83
54	0.69	0.47	0.84
52	0.70	0.53	0.92
50	0.79	0.56	1.01
48	0.79	0.59	1.01
46	0.86	0.66	1.10
44	0.89	0.67	1.18
42	0.94	0.75	1.27
40	0.99	0.84	1.27
38	1.01	0.87	1.43
36	1.07	0.96	1.44
34	1.12	1.00	1.61
32	1.20	1.11	2.75
30	1.31	1.16	3.61
28	1.45	1.27	4.48
26	3.00	1.29	6.10
24	3.95	1.44	9.45
22	5.33	2.45	11.95
20	6.50	4.82	15.48
18	8.28	10.82	18.53
16	9.42	15.31	24.37
14	10.90	19.37	27.72
12	14.06	24.06	30.04
10	15.98	33.19	34.47
8	22.39	40.42	40.17
6	37.87	46.29	46.87
4	52.71	54.32	57.50
2	77.23	66.08	66.17
0	100.00	100.00	100.00

APPENDIX K-21
PERCENT EXCEEDENCE FOR MAXIMUM WUA, HABITAT REACH L, MEDIUM POOL GUILD, FALL
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	MOD55	WET
100	3.29	2.05	6.96
98	5.75	2.87	12.19
96	8.63	3.69	17.97
94	10.25	5.74	21.46
92	11.09	6.96	24.11
90	15.20	9.50	26.61
88	19.57	12.29	27.06
86	21.68	13.14	27.97
84	24.42	14.34	28.32
82	25.10	16.39	28.88
80	25.65	20.07	30.70
78	26.24	20.94	30.70
76	26.93	22.59	30.70
74	27.84	23.44	32.29
72	28.75	24.80	32.29
70	29.57	25.71	32.29
68	30.37	26.63	34.11
66	31.26	27.30	34.11
64	31.26	27.76	34.11
62	32.17	28.67	35.93
60	33.31	28.89	35.93
58	34.16	29.91	35.93
56	35.13	30.71	37.52
54	36.27	30.99	37.74
52	36.50	32.20	39.33
50	38.55	32.99	41.15
48	38.55	33.67	41.15
46	40.04	35.03	42.97
44	40.83	35.26	44.56
42	41.87	37.08	46.38
40	43.11	39.12	46.42
38	43.57	39.81	49.79
36	44.77	41.85	50.01
34	45.85	42.77	53.42
32	47.67	45.03	55.76
30	50.27	46.17	56.72
28	53.37	48.67	57.69
26	56.59	49.22	59.49
24	57.76	52.38	63.22
22	59.47	55.69	66.01
20	60.90	58.56	69.94
18	63.10	65.79	73.33
16	64.52	71.23	79.83
14	66.34	76.13	83.56
12	70.24	81.80	86.14
10	72.62	90.86	90.78
8	80.53	93.59	92.50
6	92.10	95.36	94.53
4	96.04	97.12	97.55
2	98.31	99.07	99.08
0	100.00	100.00	100.00

APPENDIX K-22
PERCENT EXCEEDENCE FOR MAXIMUM WUA, HABITAT REACH L, DEEP POOL GUILD, FALL
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	MOD55	WET
100	0.00	0.00	0.00
98	0.00	0.00	0.00
96	0.00	0.00	0.00
94	0.00	0.00	0.00
92	0.00	0.00	0.00
90	0.00	0.00	0.00
88	0.00	0.00	0.00
86	0.00	0.00	0.00
84	0.00	0.00	0.00
82	0.00	0.00	0.00
80	0.00	0.00	0.00
78	0.00	0.00	0.00
76	0.00	0.00	0.00
74	0.00	0.00	0.00
72	0.00	0.00	0.00
70	0.00	0.00	0.00
68	0.00	0.00	0.00
66	0.00	0.00	0.00
64	0.00	0.00	0.00
62	0.00	0.00	0.00
60	0.00	0.00	0.00
58	0.00	0.00	0.00
56	0.00	0.00	0.00
54	0.00	0.00	0.00
52	0.00	0.00	0.00
50	0.00	0.00	0.00
48	0.00	0.00	0.00
46	0.00	0.00	0.00
44	0.00	0.00	0.00
42	0.00	0.00	0.00
40	0.00	0.00	0.00
38	0.00	0.00	0.00
36	0.00	0.00	0.00
34	0.00	0.00	0.00
32	0.00	0.00	0.00
30	0.00	0.00	0.00
28	0.00	0.00	0.00
26	0.00	0.00	0.00
24	0.00	0.00	0.00
22	0.00	0.00	0.00
20	0.00	0.00	0.00
18	0.00	0.00	0.00
16	0.00	0.00	0.00
14	0.00	0.00	0.00
12	0.00	0.00	0.00
10	0.00	0.00	0.00
8	0.00	0.00	0.00
6	0.00	0.00	0.00
4	0.00	0.00	0.00
2	60.12	19.50	3.38
0	100.00	100.00	100.00

APPENDIX K-23
PERCENT EXCEEDENCE FOR MAXIMUM WUA, HABITAT REACH L, LOW GRADIENT GROUP, FALL
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	MOD55	WET
100	15.04	9.36	31.81
98	26.31	13.10	55.69
96	39.47	16.85	82.12
94	46.92	26.21	88.11
92	50.75	31.82	88.56
90	69.55	43.43	88.78
88	88.50	56.16	89.22
86	89.63	60.05	89.94
84	90.23	65.52	90.18
82	90.76	74.88	90.60
80	91.04	88.03	90.95
78	91.27	89.01	91.26
76	91.52	89.38	91.63
74	91.79	90.02	91.81
72	91.95	90.55	91.91
70	92.20	91.24	92.04
68	92.32	91.73	92.22
66	92.50	92.01	92.26
64	92.65	92.24	92.37
62	92.81	92.37	92.44
60	92.89	92.45	92.51
58	92.96	92.52	92.59
56	93.00	92.59	92.65
54	93.04	92.66	92.73
52	93.10	92.73	92.73
50	93.14	92.77	92.80
48	93.15	92.84	92.80
46	93.22	92.87	92.87
44	93.24	92.99	92.88
42	93.25	93.00	92.94
40	93.34	93.03	92.94
38	93.36	93.06	92.94
36	93.40	93.11	93.01
34	93.44	93.13	93.01
32	93.48	93.18	93.01
30	93.52	93.18	93.09
28	93.54	93.23	93.09
26	93.55	93.26	93.09
24	93.59	93.28	93.15
22	93.63	93.31	93.15
20	93.65	93.33	93.18
18	93.68	93.36	93.23
16	93.74	93.40	93.27
14	93.75	93.43	93.27
12	93.79	93.48	93.31
10	93.79	93.52	93.32
8	93.85	93.59	93.42
6	93.97	94.27	93.54
4	96.99	96.65	97.05
2	97.94	98.94	98.97
0	100.00	100.00	100.00

APPENDIX K-24
PERCENT EXCEEDENCE FOR MAXIMUM WUA, HABITAT REACH L, TRICHOPTERA GROUP, FALL
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	MOD55	WET
100	6.18	19.90	13.13
98	10.81	22.36	22.98
96	16.21	34.71	33.89
94	19.27	40.08	39.35
92	20.84	60.95	41.33
90	28.56	64.12	43.19
88	36.78	67.25	43.53
86	39.45	69.79	44.21
84	41.48	72.20	44.47
82	41.99	75.63	44.89
80	42.40	77.88	46.25
78	42.84	81.12	46.25
76	43.35	82.66	46.25
74	44.02	83.98	47.43
72	44.70	85.20	47.43
70	45.31	86.13	47.43
68	45.90	86.80	48.79
66	46.57	87.27	48.79
64	46.57	87.52	48.79
62	47.25	87.93	50.15
60	48.09	88.22	50.15
58	48.73	88.59	50.15
56	49.45	88.86	51.34
54	50.30	89.20	51.51
52	50.47	89.47	52.69
50	52.00	89.74	54.05
48	52.00	90.18	54.05
46	53.10	90.83	55.41
44	53.69	91.11	56.60
42	54.46	91.27	57.95
40	55.39	91.65	57.99
38	55.73	92.11	60.50
36	56.61	92.45	60.67
34	57.42	92.89	63.21
32	58.77	93.51	64.64
30	60.71	94.05	65.11
28	63.02	94.71	65.57
26	64.92	95.21	66.45
24	65.49	95.87	68.25
22	66.31	96.57	69.60
20	67.00	96.90	71.49
18	68.06	97.39	73.14
16	68.74	97.66	76.28
14	69.62	98.02	78.08
12	71.50	98.28	79.32
10	72.64	98.45	81.66
8	76.45	98.75	83.94
6	84.58	99.00	86.61
4	91.13	99.29	90.86
2	97.58	99.57	94.08
0	100.00	100.00	100.00

HABITAT REACH H

APPENDIX K-25
PERCENT EXCEEDENCE FOR MAXIMUM HABITAT
REACH H, SHALLOW POOL GUILD, SPRING
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	300MOD50	MOD55	480MOD55	WET	WETOF
100	14.11	14.11	16.83	16.83	18.49	26.91
98	18.04	17.97	21.25	21.41	18.80	27.58
96	18.56	18.32	21.70	22.15	19.02	27.96
94	18.97	18.71	22.08	22.88	19.35	28.33
92	19.43	19.09	22.52	23.47	19.68	28.69
90	19.81	19.35	23.08	24.09	19.98	29.08
88	20.36	19.70	23.60	24.62	20.27	29.64
86	20.72	20.14	24.05	25.38	20.63	30.18
84	21.29	20.55	24.47	26.65	20.99	30.57
82	21.77	20.89	24.93	27.42	21.38	30.83
80	22.16	21.38	25.34	28.14	21.91	31.58
78	22.33	21.69	25.77	28.61	22.37	32.45
76	22.79	22.14	26.36	28.93	22.59	32.87
74	23.06	22.36	26.88	28.96	22.89	33.32
72	23.32	22.68	27.42	28.97	23.11	33.96
70	23.65	23.06	28.02	28.99	23.39	34.56
68	24.20	23.50	28.39	29.01	23.69	35.33
66	24.54	23.85	28.71	29.02	24.09	36.12
64	24.63	24.26	28.98	29.04	24.47	36.78
62	24.68	24.60	29.07	29.07	24.91	37.66
60	24.74	24.68	29.16	29.12	25.24	37.75
58	24.84	24.73	29.29	29.16	25.56	37.80
56	24.91	24.83	29.38	29.20	25.62	37.86
54	25.00	24.92	29.48	29.26	25.65	37.92
52	25.10	25.00	29.55	29.33	25.69	38.00
50	25.19	25.10	29.61	29.39	25.76	38.06
48	25.28	25.18	29.69	29.47	25.84	38.13
46	25.59	25.28	29.82	29.52	25.92	38.20
44	26.34	25.60	30.31	29.61	26.02	38.29
42	27.90	28.04	31.02	29.68	26.12	38.37
40	29.99	29.99	32.21	29.76	26.24	38.46
38	32.20	32.06	33.22	29.89	26.37	38.55
36	35.07	33.88	34.29	30.83	26.90	38.63
34	37.03	35.31	35.93	32.21	28.16	38.73
32	38.15	37.14	37.75	33.55	29.66	38.80
30	39.78	38.46	39.57	35.91	30.81	38.85
28	42.55	41.01	41.03	38.59	32.72	39.14
26	47.66	46.48	42.46	41.45	34.02	40.74
24	52.74	49.59	44.41	44.24	36.08	42.59
22	54.79	53.85	46.38	47.69	39.03	44.13
20	55.16	55.07	49.62	51.76	40.22	47.63
18	57.34	56.99	53.87	54.85	44.05	52.26
16	58.83	57.66	57.96	57.97	47.94	56.74
14	61.74	61.75	58.40	58.64	51.58	61.84
12	62.01	62.01	61.26	61.27	55.17	67.03
10	64.22	64.18	64.42	63.94	59.78	70.16
8	68.29	68.29	70.81	70.58	63.43	73.37
6	73.61	73.61	76.87	76.73	64.50	79.73
4	89.53	89.53	79.38	79.38	66.82	87.08
2	91.25	91.25	85.62	85.62	71.12	95.66
0	100.00	100.00	100.00	100.00	100.00	100.00

APPENDIX K-26
PERCENT EXCEEDENCE FOR MAXIMUM HABITAT
REACH H, SLOW RIFFLE GUILD, SPRING
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	300MOD50	MOD55	480MOD55	WET	WETOF
100	1.15	1.15	24.88	25.21	11.54	25.43
98	6.45	6.44	25.90	26.14	25.71	25.70
96	25.63	25.58	26.65	26.42	26.75	26.09
94	26.38	26.10	27.14	26.93	27.80	26.59
92	27.11	26.96	27.72	27.34	28.39	27.04
90	28.00	27.79	28.24	27.93	29.12	27.47
88	29.07	28.55	28.86	28.26	29.92	27.93
86	29.76	29.27	29.44	28.71	30.68	28.42
84	30.77	30.03	30.26	29.23	31.38	28.78
82	31.26	30.90	30.96	29.65	31.77	29.34
80	31.72	31.43	31.47	30.04	32.03	29.74
78	32.47	32.15	32.34	30.47	32.26	30.05
76	34.38	33.56	33.38	30.74	32.95	30.35
74	35.49	34.78	34.63	31.04	33.72	30.81
72	36.90	35.98	35.97	31.36	34.97	31.13
70	38.49	37.51	36.69	31.71	36.01	31.54
68	40.10	39.10	37.99	31.95	37.00	31.87
66	41.54	40.13	39.67	32.08	37.86	32.15
64	42.78	41.71	40.30	32.18	38.58	32.68
62	43.97	42.71	41.37	32.32	39.58	33.88
60	45.17	43.54	42.78	32.43	40.87	34.63
58	46.23	44.57	43.66	32.53	41.92	35.60
56	47.24	45.52	44.64	32.71	43.02	36.52
54	48.15	46.37	45.50	33.09	43.92	37.22
52	48.84	47.13	46.50	34.34	44.63	38.01
50	49.72	47.72	47.27	36.01	45.14	38.66
48	50.34	48.58	48.03	36.66	45.95	39.60
46	50.83	49.33	48.97	38.13	46.59	41.00
44	51.30	49.74	49.49	40.09	47.19	41.80
42	51.79	50.33	50.00	40.84	47.66	42.74
40	52.40	50.62	50.89	42.22	48.22	43.71
38	52.81	51.24	51.55	43.22	49.14	44.20
36	53.28	52.02	52.36	44.21	49.90	44.65
34	53.58	52.51	52.64	45.67	50.45	45.38
32	54.00	53.07	53.44	46.97	50.94	45.96
30	54.47	53.49	53.97	48.28	51.50	46.65
28	56.82	54.03	54.70	49.12	52.20	47.19
26	59.66	55.60	57.07	49.95	52.75	47.79
24	62.14	60.40	59.30	51.19	53.24	48.19
22	66.76	62.96	61.16	52.24	54.01	48.86
20	70.81	67.70	63.00	53.08	55.64	49.77
18	74.28	72.97	67.84	53.74	57.47	50.85
16	77.80	75.61	70.62	55.48	60.17	52.26
14	80.33	77.67	72.92	59.27	62.86	53.17
12	82.50	78.67	76.26	61.89	69.66	53.98
10	83.59	82.37	81.34	67.93	71.86	54.21
8	85.13	84.85	85.72	73.22	75.84	57.27
6	87.05	85.31	89.14	76.00	77.84	59.87
4	90.62	88.98	91.40	89.59	85.64	61.72
2	94.80	92.19	93.44	92.66	92.24	69.30
0	100.00	100.00	100.00	100.00	100.00	100.00

APPENDIX K-27
PERCENT EXCEEDENCE FOR MAXIMUM HABITAT
REACH H, FAST RIFFLE GUILD, SPRING
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	300MOD50	MOD55	480MOD55	WET	WETOF
100	0.00	0.00	0.95	0.95	0.28	21.67
98	0.14	0.14	1.69	1.69	3.36	61.66
96	0.67	0.67	4.03	4.03	7.16	71.93
94	1.64	1.64	6.33	7.24	8.70	75.99
92	3.33	3.33	16.79	17.14	22.81	77.85
90	7.15	7.15	19.09	19.13	38.36	77.92
88	8.75	8.75	23.05	59.41	56.81	78.04
86	12.17	12.32	37.55	69.14	65.26	78.11
84	12.70	14.26	45.39	75.26	70.35	78.19
82	14.31	14.69	54.47	77.80	74.59	78.24
80	18.00	21.17	61.41	77.96	77.94	78.31
78	30.30	38.05	66.01	78.13	78.04	78.41
76	38.14	49.25	71.69	78.22	78.14	78.50
74	45.56	58.76	74.58	78.32	78.23	78.59
72	61.06	67.11	76.14	78.36	78.31	78.67
70	70.51	73.74	77.86	78.43	78.37	78.72
68	74.94	77.88	78.01	78.51	78.44	78.76
66	77.76	77.99	78.15	78.60	78.52	78.83
64	77.93	78.16	78.28	78.65	78.61	78.91
62	78.06	78.32	78.38	78.74	78.69	79.03
60	78.19	78.45	78.47	78.81	78.78	79.11
58	78.33	78.58	78.59	78.92	78.87	79.21
56	78.50	78.66	78.68	79.07	78.95	79.27
54	78.60	78.75	78.77	79.18	79.00	79.40
52	78.71	78.83	78.92	79.36	79.09	79.51
50	78.81	78.95	79.02	79.49	79.20	79.66
48	78.95	79.09	79.17	79.62	79.27	79.89
46	79.09	79.15	79.32	79.83	79.35	80.02
44	79.19	79.26	79.45	79.92	79.45	80.16
42	79.32	79.38	79.51	80.01	79.61	80.20
40	79.46	79.49	79.62	80.17	79.72	80.45
38	79.55	79.55	79.76	80.55	79.80	80.96
36	79.61	79.64	79.88	81.05	79.86	81.46
34	79.69	79.69	79.95	81.68	79.96	82.07
32	79.75	79.78	80.02	82.23	80.08	82.60
30	79.85	79.91	80.11	82.89	80.17	83.21
28	79.96	79.99	80.21	83.35	80.26	83.82
26	80.02	80.08	80.93	84.19	80.38	84.36
24	80.07	80.14	82.01	84.86	81.08	84.97
22	80.15	80.25	82.91	85.49	82.04	85.60
20	80.20	81.44	83.59	86.15	83.26	85.99
18	81.21	82.41	84.26	86.83	84.48	86.62
16	82.31	83.61	85.37	87.76	85.85	87.81
14	83.50	84.54	86.20	88.64	87.32	88.95
12	84.63	85.93	87.42	89.87	88.56	90.01
10	86.28	87.78	88.78	91.00	89.75	91.66
8	88.15	89.01	90.20	92.25	91.58	93.06
6	90.34	90.68	92.08	93.83	93.52	94.28
4	92.93	93.12	94.39	94.87	95.61	95.97
2	97.40	97.46	95.71	96.49	97.63	98.13
0	100.00	100.00	100.00	100.00	100.00	100.00

APPENDIX K-28
PERCENT EXCEEDENCE FOR MAXIMUM HABITAT
REACH H, RACEWAY GUILD, SPRING
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	300MOD50	MOD55	480MOD55	WET	WETOF
100	0.00	0.00	0.00	0.00	0.00	1.86
98	0.00	0.00	0.00	0.00	0.14	9.24
96	0.00	0.00	0.20	0.20	0.50	11.37
94	0.00	0.00	0.41	0.49	0.64	13.48
92	0.14	0.14	1.37	1.40	1.96	15.10
90	0.49	0.49	1.58	1.59	4.46	20.64
88	0.63	0.63	1.94	8.35	7.73	29.24
86	0.95	0.96	4.23	11.68	9.52	34.92
84	0.99	1.14	5.59	17.65	10.90	39.12
82	1.14	1.18	7.17	20.27	12.04	41.19
80	1.48	1.77	8.91	26.28	14.22	44.69
78	2.97	4.31	10.39	33.73	17.85	48.25
76	4.33	6.25	11.01	39.69	20.76	50.51
74	5.62	8.04	11.68	47.06	24.51	51.80
72	8.73	10.14	12.98	51.89	27.59	52.67
70	10.58	12.88	15.27	54.41	29.79	54.19
68	11.90	15.40	18.57	56.86	32.20	56.03
66	13.33	17.06	20.07	60.44	37.03	58.01
64	15.31	19.96	23.53	65.28	39.58	60.51
62	16.61	22.43	26.86	68.37	42.99	61.60
60	18.50	26.36	31.05	68.89	45.63	63.04
58	20.98	27.77	33.64	69.07	49.06	64.62
56	24.10	30.26	38.71	69.21	51.48	66.81
54	25.82	32.21	43.08	69.38	52.54	69.12
52	28.21	35.63	46.50	69.57	54.47	70.03
50	30.12	39.48	50.23	69.74	56.23	70.59
48	33.96	41.93	52.17	69.96	58.43	70.99
46	37.72	45.28	54.10	70.30	60.87	71.40
44	41.84	49.58	56.19	70.83	62.04	71.91
42	47.31	50.81	57.93	71.25	63.93	72.39
40	50.03	52.66	61.12	71.49	65.85	72.87
38	52.54	54.48	63.77	71.88	68.20	73.38
36	54.54	57.23	67.30	72.24	69.91	73.80
34	57.71	60.28	68.85	72.59	70.47	74.18
32	61.34	63.86	70.00	73.21	70.82	74.60
30	64.05	66.12	70.87	73.76	71.24	75.09
28	67.51	68.66	71.53	74.16	71.72	75.48
26	68.78	69.45	72.30	74.60	72.40	76.01
24	69.46	70.15	72.98	75.15	73.06	76.56
22	70.16	71.21	73.89	75.58	74.02	77.14
20	70.92	72.49	74.55	75.98	74.71	77.61
18	72.00	73.42	75.31	76.48	75.33	78.04
16	73.20	74.36	75.83	76.97	76.11	78.45
14	74.33	75.29	76.37	77.46	76.97	78.89
12	75.35	75.87	76.94	77.85	77.60	79.33
10	76.07	76.62	77.51	78.30	78.62	79.97
8	77.01	77.21	78.17	78.66	79.22	80.38
6	77.65	77.92	78.83	78.97	80.02	80.63
4	78.86	78.82	79.31	79.33	80.63	80.92
2	85.84	85.84	90.60	90.65	85.45	86.85
0	100.00	100.00	100.00	100.00	100.00	100.00

APPENDIX K-29
PERCENT EXCEEDENCE FOR MAXIMUM HABITAT
REACH H, MEDIUM POOL GUILD, SPRING
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	300MOD50	MOD55	480MOD55	WET	WETOF
100	0.00	0.00	13.71	13.71	4.06	49.03
98	2.04	2.04	24.42	24.42	31.37	51.82
96	9.70	9.69	33.33	33.33	42.80	55.45
94	23.67	23.65	40.24	43.02	47.46	58.65
92	31.24	31.23	51.57	53.42	51.65	60.18
90	42.75	42.73	57.64	58.50	55.98	61.34
88	47.58	47.55	59.74	59.54	58.80	61.81
86	52.05	52.03	61.76	60.71	59.74	62.82
84	53.78	53.79	63.17	61.31	60.57	63.68
82	56.68	58.00	64.57	61.80	61.41	64.34
80	58.38	59.27	65.50	62.31	62.37	65.43
78	59.91	60.43	66.81	62.96	63.07	66.19
76	61.25	61.75	68.13	63.49	64.23	66.92
74	62.51	63.31	69.10	63.89	65.01	67.67
72	63.76	64.17	70.27	64.42	65.91	68.23
70	64.29	64.74	71.27	65.08	67.06	69.06
68	64.98	65.51	71.89	65.94	67.80	70.24
66	65.66	66.98	73.07	67.51	68.94	71.16
64	67.13	68.73	74.15	68.16	70.06	72.10
62	68.74	70.24	75.65	68.99	71.26	72.70
60	70.29	71.86	76.76	70.11	72.61	73.56
58	72.03	73.51	77.87	70.70	73.66	74.54
56	73.62	74.89	78.72	71.64	74.61	75.34
54	75.30	75.92	79.21	72.17	75.84	76.18
52	76.93	77.33	79.85	73.03	77.00	76.90
50	78.03	78.03	80.38	73.88	77.89	77.50
48	79.20	79.19	80.78	75.03	78.93	78.31
46	80.02	79.97	81.21	76.05	79.58	78.94
44	80.62	80.50	81.77	77.52	80.16	79.48
42	81.22	80.79	82.12	78.65	80.56	80.03
40	81.64	81.29	82.45	78.86	80.85	80.53
38	82.21	81.58	82.95	79.82	81.29	80.97
36	82.65	82.00	83.30	80.59	81.66	81.26
34	82.92	82.36	83.72	81.07	82.11	81.99
32	83.30	82.68	84.03	81.89	82.58	82.56
30	83.63	82.95	84.40	82.53	82.91	83.33
28	83.81	83.12	84.56	83.44	83.20	83.95
26	84.30	83.38	84.69	84.11	83.59	84.45
24	84.71	83.91	84.99	84.42	83.93	84.94
22	84.97	84.35	85.37	84.67	84.37	85.46
20	85.20	84.68	85.59	85.21	84.70	85.68
18	85.35	85.07	85.88	85.81	85.08	85.98
16	85.65	85.32	86.38	86.81	85.52	87.63
14	85.89	85.68	88.36	88.93	85.80	89.17
12	86.90	85.94	89.59	90.67	86.12	91.06
10	89.17	88.22	91.10	92.70	88.93	92.55
8	91.12	90.76	92.62	94.32	91.41	94.01
6	92.55	91.95	94.42	95.98	92.98	96.13
4	94.62	93.40	96.27	97.22	95.13	97.89
2	96.88	96.42	98.44	98.47	97.37	98.83
0	100.00	100.00	100.00	100.00	100.00	100.00

APPENDIX K-30
PERCENT EXCEEDENCE FOR MAXIMUM HABITAT
REACH H, DEEP POOL GUILD, SPRING
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	300MOD50	MOD55	480MOD55	WET	WETOF
100	0.00	0.00	0.00	0.00	0.00	0.00
98	0.00	0.00	0.00	0.00	0.00	0.00
96	0.00	0.00	0.00	0.00	0.00	0.00
94	0.00	0.00	0.00	0.00	0.00	0.00
92	0.00	0.00	0.00	0.00	0.00	0.00
90	0.00	0.00	0.00	0.00	0.00	0.00
88	0.00	0.00	0.00	0.00	0.00	0.00
86	0.00	0.00	0.00	0.00	0.00	0.00
84	0.00	0.00	0.00	0.00	0.00	0.00
82	0.00	0.00	0.00	0.00	0.00	0.00
80	0.00	0.00	0.00	0.00	0.00	0.00
78	0.00	0.00	0.00	0.00	0.00	0.00
76	0.00	0.00	0.00	0.00	0.00	0.00
74	0.00	0.00	0.00	0.00	0.00	0.00
72	0.00	0.00	0.00	0.00	0.00	0.00
70	0.00	0.00	0.00	0.00	0.00	0.00
68	0.00	0.00	0.00	0.00	0.00	0.00
66	0.00	0.00	0.00	0.00	0.00	0.00
64	0.00	0.00	0.00	0.00	0.00	0.00
62	0.00	0.00	0.00	0.00	0.00	0.00
60	0.00	0.00	0.00	0.00	0.00	0.00
58	0.00	0.00	0.00	0.00	0.00	0.00
56	0.00	0.00	0.00	0.00	0.00	0.00
54	0.00	0.00	0.00	0.00	0.00	0.00
52	0.00	0.00	0.00	0.00	0.00	0.00
50	0.00	0.00	0.00	0.00	0.00	0.00
48	0.00	0.00	0.00	0.00	0.00	0.00
46	0.00	0.00	0.00	0.00	0.00	0.00
44	0.00	0.00	0.00	0.00	0.00	0.00
42	0.00	0.00	0.00	0.00	0.00	0.00
40	0.00	0.00	0.00	0.00	0.00	0.00
38	0.00	0.00	0.00	0.00	0.00	0.00
36	0.00	0.00	0.00	0.00	0.00	0.00
34	0.00	0.00	0.00	0.00	0.00	0.00
32	0.00	0.00	0.00	0.00	0.00	0.00
30	0.00	0.00	0.00	0.00	0.00	0.00
28	0.00	0.00	0.00	0.00	0.00	0.00
26	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00
6	4.68	4.68	0.31	2.42	0.00	6.26
4	27.37	27.37	30.08	34.75	24.94	31.51
2	56.12	56.12	70.77	70.94	52.38	57.26
0	100.00	100.00	100.00	100.00	100.00	100.00

APPENDIX K-31
PERCENT EXCEEDENCE FOR MAXIMUM HABITAT
REACH H, LOW GRADIENT GUILD, SPRING
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	300MOD50	MOD55	480MOD55	WET	WETOF
100	28.39	28.40	28.65	28.65	31.43	30.97
98	32.50	32.44	31.72	31.51	32.80	31.34
96	33.80	33.50	32.56	31.96	34.59	31.94
94	35.18	34.53	33.48	32.58	35.54	32.62
92	36.42	36.16	34.19	33.33	36.58	33.27
90	37.69	37.08	35.04	34.05	37.66	33.92
88	39.04	38.65	36.04	34.61	38.62	34.45
86	39.68	39.36	37.11	35.22	39.71	35.23
84	40.71	40.36	38.11	35.89	40.38	35.88
82	41.39	41.30	38.86	36.49	40.71	36.49
80	41.81	41.74	39.86	37.16	41.08	36.99
78	42.45	42.39	40.86	37.64	41.54	37.54
76	43.02	42.92	41.49	38.02	42.04	37.94
74	43.51	43.46	42.04	38.50	42.37	38.64
72	44.00	43.78	42.53	38.84	42.66	39.14
70	44.37	44.05	42.99	39.30	42.92	39.67
68	45.58	44.33	43.32	39.54	43.20	40.08
66	47.31	44.88	43.73	39.66	43.57	40.50
64	48.74	46.45	44.04	39.83	43.96	41.19
62	49.85	47.52	44.39	40.02	44.30	41.54
60	51.22	48.66	45.52	40.15	44.66	41.91
58	52.10	49.81	46.45	40.30	44.87	42.19
56	52.48	50.97	47.98	40.74	45.51	42.46
54	53.37	51.43	49.41	41.40	46.51	42.66
52	53.97	52.22	50.58	42.12	47.32	43.11
50	54.88	52.74	51.39	42.91	48.14	43.47
48	55.99	53.36	52.57	43.32	49.29	43.78
46	56.61	54.73	53.97	43.70	50.40	44.08
44	57.13	55.52	55.27	44.19	51.92	44.22
42	57.60	56.57	55.81	45.43	52.75	44.45
40	58.16	57.09	56.62	47.26	53.54	45.00
38	59.15	57.69	57.56	48.95	54.55	46.09
36	60.83	58.36	58.42	50.34	55.79	46.65
34	62.89	61.14	59.76	52.06	56.73	47.97
32	67.25	64.42	61.21	54.20	57.68	48.66
30	71.15	68.71	62.68	55.46	58.75	49.77
28	73.23	71.66	65.05	56.38	60.18	51.25
26	76.36	72.20	67.62	58.33	62.98	52.43
24	79.05	74.84	70.76	60.82	64.94	55.13
22	80.48	79.00	73.65	63.11	66.74	56.59
20	84.17	81.10	75.84	68.36	68.39	57.91
18	87.13	86.17	77.78	73.17	71.78	58.37
16	90.37	88.91	80.18	77.61	76.13	61.15
14	91.06	90.96	84.41	79.26	80.48	63.05
12	91.61	91.12	88.70	86.60	82.34	67.00
10	91.85	91.88	89.18	89.16	88.15	71.91
8	92.81	92.84	91.04	90.07	90.99	78.23
6	93.28	93.31	92.72	92.49	94.52	84.43
4	94.65	94.68	94.58	94.66	95.13	88.10
2	95.39	95.42	95.37	95.37	96.42	95.60
0	100.00	100.00	100.00	100.00	100.00	100.00

APPENDIX K-32
PERCENT EXCEEDENCE FOR MAXIMUM HABITAT
REACH H, TRICHOPTERA GUILD, SPRING
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	300MOD50	MOD55	480MOD55	WET	WETOF
100	49.24	49.26	49.23	49.23	49.73	49.31
98	50.27	50.22	49.89	49.68	50.71	49.57
96	51.02	50.86	50.52	50.09	51.82	49.94
94	51.86	51.52	51.06	50.47	52.53	50.43
92	52.76	52.28	51.50	50.95	53.20	50.86
90	53.63	53.14	52.17	51.35	53.84	51.24
88	54.32	54.15	52.72	51.69	54.55	51.65
86	54.86	54.72	53.29	52.22	55.08	52.12
84	55.40	55.38	54.19	52.57	55.54	52.59
82	56.42	56.11	54.66	52.96	55.75	52.97
80	57.20	56.94	55.31	53.40	56.01	53.32
78	58.00	57.60	55.98	53.71	56.67	53.63
76	58.88	58.74	57.13	53.98	57.58	53.93
74	59.95	59.67	58.12	54.23	58.16	54.37
72	60.98	60.45	58.82	54.53	58.68	54.70
70	61.70	61.21	59.90	54.73	59.24	55.04
68	62.57	61.86	60.41	54.86	59.76	55.28
66	63.35	62.56	61.11	54.95	60.55	55.70
64	65.51	62.97	61.80	55.08	61.24	56.58
62	66.95	64.19	62.46	55.18	61.75	57.12
60	67.82	65.71	62.98	55.27	62.32	57.76
58	68.95	67.07	64.74	55.44	62.87	58.38
56	70.75	67.81	66.45	55.79	63.18	58.88
54	72.09	68.95	68.91	56.99	63.70	59.27
52	74.21	70.67	70.51	58.12	64.96	60.01
50	75.90	71.67	72.07	59.36	66.87	60.69
48	76.75	73.60	73.44	60.16	68.27	61.13
46	78.04	74.62	74.58	61.03	69.12	61.81
44	79.15	76.04	76.29	61.74	70.92	62.30
42	80.43	76.99	78.06	62.75	72.62	62.55
40	82.13	78.01	79.63	64.33	74.88	62.97
38	83.15	80.04	80.99	66.21	76.11	63.72
36	84.05	81.50	82.03	68.95	77.08	65.41
34	84.69	82.30	82.47	70.49	77.93	66.62
32	85.45	83.71	84.06	71.80	79.55	68.07
30	86.02	84.70	84.94	73.65	81.43	69.70
28	86.89	85.44	85.67	75.75	82.89	70.56
26	87.74	86.22	86.44	78.50	84.08	72.28
24	88.51	87.38	87.21	80.22	85.78	74.33
22	89.37	88.56	88.01	81.42	86.86	76.21
20	90.38	89.41	89.01	82.13	87.49	78.86
18	90.86	90.50	90.15	83.76	88.46	80.93
16	91.58	91.46	91.21	85.01	89.85	82.68
14	92.54	92.56	93.68	86.55	90.12	85.02
12	92.72	92.74	94.66	87.35	91.31	85.73
10	94.37	94.56	95.30	89.00	92.95	87.04
8	96.44	95.99	96.20	91.04	94.91	89.42
6	97.63	96.92	97.24	93.99	96.69	91.13
4	98.15	97.64	97.84	95.30	98.03	96.75
2	98.57	98.29	98.42	96.79	99.10	97.85
0	100.00	100.00	100.00	100.00	100.00	100.00

APPENDIX K-33
PERCENT EXCEEDENCE FOR MAXIMUM HABITAT
REACH H, SHALLOW POOL GUILD, SUMMER
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	300MOD50	MOD55	480MOD55	WET	WETOF
100	17.70	17.73	17.70	46.34	17.76	17.76
98	18.04	18.00	18.37	61.97	18.18	18.00
96	18.41	18.25	18.83	62.00	18.43	18.28
94	19.04	18.75	19.16	62.10	18.89	18.55
92	19.52	19.18	19.63	62.21	19.18	18.81
90	19.88	19.43	20.05	62.32	19.46	19.12
88	20.18	19.98	20.34	62.43	19.71	19.36
86	20.57	20.52	20.79	62.59	19.97	19.64
84	20.87	21.02	21.10	62.67	20.28	19.87
82	21.35	21.42	21.60	62.76	20.70	20.11
80	21.72	21.71	22.10	62.87	21.01	20.38
78	22.21	22.47	22.44	62.96	21.32	20.67
76	22.61	22.97	22.81	63.20	21.61	20.99
74	22.95	23.47	23.27	63.27	21.85	21.34
72	23.57	24.00	23.83	63.27	22.20	21.64
70	24.22	24.51	24.27	63.28	22.49	21.91
68	24.64	24.57	24.66	63.30	22.80	22.23
66	25.01	24.67	25.10	63.30	23.25	22.55
64	25.55	24.74	25.59	63.31	23.63	22.84
62	27.80	24.86	27.33	63.32	23.83	23.16
60	29.79	25.01	29.26	63.33	23.99	23.60
58	31.80	25.28	30.87	63.34	24.25	24.01
56	33.31	25.68	32.46	63.36	24.59	24.18
54	34.26	27.32	34.12	63.37	24.78	24.43
52	35.88	29.06	35.49	63.38	25.08	24.59
50	37.63	30.13	36.91	63.40	25.34	24.62
48	38.46	31.98	38.36	63.41	25.63	24.64
46	39.67	33.59	39.75	63.43	26.41	24.66
44	40.89	34.98	40.68	63.46	27.90	24.69
42	43.62	37.06	43.33	63.49	28.99	24.72
40	45.57	38.85	45.09	63.52	30.99	24.75
38	48.29	40.18	49.68	63.54	32.98	24.77
36	52.87	42.76	51.35	63.58	35.13	24.81
34	56.04	47.00	53.26	63.61	36.26	24.85
32	58.96	50.97	55.23	63.64	37.67	24.91
30	61.74	54.63	57.34	63.68	38.61	24.94
28	63.55	58.01	59.21	63.73	40.04	24.96
26	65.66	60.31	61.88	63.80	41.68	25.01
24	67.95	63.72	63.63	63.87	45.14	25.10
22	70.04	66.05	66.19	63.93	48.92	25.22
20	74.10	68.46	68.50	64.01	51.92	25.71
18	78.18	69.90	73.01	64.11	54.02	28.82
16	80.37	75.34	76.48	64.24	56.82	31.97
14	82.87	78.83	78.76	64.36	59.92	35.57
12	84.25	81.19	82.86	64.44	62.47	36.81
10	86.49	83.35	85.36	64.55	63.25	38.91
8	88.34	85.25	88.59	64.67	66.33	47.24
6	90.83	89.72	90.99	64.77	68.23	58.50
4	95.46	94.40	93.53	64.93	73.62	67.08
2	98.31	98.04	97.02	65.76	83.52	83.52
0	100.00	100.00	100.00	100.00	100.00	100.00

APPENDIX K-34
PERCENT EXCEEDENCE FOR MAXIMUM HABITAT
REACH H, SLOW RIFFLE GUILD, SUMMER
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	300MOD50	MOD55	480MOD55	WET	WETOF
100	0.50	0.75	0.36	27.44	0.61	0.61
98	0.95	3.99	0.51	28.46	1.19	1.19
96	1.62	9.56	0.73	29.01	31.18	26.39
94	6.57	19.01	1.14	29.41	33.80	27.84
92	15.90	27.95	8.56	29.94	37.30	28.78
90	26.30	29.64	16.41	30.29	38.69	29.10
88	30.11	30.80	22.07	30.52	40.05	29.31
86	31.84	31.86	27.41	30.85	41.45	29.82
84	34.97	32.39	31.91	31.33	42.45	30.15
82	36.35	34.06	34.59	31.92	43.20	30.64
80	37.59	36.05	36.02	32.23	44.18	30.89
78	39.07	37.88	37.44	32.47	45.19	31.20
76	40.24	38.82	39.14	32.65	46.30	31.43
74	41.46	40.10	39.99	32.95	47.20	31.73
72	42.97	41.70	41.26	33.24	47.79	31.92
70	44.26	42.50	42.55	33.42	48.30	32.16
68	45.08	43.39	43.35	33.54	48.98	32.41
66	46.07	44.39	44.62	33.66	49.56	33.01
64	47.11	45.02	46.22	33.74	50.04	34.16
62	47.93	45.80	47.46	33.90	50.53	35.30
60	48.51	46.92	48.25	33.99	50.96	36.32
58	49.15	47.80	49.17	34.13	51.48	37.26
56	49.74	48.74	49.69	34.25	51.87	38.28
54	50.35	49.49	50.62	34.33	52.10	39.30
52	51.11	50.57	51.27	34.39	52.35	40.23
50	51.90	51.21	51.93	34.45	52.84	41.05
48	52.66	52.01	52.61	34.51	53.25	41.77
46	53.30	52.79	53.37	34.57	53.56	42.69
44	53.92	53.20	54.01	34.61	53.80	43.47
42	55.71	53.65	54.76	34.66	54.09	44.05
40	59.38	54.10	57.67	34.71	57.15	44.82
38	62.58	55.70	62.42	34.74	60.70	45.60
36	66.97	59.78	65.29	34.78	63.09	46.42
34	69.21	63.42	69.45	34.81	67.74	47.15
32	71.21	65.98	71.63	34.84	70.53	47.84
30	73.14	69.05	73.47	34.89	71.94	48.60
28	74.08	70.18	74.96	34.92	73.50	49.40
26	75.60	71.53	76.94	34.96	76.08	50.13
24	77.25	73.18	78.55	35.10	76.95	51.09
22	78.58	74.98	80.69	35.23	79.23	52.00
20	80.84	77.28	82.34	35.32	81.00	52.52
18	82.84	79.40	83.55	35.40	82.81	53.17
16	84.79	81.12	85.64	35.46	84.45	53.70
14	87.04	83.61	87.06	35.55	86.30	59.21
12	89.65	85.63	88.64	35.65	87.84	67.39
10	91.45	88.59	90.59	35.73	89.34	73.33
8	93.01	91.12	93.47	35.82	91.58	79.77
6	95.27	93.45	95.82	35.90	94.12	83.56
4	96.57	95.53	97.31	35.98	96.38	87.86
2	98.74	97.92	98.72	36.01	97.83	93.11
0	100.00	100.00	100.00	100.00	100.00	100.00

APPENDIX K-35
PERCENT EXCEEDENCE FOR MAXIMUM HABITAT
REACH H, FAST RIFFLE GUILD, SUMMER
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	300MOD50	MOD55	480MOD55	WET	WETOF
100	0.00	0.00	0.00	40.17	0.00	0.00
98	0.00	0.09	0.00	88.48	0.00	0.00
96	0.01	0.27	0.00	88.49	1.43	1.35
94	0.18	0.59	0.00	88.49	2.17	9.25
92	0.50	1.00	0.25	88.50	4.40	23.74
90	0.85	1.20	0.52	88.51	6.70	40.97
88	0.98	1.34	0.71	88.51	9.57	51.28
86	1.15	1.48	0.89	88.52	11.03	57.41
84	1.27	1.68	1.16	88.53	14.33	73.07
82	1.48	2.08	1.40	88.54	17.49	83.56
80	1.64	2.95	1.65	88.54	20.19	90.79
78	1.97	4.86	1.91	88.55	22.93	90.85
76	2.30	7.32	2.48	88.55	27.98	90.94
74	4.94	10.89	5.82	88.56	31.54	91.04
72	7.17	14.01	8.15	88.56	37.57	91.12
70	9.22	17.60	10.45	88.60	45.02	91.18
68	11.72	21.26	12.99	88.66	49.94	91.27
66	15.02	25.24	15.29	88.69	57.34	91.34
64	17.94	29.48	17.60	88.72	63.22	91.42
62	22.45	35.39	20.31	88.77	73.99	91.50
60	25.61	42.15	22.97	88.81	81.06	91.57
58	28.71	51.27	27.47	88.88	88.12	91.63
56	31.45	61.84	29.82	88.95	91.96	91.69
54	36.91	68.92	33.22	89.00	96.45	91.74
52	44.27	75.11	38.49	89.08	96.79	91.82
50	49.27	81.49	46.98	89.14	96.96	91.90
48	58.51	85.20	54.11	89.20	97.09	91.95
46	67.07	91.19	62.42	89.29	97.24	92.01
44	72.09	93.80	72.15	89.43	97.35	92.09
42	77.92	93.99	78.31	89.55	97.44	92.21
40	85.09	94.20	86.19	89.69	97.53	92.32
38	92.21	94.34	94.18	89.81	97.64	92.40
36	97.18	94.50	97.16	89.98	97.77	92.50
34	97.36	94.67	97.36	90.11	97.99	92.58
32	97.59	94.78	97.54	90.25	98.14	92.69
30	97.74	94.89	97.66	90.42	98.26	92.80
28	97.89	94.96	97.80	90.64	98.38	92.92
26	98.10	95.08	97.95	90.99	98.49	93.01
24	98.20	95.31	98.05	91.31	98.60	93.12
22	98.42	95.49	98.22	91.59	98.70	93.26
20	98.68	95.63	98.52	91.90	98.77	93.36
18	98.78	95.78	98.73	92.31	98.86	93.44
16	98.92	95.99	98.85	92.96	98.96	93.55
14	99.05	96.09	99.03	93.58	99.03	93.63
12	99.18	96.23	99.25	93.98	99.08	94.06
10	99.33	96.41	99.37	94.38	99.13	94.62
8	99.46	96.49	99.49	94.91	99.23	95.12
6	99.61	96.57	99.65	95.53	99.30	95.43
4	99.80	96.65	99.79	96.03	99.37	96.01
2	99.87	97.80	99.92	97.05	99.41	97.39
0	100.00	100.00	100.00	100.00	100.00	100.00

APPENDIX K-36
PERCENT EXCEEDENCE FOR MAXIMUM HABITAT
REACH H, RACEWAY GUILD, SUMMER
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	300MOD50	MOD55	480MOD55	WET	WETOF
100	0.00	0.00	0.00	4.84	0.00	0.00
98	0.00	0.00	0.00	84.43	0.00	0.00
96	0.00	0.00	0.00	84.49	0.00	0.00
94	0.00	0.00	0.00	84.61	0.00	0.71
92	0.00	0.00	0.00	84.76	0.22	2.15
90	0.00	0.00	0.00	84.91	0.45	4.82
88	0.00	0.00	0.00	85.06	0.75	6.76
86	0.00	0.00	0.00	85.23	0.89	7.92
84	0.00	0.00	0.00	85.38	1.23	10.96
82	0.00	0.00	0.00	85.49	1.56	13.14
80	0.00	0.07	0.00	85.63	1.83	15.65
78	0.00	0.27	0.00	85.79	2.11	19.50
76	0.00	0.51	0.02	86.02	2.63	22.60
74	0.27	0.88	0.36	86.27	2.99	25.56
72	0.50	1.19	0.60	86.33	4.11	30.16
70	0.71	1.55	0.84	86.39	5.55	35.48
68	0.97	1.92	1.10	86.47	6.51	39.48
66	1.31	2.32	1.34	86.54	7.94	44.02
64	1.61	2.75	1.58	86.58	9.09	48.38
62	2.07	3.72	1.86	86.65	11.19	52.62
60	2.40	5.02	2.13	86.72	12.71	56.31
58	2.72	6.76	2.60	86.80	14.22	61.18
56	3.00	8.79	2.84	86.89	15.04	63.33
54	3.98	10.14	3.28	86.97	16.17	64.58
52	5.42	11.41	4.31	87.06	17.61	66.20
50	6.39	12.76	5.97	87.17	19.46	67.93
48	8.20	13.54	7.37	87.27	21.09	69.45
46	9.87	14.81	8.99	87.40	23.35	70.74
44	10.85	16.23	10.90	87.53	25.76	72.33
42	12.07	18.69	12.20	87.75	28.16	74.08
40	13.62	21.17	13.91	88.00	29.46	76.22
38	15.15	23.50	15.63	88.16	31.73	77.94
36	17.30	28.64	17.61	88.44	34.09	79.71
34	20.86	33.16	20.80	88.59	37.20	81.56
32	23.65	38.34	25.33	88.80	39.40	84.23
30	29.84	44.06	28.85	89.02	42.40	85.99
28	34.35	50.07	33.39	89.34	45.64	86.97
26	39.04	56.02	37.92	89.86	48.80	87.45
24	43.09	63.20	43.43	90.39	52.62	87.91
22	47.80	66.28	49.83	90.81	56.08	88.36
20	52.04	68.10	53.80	91.28	61.03	88.96
18	55.32	70.52	61.31	91.88	67.93	89.31
16	60.85	73.12	69.82	92.84	70.35	89.88
14	69.18	77.05	73.33	93.74	72.54	90.49
12	71.21	79.89	75.04	94.34	74.29	91.44
10	75.10	85.17	78.58	94.91	76.19	92.25
8	78.68	90.78	81.33	95.69	79.20	92.97
6	81.75	91.93	84.50	96.61	82.08	93.41
4	86.82	94.16	87.69	97.34	85.20	94.24
2	91.39	96.78	92.61	98.56	92.46	96.24
0	100.00	100.00	100.00	100.00	100.00	100.00

APPENDIX K-37
PERCENT EXCEEDENCE FOR MAXIMUM HABITAT
REACH H, MEDIUM POOL GUILD, SUMMER
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	300MOD50	MOD55	480MOD55	WET	WETOF
100	0.00	0.00	0.00	58.76	0.00	0.00
98	0.00	1.07	0.00	58.89	0.00	0.00
96	0.13	3.30	0.00	59.00	16.84	16.86
94	2.10	7.08	0.00	59.10	25.43	45.40
92	5.83	12.14	2.90	59.17	32.10	59.40
90	9.99	14.50	6.04	59.24	37.74	60.10
88	11.51	16.25	8.30	59.32	44.76	60.68
86	13.47	17.91	10.43	59.38	48.33	61.66
84	14.82	20.27	13.52	59.47	56.42	62.44
82	17.29	25.17	16.35	59.54	60.75	63.25
80	19.20	28.78	19.33	59.64	63.59	63.97
78	23.03	33.58	22.37	59.71	66.22	64.84
76	26.85	39.78	27.42	59.78	67.81	65.42
74	33.37	48.80	35.58	59.84	69.46	66.30
72	38.80	56.66	41.26	59.91	71.06	66.93
70	43.78	60.27	46.87	60.00	72.81	67.73
68	49.88	61.67	53.07	60.09	73.90	68.53
66	57.92	63.57	58.70	60.16	75.06	69.29
64	62.30	66.36	61.91	60.22	76.13	70.16
62	64.32	67.57	63.53	60.25	77.77	71.24
60	66.84	68.77	66.06	60.39	79.42	72.13
58	69.30	70.42	67.04	60.64	80.39	72.92
56	70.86	72.47	68.98	60.91	80.95	73.63
54	72.78	74.49	70.44	61.17	81.27	74.26
52	75.36	75.41	72.38	61.50	81.66	75.39
50	77.42	76.76	73.77	61.77	81.91	76.17
48	78.73	78.37	75.38	62.10	82.37	77.10
46	80.25	79.34	76.72	62.51	82.69	77.84
44	81.00	79.92	78.50	63.12	82.99	78.46
42	81.37	80.91	80.45	63.82	83.34	79.07
40	81.58	81.28	81.17	64.28	83.59	79.67
38	81.84	81.76	81.63	64.98	83.90	80.26
36	82.22	82.12	81.98	65.55	84.09	80.84
34	82.55	82.50	82.44	66.17	84.38	81.13
32	82.91	82.92	82.88	66.89	84.61	81.56
30	83.27	83.36	83.40	67.72	84.79	81.95
28	83.59	83.78	83.84	69.18	84.89	82.47
26	84.00	84.07	84.19	70.18	85.04	82.83
24	84.34	84.37	84.54	71.97	85.30	83.30
22	84.77	84.76	84.94	73.12	85.59	83.73
20	85.08	85.13	85.39	74.65	85.81	84.33
18	85.69	85.49	85.75	77.33	86.00	84.76
16	86.01	85.70	86.08	79.90	86.15	85.14
14	86.39	86.06	86.45	81.99	86.34	85.41
12	87.05	86.28	86.66	83.29	86.54	85.83
10	89.25	86.49	89.78	85.27	88.60	86.22
8	91.77	88.57	91.22	87.25	90.95	86.73
6	93.66	92.37	93.93	89.89	93.39	88.91
4	96.23	95.14	96.13	92.35	95.13	91.66
2	97.98	97.39	98.29	95.71	97.63	94.81
0	100.00	100.00	100.00	100.00	100.00	100.00

APPENDIX K-38
PERCENT EXCEEDENCE FOR MAXIMUM HABITAT
REACH H, DEEP POOL GUILD, SUMMER
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	300MOD50	MOD55	480MOD55	WET	WETOF
100	0.00	0.00	0.00	0.00	0.00	0.00
98	0.00	0.00	0.00	0.00	0.00	0.00
96	0.00	0.00	0.00	0.00	0.00	0.00
94	0.00	0.00	0.00	0.00	0.00	0.00
92	0.00	0.00	0.00	0.00	0.00	0.00
90	0.00	0.00	0.00	0.00	0.00	0.00
88	0.00	0.00	0.00	0.00	0.00	0.00
86	0.00	0.00	0.00	0.00	0.00	0.00
84	0.00	0.00	0.00	0.00	0.00	0.00
82	0.00	0.00	0.00	0.00	0.00	0.00
80	0.00	0.00	0.00	0.00	0.00	0.00
78	0.00	0.00	0.00	0.00	0.00	0.00
76	0.00	0.00	0.00	0.00	0.00	0.00
74	0.00	0.00	0.00	0.00	0.00	0.00
72	0.00	0.00	0.00	0.00	0.00	0.00
70	0.00	0.00	0.00	0.00	0.00	0.00
68	0.00	0.00	0.00	0.00	0.00	0.00
66	0.00	0.00	0.00	0.00	0.00	0.00
64	0.00	0.00	0.00	0.00	0.00	0.00
62	0.00	0.00	0.00	0.00	0.00	0.00
60	0.00	0.00	0.00	0.00	0.00	0.00
58	0.00	0.00	0.00	0.00	0.00	0.00
56	0.00	0.00	0.00	0.00	0.00	0.00
54	0.00	0.00	0.00	0.00	0.00	0.00
52	0.00	0.00	0.00	0.00	0.00	0.00
50	0.00	0.00	0.00	0.00	0.00	0.00
48	0.00	0.00	0.00	0.00	0.00	0.00
46	0.00	0.00	0.00	0.00	0.00	0.00
44	0.00	0.00	0.00	0.00	0.00	0.00
42	0.00	0.00	0.00	0.00	0.00	0.00
40	0.00	0.00	0.00	0.00	0.00	0.00
38	0.00	0.00	0.00	0.00	0.00	0.00
36	0.00	0.00	0.00	0.00	0.00	0.00
34	0.00	0.00	0.00	0.00	0.00	0.00
32	0.00	0.00	0.00	0.00	0.00	0.00
30	0.00	0.00	0.00	0.00	0.00	0.00
28	0.00	0.00	0.00	0.00	0.00	0.00
26	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00
0	0.00	0.00	0.00	0.00	0.00	0.00

APPENDIX K-39
PERCENT EXCEEDENCE FOR MAXIMUM HABITAT
REACH H, LOW GRADIENT GUILD, SUMMER
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	300MOD50	MOD55	480MOD55	WET	WETOF
100	23.02	34.74	16.59	38.25	28.50	28.54
98	40.54	37.65	23.59	39.76	41.01	34.28
96	43.18	39.37	33.79	40.65	43.01	36.16
94	43.80	40.97	41.79	41.33	44.03	37.40
92	44.53	42.18	43.51	42.07	44.47	37.77
90	44.94	42.83	43.96	42.69	44.86	38.03
88	45.46	43.95	44.50	43.15	45.29	38.73
86	46.00	44.31	44.84	43.75	45.57	39.22
84	46.29	44.88	45.24	44.44	45.80	39.93
82	48.32	45.44	45.59	45.22	46.15	40.34
80	49.94	45.75	46.01	45.73	46.75	40.77
78	50.76	46.09	47.14	46.05	48.59	41.10
76	51.97	46.32	48.95	46.47	49.92	41.52
74	53.17	47.94	50.77	46.84	50.88	41.79
72	54.03	49.83	52.29	47.31	51.91	42.15
70	55.42	51.71	53.48	47.56	52.85	42.51
68	56.43	53.19	55.07	47.74	53.73	42.80
66	57.59	55.16	56.34	47.93	54.60	43.14
64	59.23	56.13	57.62	48.07	55.24	43.48
62	59.88	57.61	58.39	48.30	56.10	43.78
60	60.85	58.94	59.77	48.44	56.84	44.06
58	62.39	59.71	60.75	48.65	57.41	44.37
56	64.01	60.36	62.16	48.85	57.79	44.67
54	65.70	61.26	64.37	48.96	58.45	44.97
52	68.23	62.74	65.81	49.06	59.14	45.20
50	69.96	64.10	68.11	49.15	59.78	45.42
48	71.78	66.01	69.91	49.24	60.24	45.69
46	73.26	67.26	71.49	49.33	60.77	45.94
44	75.21	69.08	72.89	49.39	61.90	46.15
42	77.13	70.75	74.64	49.48	63.97	46.38
40	78.15	72.27	76.94	49.55	65.57	47.23
38	79.61	74.53	78.64	49.60	68.10	48.69
36	81.27	76.99	80.44	49.67	70.31	49.70
34	82.53	79.50	82.06	49.70	74.06	51.05
32	83.85	81.76	84.24	49.76	77.55	52.27
30	85.45	82.99	86.10	49.83	79.68	53.73
28	86.70	84.67	88.45	49.88	82.73	54.92
26	88.66	86.08	89.29	49.94	85.26	56.53
24	90.23	87.44	90.59	50.02	87.75	57.96
22	90.96	89.24	91.37	50.06	89.48	58.81
20	91.64	90.66	92.40	50.09	91.02	59.78
18	92.60	91.82	93.26	50.11	92.31	61.00
16	93.52	92.86	93.89	50.13	93.72	65.08
14	94.58	93.88	94.73	50.16	94.57	68.96
12	95.60	95.14	95.51	50.19	95.41	72.66
10	96.43	96.22	96.23	50.22	96.35	78.52
8	97.13	97.11	96.97	50.25	97.45	81.46
6	97.87	98.26	97.48	50.28	97.74	85.48
4	98.52	98.94	98.20	50.30	98.63	90.09
2	99.44	99.59	99.22	50.31	99.39	95.91
0	100.00	100.00	100.00	100.00	100.00	100.00

APPENDIX K-40
PERCENT EXCEEDENCE FOR MAXIMUM HABITAT
REACH H, TRICHOPTERA GUILD, SUMMER
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	300MOD50	MOD55	480MOD55	WET	WETOF
100	21.68	32.72	15.63	50.26	26.81	26.81
98	41.46	52.06	22.22	51.06	51.77	49.37
96	54.86	53.81	31.83	51.57	56.71	51.75
94	57.32	54.88	49.63	51.88	58.65	52.61
92	58.21	55.82	56.18	52.29	59.44	53.01
90	58.99	56.43	58.08	52.62	60.25	53.21
88	59.89	57.84	58.86	52.86	61.18	53.55
86	60.49	58.99	59.65	53.20	61.67	53.92
84	61.34	59.56	60.26	53.57	62.14	54.37
82	62.24	60.35	60.93	54.02	62.79	54.64
80	63.04	61.23	61.55	54.26	63.25	54.91
78	63.54	61.92	62.18	54.43	64.90	55.07
76	65.50	62.46	62.82	54.65	67.58	55.35
74	67.56	63.12	63.55	54.85	69.46	55.56
72	68.51	63.51	65.30	55.11	70.96	55.77
70	69.66	64.77	66.58	55.24	72.76	55.98
68	70.69	66.46	67.91	55.35	74.27	56.34
66	71.45	68.68	69.67	55.44	75.42	56.83
64	72.49	70.54	70.90	55.53	76.70	57.71
62	73.18	71.86	72.19	55.65	77.63	58.28
60	74.37	73.17	73.71	55.72	78.74	58.75
58	75.51	74.34	75.01	55.83	80.05	59.28
56	76.34	75.03	76.80	55.94	80.99	59.87
54	77.79	76.55	77.89	56.00	81.64	60.48
52	78.95	78.02	79.01	56.05	82.27	60.94
50	80.24	79.00	80.38	56.10	83.15	61.37
48	81.53	80.41	81.31	56.15	84.37	61.71
46	82.91	81.81	82.85	56.20	85.20	62.27
44	84.54	83.81	84.33	56.23	85.93	62.77
42	85.54	84.80	86.03	56.27	86.50	63.18
40	86.66	85.79	86.74	56.31	87.04	63.55
38	87.17	86.37	87.29	56.35	87.44	65.17
36	88.19	86.86	88.20	56.37	88.19	67.70
34	88.86	87.38	89.06	56.39	89.05	69.36
32	89.62	88.08	89.91	56.43	89.57	71.16
30	90.42	88.96	90.69	56.46	90.17	73.29
28	91.36	90.08	91.48	56.49	90.95	75.31
26	92.23	91.07	92.31	56.52	91.68	76.88
24	93.25	91.80	92.84	56.61	92.72	78.82
22	94.27	92.80	93.79	56.68	93.73	81.03
20	95.55	93.42	94.80	56.73	94.37	82.61
18	96.58	94.59	95.71	56.78	95.26	84.34
16	97.29	95.59	96.67	56.81	96.53	85.78
14	97.70	96.58	97.49	56.85	97.62	87.84
12	98.01	97.47	98.04	56.91	98.03	90.53
10	98.35	97.83	98.32	56.95	98.33	93.57
8	98.80	98.28	98.71	57.00	98.63	96.35
6	99.08	98.82	98.99	57.05	98.97	98.02
4	99.35	99.28	99.43	57.09	99.31	98.52
2	99.69	99.61	99.76	57.10	99.67	99.12
0	100.00	100.00	100.00	100.00	100.00	100.00

APPENDIX K-41
PERCENT EXCEEDENCE FOR MAXIMUM HABITAT
REACH H, SHALLOW POOL GUILD, FALL
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	300MOD50	MOD55	480MOD55	WET	WETOF
100	17.75	18.21	17.93	22.55	20.95	23.29
98	21.16	19.94	20.83	24.22	21.67	23.78
96	23.39	21.14	22.55	24.25	23.06	24.10
94	23.88	22.10	24.25	24.28	24.70	24.36
92	24.32	22.75	25.13	24.39	25.90	24.54
90	24.48	22.94	25.47	24.46	27.05	24.89
88	24.72	23.35	25.94	24.54	28.31	25.07
86	25.47	24.68	26.95	24.60	29.12	25.26
84	27.69	25.26	27.68	24.64	29.43	25.55
82	29.33	25.61	28.61	24.68	30.92	25.83
80	30.60	26.45	29.33	24.72	34.62	26.17
78	32.15	27.48	30.12	24.72	36.00	26.88
76	33.39	28.97	30.94	24.72	37.29	27.09
74	35.02	30.02	31.75	24.72	37.92	27.63
72	35.43	31.20	32.31	24.72	38.54	28.29
70	36.48	31.85	33.04	24.73	39.55	28.99
68	37.12	32.68	33.59	24.73	40.23	29.85
66	37.93	33.69	34.27	24.73	40.70	30.48
64	38.82	34.24	35.52	24.73	41.28	31.10
62	39.55	34.83	36.28	24.73	41.79	31.63
60	40.48	35.29	36.79	24.74	42.35	32.03
58	41.14	35.62	37.43	24.74	42.82	32.29
56	42.50	36.07	38.25	24.74	43.41	32.48
54	44.43	36.58	38.98	24.75	44.04	32.63
52	45.36	37.49	39.95	24.76	44.72	32.77
50	47.18	38.23	41.33	24.76	45.28	32.91
48	48.62	38.71	43.87	24.77	45.73	33.04
46	51.60	39.47	48.45	24.77	46.29	33.19
44	53.60	40.28	52.34	24.78	46.78	33.29
42	56.22	41.95	55.02	24.78	47.28	33.45
40	57.65	45.53	56.88	24.79	47.86	33.54
38	59.52	48.43	58.15	24.79	48.54	33.85
36	61.99	50.49	59.50	24.80	49.86	35.41
34	62.98	51.90	60.17	24.80	51.17	36.33
32	64.34	54.47	60.96	24.80	53.11	37.98
30	65.20	56.13	62.45	24.81	53.62	39.79
28	66.11	57.90	63.46	24.81	54.43	41.37
26	67.22	60.10	63.91	24.82	56.43	44.04
24	68.96	62.63	64.96	24.83	58.72	48.67
22	71.61	64.16	66.00	24.83	59.43	50.43
20	74.18	65.27	66.81	24.84	60.68	51.09
18	76.32	66.27	67.79	24.86	61.50	51.83
16	79.40	68.12	68.40	24.88	63.93	52.65
14	81.22	69.21	70.67	24.92	65.53	53.25
12	83.76	72.29	73.63	24.98	67.48	53.54
10	85.46	74.34	78.82	25.05	71.28	55.52
8	87.75	79.22	83.76	27.01	73.41	57.22
6	90.46	81.07	87.71	28.90	79.55	63.47
4	92.24	85.49	91.60	33.43	87.22	67.69
2	93.74	94.64	94.64	59.77	95.91	81.06
0	100.00	100.00	100.00	100.00	100.00	100.00

APPENDIX K-42
PERCENT EXCEEDENCE FOR MAXIMUM HABITAT
REACH H, SLOW RIFFLE GUILD, FALL
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	300MOD50	MOD55	480MOD55	WET	WETOF
100	0.76	1.09	0.45	4.06	0.63	0.63
98	6.14	12.00	0.51	29.83	0.68	0.68
96	16.72	34.15	0.79	30.54	29.53	28.35
94	19.90	40.06	0.91	31.01	35.73	32.11
92	26.48	43.37	10.11	31.31	40.61	35.25
90	30.55	46.17	18.90	31.45	42.43	37.58
88	36.57	48.53	28.90	31.61	45.32	39.57
86	41.62	49.81	33.79	31.67	47.71	40.10
84	45.63	50.55	46.40	31.73	49.76	42.01
82	47.82	51.12	48.99	31.81	50.72	42.52
80	51.07	51.43	50.23	31.84	52.25	42.82
78	51.85	52.46	52.03	31.91	53.08	43.68
76	52.30	53.38	53.01	31.95	54.22	44.40
74	52.77	53.83	53.44	31.99	60.81	45.63
72	52.98	54.54	54.01	32.02	65.97	46.28
70	53.26	56.63	55.78	32.07	68.42	46.55
68	53.95	59.12	57.35	32.10	70.51	46.94
66	57.37	61.05	59.12	32.13	71.60	47.72
64	59.55	63.32	61.48	32.17	72.39	48.35
62	62.51	65.52	62.59	32.22	74.35	49.44
60	64.39	68.03	64.17	32.29	76.41	50.84
58	66.43	69.51	66.05	32.34	77.27	51.48
56	68.84	70.30	67.71	32.40	78.07	52.23
54	69.93	70.98	69.15	32.45	78.84	52.59
52	71.66	71.87	70.20	32.50	79.93	52.95
50	72.72	72.71	71.38	32.53	80.86	53.17
48	73.34	73.61	71.76	32.55	81.99	53.32
46	74.01	74.30	72.45	32.57	83.15	53.50
44	74.86	75.39	73.09	32.60	84.03	53.66
42	76.17	76.58	73.57	32.61	84.70	53.76
40	77.10	77.60	74.38	32.63	85.30	53.90
38	78.56	78.55	74.90	32.64	85.91	53.97
36	80.56	80.07	75.62	32.66	87.03	54.18
34	81.20	80.91	76.33	32.68	88.18	55.86
32	82.06	81.71	77.13	32.69	88.83	58.57
30	83.48	82.37	78.44	32.70	89.72	60.89
28	84.94	83.34	79.63	32.74	90.40	64.59
26	86.08	84.09	80.07	32.82	91.48	68.06
24	86.89	84.84	81.10	32.91	92.11	71.68
22	88.19	85.80	81.97	33.00	92.82	76.45
20	89.99	87.28	82.91	33.16	93.62	83.62
18	91.17	88.30	84.10	33.29	94.55	88.44
16	92.44	89.47	85.07	33.39	94.95	91.59
14	93.37	90.59	86.63	33.59	95.56	93.12
12	94.07	91.54	87.86	33.64	95.80	94.56
10	95.53	92.50	89.67	33.66	96.80	96.11
8	96.32	93.64	91.00	53.71	97.52	97.19
6	97.58	95.35	92.76	58.88	98.44	98.36
4	98.61	96.49	95.29	65.86	98.82	98.77
2	99.25	98.51	98.46	78.19	99.60	99.09
0	100.00	100.00	100.00	100.00	100.00	100.00

APPENDIX K-43
PERCENT EXCEEDENCE FOR MAXIMUM HABITAT
REACH H, FAST RIFFLE GUILD, FALL
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	300MOD50	MOD55	480MOD55	WET	WETOF
100	0.00	0.00	0.00	0.09	0.00	0.00
98	0.17	0.37	0.00	13.13	0.00	0.00
96	0.53	1.12	0.00	72.17	1.27	9.20
94	0.64	1.46	0.00	87.95	1.67	21.70
92	0.86	1.60	0.30	94.52	3.76	26.89
90	1.00	1.97	0.60	95.21	9.47	28.10
88	1.20	2.12	0.94	95.22	11.04	30.49
86	1.38	3.01	1.11	95.22	14.24	31.54
84	1.56	4.14	1.65	95.23	15.95	33.70
82	1.78	6.05	2.09	95.24	17.30	36.66
80	1.94	7.08	2.31	95.25	19.31	39.37
78	2.16	8.24	4.86	95.25	20.27	41.76
76	3.06	9.82	5.60	95.26	21.44	48.13
74	4.87	12.45	6.35	95.27	23.40	64.92
72	6.08	14.73	7.57	95.28	25.03	73.00
70	7.03	16.56	8.45	95.29	25.69	75.97
68	7.88	18.28	9.39	95.30	26.10	80.80
66	9.29	20.96	10.33	95.30	27.68	84.57
64	10.44	22.41	12.46	95.30	28.74	87.69
62	12.95	24.56	13.11	95.32	29.90	88.00
60	14.96	27.56	14.17	95.35	32.10	88.20
58	16.45	31.27	15.67	95.37	34.47	88.37
56	19.17	35.79	17.16	95.39	36.57	88.45
54	21.24	40.02	19.94	95.42	38.57	88.61
52	24.34	44.06	23.75	95.46	40.89	88.67
50	25.83	46.58	27.30	95.49	42.74	88.71
48	27.72	50.48	32.40	95.55	45.07	88.76
46	28.68	55.25	39.84	95.61	47.86	88.85
44	30.69	57.96	46.95	95.72	50.46	88.94
42	32.10	60.35	50.90	95.79	52.90	89.05
40	34.60	62.05	55.50	95.87	54.86	89.14
38	39.50	64.47	58.48	95.96	57.18	89.20
36	43.38	67.62	62.75	96.02	59.28	89.30
34	48.07	70.49	69.45	96.06	61.66	89.40
32	52.33	75.05	72.99	96.10	63.61	89.52
30	55.70	78.00	75.11	96.16	66.43	89.69
28	61.26	80.34	77.67	96.21	69.77	89.94
26	63.38	84.56	79.64	96.25	71.52	90.05
24	71.99	88.28	82.51	96.32	73.28	90.19
22	76.90	93.60	85.39	96.42	76.88	90.25
20	82.42	97.09	88.19	96.47	80.74	90.31
18	86.96	97.96	90.72	96.56	90.21	90.36
16	92.81	98.74	93.99	96.64	90.65	90.38
14	98.27	99.02	96.59	96.72	90.97	90.41
12	99.17	99.23	98.46	96.85	91.26	90.44
10	99.53	99.37	99.04	97.11	91.74	90.46
8	99.63	99.43	99.50	97.36	91.97	90.48
6	99.71	99.61	99.66	97.78	92.26	90.50
4	99.75	99.83	99.84	98.17	92.43	90.52
2	99.82	99.92	99.92	99.03	92.63	92.30
0	100.00	100.00	100.00	100.00	100.00	100.00

APPENDIX K-44
PERCENT EXCEEDENCE FOR MAXIMUM HABITAT
REACH H, RACEWAY GUILD, FALL
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	300MOD50	MOD55	480MOD55	WET	WETOF
100	0.00	0.00	0.00	0.00	0.00	0.00
98	0.00	0.00	0.00	1.11	0.00	0.00
96	0.00	0.00	0.00	10.80	0.00	0.73
94	0.00	0.00	0.00	14.16	0.00	2.01
92	0.00	0.00	0.00	15.55	0.16	2.54
90	0.00	0.00	0.00	48.18	0.74	2.67
88	0.00	0.00	0.00	91.06	0.89	3.02
86	0.00	0.08	0.00	91.17	1.22	3.23
84	0.00	0.21	0.00	91.44	1.39	3.65
82	0.00	0.43	0.00	91.77	1.52	4.22
80	0.00	0.55	0.00	92.01	1.73	4.75
78	0.00	0.68	0.37	92.30	1.82	5.21
76	0.11	0.86	0.48	92.51	1.94	6.45
74	0.37	1.17	0.59	92.64	2.14	9.71
72	0.54	1.43	0.76	92.85	2.30	11.42
70	0.68	1.64	0.89	92.96	2.37	12.05
68	0.80	1.84	1.03	92.99	2.41	13.09
66	1.01	2.14	1.17	93.02	2.57	13.90
64	1.17	2.31	1.48	93.05	2.67	14.59
62	1.53	2.56	1.57	93.08	2.80	15.20
60	1.82	2.90	1.72	93.11	3.20	16.50
58	2.04	3.33	1.94	93.15	3.65	16.94
56	2.43	4.21	2.16	93.18	4.05	17.53
54	2.73	5.13	2.56	93.21	4.43	18.04
52	3.17	6.01	3.12	93.26	4.88	18.81
50	3.39	6.56	3.63	93.31	5.23	19.51
48	3.66	7.41	4.38	93.36	5.67	20.51
46	3.80	8.45	6.43	93.45	6.20	21.36
44	4.09	9.04	8.39	93.54	6.70	22.88
42	4.29	9.56	9.48	93.70	7.16	24.87
40	4.95	9.93	10.74	93.81	7.54	28.27
38	6.29	10.46	11.56	93.93	7.98	31.73
36	7.35	11.15	12.74	94.05	8.38	39.46
34	8.62	11.77	14.59	94.14	8.83	44.89
32	9.79	12.80	15.56	94.21	9.20	49.03
30	10.71	13.51	16.19	94.26	9.74	51.75
28	12.23	14.07	16.97	94.36	10.41	55.10
26	12.81	15.09	17.57	94.43	10.77	56.83
24	15.16	15.98	18.44	94.48	11.14	59.70
22	16.60	17.26	19.32	94.58	11.90	63.25
20	18.26	18.15	20.17	94.73	12.71	64.65
18	19.63	19.35	20.94	94.80	15.45	66.66
16	21.39	21.92	21.93	94.94	21.93	67.29
14	25.43	26.11	22.72	95.07	27.82	68.15
12	32.24	35.79	24.14	95.18	35.38	70.01
10	34.45	38.84	28.41	95.42	42.42	72.48
8	35.94	40.23	31.45	95.81	60.41	74.81
6	39.87	47.09	39.43	96.36	65.54	79.00
4	44.38	56.56	54.80	97.04	73.16	84.99
2	64.66	82.88	70.40	98.58	89.31	93.05
0	100.00	100.00	100.00	100.00	100.00	100.00

APPENDIX K-45
PERCENT EXCEEDENCE FOR MAXIMUM HABITAT
REACH H, MEDIUM POOL GUILD, FALL
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	300MOD50	MOD55	480MOD55	WET	WETOF
100	0.00	0.00	0.00	1.09	0.00	0.00
98	1.93	4.27	0.00	53.87	0.00	0.00
96	6.16	13.12	0.00	59.44	16.06	45.89
94	7.42	17.04	0.00	59.51	21.03	60.53
92	10.05	18.68	3.52	59.54	31.23	64.30
90	11.68	23.01	7.03	59.61	46.25	67.05
88	14.08	24.82	11.03	59.63	50.38	70.04
86	16.10	28.66	12.99	59.69	58.79	70.88
84	18.27	31.42	19.25	59.76	62.98	73.47
82	20.83	36.08	24.36	59.80	65.64	74.40
80	22.63	38.60	26.95	59.87	67.42	74.96
78	25.20	41.42	33.14	59.94	70.62	75.75
76	28.81	45.27	34.95	60.01	72.79	77.28
74	33.22	51.66	36.78	60.07	74.67	78.62
72	36.17	57.23	39.73	60.12	77.01	79.62
70	38.48	61.69	41.88	60.23	77.92	80.03
68	40.55	65.15	44.18	60.29	80.03	80.29
66	44.01	69.70	46.47	60.35	81.07	80.71
64	46.80	73.00	51.65	60.44	81.46	81.06
62	52.93	75.91	53.24	60.55	81.69	81.36
60	57.83	79.30	55.83	60.69	81.94	81.75
58	61.46	81.15	59.47	60.76	82.28	82.24
56	68.09	81.47	63.09	60.85	82.72	82.61
54	73.13	81.84	69.87	60.86	82.96	83.02
52	79.07	82.14	77.95	61.06	83.22	83.63
50	81.04	82.54	80.96	61.51	83.58	83.93
48	81.57	82.89	81.16	61.81	83.84	84.29
46	82.34	83.15	81.55	62.14	84.34	84.63
44	82.80	83.45	81.88	62.50	84.97	84.82
42	83.42	83.72	82.21	62.74	85.23	85.00
40	83.95	84.02	82.43	62.94	85.62	85.19
38	84.42	84.15	82.75	63.10	86.01	85.34
36	84.73	84.41	83.04	63.32	86.32	85.44
34	85.06	84.68	83.38	63.56	86.95	85.58
32	85.31	85.11	83.79	63.70	87.55	85.67
30	85.49	85.40	84.25	63.99	87.98	85.78
28	85.60	85.73	84.62	64.40	88.75	85.84
26	85.76	86.03	84.97	64.60	89.37	85.94
24	86.02	86.20	85.17	65.00	90.00	86.00
22	86.37	86.35	85.55	65.35	90.82	86.11
20	87.85	86.56	85.80	65.67	92.18	86.59
18	89.19	87.33	85.96	66.30	93.15	89.37
16	90.30	88.23	86.25	67.37	93.85	91.61
14	90.92	89.34	86.44	68.73	94.55	93.49
12	92.52	90.98	87.79	70.83	95.44	94.34
10	94.18	92.92	88.88	74.84	96.48	95.50
8	95.09	94.12	91.12	78.65	96.96	96.54
6	96.37	95.26	92.90	84.03	97.81	97.38
4	98.40	96.85	94.98	85.61	98.81	98.31
2	99.33	98.47	97.50	86.64	99.33	98.71
0	100.00	100.00	100.00	100.00	100.00	100.00

APPENDIX K-46
PERCENT EXCEEDENCE FOR MAXIMUM HABITAT
REACH H, DEEP POOL GUILD, FALL
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	300MOD50	MOD55	480MOD55	WET	WETOF
100	0.00	0.00	0.00	0.00	0.00	0.00
98	0.00	0.00	0.00	0.00	0.00	0.00
96	0.00	0.00	0.00	0.00	0.00	0.00
94	0.00	0.00	0.00	0.00	0.00	0.00
92	0.00	0.00	0.00	0.00	0.00	0.00
90	0.00	0.00	0.00	0.00	0.00	0.00
88	0.00	0.00	0.00	0.00	0.00	0.00
86	0.00	0.00	0.00	0.00	0.00	0.00
84	0.00	0.00	0.00	0.00	0.00	0.00
82	0.00	0.00	0.00	0.00	0.00	0.00
80	0.00	0.00	0.00	0.00	0.00	0.00
78	0.00	0.00	0.00	0.00	0.00	0.00
76	0.00	0.00	0.00	0.00	0.00	0.00
74	0.00	0.00	0.00	0.00	0.00	0.00
72	0.00	0.00	0.00	0.00	0.00	0.00
70	0.00	0.00	0.00	0.00	0.00	0.00
68	0.00	0.00	0.00	0.00	0.00	0.00
66	0.00	0.00	0.00	0.00	0.00	0.00
64	0.00	0.00	0.00	0.00	0.00	0.00
62	0.00	0.00	0.00	0.00	0.00	0.00
60	0.00	0.00	0.00	0.00	0.00	0.00
58	0.00	0.00	0.00	0.00	0.00	0.00
56	0.00	0.00	0.00	0.00	0.00	0.00
54	0.00	0.00	0.00	0.00	0.00	0.00
52	0.00	0.00	0.00	0.00	0.00	0.00
50	0.00	0.00	0.00	0.00	0.00	0.00
48	0.00	0.00	0.00	0.00	0.00	0.00
46	0.00	0.00	0.00	0.00	0.00	0.00
44	0.00	0.00	0.00	0.00	0.00	0.00
42	0.00	0.00	0.00	0.00	0.00	0.00
40	0.00	0.00	0.00	0.00	0.00	0.00
38	0.00	0.00	0.00	0.00	0.00	0.00
36	0.00	0.00	0.00	0.00	0.00	0.00
34	0.00	0.00	0.00	0.00	0.00	0.00
32	0.00	0.00	0.00	0.00	0.00	0.00
30	0.00	0.00	0.00	0.00	0.00	0.00
28	0.00	0.00	0.00	0.00	0.00	0.00
26	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00
0	100.00	100.00	100.00	100.00	100.00	100.00

APPENDIX K-47
PERCENT EXCEEDENCE FOR MAXIMUM HABITAT
REACH H, LOW GRADIENT GUILD, FALL
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	300MOD50	MOD55	480MOD55	WET	WETOF
100	35.17	43.40	21.13	38.33	29.38	29.59
98	49.97	45.59	23.74	39.34	31.53	31.76
96	55.71	51.31	36.85	40.42	39.08	37.74
94	57.03	53.76	42.55	40.90	44.00	42.94
92	58.02	55.39	50.19	41.29	45.49	43.92
90	58.60	55.86	53.18	41.56	46.42	44.58
88	59.04	56.51	57.15	41.73	50.86	45.04
86	59.79	58.91	58.37	41.81	53.81	45.17
84	61.11	60.09	59.68	41.90	56.11	45.75
82	64.10	60.75	60.52	42.00	58.55	45.89
80	66.42	61.72	61.48	42.05	60.14	45.97
78	67.34	62.86	62.72	42.15	63.99	46.24
76	69.30	64.53	63.76	42.22	67.77	46.44
74	70.03	66.09	65.17	42.26	69.73	47.11
72	71.29	67.71	65.97	42.31	70.78	48.19
70	72.29	68.82	67.21	42.37	71.27	48.65
68	74.65	70.31	68.27	42.41	72.48	49.30
66	76.29	71.26	69.30	42.46	74.26	50.60
64	77.03	72.62	69.98	42.53	75.08	51.65
62	77.72	74.48	70.76	42.61	76.29	53.47
60	79.50	75.86	71.57	42.70	77.16	55.79
58	80.39	76.78	72.42	42.77	78.25	56.86
56	81.40	77.66	73.32	42.88	79.05	58.10
54	82.28	78.49	75.43	42.95	79.96	58.71
52	83.83	79.45	76.89	43.01	81.28	59.31
50	85.00	80.23	77.97	43.05	82.40	59.68
48	85.75	81.58	79.28	43.08	83.49	59.92
46	87.26	83.47	80.13	43.12	84.26	60.23
44	88.68	84.33	81.93	43.14	84.69	60.50
42	89.35	85.15	83.57	43.16	85.65	60.66
40	90.19	86.24	86.00	43.19	86.76	60.89
38	90.73	87.02	87.91	43.21	87.65	61.01
36	91.30	88.35	90.02	43.23	88.75	61.37
34	91.55	89.92	91.05	43.25	89.74	62.39
32	92.18	90.80	92.49	43.27	90.34	63.93
30	92.60	91.95	93.42	43.29	90.65	65.25
28	93.15	92.77	94.49	43.32	91.05	67.35
26	93.73	93.44	95.30	43.36	91.58	69.32
24	94.39	93.87	95.64	43.38	91.72	71.83
22	95.11	94.62	96.18	43.41	91.96	80.62
20	95.59	95.03	96.43	43.45	92.52	84.02
18	96.20	95.53	96.55	43.49	93.23	85.57
16	96.73	96.16	97.09	43.54	93.55	86.87
14	97.34	96.88	97.53	43.58	93.99	88.48
12	97.64	97.53	97.80	43.59	94.67	89.58
10	98.02	98.01	98.08	53.42	94.99	89.94
8	98.37	98.42	98.48	63.50	95.40	91.14
6	98.64	98.75	98.70	66.53	96.57	91.55
4	99.07	99.18	99.04	72.62	97.18	92.53
2	99.66	99.60	99.29	86.24	97.72	97.36
0	100.00	100.00	100.00	100.00	100.00	100.00

APPENDIX K-48
PERCENT EXCEEDENCE FOR MAXIMUM HABITAT
REACH H, TRICHOPTERA GUILD, FALL
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	300MOD50	MOD55	480MOD55	WET	WETOF
100	33.14	47.62	19.90	53.09	27.65	27.65
98	59.25	59.25	22.36	53.71	29.67	29.67
96	63.49	62.28	34.71	54.38	53.45	52.38
94	64.89	68.97	40.08	54.67	58.19	56.00
92	66.53	71.69	60.95	54.91	61.81	58.11
90	68.94	74.03	64.12	55.08	63.70	59.17
88	70.84	75.73	67.25	55.19	70.88	60.27
86	72.77	76.54	69.79	55.23	74.00	60.58
84	74.42	77.75	72.20	55.29	75.80	61.71
82	76.25	78.92	75.63	55.35	77.91	62.00
80	78.55	79.38	77.88	55.38	80.71	62.18
78	80.02	80.77	81.12	55.45	82.92	62.68
76	81.19	82.56	82.66	55.49	85.23	63.11
74	81.96	84.22	83.98	55.51	87.15	64.29
72	82.90	85.73	85.20	55.54	88.93	66.03
70	83.51	86.31	86.13	55.58	90.09	66.75
68	83.90	86.75	86.80	55.61	90.99	67.80
66	84.46	87.07	87.27	55.64	92.23	69.88
64	85.70	87.60	87.52	55.68	92.98	71.56
62	86.60	87.92	87.93	55.73	93.41	74.47
60	87.30	88.37	88.22	55.78	93.73	78.20
58	87.89	88.74	88.59	55.83	94.27	79.91
56	88.24	89.14	88.86	55.90	94.82	81.90
54	88.68	89.69	89.20	55.94	95.22	82.87
52	89.09	90.47	89.47	55.98	95.68	83.84
50	89.65	91.18	89.74	56.00	95.90	84.43
48	89.96	91.79	90.18	56.02	96.33	84.82
46	90.93	92.43	90.83	56.04	96.74	85.31
44	91.49	92.98	91.11	56.05	97.21	85.74
42	92.21	93.36	91.27	56.07	97.51	85.99
40	92.64	94.09	91.65	56.08	97.63	86.37
38	93.27	94.77	92.11	56.10	97.71	86.56
36	93.98	95.21	92.45	56.11	97.82	87.13
34	94.73	95.53	92.89	56.13	97.95	87.91
32	95.27	96.04	93.51	56.14	98.05	88.97
30	96.20	96.48	94.05	56.15	98.12	89.82
28	96.68	97.25	94.71	56.19	98.24	90.93
26	97.11	97.60	95.21	56.25	98.35	92.18
24	97.69	97.74	95.87	56.29	98.49	93.57
22	98.01	97.93	96.57	56.35	98.64	95.11
20	98.12	98.07	96.90	56.43	98.81	97.12
18	98.30	98.17	97.39	56.50	98.92	98.32
16	98.51	98.31	97.66	56.60	99.11	98.71
14	98.66	98.49	98.02	56.67	99.18	99.04
12	98.84	98.71	98.28	56.71	99.33	99.23
10	99.08	98.96	98.45	58.05	99.42	99.36
8	99.31	99.15	98.75	84.22	99.55	99.46
6	99.46	99.29	99.00	89.25	99.67	99.66
4	99.74	99.53	99.29	91.38	99.77	99.78
2	99.90	99.75	99.57	96.80	99.89	99.88
0	100.00	100.00	100.00	100.00	100.00	100.00

HABITAT SEGMENT E

APPENDIX K-49
PERCENT EXCEEDENCE FOR MAXIMUM HABITAT
REACH E, SHALLOW POOL GUILD, SPRING
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	300MOD50	MOD55	480MOD55	WET	WETOF
100	1.34	1.49	1.43	1.59	1.57	1.49
98	2.70	2.41	2.42	2.42	2.43	2.42
96	3.59	2.46	2.49	2.48	2.52	2.49
94	4.26	2.59	2.58	2.55	2.65	2.57
92	4.52	3.68	3.52	3.27	3.37	3.30
90	4.95	4.61	4.56	4.40	4.49	4.16
88	5.20	4.83	4.87	4.65	4.68	4.59
86	5.42	5.34	5.32	4.89	5.00	4.80
84	5.76	5.86	5.78	5.01	5.28	5.10
82	6.14	6.22	6.09	5.14	5.65	5.35
80	6.53	6.52	6.37	5.27	5.84	5.57
78	7.11	6.97	6.67	5.37	6.07	5.77
76	7.43	7.30	6.91	5.49	6.24	5.90
74	7.91	7.63	7.21	5.70	6.62	6.07
72	8.20	8.08	7.47	5.92	6.87	6.28
70	8.63	8.41	7.77	6.09	7.10	6.46
68	8.93	8.82	8.09	6.31	7.35	6.62
66	9.23	9.19	8.34	6.51	7.54	6.78
64	9.52	9.48	8.68	6.79	7.84	6.99
62	9.82	9.80	9.05	7.07	7.99	7.17
60	10.39	10.09	9.29	7.30	8.20	7.36
58	11.28	10.41	9.55	7.52	8.36	7.59
56	16.10	10.96	9.76	7.76	8.62	7.84
54	19.74	11.38	9.97	8.06	8.89	7.98
52	23.05	13.81	10.18	8.31	9.12	8.15
50	26.44	16.91	10.55	8.55	9.45	8.36
48	28.13	18.95	11.07	8.78	9.81	8.52
46	30.23	22.27	11.39	9.13	9.92	8.74
44	31.75	25.66	17.62	9.28	10.28	9.02
42	34.49	27.29	21.82	9.53	10.62	9.24
40	36.68	29.96	27.22	9.83	10.99	9.47
38	38.35	32.04	31.26	10.07	11.45	9.68
36	39.49	36.07	34.85	10.32	13.71	9.93
34	41.24	39.06	40.19	10.69	17.03	10.11
32	42.43	41.53	43.84	10.99	21.58	10.37
30	42.81	44.20	45.19	11.23	25.54	10.67
28	43.35	45.30	45.72	11.51	28.23	10.94
26	55.32	47.39	52.73	18.66	30.58	11.16
24	61.85	63.42	65.13	26.79	33.34	11.30
22	68.75	76.87	80.63	37.32	36.49	12.58
20	78.13	81.03	89.43	48.68	40.97	15.33
18	80.70	85.79	93.84	75.36	45.17	18.11
16	81.82	90.34	97.41	85.96	62.51	22.37
14	82.19	95.98	100.00	92.54	79.63	26.97
12	84.58	100.00	100.00	96.40	87.37	34.71
10	85.70	100.00	100.00	100.00	92.90	38.94
8	87.96	100.00	100.00	100.00	100.00	43.13
6	90.20	100.00	100.00	100.00	100.00	45.31
4	95.77	100.00	100.00	100.00	100.00	59.80
2	96.90	100.00	100.00	100.00	100.00	100.00
0	100.00	100.00	100.00	100.00	100.00	100.00

APPENDIX K-50
PERCENT EXCEEDENCE FOR MAXIMUM HABITAT
REACH E, SLOW RIFFLE GUILD, SPRING
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	300MOD50	MOD55	480MOD55	WET	WETOF
100	0.05	0.22	0.08	0.46	0.42	0.22
98	3.57	2.48	2.50	2.52	2.56	2.56
96	5.87	2.60	2.66	2.66	2.76	2.73
94	7.69	2.90	2.88	2.84	3.09	2.91
92	9.03	5.57	5.17	4.63	4.87	4.76
90	10.65	8.58	7.82	7.41	8.33	6.91
88	12.34	11.66	10.19	8.90	10.25	9.15
86	13.86	13.64	11.46	10.31	11.51	10.10
84	14.94	14.85	12.45	11.51	12.39	11.04
82	17.38	16.26	13.41	12.46	13.29	11.93
80	19.06	19.58	14.24	13.11	14.19	12.80
78	20.39	21.32	15.57	13.71	15.03	13.67
76	21.38	22.66	17.16	14.25	17.16	14.17
74	22.63	23.94	18.19	14.65	20.42	14.54
72	24.32	25.67	20.43	15.08	21.22	14.90
70	25.13	25.78	22.16	16.15	22.09	15.26
68	26.22	25.78	23.56	17.50	22.86	16.94
66	28.71	25.78	24.44	18.92	24.29	18.53
64	30.60	25.78	25.70	20.16	25.02	19.80
62	33.26	25.78	25.76	21.08	26.07	21.05
60	36.01	25.78	25.76	22.05	26.07	21.64
58	37.57	25.98	25.76	23.06	26.07	22.65
56	39.26	27.30	25.76	23.82	26.07	23.16
54	40.68	30.40	25.76	24.23	26.07	23.76
52	42.11	32.47	25.76	24.77	26.86	24.56
50	43.78	34.90	25.76	25.33	27.90	25.26
48	44.97	36.24	26.06	25.61	30.15	26.05
46	47.60	38.72	28.25	25.83	31.74	26.36
44	48.28	39.99	30.97	26.08	32.98	26.85
42	50.18	41.36	33.05	26.08	34.73	27.67
40	51.71	42.26	34.64	26.08	36.61	29.61
38	52.69	43.70	35.92	26.08	37.87	31.26
36	53.67	45.69	37.10	26.08	39.47	32.26
34	55.11	48.07	38.81	26.08	41.04	33.55
32	55.65	49.23	40.05	26.15	42.04	35.02
30	57.44	50.90	40.98	26.42	42.57	37.31
28	58.84	52.92	42.66	26.82	43.64	38.49
26	60.43	55.07	45.02	30.16	45.15	39.76
24	61.68	56.25	48.59	33.15	47.28	41.80
22	63.57	57.60	51.19	35.40	49.61	42.96
20	65.55	59.36	55.39	36.74	52.54	44.71
18	66.91	60.89	57.96	38.77	55.06	47.45
16	68.00	63.45	60.61	40.48	57.36	49.61
14	68.92	65.57	62.91	43.14	58.99	51.96
12	70.30	67.16	66.83	46.88	60.20	56.96
10	73.09	68.28	68.99	51.11	62.60	62.42
8	77.10	70.10	71.56	56.62	64.85	66.51
6	81.38	76.36	79.79	61.99	67.86	69.65
4	84.67	82.78	85.23	67.86	70.58	72.41
2	89.83	92.77	92.16	82.27	84.25	83.27
0	100.00	100.00	100.00	100.00	100.00	100.00

APPENDIX K-51
PERCENT EXCEEDENCE FOR MAXIMUM HABITAT
REACH E, FAST RIFFLE GUILD, SPRING
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	300MOD50	MOD55	480MOD55	WET	WETOF
100	0.00	0.00	0.00	0.00	0.00	0.00
98	0.00	0.00	0.00	0.00	0.00	0.00
96	0.00	0.00	0.00	0.00	0.00	0.00
94	0.00	0.00	0.00	0.00	0.00	3.91
92	0.00	0.00	0.00	0.00	0.00	5.88
90	0.00	0.00	0.00	0.00	0.00	5.88
88	0.00	0.00	0.00	0.00	0.00	5.88
86	0.00	0.00	0.00	0.00	0.00	5.88
84	0.00	0.00	0.00	0.00	0.00	5.88
82	0.00	0.00	0.00	0.00	4.57	5.88
80	0.00	0.00	0.00	0.00	5.88	5.88
78	0.00	0.00	0.00	5.88	5.88	5.88
76	0.00	0.00	0.00	5.88	5.88	7.76
74	0.00	0.00	0.00	5.88	5.88	13.22
72	1.14	3.97	2.00	10.62	5.88	13.68
70	3.81	5.88	4.46	13.48	5.88	14.16
68	5.71	5.88	5.88	13.89	5.88	14.82
66	5.88	5.88	5.88	14.22	5.88	18.67
64	5.88	5.88	5.88	18.43	5.88	19.61
62	5.88	5.88	5.88	22.64	5.88	25.46
60	5.88	5.88	5.88	26.43	9.64	30.02
58	5.88	5.88	5.88	30.55	13.22	35.96
56	5.88	5.88	5.88	38.92	13.73	40.03
54	5.88	5.88	5.96	46.38	14.19	44.76
52	5.88	5.88	13.14	50.87	14.99	48.86
50	5.88	5.88	13.74	56.72	18.83	54.66
48	5.88	5.88	14.07	62.60	21.64	60.43
46	5.88	6.61	14.72	69.99	26.32	64.19
44	5.88	11.26	18.58	73.90	32.06	67.95
42	5.88	13.26	22.13	79.72	38.58	72.13
40	9.11	13.78	26.08	83.79	43.86	75.09
38	14.32	14.30	31.71	87.91	50.64	78.79
36	18.61	14.85	39.98	91.71	56.64	82.25
34	22.60	20.57	46.45	95.60	61.14	85.45
32	25.45	23.99	51.10	96.70	65.92	88.25
30	29.96	29.39	55.79	97.13	71.41	90.59
28	38.10	39.20	62.05	97.49	74.40	93.51
26	46.43	49.05	68.16	97.89	79.32	96.08
24	58.27	58.04	74.43	98.18	84.38	96.94
22	68.29	66.90	80.22	98.45	88.97	97.41
20	76.60	75.12	85.34	98.70	94.28	97.77
18	82.86	81.09	91.82	98.97	96.87	98.11
16	88.93	91.05	96.64	99.09	97.78	98.30
14	96.60	96.48	97.12	99.24	98.13	98.57
12	97.28	97.03	97.42	99.40	98.42	98.74
10	97.74	97.85	98.08	99.50	98.60	98.91
8	98.41	98.38	98.51	99.57	98.87	99.14
6	98.91	98.77	99.01	99.65	99.28	99.34
4	99.39	99.13	99.25	99.72	99.48	99.55
2	99.61	99.65	99.64	99.78	99.79	99.81
0	100.00	100.00	100.00	100.00	100.00	100.00

APPENDIX K-52
PERCENT EXCEEDENCE FOR MAXIMUM HABITAT
REACH E, RACEWAY GUILD, SPRING
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	300MOD50	MOD55	480MOD55	WET	WETOF
100	0.00	0.00	0.00	0.00	0.00	0.00
98	0.00	0.00	0.00	0.00	0.00	0.00
96	0.00	0.00	0.00	0.00	0.00	6.94
94	0.00	0.00	0.00	0.00	0.00	20.94
92	0.29	0.00	0.00	0.00	0.00	25.16
90	1.04	0.00	0.00	0.00	0.47	25.48
88	1.36	0.00	0.00	0.00	1.94	25.77
86	2.03	0.00	0.00	0.57	4.00	26.20
84	2.14	1.15	0.00	2.32	6.59	29.00
82	2.45	2.36	0.22	4.94	22.24	31.67
80	3.18	3.63	1.39	8.37	25.44	33.74
78	5.27	4.74	3.74	25.26	25.75	35.11
76	6.21	6.47	6.25	25.53	26.03	36.09
74	7.09	8.53	7.84	25.73	28.57	36.86
72	12.27	21.15	14.97	26.42	30.65	37.48
70	20.64	25.14	22.60	31.02	34.24	38.24
68	24.45	25.53	25.34	33.60	35.89	39.01
66	26.93	25.78	25.56	35.19	36.94	39.36
64	28.65	26.15	25.80	36.40	37.73	39.73
62	30.23	29.00	26.88	37.24	38.39	39.97
60	31.75	32.08	29.73	38.08	39.37	40.31
58	33.49	34.34	32.90	38.58	39.95	43.20
56	34.45	36.09	34.89	39.18	42.49	48.46
54	35.79	37.69	36.05	39.60	46.99	54.10
52	37.55	39.24	37.13	40.02	51.22	59.67
50	38.52	40.21	37.85	40.35	56.49	63.50
48	39.55	43.43	38.88	45.07	59.66	66.74
46	40.34	46.29	39.59	50.62	63.40	69.87
44	44.67	52.02	40.25	54.91	66.62	72.61
42	49.06	56.53	45.42	59.49	69.48	76.22
40	51.42	60.20	50.44	65.04	72.34	78.45
38	53.99	63.73	53.01	67.69	75.00	80.67
36	57.96	65.78	55.93	72.44	77.74	82.38
34	59.68	69.48	60.63	76.29	80.58	84.65
32	62.97	73.35	65.67	79.87	85.51	86.66
30	66.85	76.33	70.20	83.18	87.97	88.95
28	72.13	79.99	75.88	84.45	90.40	90.96
26	75.27	83.18	80.40	86.84	94.15	93.42
24	80.25	85.49	83.64	89.61	96.40	96.73
22	84.96	89.30	86.60	91.40	98.74	99.12
20	88.05	93.29	92.19	92.54	99.46	99.48
18	91.49	97.18	96.42	93.53	99.48	99.51
16	95.51	99.44	99.46	94.62	99.53	99.58
14	98.54	99.47	99.51	95.97	99.59	99.62
12	99.48	99.52	99.55	97.72	99.64	99.67
10	99.55	99.57	99.62	99.51	99.70	99.74
8	99.63	99.66	99.68	99.60	99.76	99.80
6	99.71	99.72	99.73	99.68	99.82	99.84
4	99.81	99.81	99.81	99.75	99.86	99.87
2	99.89	99.88	99.89	99.86	99.93	99.93
0	100.00	100.00	100.00	100.00	100.00	100.00

APPENDIX K-53
PERCENT EXCEEDENCE FOR MAXIMUM HABITAT
REACH E, MEDIUM POOL GUILD, SPRING
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	300MOD50	MOD55	480MOD55	WET	WETOF
100	6.03	6.13	6.04	6.25	6.19	6.10
98	7.53	7.11	7.08	7.13	7.10	7.08
96	8.52	7.16	7.15	7.19	7.18	7.15
94	9.29	7.29	7.24	7.27	7.32	7.23
92	10.20	8.44	8.23	8.03	8.08	8.00
90	11.52	9.75	9.36	9.22	9.56	8.90
88	12.17	11.17	10.44	9.88	10.42	9.87
86	12.93	12.08	11.03	10.52	11.00	10.30
84	13.73	12.64	11.48	11.07	11.40	10.72
82	14.59	13.23	11.92	11.50	11.81	11.12
80	15.34	14.60	12.30	11.80	12.22	11.50
78	16.02	15.31	12.88	12.07	12.60	11.90
76	16.68	15.87	13.54	12.32	13.46	12.12
74	17.10	16.39	13.96	12.51	14.79	12.29
72	18.70	17.11	14.88	12.70	15.11	12.45
70	24.04	17.65	15.59	13.14	15.47	12.61
68	28.22	24.02	16.16	13.69	15.78	13.28
66	32.66	27.85	16.53	14.27	16.36	13.92
64	35.68	32.33	17.04	14.78	16.65	14.43
62	37.43	36.06	18.96	15.15	17.15	14.93
60	38.92	40.45	24.90	15.55	17.48	15.17
58	39.88	40.54	29.47	15.97	20.57	15.57
56	42.35	40.54	32.36	16.27	23.71	15.78
54	43.94	40.54	35.53	16.44	26.35	16.02
52	45.78	40.54	38.51	16.66	29.66	16.34
50	48.34	40.54	40.33	16.89	32.50	16.62
48	50.95	40.54	40.33	17.01	35.76	16.94
46	53.03	41.03	40.33	17.10	38.33	17.30
44	54.69	43.38	40.33	17.20	40.37	18.76
42	57.55	44.87	40.33	17.29	40.37	22.18
40	58.20	46.51	40.33	17.40	40.37	24.63
38	60.30	48.72	40.33	20.57	40.37	26.39
36	60.72	52.57	40.33	27.28	40.55	28.59
34	63.89	55.79	42.03	32.86	43.49	32.34
32	67.54	58.36	43.16	36.59	45.18	35.60
30	71.97	60.63	44.57	40.29	46.32	37.95
28	75.24	63.85	47.07	40.65	47.92	40.33
26	77.17	66.59	50.80	40.65	50.39	40.33
24	79.05	69.92	57.85	40.65	53.60	43.73
22	80.76	72.57	62.16	40.65	57.40	45.78
20	82.06	74.46	66.83	40.65	62.69	48.99
18	83.28	76.41	72.35	42.07	66.13	54.04
16	85.75	79.45	75.99	43.61	70.77	58.03
14	89.22	82.10	80.01	47.42	73.59	62.04
12	90.97	85.16	82.89	52.91	76.51	70.65
10	93.25	88.32	86.21	60.59	78.84	75.66
8	94.73	91.04	89.48	67.58	82.49	84.46
6	96.02	93.96	93.14	76.40	86.17	89.64
4	97.80	95.74	95.98	83.40	90.34	95.31
2	98.84	98.51	97.92	89.44	95.36	96.96
0	100.00	100.00	100.00	100.00	100.00	100.00

APPENDIX K-54
PERCENT EXCEEDENCE FOR MAXIMUM HABITAT
REACH E, DEEP POOL GUILD, SPRING
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	300MOD50	MOD55	480MOD55	WET	WETOF
100	0.00	0.00	0.00	0.00	0.00	0.00
98	0.00	0.00	0.00	0.00	0.00	0.00
96	0.00	0.00	0.00	0.00	0.00	3.38
94	0.00	0.00	0.00	0.00	0.00	6.09
92	0.00	0.00	0.00	0.00	0.00	10.87
90	0.00	0.00	0.00	0.00	0.00	22.24
88	0.00	0.00	0.00	0.00	0.00	27.16
86	0.00	0.00	0.00	0.00	0.00	27.54
84	0.00	0.00	0.00	0.00	2.84	27.92
82	0.00	0.00	0.00	0.30	6.08	28.35
80	0.00	0.00	0.00	5.61	16.73	28.95
78	0.81	0.00	0.00	26.52	26.94	29.68
76	2.25	2.66	2.32	27.34	27.86	30.57
74	3.62	5.84	4.78	27.98	28.68	31.64
72	6.08	6.08	6.08	28.47	29.70	32.33
70	6.08	7.97	6.08	28.98	30.54	33.12
68	6.08	15.21	8.93	29.77	31.68	34.18
66	9.41	21.92	18.85	30.39	32.50	35.05
64	14.44	27.18	27.29	31.23	34.12	35.68
62	17.73	28.23	28.17	31.92	35.58	35.98
60	22.53	29.26	29.09	33.07	35.97	36.01
58	27.00	30.72	29.80	34.03	36.00	36.03
56	28.40	32.53	31.09	35.07	36.04	36.36
54	29.78	34.95	31.70	36.01	36.35	36.54
52	31.01	35.94	32.90	36.14	36.61	36.92
50	32.43	35.99	33.70	36.17	37.64	38.02
48	34.32	36.03	35.06	36.20	38.95	39.71
46	35.57	36.15	35.93	36.51	40.94	41.16
44	36.08	36.62	35.97	36.86	42.26	42.61
42	36.43	37.34	36.00	37.14	43.85	43.85
40	36.72	40.62	36.06	38.46	45.46	45.21
38	37.05	42.21	36.63	40.38	47.04	46.79
36	38.20	44.36	36.96	42.20	48.23	48.12
34	40.84	46.18	39.65	43.98	50.32	49.77
32	43.51	48.98	42.28	45.24	51.66	51.52
30	46.08	51.13	44.75	46.42	53.84	54.21
28	47.57	53.54	46.14	47.46	57.13	58.02
26	48.50	56.09	49.04	48.49	61.07	61.83
24	50.45	60.87	50.92	49.05	64.52	64.38
22	53.57	64.72	54.49	49.43	66.95	66.61
20	58.75	68.26	59.72	49.95	71.14	69.97
18	62.61	72.73	65.65	50.50	74.02	73.78
16	66.85	76.21	70.56	51.13	77.46	78.31
14	70.92	79.21	74.30	55.92	81.67	80.72
12	76.06	82.14	77.41	64.41	84.39	82.82
10	80.25	86.06	80.76	72.45	88.08	85.63
8	84.44	89.96	84.68	76.99	90.39	87.87
6	89.19	92.26	88.66	80.94	94.04	91.87
4	93.14	95.75	92.64	86.85	96.26	94.78
2	97.09	98.08	96.21	92.21	98.07	97.50
0	100.00	100.00	100.00	100.00	100.00	100.00

APPENDIX K-55
PERCENT EXCEEDENCE FOR MAXIMUM HABITAT
REACH E, LOW GRADIENT GROUP, SPRING
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	300MOD50	MOD55	480MOD55	WET	WETOF
100	8.44	8.90	8.53	9.50	9.40	8.90
98	17.44	14.71	14.76	14.71	14.85	14.81
96	23.33	15.02	15.17	15.08	15.37	15.24
94	27.99	15.78	15.74	15.53	16.21	15.70
92	34.25	22.65	21.62	20.09	20.76	20.36
90	43.64	30.76	28.43	27.15	29.71	25.78
88	48.24	40.85	36.01	31.45	35.89	32.06
86	52.44	47.29	40.17	35.99	39.96	35.12
84	55.02	51.25	43.40	39.87	42.83	38.11
82	57.79	53.36	46.53	42.91	45.74	40.98
80	60.23	57.76	49.25	45.01	48.65	43.75
78	62.42	60.07	52.40	46.94	51.35	46.55
76	64.56	61.85	54.51	48.70	54.36	48.14
74	65.91	63.54	55.87	50.00	58.63	49.33
72	67.44	65.84	58.85	51.38	59.68	50.47
70	68.23	67.49	61.13	52.90	60.83	51.65
68	68.76	68.43	63.00	54.67	61.84	53.91
66	69.53	69.00	64.16	56.53	63.72	55.99
64	70.15	69.66	65.83	58.15	64.67	57.64
62	70.75	70.21	67.62	59.35	66.27	59.26
60	71.28	70.86	68.50	60.62	67.34	60.03
58	71.80	71.27	69.18	61.95	68.01	61.34
56	72.66	71.60	69.61	62.94	68.48	62.01
54	73.40	71.85	70.08	63.48	68.87	62.78
52	74.01	72.59	70.52	64.19	69.36	63.83
50	74.54	73.22	71.01	64.92	69.78	64.74
48	75.24	73.62	71.31	65.29	70.27	65.77
46	75.51	74.14	71.80	65.58	70.65	66.94
44	75.83	74.55	73.28	65.92	71.04	67.86
42	76.19	75.02	73.89	66.21	71.55	68.37
40	76.41	75.30	74.88	66.57	71.75	68.74
38	76.68	75.80	75.26	67.84	72.09	69.00
36	77.11	76.17	75.77	68.82	72.66	69.32
34	77.42	76.76	76.33	69.64	73.33	69.88
32	77.66	77.24	76.75	70.19	74.20	70.37
30	77.88	77.66	77.48	70.74	74.78	70.72
28	78.08	78.11	78.04	71.57	75.37	71.11
26	78.35	78.53	78.49	73.49	75.83	71.60
24	78.56	79.59	80.11	74.96	76.15	71.97
22	79.80	84.38	87.66	76.21	76.89	72.55
20	82.14	88.12	89.62	77.68	77.46	73.11
18	85.29	89.72	89.62	83.75	78.16	73.67
16	86.65	89.72	89.62	89.62	79.38	74.29
14	90.62	89.72	89.62	89.62	86.96	75.33
12	91.79	89.72	89.62	89.62	89.83	76.64
10	92.89	89.72	89.62	89.62	89.83	77.18
8	94.04	89.72	89.62	89.62	89.83	77.74
6	95.48	89.73	89.62	89.62	89.83	78.41
4	96.55	93.15	95.07	94.99	91.50	79.01
2	98.10	97.27	98.04	98.05	97.47	89.98
0	100.00	100.00	100.00	100.00	100.00	100.00

APPENDIX K-56
PERCENT EXCEEDENCE FOR MAXIMUM HABITAT
REACH E, TRICHOPTERA GROUP, SPRING
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	300MOD50	MOD55	480MOD55	WET	WETOF
100	11.92	12.42	12.01	13.16	13.00	12.40
98	22.51	19.24	19.32	19.28	19.38	19.31
96	29.45	19.61	19.80	19.71	20.00	19.81
94	32.98	20.50	20.47	20.25	20.98	20.35
92	36.10	28.56	27.38	25.60	26.30	25.80
90	39.71	38.20	35.37	33.90	36.84	32.15
88	40.69	42.53	42.52	39.14	42.52	39.71
86	44.64	42.53	42.52	42.56	42.52	42.53
84	48.36	42.53	42.52	42.56	42.52	43.26
82	52.01	42.53	42.52	42.56	42.52	46.88
80	54.24	42.53	42.52	42.56	42.79	50.19
78	55.98	42.53	42.52	42.56	48.05	53.36
76	57.88	42.53	42.52	42.56	50.21	56.99
74	59.92	48.51	42.52	45.52	52.41	59.44
72	60.41	52.98	45.00	47.50	54.87	60.88
70	62.19	57.05	47.03	49.99	57.33	62.24
68	62.66	60.17	49.96	52.48	60.33	63.46
66	66.25	63.28	52.00	54.52	63.10	66.17
64	69.66	65.33	55.17	56.47	65.77	70.35
62	72.62	67.97	57.90	58.89	70.22	72.99
60	75.57	72.37	60.93	60.80	74.35	74.99
58	76.50	74.59	63.70	62.31	76.22	76.85
56	77.03	76.11	66.76	64.00	77.40	77.91
54	78.17	77.23	69.23	66.00	78.80	79.35
52	79.93	79.01	71.26	68.25	79.97	80.73
50	82.37	80.45	74.63	70.76	81.71	82.07
48	84.84	82.75	76.71	73.17	84.57	83.18
46	86.01	84.86	77.80	75.42	86.02	85.17
44	87.25	87.16	78.85	76.76	88.19	85.85
42	88.72	88.86	80.93	78.22	89.47	87.01
40	89.32	89.64	83.27	79.39	90.33	88.20
38	89.70	90.21	84.53	81.25	91.03	89.59
36	90.16	90.85	86.07	83.10	91.69	90.23
34	90.59	91.56	87.79	84.01	92.23	91.04
32	91.04	92.15	89.15	85.06	92.73	91.69
30	91.63	92.93	89.98	86.23	93.32	92.23
28	92.20	93.51	90.73	87.03	93.53	92.84
26	92.71	93.86	91.91	87.55	93.96	93.30
24	92.98	94.47	92.67	87.98	94.45	93.87
22	93.58	94.86	93.28	88.48	94.78	94.51
20	93.93	95.26	93.89	89.05	95.33	94.98
18	94.38	95.80	94.57	89.96	95.93	95.87
16	94.94	96.29	95.08	91.65	96.44	96.38
14	95.74	96.94	95.62	92.98	96.90	96.93
12	96.31	97.50	96.37	94.24	97.44	97.41
10	96.95	97.91	96.95	95.14	98.02	97.75
8	97.61	98.40	97.56	96.05	98.63	98.32
6	98.20	98.85	98.20	96.91	99.00	98.71
4	98.83	99.22	98.72	97.72	99.39	99.05
2	99.51	99.69	99.39	98.64	99.65	99.62
0	100.00	100.00	100.00	100.00	100.00	100.00

APPENDIX K-57
PERCENT EXCEEDENCE FOR MAXIMUM HABITAT
REACH E, SHALLOW POOL GUILD, SUMMER
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	300MOD50	MOD55	480MOD55	WET	WETOF
100	4.24	4.49	4.45	9.75	4.45	4.46
98	5.45	5.07	4.94	9.81	4.86	4.62
96	6.05	5.64	5.42	9.87	5.16	4.80
94	7.03	6.19	5.87	9.93	5.50	4.99
92	7.66	6.66	6.31	9.97	5.97	5.16
90	8.40	7.03	6.78	10.03	6.27	5.41
88	9.19	7.58	7.34	10.08	6.92	5.69
86	9.61	8.05	8.12	10.12	7.67	5.86
84	14.66	8.39	8.66	10.16	8.24	6.02
82	18.13	8.77	9.02	10.20	8.72	6.18
80	20.20	8.96	9.64	10.25	9.11	6.34
78	22.86	9.35	11.11	10.30	9.65	6.51
76	25.82	9.86	16.66	10.35	10.03	6.73
74	28.36	10.09	21.53	10.40	10.95	6.86
72	31.31	10.58	24.68	10.44	13.57	7.07
70	34.14	14.36	28.29	10.51	17.58	7.23
68	37.96	20.15	31.35	10.57	19.79	7.45
66	39.52	23.34	34.42	10.60	21.66	7.58
64	41.77	26.54	37.46	10.66	23.71	7.82
62	42.57	30.81	40.46	10.69	25.94	7.95
60	42.87	32.82	42.14	10.76	27.21	8.13
58	43.21	35.47	44.09	10.91	29.30	8.36
56	43.45	38.24	44.98	11.09	31.00	8.58
54	46.63	40.57	45.32	11.25	33.22	8.76
52	51.97	42.91	45.63	11.46	35.62	9.08
50	56.65	44.57	46.03	11.65	37.12	9.35
48	61.29	45.03	50.07	11.81	38.37	9.54
46	65.68	45.33	56.90	12.05	39.97	9.81
44	70.12	45.58	64.16	12.26	41.92	10.16
42	72.99	45.89	70.63	12.41	43.44	10.52
40	74.47	46.48	76.38	12.61	44.80	10.99
38	76.17	53.04	78.60	12.84	45.22	11.41
36	77.85	61.36	81.03	13.15	45.56	14.19
34	80.00	68.38	82.99	13.53	45.85	18.68
32	81.86	74.16	85.44	13.98	46.97	24.12
30	83.43	77.54	87.59	14.52	56.29	27.56
28	84.94	80.20	89.54	15.10	62.58	30.72
26	86.19	82.27	91.19	15.53	70.33	34.13
24	87.46	84.59	92.94	16.28	76.58	37.31
22	88.58	86.31	95.35	16.99	79.38	39.65
20	90.24	89.34	97.49	18.14	82.85	42.28
18	91.53	91.61	99.09	18.93	84.20	44.95
16	92.51	93.58	100.00	19.59	85.75	45.52
14	93.41	94.45	100.00	20.43	88.00	46.11
12	94.31	97.64	100.00	21.54	89.82	56.89
10	94.86	99.19	100.00	22.27	90.63	65.79
8	95.49	100.00	100.00	23.11	92.33	79.34
6	96.58	100.00	100.00	23.78	95.39	89.25
4	97.92	100.00	100.00	24.41	100.00	98.17
2	99.39	100.00	100.00	24.84	100.00	100.00
0	100.00	100.00	100.00	100.00	100.00	100.00

APPENDIX K-58
PERCENT EXCEEDENCE FOR MAXIMUM HABITAT
REACH E, SLOW RIFFLE GUILD, SUMMER
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	300MOD50	MOD55	480MOD55	WET	WETOF
100	3.75	16.87	21.73	15.42	13.66	11.29
98	7.18	19.26	24.00	16.37	24.30	15.41
96	10.04	20.59	25.71	16.88	25.53	16.63
94	12.21	23.13	25.71	17.90	25.72	18.41
92	16.31	24.82	25.71	18.98	25.72	19.56
90	20.89	25.73	25.71	20.08	26.42	20.51
88	22.56	25.73	25.71	21.09	28.15	21.12
86	24.20	25.73	25.71	21.66	30.37	21.64
84	25.58	25.73	25.71	22.42	31.68	22.18
82	26.86	25.97	25.71	23.01	33.53	22.79
80	28.99	27.05	25.71	23.84	35.54	23.24
78	30.55	28.90	26.27	24.64	36.61	23.64
76	31.72	30.32	28.00	25.51	38.11	24.15
74	33.34	32.88	29.46	25.87	39.36	24.64
72	35.19	34.33	30.97	26.35	40.49	25.53
70	36.25	35.93	32.50	26.84	41.48	25.65
68	37.40	37.18	34.00	27.26	42.07	25.65
66	39.33	38.46	35.17	27.66	43.16	25.93
64	40.69	39.26	36.89	27.98	44.14	26.42
62	41.32	40.11	38.21	28.21	45.75	27.05
60	42.24	40.91	39.20	28.39	46.86	28.45
58	43.84	41.69	40.35	28.55	48.18	30.17
56	45.14	42.52	41.39	28.74	49.54	31.17
54	46.64	43.71	42.98	28.88	50.49	31.97
52	48.02	44.82	44.80	29.05	51.51	33.23
50	49.55	47.51	46.38	29.22	52.97	34.40
48	50.74	49.62	48.21	29.42	53.91	35.40
46	51.85	51.42	49.65	29.56	55.01	36.38
44	53.39	53.37	51.65	29.73	55.91	37.39
42	54.64	54.41	52.92	29.87	56.61	38.21
40	55.97	56.05	54.40	29.99	57.61	39.66
38	57.24	57.87	55.84	30.09	58.45	40.46
36	59.22	59.69	57.93	30.19	59.42	41.49
34	60.63	60.70	59.39	30.27	60.82	42.38
32	61.87	61.90	60.54	30.35	62.23	44.46
30	63.33	63.30	62.25	30.43	63.61	46.30
28	64.66	64.41	64.22	30.48	64.45	48.82
26	65.79	66.42	65.33	30.55	65.24	52.79
24	67.65	67.50	66.52	30.64	66.38	55.21
22	68.46	68.66	67.82	30.69	67.29	57.42
20	69.97	69.75	68.52	30.78	68.45	59.70
18	71.48	70.63	69.97	31.03	69.56	62.10
16	75.47	72.57	71.35	31.19	70.45	64.39
14	78.49	76.42	73.99	31.35	73.14	66.20
12	81.31	79.89	77.05	31.46	77.57	67.91
10	84.16	82.83	81.34	31.65	81.83	70.25
8	88.06	86.06	85.36	31.78	85.02	77.58
6	91.44	90.74	88.85	31.97	88.73	83.59
4	95.43	93.92	93.02	32.09	91.51	87.39
2	98.35	97.02	97.40	32.12	95.42	92.74
0	100.00	100.00	100.00	100.00	100.00	100.00

APPENDIX K-59
PERCENT EXCEEDENCE FOR MAXIMUM HABITAT
REACH E, FAST RIFFLE GUILD, SUMMER
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	300MOD50	MOD55	480MOD55	WET	WETOF
100	0.00	0.00	0.00	2.60	0.00	0.00
98	0.00	0.00	0.00	85.92	0.00	0.00
96	0.00	0.00	0.00	91.85	0.00	0.00
94	0.00	0.00	0.00	93.15	0.00	0.00
92	0.00	0.00	0.00	93.42	0.00	0.00
90	0.00	0.00	0.00	94.03	0.00	0.00
88	0.00	0.00	0.00	94.82	0.00	0.00
86	0.00	0.00	0.00	95.46	0.00	0.18
84	0.00	0.00	0.00	96.39	0.00	2.93
82	0.00	0.00	0.00	96.63	0.00	5.61
80	0.00	0.00	0.00	96.81	0.00	5.88
78	0.00	0.00	0.00	96.99	0.00	5.88
76	0.00	0.00	0.00	97.16	0.00	5.88
74	0.00	0.00	0.00	97.35	0.00	5.88
72	0.00	0.00	0.00	97.56	0.00	5.88
70	0.00	0.00	0.00	97.71	0.00	5.88
68	0.00	0.00	0.00	97.89	0.00	5.88
66	0.00	0.00	0.00	97.98	1.37	5.88
64	0.00	0.00	0.00	98.16	2.73	5.88
62	0.00	0.00	0.00	98.33	4.34	5.88
60	0.00	0.02	0.00	98.44	5.88	9.95
58	0.00	1.20	0.00	98.65	5.88	15.99
56	0.00	2.66	0.00	98.74	5.88	21.06
54	0.00	3.81	0.00	98.85	5.88	30.11
52	0.00	5.24	0.00	98.97	5.88	34.94
50	0.00	5.88	0.55	99.08	5.88	41.04
48	0.00	5.88	2.43	99.17	5.88	45.54
46	0.00	5.88	3.84	99.25	5.88	52.70
44	0.00	5.88	5.45	99.32	5.88	60.21
42	0.99	5.88	5.88	99.36	5.88	67.74
40	2.58	5.88	5.88	99.40	5.88	73.43
38	4.16	5.88	5.88	99.44	5.88	79.51
36	5.88	5.88	5.88	99.50	5.88	88.14
34	5.88	5.88	5.88	99.54	5.88	95.39
32	5.88	5.88	5.88	99.57	5.88	96.81
30	5.88	5.88	5.88	99.61	5.88	97.10
28	5.88	5.88	5.88	99.66	5.88	97.60
26	5.88	10.11	5.88	99.70	5.88	97.94
24	5.88	19.17	5.88	99.74	10.69	98.17
22	5.88	27.23	5.88	99.77	16.98	98.36
20	5.88	34.47	16.23	99.80	25.30	98.50
18	5.88	42.84	26.22	99.82	32.71	98.67
16	5.88	51.69	32.16	99.85	42.85	98.83
14	7.37	63.83	40.73	99.87	52.80	98.98
12	14.50	80.61	54.70	99.89	64.19	99.08
10	28.11	97.13	66.35	99.91	75.19	99.23
8	40.67	97.79	81.45	99.92	89.32	99.40
6	51.44	98.29	96.61	99.95	98.37	99.64
4	69.18	98.96	99.05	99.96	99.38	99.73
2	85.22	99.53	99.54	99.98	99.69	99.88
0	100.00	100.00	100.00	100.00	100.00	100.00

APPENDIX K-60
PERCENT EXCEEDENCE FOR MAXIMUM HABITAT
REACH E, RACEWAY GUILD, SUMMER
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	300MOD50	MOD55	480MOD55	WET	WETOF
100	0.00	0.00	0.00	16.85	0.00	0.00
98	0.00	0.00	0.00	39.70	0.00	0.00
96	0.00	0.00	0.00	40.12	0.00	0.00
94	0.00	0.00	0.00	42.65	0.00	1.44
92	0.00	0.00	0.00	47.48	0.62	4.08
90	0.00	0.00	0.00	51.98	1.07	6.17
88	0.00	0.00	0.00	56.02	1.29	7.31
86	0.00	0.05	0.00	59.24	1.77	9.25
84	0.00	0.29	0.00	62.58	2.37	17.88
82	0.00	0.81	0.00	65.14	2.79	26.29
80	0.00	1.42	0.00	68.22	3.15	32.59
78	0.00	2.22	0.00	72.52	4.07	37.66
76	0.00	2.68	0.46	75.59	4.78	40.64
74	0.42	3.30	0.92	78.20	5.58	42.99
72	0.77	3.85	1.36	79.85	6.58	46.40
70	1.09	4.56	1.88	82.20	7.39	49.56
68	1.49	5.09	2.46	84.03	8.59	54.11
66	2.01	5.83	3.11	85.91	12.99	58.00
64	2.47	6.74	3.63	87.16	17.25	60.94
62	3.18	7.81	4.28	88.43	22.31	63.77
60	3.68	8.73	4.80	89.30	27.31	66.43
58	4.17	12.44	5.54	89.93	30.15	69.06
56	4.61	17.03	6.37	90.51	33.33	71.51
54	5.19	20.65	7.31	91.50	37.41	73.79
52	5.89	25.13	8.19	92.20	40.38	75.81
50	6.37	27.81	10.40	92.88	43.13	78.26
48	7.26	31.28	16.32	93.64	45.44	80.41
46	8.08	36.17	20.75	94.41	51.08	82.21
44	8.57	41.03	25.77	95.03	55.22	84.22
42	11.81	46.82	28.81	95.74	59.13	86.11
40	16.79	51.13	32.88	96.23	63.26	88.26
38	21.73	54.30	36.40	96.81	66.36	90.49
36	27.81	58.88	42.66	97.21	69.58	93.00
34	32.76	62.67	49.01	97.58	73.64	94.50
32	36.65	66.67	55.43	97.93	77.35	95.98
30	45.27	71.23	61.82	98.26	81.37	97.88
28	51.56	76.46	69.36	98.55	85.61	99.44
26	58.10	81.01	75.03	98.80	89.59	99.47
24	63.74	85.39	81.19	99.25	92.96	99.51
22	70.30	90.67	85.82	99.50	96.27	99.54
20	76.20	96.27	90.18	99.77	98.66	99.59
18	80.78	99.16	96.48	99.96	99.46	99.61
16	86.79	99.47	99.45	99.96	99.50	99.65
14	94.49	99.53	99.51	99.96	99.55	99.68
12	99.51	99.58	99.56	99.97	99.59	99.72
10	99.55	99.62	99.61	99.97	99.65	99.77
8	99.64	99.66	99.69	99.98	99.70	99.82
6	99.71	99.72	99.76	99.98	99.77	99.85
4	99.77	99.79	99.83	99.99	99.84	99.89
2	99.89	99.89	99.91	99.99	99.93	99.96
0	100.00	100.00	100.00	100.00	100.00	100.00

APPENDIX K-61
PERCENT EXCEEDENCE FOR MAXIMUM HABITAT
REACH E, MEDIUM POOL GUILD, SUMMER
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	300MOD50	MOD55	480MOD55	WET	WETOF
100	13.67	13.43	15.42	11.98	12.05	10.97
98	17.11	14.41	16.36	12.36	16.48	12.85
96	24.25	14.96	17.13	12.57	16.99	13.35
94	27.14	16.00	18.59	12.95	17.41	14.08
92	31.25	16.70	23.36	13.33	20.67	14.56
90	33.83	17.48	28.11	13.73	25.34	14.95
88	36.13	23.63	31.77	14.09	28.80	15.20
86	36.68	28.91	36.17	14.30	32.38	15.41
84	37.34	32.73	38.86	14.57	35.51	15.63
82	38.42	35.52	40.32	14.78	38.70	15.89
80	39.15	38.15	40.32	15.08	40.33	16.07
78	39.59	40.33	40.32	15.37	40.33	16.24
76	40.09	40.33	40.32	15.68	40.73	16.45
74	40.46	40.33	40.32	15.81	42.31	16.65
72	41.12	40.33	40.32	15.98	43.67	17.02
70	41.75	40.33	40.32	16.16	45.27	17.14
68	42.43	40.68	40.32	16.31	46.28	17.36
66	43.31	41.44	40.38	16.45	48.15	17.61
64	44.18	42.51	40.93	16.57	49.56	19.98
62	45.67	43.89	41.85	16.65	51.75	23.83
60	46.88	44.94	42.71	16.72	52.53	25.82
58	48.96	45.89	43.85	16.77	54.73	27.50
56	50.64	46.96	45.71	16.84	57.25	30.05
54	52.12	48.64	47.74	16.89	59.25	32.41
52	54.62	50.40	49.84	16.95	61.03	34.67
50	56.44	53.54	52.46	17.01	62.43	36.08
48	59.01	56.60	54.24	17.08	63.60	38.00
46	60.75	59.43	56.80	17.14	64.86	39.52
44	62.56	62.01	59.30	17.20	67.20	40.34
42	64.96	63.97	61.36	17.25	68.99	40.34
40	67.34	66.51	64.52	17.29	71.16	42.10
38	68.61	68.75	66.60	17.33	72.52	43.38
36	70.94	70.69	68.81	17.36	74.06	45.40
34	72.15	73.49	71.36	17.39	75.99	46.88
32	74.31	75.72	73.02	17.42	77.38	50.54
30	75.85	77.64	75.21	17.45	78.83	53.33
28	77.38	79.30	77.16	17.47	80.71	57.01
26	79.27	80.72	78.83	17.49	82.23	63.83
24	80.64	82.35	80.65	17.52	83.99	68.95
22	81.76	84.56	82.90	17.54	85.57	73.27
20	83.88	86.27	84.76	17.57	86.87	76.75
18	85.39	87.94	86.38	17.96	88.45	79.62
16	87.16	89.95	88.21	18.23	89.99	82.21
14	88.79	91.49	90.33	18.50	91.26	84.11
12	90.29	92.66	91.77	18.66	92.51	86.50
10	91.91	94.15	93.68	18.98	93.58	88.86
8	93.76	95.36	95.18	19.19	95.43	91.01
6	95.29	96.60	96.13	19.51	96.39	93.12
4	96.85	98.21	97.73	19.70	97.62	95.35
2	98.42	99.42	99.12	19.76	99.23	97.46
0	100.00	100.00	100.00	100.00	100.00	100.00

APPENDIX K-62
PERCENT EXCEEDENCE FOR MAXIMUM HABITAT
REACH E, DEEP POOL GUILD, SUMMER
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	300MOD50	MOD55	480MOD55	WET	WETOF
100	0.00	0.00	0.00	6.26	0.00	0.00
98	0.00	0.00	0.00	28.09	0.00	0.00
96	0.00	0.00	0.00	28.54	0.00	0.00
94	0.00	0.00	0.00	29.18	0.00	0.00
92	0.00	0.00	0.00	30.66	0.00	0.00
90	0.00	0.00	0.00	32.61	0.00	2.20
88	0.00	0.00	0.00	34.37	0.00	3.96
86	0.00	0.00	0.00	35.84	0.00	6.10
84	0.00	0.00	0.00	37.25	0.00	6.10
82	0.00	0.00	0.00	38.42	0.00	6.10
80	0.00	0.00	0.00	39.82	0.00	13.20
78	0.00	0.00	0.00	41.56	0.00	20.37
76	0.00	0.00	0.00	42.94	0.06	26.72
74	0.00	0.00	0.00	44.03	1.29	28.14
72	0.00	0.00	0.00	44.76	2.83	30.11
70	0.00	0.00	0.00	45.85	4.07	31.64
68	0.00	0.54	0.00	46.57	5.92	34.72
66	0.00	1.68	0.00	47.38	6.08	36.77
64	0.00	3.07	0.00	47.95	6.08	38.30
62	0.00	4.72	0.00	48.48	6.08	39.88
60	0.00	6.02	0.09	48.86	6.32	40.98
58	0.00	6.09	1.23	49.11	10.02	41.73
56	0.00	6.09	2.51	49.41	14.15	42.76
54	0.68	6.09	3.95	49.82	19.45	43.78
52	1.77	6.09	5.31	50.10	23.79	44.64
50	2.52	6.97	6.08	50.44	27.18	45.45
48	3.89	11.47	6.08	50.73	29.88	46.51
46	5.16	17.83	6.08	51.09	37.17	47.41
44	5.90	24.16	6.08	51.34	41.77	48.86
42	6.11	30.99	8.27	51.65	45.60	49.85
40	6.11	33.56	13.55	51.87	47.46	50.50
38	6.11	36.46	18.12	52.10	49.07	51.40
36	6.98	38.81	26.26	52.29	50.52	52.58
34	13.42	41.79	34.51	52.44	52.26	55.52
32	18.49	44.24	41.20	52.59	55.49	59.30
30	29.74	46.18	44.80	52.75	57.41	62.44
28	37.94	50.19	46.99	52.86	60.48	64.92
26	45.20	53.51	50.23	52.96	64.00	67.04
24	49.99	59.00	52.11	53.17	66.18	70.89
22	55.80	63.32	57.18	53.28	69.55	74.13
20	62.08	68.42	61.43	53.40	71.93	76.57
18	65.03	71.24	64.66	53.88	75.09	79.93
16	69.55	75.77	69.37	54.39	78.52	81.65
14	72.71	79.85	72.66	54.93	81.13	84.11
12	76.66	82.76	76.80	55.23	84.69	86.63
10	80.09	86.38	82.29	55.67	87.60	89.12
8	83.93	89.32	86.12	56.07	90.40	91.82
6	88.45	92.57	89.13	56.48	93.51	93.84
4	93.91	96.34	92.18	56.90	96.34	96.16
2	96.78	98.49	96.14	57.07	98.08	98.27
0	100.00	100.00	100.00	100.00	100.00	100.00

APPENDIX K-63
PERCENT EXCEEDENCE FOR MAXIMUM HABITAT
REACH E, LOW GRADIENT GROUP, SUMMER
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	300MOD50	MOD55	480MOD55	WET	WETOF
100	29.32	54.02	60.49	59.32	47.41	39.85
98	56.08	57.19	63.51	62.77	64.02	52.40
96	66.22	58.96	65.99	64.62	65.66	54.02
94	68.51	62.32	67.43	66.66	67.02	56.39
92	69.09	64.56	68.13	68.24	67.87	57.93
90	69.78	67.08	68.84	69.86	68.57	59.20
88	70.30	68.15	69.38	71.35	69.08	60.02
86	70.89	68.94	70.03	72.19	69.61	60.70
84	71.33	69.50	70.43	73.31	70.08	61.42
82	71.93	69.91	70.71	74.17	70.55	62.23
80	72.92	70.30	71.17	75.40	70.90	62.84
78	73.43	70.64	71.82	76.58	71.29	63.37
76	73.64	71.02	72.93	77.86	71.58	64.05
74	73.93	71.44	73.58	78.38	71.86	64.70
72	74.30	71.69	74.00	79.09	72.46	65.90
70	74.60	72.45	74.40	79.81	73.27	66.29
68	74.89	73.41	74.70	80.42	73.65	66.99
66	75.21	73.79	75.23	81.02	73.93	67.56
64	75.60	74.10	75.69	81.48	74.20	67.93
62	76.06	74.44	76.03	81.82	74.48	68.50
60	76.36	74.83	76.34	82.09	74.88	68.79
58	76.78	75.37	76.65	82.31	75.06	69.04
56	76.95	75.72	77.01	82.60	75.26	69.42
54	77.38	75.97	77.39	82.81	75.54	69.77
52	77.75	76.23	77.77	83.05	75.80	70.11
50	77.96	76.53	78.03	83.31	76.15	70.32
48	78.22	76.90	78.22	83.59	76.42	70.61
46	78.53	77.24	78.48	83.80	76.73	70.83
44	79.36	77.56	79.60	84.06	77.01	71.26
42	79.97	77.81	81.90	84.26	77.21	71.49
40	81.29	78.22	83.94	84.44	77.39	71.78
38	82.63	78.45	85.67	84.58	77.64	72.11
36	83.74	78.60	87.84	84.74	77.90	72.75
34	84.67	81.08	89.44	84.85	78.21	73.57
32	85.92	83.13	89.44	84.96	78.39	74.43
30	86.44	84.69	89.44	85.08	78.64	74.99
28	87.24	87.07	89.44	85.16	79.21	75.44
26	88.15	88.92	89.44	85.25	81.96	75.83
24	89.08	89.41	89.44	85.39	84.19	76.27
22	89.71	89.41	89.44	85.47	86.54	76.79
20	90.75	89.41	89.44	85.60	89.61	77.19
18	91.85	89.41	89.44	85.69	89.62	77.56
16	92.48	89.76	90.15	85.74	89.62	77.95
14	93.47	91.01	91.67	85.79	90.59	78.23
12	94.52	92.11	93.16	85.83	92.00	78.64
10	95.61	93.21	93.95	85.89	93.48	80.53
8	96.52	95.20	95.20	85.92	94.91	86.70
6	97.28	96.71	96.16	85.98	96.23	89.82
4	97.97	98.40	97.28	86.02	96.97	89.82
2	99.09	99.45	98.71	86.03	98.24	94.76
0	100.00	100.00	100.00	100.00	100.00	100.00

APPENDIX K-64
PERCENT EXCEEDENCE FOR MAXIMUM HABITAT
REACH E, TRICHOPTERA GROUP, SUMMER
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	300MOD50	MOD55	480MOD55	WET	WETOF
100	13.62	42.53	42.52	58.47	42.52	42.54
98	26.05	42.53	42.52	61.88	42.52	42.54
96	35.98	42.53	42.52	63.71	42.52	44.53
94	36.89	42.53	42.52	66.10	47.53	55.50
92	38.61	42.53	42.52	68.20	51.84	63.38
90	40.53	43.41	42.52	70.34	54.41	66.37
88	41.23	45.09	42.52	72.31	55.64	68.50
86	42.14	48.64	42.52	73.42	58.38	72.10
84	42.76	49.96	42.52	74.90	61.52	74.63
82	43.90	52.93	43.51	76.05	63.90	75.85
80	44.78	56.36	45.25	77.67	65.95	76.80
78	46.55	60.93	47.57	79.23	70.59	77.49
76	48.31	63.54	50.92	80.92	74.40	78.08
74	50.72	67.04	53.55	81.62	75.91	78.69
72	52.72	69.62	56.05	82.55	76.95	79.47
70	54.55	71.07	59.00	83.51	77.79	80.42
68	56.79	74.01	62.25	84.31	78.63	81.53
66	59.75	75.05	65.94	85.09	80.82	82.29
64	62.37	75.80	68.90	85.71	82.60	83.17
62	66.41	76.40	72.57	86.16	84.81	83.90
60	69.24	77.24	75.27	86.51	85.93	84.82
58	72.02	78.37	76.06	86.80	87.39	85.75
56	74.47	79.17	76.94	87.18	88.44	86.71
54	75.73	80.58	77.93	87.47	89.21	88.00
52	76.48	81.93	78.87	87.78	89.65	88.67
50	76.99	83.41	80.17	88.13	90.05	89.43
48	77.94	84.32	82.01	88.45	90.59	89.89
46	78.81	85.78	83.89	88.79	90.92	90.46
44	79.32	87.54	85.29	89.12	91.33	90.80
42	81.10	88.88	86.91	89.35	91.61	91.24
40	83.45	89.39	88.48	89.61	91.85	91.52
38	85.94	89.91	89.27	89.81	92.35	92.11
36	88.20	90.46	89.74	90.00	92.85	92.70
34	89.44	90.97	90.19	90.16	93.33	93.16
32	90.16	91.72	90.71	90.31	93.68	93.44
30	91.08	92.26	91.43	90.47	94.09	93.83
28	91.96	92.74	91.97	90.58	94.51	94.32
26	92.82	93.26	92.48	90.68	94.84	94.64
24	93.28	94.02	93.03	90.89	95.17	95.11
22	93.83	94.56	93.58	91.00	95.64	95.53
20	94.49	95.10	94.16	91.12	95.97	95.97
18	95.01	95.70	94.68	91.30	96.42	96.35
16	95.66	96.12	95.41	91.38	96.75	96.83
14	96.07	96.62	95.75	91.48	97.14	97.30
12	96.61	97.12	96.51	91.53	97.52	97.65
10	97.02	97.72	97.04	91.63	97.95	98.27
8	97.51	98.19	97.53	91.69	98.46	98.70
6	98.17	98.78	98.01	91.77	98.94	98.93
4	99.03	99.40	98.64	91.85	99.42	99.35
2	99.54	99.73	99.28	91.88	99.69	99.75
0	100.00	100.00	100.00	100.00	100.00	100.00

APPENDIX K-65
PERCENT EXCEEDENCE FOR MAXIMUM HABITAT
REACH E, SHALLOW POOL GUILD, FALL
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	300MOD50	MOD55	480MOD55	WET	WETOF
100	4.47	4.47	4.45	4.45	4.46	4.47
98	7.24	6.31	7.20	4.50	5.10	4.70
96	9.16	7.73	9.05	4.66	5.54	5.15
94	9.75	8.72	9.40	4.80	6.24	5.44
92	10.22	9.33	9.68	4.85	7.36	5.62
90	12.30	9.68	9.99	4.87	8.50	5.86
88	14.31	9.91	10.73	5.00	9.39	6.32
86	15.73	10.21	12.20	5.20	9.84	6.55
84	16.79	10.67	13.92	5.34	10.05	6.79
82	17.61	13.84	14.80	5.54	10.42	7.16
80	18.66	14.94	16.28	5.70	12.05	7.53
78	20.50	16.49	17.49	5.79	14.08	7.74
76	21.68	18.05	18.49	5.85	15.61	7.94
74	23.19	19.26	19.80	5.88	17.27	8.14
72	24.14	20.73	20.87	5.91	19.43	8.35
70	24.76	21.60	22.15	5.94	20.52	8.59
68	25.69	22.36	23.24	5.97	21.54	8.81
66	26.80	23.14	24.08	6.00	22.24	9.00
64	27.69	24.06	25.02	6.02	23.52	9.21
62	28.39	25.19	25.62	6.05	24.28	9.48
60	29.66	26.17	26.47	6.09	25.19	9.61
58	30.43	26.89	27.13	6.15	25.64	9.80
56	31.27	27.48	27.97	6.21	26.23	10.09
54	32.16	28.67	29.52	6.29	26.63	10.21
52	32.93	29.23	30.41	6.39	27.31	10.86
50	33.43	29.71	31.57	6.45	27.95	12.07
48	33.94	30.67	32.86	6.50	28.34	13.53
46	34.65	31.51	34.05	6.55	28.92	14.70
44	35.59	32.31	35.39	6.64	29.28	16.27
42	36.33	33.07	36.44	6.74	29.81	17.51
40	37.24	33.90	37.14	6.78	30.39	18.29
38	38.05	35.02	37.52	6.86	30.97	19.67
36	38.40	35.82	37.71	6.90	31.39	20.42
34	38.75	36.67	38.24	6.95	32.23	22.41
32	39.30	37.56	38.80	7.03	32.83	24.15
30	40.27	38.30	39.41	7.12	33.70	25.63
28	40.75	38.97	39.78	7.21	34.29	28.96
26	41.28	39.60	40.46	7.32	34.86	30.61
24	41.78	39.98	41.99	7.47	35.66	31.49
22	42.16	40.78	42.98	7.61	36.73	31.98
20	44.09	41.92	45.49	7.74	40.04	32.62
18	45.88	44.58	46.00	7.91	45.11	33.32
16	54.09	45.41	54.99	8.12	52.58	36.66
14	70.45	46.14	73.79	8.43	71.80	40.28
12	79.50	55.57	91.56	9.00	80.41	43.78
10	81.35	65.20	100.00	10.17	85.43	45.15
8	86.90	77.04	100.00	13.34	89.98	46.03
6	98.35	92.74	100.00	19.05	95.92	65.20
4	100.00	98.49	100.00	25.09	99.22	86.99
2	100.00	100.00	100.00	84.85	100.00	100.00
0	100.00	100.00	100.00	100.00	100.00	100.00

APPENDIX K-66
PERCENT EXCEEDENCE FOR MAXIMUM HABITAT
REACH E, SLOW RIFFLE GUILD, FALL
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	300MOD50	MOD55	480MOD55	WET	WETOF
100	18.49	18.11	22.16	15.36	12.20	11.19
98	25.82	25.68	25.77	20.80	18.04	14.86
96	25.82	28.04	25.77	22.91	26.12	22.99
94	26.67	30.44	25.77	23.52	26.47	24.82
92	34.26	33.99	25.77	24.09	27.69	25.53
90	38.55	36.31	25.77	24.37	28.72	25.91
88	41.25	38.72	26.60	24.66	30.56	26.40
86	42.49	40.07	36.75	24.94	32.59	27.70
84	43.83	40.95	39.54	25.22	35.38	29.81
82	44.71	41.58	40.42	25.46	37.61	30.64
80	46.44	42.38	41.32	25.59	41.22	32.49
78	47.37	42.90	42.33	25.80	42.25	33.06
76	48.20	44.97	43.33	25.94	42.87	34.20
74	49.08	46.23	44.42	26.05	43.63	35.25
72	49.86	47.40	45.44	26.12	45.61	36.03
70	51.18	48.83	46.28	26.27	47.22	36.58
68	52.09	49.68	47.18	26.36	48.68	37.39
66	53.29	50.94	48.23	26.56	49.53	37.83
64	54.05	51.59	49.14	26.72	51.07	38.59
62	54.57	52.27	49.80	26.81	52.10	39.05
60	55.32	52.92	51.14	26.91	52.80	39.72
58	56.20	53.59	51.68	27.03	53.35	40.22
56	56.59	54.59	52.66	27.13	54.13	40.96
54	57.40	55.37	53.35	27.37	55.02	41.41
52	58.01	55.85	54.19	27.50	55.63	41.99
50	58.81	56.34	54.77	27.62	56.31	42.64
48	59.41	57.17	55.41	27.69	56.68	43.68
46	60.20	57.78	55.96	27.75	57.15	45.01
44	60.83	58.21	56.55	27.80	57.46	46.09
42	61.28	58.83	57.49	27.85	57.86	47.01
40	61.68	59.40	58.62	27.91	58.47	48.04
38	62.03	59.97	59.24	27.97	58.87	49.01
36	62.39	60.55	60.29	28.01	59.27	49.62
34	63.04	61.13	61.21	28.07	59.56	50.64
32	63.63	62.06	62.27	28.16	59.98	51.34
30	64.12	62.82	63.53	28.36	60.51	52.91
28	64.75	63.28	64.03	28.55	60.89	54.17
26	65.37	63.97	64.63	28.98	61.38	55.30
24	65.65	64.75	64.92	29.28	61.64	58.04
22	65.85	65.36	65.02	29.58	62.31	59.33
20	66.28	65.84	65.62	29.91	62.85	60.20
18	66.85	66.33	65.97	30.71	63.50	60.65
16	67.41	66.61	66.42	31.35	63.97	61.07
14	67.83	67.27	66.90	31.79	64.53	61.47
12	68.20	68.17	67.46	32.03	65.05	62.76
10	68.55	70.13	68.61	32.10	65.90	65.90
8	68.94	76.96	69.43	47.91	67.80	69.51
6	74.47	82.20	78.34	54.17	70.67	71.12
4	86.64	87.68	88.92	58.67	76.92	78.56
2	93.59	91.57	94.87	62.77	88.99	87.52
0	100.00	100.00	100.00	100.00	100.00	100.00

APPENDIX K-67
PERCENT EXCEEDENCE FOR MAXIMUM HABITAT
REACH E, FAST RIFFLE GUILD, FALL
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	300MOD50	MOD55	480MOD55	WET	WETOF
100	0.00	0.00	0.00	0.00	0.00	0.00
98	0.00	0.00	0.00	0.00	0.00	0.00
96	0.00	0.00	0.00	5.88	0.00	0.00
94	0.00	0.00	0.00	5.88	0.00	0.00
92	0.00	0.00	0.00	5.88	0.00	0.52
90	0.00	0.00	0.00	89.58	0.00	4.68
88	0.00	0.00	0.00	93.25	0.00	5.88
86	0.00	0.04	0.00	93.79	0.00	5.88
84	0.00	3.42	0.00	96.11	0.00	5.88
82	1.23	5.88	0.68	97.29	4.85	5.88
80	5.84	5.88	3.06	97.87	5.88	5.88
78	5.89	5.88	5.88	98.06	5.88	5.88
76	5.89	5.88	5.88	98.21	5.88	5.88
74	5.89	5.88	5.88	98.32	5.88	5.88
72	5.89	5.88	5.88	98.39	5.88	5.88
70	5.89	5.88	5.88	98.47	5.88	5.88
68	5.89	5.88	5.88	98.52	5.88	5.88
66	5.89	5.88	5.88	98.59	5.88	5.88
64	5.89	5.88	5.88	98.64	5.88	5.88
62	5.89	5.88	5.88	98.70	5.88	5.88
60	5.89	5.88	5.88	98.74	5.88	5.88
58	5.89	5.88	5.88	98.77	5.88	5.88
56	5.89	5.88	5.88	98.79	5.88	5.88
54	5.89	5.88	5.88	98.82	5.88	5.88
52	5.89	5.88	5.88	98.86	5.88	5.88
50	5.89	5.88	5.88	98.89	5.88	5.88
48	5.89	5.88	5.88	98.93	5.88	6.21
46	5.89	5.88	5.88	98.96	5.88	9.00
44	5.89	5.88	5.88	98.99	5.88	13.76
42	5.89	5.88	5.88	99.01	5.88	17.26
40	5.89	5.88	5.88	99.05	5.88	19.98
38	5.89	5.88	5.88	99.09	5.88	24.11
36	5.89	5.88	5.88	99.13	5.88	27.76
34	5.89	5.88	5.88	99.16	5.88	30.80
32	5.89	5.88	5.88	99.19	5.88	35.84
30	5.89	5.88	5.88	99.22	5.88	37.71
28	5.89	5.88	5.88	99.23	5.88	41.43
26	5.89	5.88	5.88	99.24	5.88	45.42
24	5.89	5.88	5.88	99.25	5.88	50.09
22	5.89	5.88	5.88	99.27	5.88	56.06
20	5.89	5.88	5.88	99.28	5.88	61.65
18	5.89	5.88	5.88	99.29	8.59	66.31
16	5.89	5.88	5.88	99.31	12.80	71.62
14	5.89	7.14	5.88	99.34	19.93	80.33
12	5.89	11.93	5.88	99.38	40.37	84.71
10	5.89	15.66	10.66	99.48	58.59	92.02
8	6.95	21.87	15.74	99.57	78.68	97.89
6	14.48	33.23	20.26	99.64	88.89	99.00
4	26.73	49.34	25.86	99.74	96.82	99.46
2	55.85	76.17	56.27	99.96	99.06	99.69
0	100.00	100.00	100.00	100.00	100.00	100.00

APPENDIX K-68
PERCENT EXCEEDENCE FOR MAXIMUM HABITAT
REACH E, RACEWAY GUILD, FALL
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	300MOD50	MOD55	480MOD55	WET	WETOF
100	0.00	0.00	0.00	0.00	0.00	0.00
98	0.00	0.00	0.00	2.61	0.00	0.00
96	0.00	0.00	0.00	51.04	0.00	2.04
94	0.00	0.51	0.00	62.04	0.00	6.24
92	2.07	4.67	0.00	66.80	1.25	10.33
90	3.55	6.24	0.00	68.51	2.46	23.36
88	4.04	7.48	0.83	70.61	3.80	29.45
86	5.57	8.82	5.14	71.79	5.39	36.61
84	7.67	19.43	7.55	72.75	7.86	39.65
82	12.54	27.80	10.82	73.99	23.89	43.50
80	28.67	33.35	18.28	74.91	37.25	50.85
78	32.84	35.74	31.13	75.99	40.22	52.47
76	33.63	37.40	33.19	76.89	45.00	53.50
74	34.67	38.20	36.38	77.66	46.90	54.79
72	35.78	39.52	37.81	78.26	48.47	56.36
70	36.78	40.92	38.57	78.91	49.42	59.48
68	38.81	42.46	39.85	79.32	50.83	63.90
66	39.95	44.34	41.03	79.66	52.50	69.50
64	40.69	46.12	42.14	80.37	53.58	71.81
62	41.42	47.79	42.53	80.65	55.30	74.67
60	43.10	50.13	43.32	81.56	56.20	78.29
58	45.01	51.87	44.78	82.24	57.36	79.92
56	46.55	53.45	46.99	82.64	58.61	82.35
54	48.52	55.12	49.77	83.05	59.69	83.87
52	50.01	56.66	52.27	83.53	60.45	86.11
50	51.08	58.70	54.96	84.01	61.65	87.57
48	52.12	59.76	57.39	84.86	62.44	89.81
46	53.74	60.98	59.24	85.45	63.71	91.41
44	55.58	63.15	62.48	85.80	64.92	92.59
42	57.33	64.65	64.23	86.34	65.99	95.02
40	58.89	66.19	65.61	86.62	66.91	97.52
38	61.49	68.28	67.40	86.78	68.18	99.43
36	63.01	70.37	68.64	87.01	69.85	99.45
34	64.64	72.55	70.60	87.25	71.38	99.48
32	67.15	74.19	72.36	87.50	73.32	99.50
30	69.03	75.73	74.64	87.73	75.71	99.52
28	70.39	77.43	77.20	87.92	77.11	99.54
26	72.42	80.52	78.68	88.26	78.93	99.56
24	75.49	83.13	82.10	88.72	81.56	99.58
22	77.99	85.95	83.99	89.43	85.48	99.61
20	81.69	89.70	86.59	90.68	88.82	99.62
18	84.08	91.90	89.73	92.27	91.99	99.65
16	85.67	98.23	91.53	93.46	95.28	99.67
14	88.01	99.50	94.91	95.02	99.44	99.70
12	90.76	99.51	97.79	96.44	99.47	99.72
10	95.06	99.54	99.44	99.54	99.49	99.77
8	98.02	99.58	99.48	99.96	99.54	99.80
6	99.48	99.63	99.50	99.96	99.71	99.83
4	99.52	99.72	99.54	99.96	99.85	99.89
2	99.66	99.83	99.64	99.98	99.93	99.93
0	100.00	100.00	100.00	100.00	100.00	100.00

APPENDIX K-69
PERCENT EXCEEDENCE FOR MAXIMUM HABITAT
REACH E, MEDIUM POOL GUILD, FALL
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	300MOD50	MOD55	480MOD55	WET	WETOF
100	14.08	13.96	15.59	12.35	11.22	10.87
98	31.46	25.05	31.31	14.44	13.70	12.55
96	40.25	33.49	40.35	15.23	16.93	15.87
94	40.36	38.56	40.35	15.45	20.18	16.62
92	40.36	40.36	40.35	15.66	24.10	16.91
90	41.50	40.74	40.35	15.77	30.56	17.49
88	44.29	41.76	40.35	15.88	36.29	20.72
86	46.61	43.12	40.35	15.98	40.34	23.13
84	48.93	44.32	41.42	16.09	40.75	25.84
82	50.57	45.62	43.46	16.17	42.07	28.05
80	53.98	46.81	44.54	16.22	43.22	29.48
78	55.63	47.81	46.44	16.30	44.78	31.36
76	57.25	51.72	48.28	16.35	45.52	33.24
74	58.39	54.09	49.95	16.39	46.78	34.71
72	59.98	56.31	51.50	16.42	50.34	35.96
70	62.15	59.01	53.63	16.47	52.74	37.13
68	63.79	60.62	55.25	16.51	54.80	37.72
66	65.48	62.97	57.54	16.58	56.88	39.31
64	66.99	64.01	58.65	16.64	58.43	40.26
62	68.11	65.14	60.12	16.68	60.88	40.34
60	68.89	66.17	62.76	16.71	62.52	41.14
58	69.74	67.14	63.88	16.75	63.63	42.05
56	70.85	68.60	65.71	16.79	64.55	43.44
54	71.92	70.32	67.10	16.88	65.98	44.27
52	73.06	71.63	68.66	16.93	67.50	45.35
50	74.23	72.69	69.83	16.97	68.80	46.56
48	75.28	73.70	71.01	17.00	69.93	48.51
46	76.87	75.35	72.08	17.02	70.37	50.94
44	78.07	76.15	73.09	17.04	71.21	52.60
42	79.22	76.82	74.91	17.06	71.77	54.25
40	80.12	77.95	76.71	17.08	72.62	56.38
38	81.58	79.03	77.95	17.10	73.45	58.18
36	82.38	79.89	79.16	17.12	74.48	59.22
34	83.00	80.90	80.70	17.14	75.22	61.42
32	83.76	81.96	82.11	17.17	75.74	62.62
30	84.98	83.03	84.17	17.25	76.45	65.33
28	86.20	84.48	85.80	17.32	77.43	67.52
26	86.83	85.37	87.08	17.48	77.96	69.65
24	88.06	86.10	88.03	17.59	78.75	73.15
22	89.11	86.55	88.61	17.75	79.37	76.33
20	90.14	87.56	89.03	17.98	80.17	78.57
18	90.39	89.04	89.26	18.14	81.19	79.74
16	91.06	90.05	90.30	19.27	82.40	80.52
14	91.78	91.03	90.82	20.16	83.38	81.36
12	92.73	91.80	91.67	20.34	84.00	82.31
10	93.68	92.42	92.10	20.37	85.00	83.91
8	94.26	93.38	93.00	47.16	85.97	89.39
6	94.83	94.68	94.11	57.23	87.59	91.59
4	95.51	95.60	95.61	63.45	91.36	96.58
2	96.10	97.56	96.90	72.07	95.25	98.27
0	100.00	100.00	100.00	100.00	100.00	100.00

APPENDIX K-70
PERCENT EXCEEDENCE FOR MAXIMUM HABITAT
REACH E, DEEP POOL GUILD, FALL
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	300MOD50	MOD55	480MOD55	WET	WETOF
100	0.00	0.00	0.00	0.00	0.00	0.00
98	0.00	0.00	0.00	0.00	0.00	0.00
96	0.00	0.00	0.00	32.37	0.00	0.00
94	0.00	0.00	0.00	37.13	0.00	2.31
92	0.00	0.04	0.00	38.27	0.00	6.08
90	0.00	2.31	0.00	39.23	0.00	6.08
88	0.00	4.22	0.00	40.09	0.00	9.10
86	1.27	6.09	0.61	40.60	1.00	18.59
84	4.53	6.09	4.34	41.09	4.81	27.07
82	6.11	6.95	6.09	41.48	6.08	29.35
80	8.31	14.16	6.09	41.95	19.24	36.01
78	13.56	17.28	11.30	42.32	27.24	38.78
76	14.59	19.44	13.98	42.71	29.31	39.82
74	15.95	20.48	18.14	43.03	31.60	41.21
72	17.40	22.20	20.00	43.22	33.24	42.62
70	18.71	24.01	20.99	43.38	34.82	44.46
68	21.35	26.02	22.66	43.57	36.15	46.41
66	22.84	28.46	24.19	43.87	38.25	48.19
64	23.81	30.77	25.63	44.07	39.74	49.21
62	24.76	32.94	26.15	44.40	42.19	51.57
60	26.95	35.63	27.17	44.63	43.05	53.67
58	29.44	38.19	29.07	44.81	44.43	57.83
56	31.45	40.26	31.95	44.99	45.62	60.38
54	34.02	42.35	35.57	45.22	47.24	62.03
52	35.86	44.48	38.82	45.55	48.69	63.57
50	37.18	47.13	42.07	45.88	49.41	66.63
48	38.60	48.52	45.48	46.08	50.61	68.49
46	40.34	50.02	47.63	46.31	51.50	70.01
44	43.17	51.61	50.86	46.44	52.69	72.12
42	45.42	54.33	53.33	46.50	54.01	73.60
40	47.55	56.39	55.50	46.61	55.69	74.53
38	50.54	58.37	56.87	46.71	56.76	76.89
36	52.41	60.30	58.82	46.83	57.77	77.78
34	54.53	63.16	60.30	46.92	59.02	79.19
32	57.08	65.28	63.33	46.99	59.99	80.14
30	59.78	67.32	65.26	47.14	62.31	81.26
28	61.47	69.34	68.63	47.33	63.73	82.72
26	63.61	71.29	71.79	47.63	65.60	83.82
24	65.99	73.05	74.47	48.40	67.94	84.66
22	70.76	76.32	77.64	48.99	70.07	86.27
20	73.40	79.08	79.84	49.47	72.47	87.53
18	76.37	80.90	82.28	50.19	74.07	88.56
16	79.44	84.04	85.56	51.91	76.88	90.07
14	81.94	87.51	88.23	52.65	81.45	91.10
12	84.03	88.93	90.04	54.25	85.09	92.67
10	87.00	91.66	91.94	55.32	88.99	93.82
8	89.90	94.51	93.60	55.57	92.15	94.63
6	94.04	96.31	95.07	58.81	94.71	95.97
4	95.67	98.61	96.95	72.82	96.38	97.51
2	97.64	99.47	98.31	89.35	98.39	98.84
0	100.00	100.00	100.00	100.00	100.00	100.00

APPENDIX K-71
PERCENT EXCEEDENCE FOR MAXIMUM HABITAT
REACH E, LOW GRADIENT GROUP, FALL
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	300MOD50	MOD55	480MOD55	WET	WETOF
100	56.94	55.84	62.07	46.93	41.61	40.05
98	70.36	68.52	70.53	56.30	55.18	52.28
96	71.74	69.77	71.97	58.76	65.63	63.62
94	72.32	70.52	72.24	59.47	67.98	66.09
92	72.67	71.06	72.45	60.14	68.56	67.05
90	73.13	71.34	72.69	60.47	69.53	68.96
88	73.54	71.52	73.01	60.80	70.38	69.60
86	73.83	71.74	73.31	61.12	71.33	69.97
84	74.05	71.88	73.66	61.46	71.67	70.38
82	74.22	72.52	73.84	61.74	71.87	70.71
80	74.43	72.74	74.14	61.89	72.35	70.93
78	74.74	73.05	74.39	62.13	72.76	71.22
76	74.94	73.36	74.60	62.30	73.07	71.50
74	75.17	73.57	74.78	62.42	73.40	71.73
72	75.41	73.88	75.04	62.51	73.84	71.92
70	75.56	74.02	75.19	62.68	74.06	72.10
68	75.68	74.20	75.43	62.78	74.27	72.19
66	75.87	74.35	75.57	63.02	74.39	72.43
64	76.09	74.51	75.73	63.21	74.64	72.57
62	76.20	74.75	75.92	63.32	74.78	72.75
60	76.40	74.93	76.04	63.43	74.97	72.94
58	76.54	75.07	76.18	63.57	75.04	73.07
56	76.76	75.21	76.29	63.69	75.17	73.24
54	76.94	75.41	76.46	63.97	75.25	73.47
52	77.10	75.56	76.69	64.12	75.37	73.60
50	77.20	75.67	76.92	64.26	75.51	73.99
48	77.33	75.75	77.06	64.34	75.60	74.29
46	77.44	75.90	77.34	64.41	75.72	74.53
44	77.54	76.06	77.54	64.46	75.79	74.85
42	77.66	76.21	77.68	64.53	75.89	75.11
40	77.86	76.32	77.92	64.60	76.01	75.27
38	78.01	76.42	78.18	64.66	76.11	75.55
36	78.18	76.62	78.31	64.71	76.22	75.69
34	78.32	76.77	78.45	64.78	76.28	76.01
32	78.46	76.91	78.52	64.89	76.47	76.31
30	78.52	77.05	78.55	65.12	76.58	76.58
28	78.64	77.20	78.69	65.34	76.74	77.13
26	78.79	77.34	78.80	65.85	76.85	77.57
24	78.93	77.48	78.89	66.19	76.97	77.87
22	79.03	77.60	79.00	66.68	77.12	78.02
20	79.14	77.74	79.14	67.42	77.32	78.13
18	79.22	77.78	79.43	67.91	77.84	78.24
16	79.36	77.91	79.76	68.12	78.57	78.39
14	83.05	78.09	84.48	68.25	82.70	78.65
12	87.76	78.40	91.01	68.28	87.69	79.47
10	89.44	80.14	91.01	68.28	89.86	80.17
8	90.77	84.56	91.01	73.01	90.65	80.51
6	90.77	89.62	91.01	74.17	91.99	82.16
4	91.00	89.77	91.01	75.40	94.88	91.89
2	94.26	93.61	94.80	90.31	97.39	91.89
0	100.00	100.00	100.00	100.00	100.00	100.00

APPENDIX K-72
PERCENT EXCEEDENCE FOR MAXIMUM HABITAT
REACH E, TRICHOPTERA GROUP, FALL
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	300MOD50	MOD55	480MOD55	WET	WETOF
100	42.56	42.54	42.54	42.54	42.52	42.52
98	42.56	42.54	42.54	60.48	42.52	42.52
96	42.56	44.18	42.54	71.33	43.37	56.90
94	44.35	51.24	42.54	75.24	46.95	62.46
92	60.09	72.39	42.54	76.34	55.26	73.79
90	68.48	76.59	42.54	77.72	60.47	77.35
88	71.27	78.11	53.02	78.26	64.15	80.63
86	75.54	78.70	75.65	78.82	69.90	84.53
84	78.37	84.84	78.22	79.37	75.50	86.46
82	80.71	88.82	80.22	79.94	77.54	87.36
80	86.22	90.00	84.14	80.39	83.15	88.67
78	89.95	90.24	89.36	80.63	87.47	89.63
76	90.10	90.62	89.97	81.02	90.11	90.52
74	90.26	90.72	90.34	81.33	90.92	91.12
72	90.39	90.89	90.61	81.50	91.66	91.79
70	90.57	91.08	90.81	81.68	91.87	92.37
68	90.81	91.32	90.93	81.94	92.08	92.67
66	91.02	91.58	91.10	82.12	92.31	92.85
64	91.17	91.80	91.32	82.53	92.46	93.00
62	91.24	92.05	91.40	82.77	92.67	93.16
60	91.50	92.29	91.48	83.03	92.86	93.33
58	91.71	92.64	91.66	83.18	93.01	93.54
56	91.96	92.88	91.87	83.40	93.23	93.88
54	92.21	93.09	92.22	83.65	93.38	94.04
52	92.50	93.33	92.79	84.02	93.52	94.34
50	92.64	93.58	93.05	84.35	93.68	94.78
48	92.82	93.89	93.40	84.57	93.87	95.16
46	92.98	94.05	93.81	84.72	94.06	95.49
44	93.26	94.22	94.14	84.83	94.18	95.64
42	93.53	94.44	94.54	84.90	94.32	95.93
40	93.82	94.72	94.74	85.02	94.47	96.15
38	94.18	94.93	94.96	85.15	94.65	96.32
36	94.42	95.14	95.15	85.25	94.84	96.61
34	94.73	95.35	95.38	85.35	94.95	96.83
32	94.90	95.70	95.65	85.45	95.06	96.96
30	95.21	95.98	95.94	85.62	95.28	97.05
28	95.44	96.21	96.20	86.01	95.46	97.34
26	95.66	96.37	96.59	86.22	95.68	97.52
24	95.98	96.62	96.81	87.16	95.90	97.65
22	96.34	96.78	97.25	87.66	96.27	97.80
20	96.71	97.24	97.53	88.41	96.45	98.03
18	96.99	97.58	97.82	89.05	96.76	98.16
16	97.49	97.80	98.07	90.60	97.08	98.37
14	97.78	98.23	98.37	91.06	97.67	98.62
12	98.06	98.55	98.62	91.27	98.04	98.80
10	98.36	98.72	98.80	91.38	98.46	98.92
8	98.68	99.07	99.00	91.41	98.81	99.16
6	99.12	99.35	99.25	95.24	99.14	99.35
4	99.35	99.83	99.50	96.86	99.40	99.55
2	99.72	99.91	99.81	98.68	99.69	99.79
0	100.00	100.00	100.00	100.00	100.00	100.00

HABITAT REACH B

APPENDIX K-73
PERCENT EXCEEDENCE FOR MAXIMUM WUA, HABITAT REACH B, SHALLOW POOL GUILD, SPRING
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	300MOD50	MOD55	480MOD55	WET	WETOF
100	5.91	0.86	0.84	0.83	0.87	1.23
98	6.06	0.96	0.90	0.89	0.96	1.34
96	6.36	1.12	0.98	0.97	1.07	1.48
94	6.50	1.26	1.15	1.08	1.14	1.57
92	7.35	1.72	1.21	1.19	1.24	1.70
90	8.42	2.00	1.31	1.23	1.28	1.74
88	8.95	2.21	1.55	1.39	1.39	1.80
86	9.50	2.37	1.81	1.52	1.70	2.09
84	9.93	2.55	2.04	1.69	1.93	2.28
82	10.45	2.71	2.15	1.86	2.10	2.45
80	10.79	2.91	2.26	1.96	2.17	2.62
78	11.11	3.05	2.34	2.08	2.31	2.73
76	11.53	3.26	2.45	2.16	2.43	2.88
74	11.79	3.42	2.57	2.27	2.55	3.02
72	12.21	3.62	2.67	2.36	2.64	3.14
70	12.45	3.76	2.75	2.46	2.75	3.23
68	12.65	3.85	2.86	2.56	2.84	3.34
66	12.87	3.98	3.02	2.69	2.94	3.50
64	13.46	4.07	3.22	2.77	3.08	3.68
62	14.83	8.81	3.39	2.96	3.19	3.78
60	16.05	12.03	3.54	3.12	3.35	3.93
58	16.79	15.15	3.68	3.31	3.53	4.14
56	17.69	18.19	3.79	3.38	3.69	4.40
54	18.04	20.00	3.90	3.47	3.86	4.62
52	18.57	21.16	4.96	3.52	3.98	4.78
50	19.08	22.88	8.98	3.58	4.09	4.97
48	19.56	24.09	13.91	3.64	4.14	5.15
46	20.02	25.01	16.96	3.68	5.09	5.30
44	20.45	26.33	20.04	3.71	9.63	5.50
42	20.62	26.99	22.69	3.75	12.87	5.61
40	21.55	28.04	25.94	3.78	15.23	5.75
38	22.53	29.00	28.31	3.82	18.15	5.82
36	24.42	30.84	30.19	3.94	20.08	7.22
34	26.24	33.31	33.16	7.87	21.99	9.76
32	28.15	36.58	35.29	11.20	24.07	16.01
30	31.27	40.79	38.19	17.60	25.71	19.56
28	33.97	43.32	40.44	21.16	26.90	23.11
26	35.43	44.74	42.20	27.09	28.38	27.35
24	38.79	48.96	44.22	30.27	29.57	32.81
22	40.30	51.20	45.27	34.33	34.38	35.97
20	41.06	51.93	46.57	37.42	40.56	38.86
18	42.06	52.96	47.98	41.06	43.50	40.46
16	44.78	55.09	49.33	44.11	47.84	41.64
14	49.36	57.69	50.72	46.50	53.06	43.22
12	55.95	62.93	56.31	47.99	57.17	47.51
10	57.03	65.50	62.86	50.28	59.49	57.72
8	59.05	69.22	64.81	56.27	63.24	61.72
6	67.68	76.35	67.13	62.97	68.63	65.60
4	73.09	80.35	74.05	65.74	73.43	85.01
2	80.19	85.85	80.35	78.52	89.50	91.78
0	100.00	100.00	100.00	100.00	100.00	100.00

APPENDIX K-74
PERCENT EXCEEDENCE FOR MAXIMUM WUA, HABITAT REACH B, SLOW RIFFLE GUILD, SPRING
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	300MOD50	MOD55	480MOD55	WET	WETOF
100	9.27	0.82	0.70	0.80	0.77	0.72
98	9.82	2.79	1.99	3.22	2.38	3.90
96	10.59	3.82	3.53	5.58	5.06	5.70
94	11.36	5.78	5.39	7.83	6.03	9.36
92	13.98	6.69	6.98	9.68	6.60	11.81
90	15.88	8.08	9.23	11.27	8.90	14.40
88	16.82	9.72	10.85	13.22	11.03	16.82
86	17.81	11.30	12.71	15.85	13.08	19.13
84	18.58	12.75	14.84	18.10	14.88	20.12
82	19.51	13.99	16.76	19.98	18.07	21.57
80	21.92	15.90	18.67	20.95	20.26	28.58
78	26.12	18.13	20.05	22.53	21.02	32.39
76	31.77	20.85	21.05	25.74	24.34	34.91
74	35.25	23.71	22.50	28.47	29.09	36.78
72	40.74	30.24	25.81	30.96	34.92	39.35
70	44.00	33.33	27.79	34.73	38.86	42.63
68	46.56	35.51	29.45	38.12	41.88	44.68
66	49.45	40.09	32.17	41.16	45.38	49.10
64	51.10	43.50	34.82	44.45	49.12	51.69
62	58.40	47.06	37.86	47.69	51.67	55.03
60	65.68	51.11	40.62	50.40	54.66	57.36
58	70.68	55.39	43.86	54.01	58.04	59.45
56	73.41	57.53	47.82	55.57	61.30	61.78
54	74.23	61.67	51.55	58.57	64.84	64.78
52	74.95	64.62	54.39	60.97	68.17	67.66
50	75.68	68.29	56.51	63.78	70.36	69.83
48	76.15	71.05	59.13	66.08	71.91	70.85
46	76.78	72.15	61.64	68.92	72.90	71.77
44	77.62	72.91	63.79	71.09	73.81	72.54
42	78.26	73.82	66.16	73.15	75.08	73.69
40	79.25	74.54	68.75	75.93	75.85	74.78
38	80.91	75.47	70.89	78.28	76.70	76.15
36	82.03	76.63	72.36	80.26	77.90	78.18
34	82.82	77.46	73.87	82.35	79.50	80.30
32	83.46	78.46	76.30	84.13	80.78	82.35
30	84.64	79.86	77.97	86.06	81.77	83.91
28	85.85	81.02	79.30	88.25	82.81	85.59
26	87.01	82.10	80.75	89.67	83.93	86.49
24	88.15	83.26	82.03	90.79	84.68	87.69
22	89.33	84.31	83.70	92.09	86.27	88.80
20	90.25	85.93	85.11	92.85	87.72	89.87
18	91.05	87.41	86.33	93.52	89.11	91.09
16	92.25	88.90	88.58	94.36	90.41	92.46
14	92.91	90.14	90.47	94.90	91.60	93.41
12	94.11	91.99	92.23	95.47	93.27	95.07
10	95.49	93.62	93.59	95.96	95.39	96.54
8	96.61	95.08	94.79	96.55	96.50	97.44
6	97.95	95.97	96.33	97.05	97.84	98.36
4	98.46	97.27	97.50	97.56	98.99	99.05
2	99.14	98.95	99.06	98.78	99.54	99.78
0	100.00	100.00	100.00	100.00	100.00	100.00

APPENDIX K-75
PERCENT EXCEEDENCE FOR MAXIMUM WUA, HABITAT REACH B, FAST RIFFLE GUILD, SPRING
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	300MOD50	MOD55	480MOD55	WET	WETOF
100	6.14	0.00	0.00	0.00	0.00	0.00
98	7.16	0.00	0.00	0.00	0.00	0.00
96	8.27	0.00	0.00	0.00	0.00	0.20
94	9.28	0.00	0.00	0.00	0.00	0.66
92	10.01	0.00	0.00	0.31	0.02	0.68
90	10.33	0.00	0.00	0.61	0.28	0.70
88	10.50	0.00	0.31	0.63	0.44	0.75
86	10.68	0.33	0.61	0.64	0.60	0.77
84	10.88	0.51	0.62	0.65	0.64	0.80
82	11.11	0.61	0.63	0.68	0.67	0.82
80	11.85	0.62	0.64	0.70	0.69	0.85
78	13.91	0.62	0.65	0.73	0.73	0.90
76	19.02	0.64	0.66	0.76	0.79	0.96
74	23.35	0.67	0.68	0.82	0.82	1.07
72	28.58	0.68	0.69	0.98	0.86	1.14
70	32.20	0.70	0.71	1.08	0.89	1.21
68	35.79	0.73	0.73	1.25	0.93	1.28
66	41.37	0.75	0.74	1.34	0.98	1.39
64	45.83	0.77	0.77	1.75	1.03	1.44
62	52.00	0.81	0.80	3.80	1.08	1.56
60	55.83	0.83	0.86	4.52	1.16	2.37
58	59.43	0.86	0.95	4.99	1.22	4.01
56	62.42	0.88	1.03	5.69	1.30	5.29
54	64.46	0.91	1.11	6.30	1.42	7.68
52	66.63	0.94	1.19	6.99	1.72	9.44
50	69.01	0.97	1.33	7.95	2.57	11.57
48	70.80	1.02	1.44	8.96	4.26	13.86
46	72.94	1.05	2.47	9.88	6.19	15.72
44	75.28	1.10	4.49	11.46	9.07	18.28
42	76.80	1.18	6.31	12.67	11.57	21.39
40	78.26	1.26	8.79	15.92	14.48	21.81
38	80.29	1.35	11.46	18.63	17.19	21.95
36	81.60	1.56	14.26	21.43	18.94	22.04
34	81.97	3.09	17.77	21.54	21.16	22.20
32	82.81	5.33	20.57	21.70	21.39	22.34
30	83.51	6.82	21.71	21.83	21.50	22.44
28	84.44	9.17	21.81	21.97	21.64	22.52
26	85.43	12.58	21.96	22.09	21.75	22.64
24	86.27	15.29	22.11	22.23	21.90	22.76
22	87.10	18.81	22.25	22.33	22.05	22.89
20	87.90	21.31	22.37	22.50	22.22	22.99
18	88.60	21.97	22.51	22.63	22.32	23.15
16	89.89	22.18	22.66	22.85	22.52	23.31
14	91.22	22.42	22.96	23.08	22.81	23.48
12	92.38	22.62	23.31	23.25	23.20	26.62
10	93.37	22.91	23.63	25.94	27.54	34.47
8	94.90	23.27	29.41	33.14	34.26	39.62
6	96.17	26.64	41.35	53.78	51.03	56.93
4	97.52	53.42	72.40	73.17	63.49	68.26
2	98.84	81.67	87.89	87.97	84.27	86.36
0	100.00	100.00	100.00	100.00	100.00	100.00

APPENDIX K-76
PERCENT EXCEEDENCE FOR MAXIMUM WUA, HABITAT REACH B, RACEWAY GUILD, SPRING
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	300MOD50	MOD55	480MOD55	WET	WETOF
100	0.43	0.00	0.02	0.02	0.08	0.48
98	6.18	0.18	0.27	0.29	0.20	3.78
96	8.73	0.26	0.35	1.80	0.40	6.92
94	10.68	0.34	0.98	3.43	2.00	30.41
92	14.27	0.89	2.35	8.04	5.08	37.05
90	20.33	3.02	3.50	16.12	7.73	43.88
88	23.59	4.50	8.02	21.86	9.38	50.58
86	32.45	8.19	14.99	25.60	15.40	51.97
84	37.46	10.07	18.50	31.63	27.91	53.22
82	40.98	13.11	21.89	39.29	38.31	54.86
80	43.15	15.61	25.44	48.45	45.36	55.75
78	44.82	17.40	28.72	50.37	50.20	56.41
76	48.11	22.88	31.35	51.30	51.68	57.28
74	54.24	33.22	36.42	53.64	53.23	58.99
72	55.80	36.68	40.86	54.75	55.26	59.87
70	57.21	42.89	46.51	56.09	56.27	60.66
68	60.02	50.30	50.13	56.76	56.71	61.55
66	63.55	51.76	51.16	58.18	57.82	62.02
64	65.92	53.74	52.68	58.97	60.22	62.92
62	69.30	55.67	54.54	60.11	61.72	63.65
60	71.96	58.56	56.03	61.47	63.18	64.37
58	74.14	60.80	56.77	62.51	63.76	64.88
56	76.02	62.71	58.18	63.22	64.77	65.31
54	77.60	64.05	59.54	64.13	65.70	66.08
52	79.12	64.97	61.40	64.90	66.64	66.95
50	80.28	66.05	62.78	65.62	67.34	67.61
48	81.78	67.41	64.07	66.36	68.10	68.25
46	82.97	68.51	64.97	67.18	68.92	68.92
44	84.06	69.49	65.66	67.75	69.62	69.51
42	85.07	70.48	66.29	68.81	70.25	70.13
40	86.28	71.34	67.09	69.43	71.08	71.03
38	87.39	71.98	67.75	70.42	72.34	72.19
36	87.67	73.10	68.57	72.48	73.57	73.37
34	88.08	73.60	69.27	75.05	74.38	74.87
32	88.52	74.82	69.73	78.93	75.07	76.90
30	89.17	75.74	70.60	81.07	76.64	78.26
28	89.67	76.75	72.47	83.18	78.04	79.95
26	90.42	78.17	74.89	84.58	79.92	81.68
24	91.00	79.69	76.71	85.81	80.86	83.74
22	91.51	80.54	78.16	87.78	82.82	85.29
20	92.05	82.18	80.36	88.80	83.94	87.06
18	92.55	83.43	82.57	90.37	85.60	88.30
16	93.34	85.35	84.54	91.49	87.81	89.27
14	94.13	87.50	87.03	92.60	89.27	91.23
12	95.11	89.56	88.75	93.12	91.10	93.26
10	95.73	91.42	91.15	93.92	93.16	94.90
8	96.76	93.09	93.35	94.81	95.36	96.40
6	97.54	94.45	94.99	95.40	97.23	97.78
4	98.43	96.35	96.33	96.33	98.42	98.75
2	99.27	98.40	98.71	98.49	99.38	99.64
0	100.00	100.00	100.00	100.00	100.00	100.00

APPENDIX K-77
PERCENT EXCEEDENCE FOR MAXIMUM WUA, HABITAT REACH B, MEDIUM POOL GUILD, SPRING
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	300MOD50	MOD55	480MOD55	WET	WETOF
100	3.25	0.56	0.56	0.55	0.54	0.56
98	4.19	0.76	0.69	0.68	0.71	0.71
96	5.51	1.07	0.86	0.84	0.94	0.90
94	6.72	1.22	1.20	1.05	1.08	1.03
92	6.75	1.24	1.22	1.22	1.22	1.22
90	6.76	1.26	1.23	1.23	1.23	1.23
88	6.78	1.28	1.24	1.24	1.24	1.24
86	6.80	1.29	1.25	1.25	1.25	1.25
84	6.82	1.31	1.26	1.26	1.26	1.25
82	6.87	1.34	1.27	1.27	1.27	1.26
80	6.96	1.38	1.28	1.28	1.28	1.27
78	7.44	1.68	1.29	1.29	1.29	1.28
76	8.10	2.23	1.31	1.30	1.30	1.29
74	8.50	2.66	1.33	1.31	1.31	1.30
72	9.13	3.20	1.35	1.32	1.32	1.30
70	9.51	3.57	1.37	1.34	1.33	1.31
68	9.80	3.80	1.40	1.35	1.35	1.32
66	10.14	4.15	1.83	1.36	1.38	1.33
64	10.83	4.40	2.38	1.38	1.59	1.34
62	12.26	9.46	2.83	1.66	1.87	1.35
60	13.55	12.89	3.25	2.09	2.31	1.37
58	14.33	15.28	3.64	2.61	2.77	1.38
56	15.28	17.65	3.93	2.81	3.18	1.75
54	15.65	20.21	4.25	3.06	3.64	2.15
52	16.20	22.24	5.51	3.21	3.95	2.45
50	16.74	23.45	9.92	3.37	4.22	2.81
48	17.25	25.09	15.32	3.52	4.36	3.15
46	17.73	26.20	18.67	3.63	5.38	3.43
44	18.18	27.25	21.94	3.73	10.12	3.81
42	18.36	28.41	24.49	3.84	13.51	4.01
40	21.37	29.47	26.96	3.92	15.97	4.27
38	24.87	30.17	30.70	4.03	19.02	4.40
36	31.63	31.56	33.78	4.36	21.04	5.45
34	38.17	35.30	39.52	8.70	23.03	7.35
32	43.62	42.16	46.54	12.35	25.21	12.01
30	49.93	48.80	52.21	19.37	26.91	14.66
28	60.07	52.47	56.80	23.14	28.16	17.31
26	66.85	59.27	60.87	29.09	29.70	20.47
24	70.67	63.95	65.83	32.59	30.88	24.55
22	74.73	67.21	69.85	42.93	34.52	26.91
20	79.01	71.18	73.65	49.82	45.37	29.06
18	82.35	76.13	76.61	56.60	55.28	30.25
16	85.76	82.45	79.11	65.45	62.06	31.13
14	89.36	85.84	81.02	71.82	69.16	32.48
12	91.29	88.63	83.16	77.55	76.69	41.03
10	93.59	92.28	85.79	82.43	81.60	61.52
8	95.33	93.90	87.32	85.29	87.10	69.54
6	96.91	95.19	91.01	86.99	92.88	76.22
4	97.38	97.25	93.45	91.92	95.49	87.02
2	98.47	98.49	95.95	95.56	97.23	93.96
0	100.00	100.00	100.00	100.00	100.00	100.00

APPENDIX K-78
PERCENT EXCEEDENCE FOR MAXIMUM WUA, HABITAT REACH B, DEEP POOL GUILD, SPRING
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	300MOD50	MOD55	480MOD55	WET	WETOF
100	0.00	0.00	0.02	0.01	0.00	0.02
98	0.00	0.15	0.16	0.15	0.20	0.19
96	0.00	0.36	0.35	0.28	0.45	0.41
94	0.00	0.60	0.59	0.55	0.58	0.55
92	0.00	0.64	0.60	0.60	0.61	0.61
90	0.00	0.66	0.63	0.62	0.62	0.63
88	0.00	0.70	0.65	0.65	0.64	0.65
86	1.11	0.73	0.67	0.66	0.66	0.67
84	2.21	0.75	0.69	0.69	0.67	0.69
82	4.81	0.79	0.71	0.70	0.70	0.71
80	6.36	0.83	0.73	0.72	0.72	0.73
78	8.75	0.89	0.75	0.74	0.75	0.74
76	11.10	1.01	0.78	0.76	0.77	0.76
74	13.70	1.38	0.81	0.79	0.79	0.77
72	16.65	1.67	0.85	0.80	0.81	0.79
70	19.39	1.91	0.89	0.83	0.85	0.80
68	22.51	2.14	0.91	0.86	0.86	0.82
66	24.30	2.37	0.97	0.89	0.89	0.83
64	27.63	2.51	1.23	0.91	0.92	0.85
62	30.86	2.72	1.66	0.93	0.97	0.87
60	33.82	2.85	1.99	1.09	1.23	0.90
58	38.04	2.96	2.16	1.50	1.46	0.92
56	41.70	4.15	2.39	1.73	1.77	0.99
54	47.56	7.12	2.59	1.86	2.01	1.31
52	51.95	8.69	2.72	2.04	2.31	1.53
50	55.35	12.49	2.91	2.12	2.52	1.81
48	58.98	14.89	3.25	2.26	2.71	2.07
46	62.99	16.53	4.83	2.36	2.90	2.28
44	64.95	19.81	6.57	2.44	3.00	2.57
42	65.44	23.09	8.05	2.51	3.86	2.73
40	66.19	25.36	12.95	2.59	6.11	2.93
38	66.66	28.05	16.79	2.65	9.40	3.03
36	67.54	33.63	22.44	2.72	11.88	5.73
34	68.67	39.91	26.69	2.92	14.13	7.98
32	69.63	47.16	29.92	4.01	16.45	10.54
30	70.71	50.36	33.81	7.34	23.10	12.69
28	71.80	53.98	38.19	11.96	29.02	22.11
26	72.84	58.20	42.11	14.87	36.03	32.62
24	74.14	62.75	45.61	22.08	42.23	39.83
22	76.24	66.44	48.06	26.76	50.07	47.66
20	77.65	69.67	53.35	31.98	54.82	52.72
18	79.53	74.55	57.69	37.42	59.62	55.58
16	81.42	77.79	62.11	43.70	63.24	62.34
14	83.27	80.17	66.22	50.51	67.88	72.81
12	85.01	82.97	71.22	56.70	72.69	79.25
10	88.05	86.71	75.97	63.57	79.21	85.85
8	89.37	88.64	80.18	70.74	82.56	89.28
6	91.25	91.69	86.45	79.35	87.60	93.15
4	93.35	93.75	91.95	86.27	91.02	95.53
2	96.19	97.02	96.49	92.98	95.02	98.28
0	100.00	100.00	100.00	100.00	100.00	100.00

APPENDIX K-79
PERCENT EXCEEDENCE FOR MAXIMUM WUA, HABITAT REACH B, LOW GRADIENT GROUP, SPRING
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	300MOD50	MOD55	480MOD55	WET	WETOF
100	11.98	11.15	10.96	10.49	10.27	10.94
98	12.41	18.19	15.63	15.19	16.45	16.21
96	13.02	29.05	21.62	20.98	24.62	23.20
94	13.63	39.34	33.61	28.56	29.52	27.58
92	17.08	53.81	38.22	36.63	36.11	34.27
90	19.59	59.76	42.72	39.44	38.75	36.26
88	20.84	66.40	50.17	44.97	42.93	39.30
86	22.15	70.80	58.22	49.03	52.32	45.97
84	23.17	75.23	65.32	54.32	59.17	50.02
82	24.39	75.97	68.81	59.70	63.97	53.72
80	26.66	76.24	72.08	62.67	66.24	57.35
78	30.34	76.42	74.80	66.60	70.35	59.63
76	35.29	78.00	76.08	69.07	73.97	62.82
74	38.35	79.13	76.26	72.46	75.73	65.67
72	43.16	79.83	76.56	75.24	76.17	68.36
70	46.02	82.17	77.51	76.09	76.80	70.24
68	48.26	84.59	78.39	76.55	77.99	72.45
66	50.81	86.80	79.39	78.29	78.97	75.90
64	54.52	88.02	80.81	79.21	80.67	78.49
62	60.87	89.18	83.04	80.58	82.35	79.67
60	66.59	89.55	84.96	83.61	84.02	80.91
58	70.02	89.79	87.05	85.17	85.45	82.85
56	74.21	90.08	88.68	87.13	86.59	84.58
54	75.86	90.69	89.54	89.25	88.67	87.68
52	78.29	91.44	90.04	89.88	89.29	89.72
50	80.68	92.60	90.47	90.49	89.84	91.05
48	82.91	93.18	90.86	91.07	90.38	91.81
46	85.06	93.58	91.28	91.59	91.26	92.64
44	87.04	94.17	91.67	92.38	92.21	93.34
42	87.83	94.97	92.26	92.95	93.13	93.79
40	88.56	95.66	92.69	93.49	93.77	94.23
38	88.84	96.33	93.17	93.86	94.51	94.85
36	89.02	96.85	93.74	94.37	95.03	95.54
34	89.24	97.38	94.38	94.79	95.92	96.53
32	89.68	97.99	94.85	95.02	96.56	97.07
30	89.95	98.45	95.27	95.57	97.41	97.69
28	90.42	98.72	96.02	95.90	97.96	98.15
26	90.96	98.91	96.64	96.16	98.34	98.46
24	91.55	99.07	97.08	96.40	98.52	98.54
22	92.37	99.20	97.44	96.68	98.74	98.62
20	92.86	99.34	98.08	96.97	98.95	98.88
18	93.69	99.44	98.48	97.21	99.07	99.03
16	94.04	99.50	98.74	97.44	99.24	99.14
14	95.06	99.60	98.91	98.11	99.37	99.30
12	95.78	99.66	99.15	98.57	99.47	99.49
10	96.01	99.71	99.32	98.79	99.58	99.62
8	96.25	99.78	99.47	99.05	99.69	99.78
6	96.62	99.82	99.61	99.32	99.75	99.85
4	97.36	99.87	99.72	99.54	99.83	99.90
2	98.29	99.93	99.89	99.83	99.90	99.95
0	100.00	100.00	100.00	100.00	100.00	100.00

APPENDIX K-80
PERCENT EXCEEDENCE FOR MAXIMUM WUA, HABITAT REACH B, TRICHOPTERA GROUP, SPRING
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	300MOD50	MOD55	480MOD55	WET	WETOF
100	8.50	8.61	8.43	7.96	7.74	8.41
98	9.76	15.60	13.06	12.62	13.87	13.63
96	11.52	26.36	18.99	18.35	21.96	20.56
94	13.30	33.06	30.87	25.86	26.82	24.90
92	16.11	44.84	35.44	33.86	33.35	31.52
90	18.11	51.52	39.94	36.65	35.97	33.49
88	19.11	54.20	46.29	42.21	40.16	36.50
86	20.15	57.25	52.26	45.39	47.98	43.22
84	20.96	59.44	55.63	49.39	51.11	47.32
82	21.93	61.88	57.98	53.99	54.50	51.06
80	23.61	65.60	61.38	57.03	58.00	54.74
78	26.28	67.57	63.80	59.12	61.57	57.05
76	29.87	69.49	65.46	61.73	63.38	60.27
74	32.09	71.32	66.70	64.59	64.95	63.15
72	35.58	73.58	68.59	66.39	67.17	65.57
70	37.66	76.08	69.67	68.38	69.44	67.31
68	39.28	77.39	71.91	69.50	71.85	68.78
66	41.13	78.95	73.95	71.87	73.88	70.17
64	44.57	79.85	75.69	74.08	75.23	72.47
62	51.42	80.51	77.95	76.12	76.40	74.05
60	56.40	81.05	79.88	78.23	77.42	76.34
58	60.46	82.66	80.85	80.07	79.30	78.10
56	63.72	85.13	81.70	81.46	80.50	80.59
54	66.60	86.66	82.55	82.73	82.45	83.73
52	68.11	87.44	83.38	83.58	84.22	86.61
50	70.30	88.06	84.38	84.45	86.15	87.56
48	72.36	89.11	85.07	85.82	87.24	88.40
46	73.79	90.32	85.73	87.34	88.29	89.62
44	75.18	92.01	86.59	88.60	88.98	90.48
42	76.45	92.99	87.56	89.43	89.95	91.70
40	77.45	94.15	88.44	91.12	91.16	92.84
38	78.35	95.47	89.27	92.31	92.41	94.19
36	79.87	96.42	90.13	93.17	93.73	94.95
34	80.67	97.11	91.43	93.63	94.91	96.04
32	81.90	97.90	92.57	94.40	96.61	97.24
30	82.58	98.68	93.45	94.94	97.72	97.97
28	83.98	98.92	94.65	95.43	98.83	98.61
26	85.52	98.96	95.33	96.15	98.92	98.86
24	86.58	99.01	96.28	96.61	98.97	98.91
22	87.82	99.03	97.40	96.82	99.03	98.94
20	89.44	99.08	98.06	97.22	99.07	99.01
18	90.62	99.12	98.66	97.68	99.14	99.09
16	92.33	99.17	98.90	97.97	99.23	99.20
14	93.53	99.25	99.06	98.38	99.29	99.35
12	94.95	99.30	99.16	98.89	99.37	99.46
10	96.79	99.37	99.27	99.08	99.45	99.54
8	97.89	99.47	99.38	99.27	99.57	99.64
6	98.39	99.57	99.51	99.43	99.65	99.75
4	98.87	99.70	99.69	99.68	99.79	99.89
2	99.39	99.85	99.83	99.82	99.91	99.96
0	100.00	100.00	100.00	100.00	100.00	100.00

APPENDIX K-81
PERCENT EXCEEDENCE FOR MAXIMUM WUA, HABITAT REACH B, SHALLOW POOL GUILD, SUMMER
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	300MOD50	MOD55	480MOD55	WET	WETOF
100	9.80	1.84	0.91	3.42	2.00	1.26
98	12.98	2.92	2.86	7.90	2.95	2.36
96	13.40	3.11	3.27	9.54	3.45	2.62
94	13.75	3.27	3.45	9.80	3.57	2.68
92	14.14	3.47	3.60	10.18	3.64	2.76
90	14.59	3.75	3.73	10.54	3.72	2.85
88	14.80	3.92	3.83	10.84	3.79	2.97
86	14.98	4.00	3.91	11.07	3.88	3.06
84	16.55	4.16	4.01	11.30	3.96	3.13
82	17.60	4.25	4.09	11.68	4.98	3.17
80	18.30	5.55	8.69	12.09	7.35	3.25
78	19.72	9.23	12.86	12.30	10.08	3.32
76	20.85	13.88	15.03	12.56	12.71	3.39
74	22.05	18.81	17.96	12.81	14.65	3.47
72	22.70	21.21	20.70	13.11	16.32	3.56
70	23.53	23.62	22.14	13.25	18.10	3.61
68	24.90	25.22	24.54	13.41	20.56	3.70
66	27.41	27.42	26.61	13.56	22.00	3.76
64	29.47	29.56	29.20	13.73	22.91	3.81
62	31.30	32.03	30.16	14.02	24.40	3.87
60	33.16	34.64	32.48	14.18	25.28	3.92
58	35.08	36.54	35.50	14.32	26.75	3.95
56	36.83	38.47	37.89	14.50	27.96	4.01
54	37.99	40.46	39.46	14.64	29.10	6.51
52	39.48	43.24	40.56	14.71	30.69	9.02
50	41.05	44.23	42.43	14.76	31.98	11.16
48	42.39	45.73	43.93	14.81	33.60	12.50
46	43.02	47.75	45.02	14.89	34.94	14.23
44	44.49	49.26	46.48	14.96	36.35	15.60
42	45.23	50.22	48.02	15.02	37.73	17.67
40	46.30	51.44	49.21	15.09	38.70	18.99
38	46.95	52.23	50.26	15.16	40.48	20.52
36	47.80	52.94	51.08	15.19	41.60	21.49
34	48.58	54.10	51.56	15.22	43.19	22.88
32	50.14	54.75	52.48	15.29	44.29	25.71
30	51.99	55.69	53.20	15.36	45.62	28.70
28	55.38	56.53	54.34	15.40	47.02	30.02
26	58.93	58.65	57.11	15.45	48.18	31.78
24	61.41	60.50	59.82	15.49	49.43	33.97
22	63.36	62.56	61.34	15.53	51.17	37.24
20	63.95	64.22	62.72	15.59	52.23	40.88
18	64.73	65.48	63.68	15.64	54.22	43.22
16	65.44	66.76	65.07	15.73	58.49	46.18
14	65.81	67.72	66.11	15.77	63.52	50.26
12	66.50	68.97	67.08	15.81	66.58	52.65
10	67.44	70.32	68.39	15.85	68.03	54.06
8	72.99	71.66	69.66	15.88	68.86	62.31
6	78.00	75.06	72.56	15.91	72.06	65.77
4	82.21	80.74	77.31	15.94	81.49	74.71
2	88.69	87.35	81.81	15.99	88.01	85.99
0	100.00	100.00	100.00	100.00	100.00	100.00

APPENDIX K-82
PERCENT EXCEEDENCE FOR MAXIMUM WUA, HABITAT REACH B, SLOW RIFFLE GUILD, SUMMER
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	300MOD50	MOD55	480MOD55	WET	WETOF
100	16.08	0.68	0.69	8.22	0.67	0.81
98	28.65	1.64	1.32	48.55	1.17	3.03
96	33.53	2.35	2.02	64.07	1.84	5.22
94	37.47	2.96	2.68	66.46	2.71	6.98
92	42.04	3.63	3.23	70.04	4.52	8.62
90	47.22	4.16	3.79	73.45	5.83	14.86
88	49.62	4.79	4.46	76.28	7.05	24.53
86	51.50	5.19	4.97	78.45	9.41	33.26
84	60.10	5.60	5.31	80.52	11.71	36.57
82	65.87	6.11	5.75	82.41	14.71	41.62
80	69.53	6.58	6.42	84.04	18.63	48.37
78	71.20	7.13	7.09	84.98	21.69	53.58
76	73.67	8.64	8.58	85.90	24.64	58.04
74	74.32	10.91	10.64	86.96	28.30	62.23
72	74.86	12.26	12.17	88.16	31.70	66.00
70	75.37	14.68	14.17	88.68	34.17	69.81
68	75.81	16.69	15.48	89.25	37.89	71.18
66	76.22	18.27	17.43	89.92	41.12	72.58
64	76.60	19.68	19.79	90.50	44.88	73.93
62	77.25	21.96	22.51	91.69	47.54	75.43
60	77.80	24.12	24.59	92.31	49.64	77.08
58	78.12	27.07	27.78	92.98	53.42	78.26
56	78.62	31.27	30.55	93.68	55.82	79.31
54	79.26	34.89	33.60	94.30	59.19	80.46
52	80.11	38.13	36.11	94.54	61.76	81.32
50	80.72	40.24	39.83	94.76	66.58	82.05
48	81.31	44.24	44.48	94.92	69.18	82.90
46	82.18	49.56	47.64	95.28	71.41	83.75
44	83.00	52.94	50.86	95.54	72.61	84.75
42	83.90	57.71	56.13	95.77	73.96	85.60
40	84.56	62.02	62.04	96.05	75.55	86.00
38	85.31	67.15	67.75	96.32	76.60	86.60
36	85.82	71.99	71.24	96.46	77.83	87.53
34	86.48	74.17	72.52	96.58	79.04	88.13
32	87.12	75.80	75.28	96.86	80.17	88.62
30	87.82	77.74	77.77	97.14	82.02	89.39
28	88.38	78.90	79.87	97.26	83.90	90.15
26	88.75	80.79	81.16	97.49	85.38	90.85
24	89.29	82.46	83.65	97.65	87.45	91.58
22	90.22	83.58	85.95	97.84	88.69	92.24
20	90.58	84.97	87.73	98.05	90.86	93.10
18	91.34	87.16	89.03	98.25	91.83	93.90
16	92.04	88.70	90.16	98.58	93.07	94.67
14	92.76	91.48	91.26	98.77	93.95	95.46
12	93.18	93.27	92.60	98.93	95.07	96.42
10	93.69	94.83	94.47	99.06	95.66	96.83
8	94.12	95.64	95.53	99.21	96.39	97.57
6	95.40	96.54	96.66	99.33	97.41	98.33
4	97.12	98.54	97.77	99.45	98.20	98.73
2	98.81	99.19	98.78	99.63	99.14	99.40
0	100.00	100.00	100.00	100.00	100.00	100.00

APPENDIX K-83
PERCENT EXCEEDENCE FOR MAXIMUM WUA, HABITAT REACH B, FAST RIFFLE GUILD, SUMMER
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	300MOD50	MOD55	480MOD55	WET	WETOF
100	6.29	0.00	0.00	0.91	0.00	0.00
98	6.62	0.00	0.00	1.91	0.00	0.00
96	7.19	0.00	0.00	2.10	0.00	0.00
94	8.00	0.00	0.00	2.25	0.00	0.00
92	8.80	0.00	0.00	2.38	0.00	0.00
90	9.61	0.00	0.00	2.52	0.00	2.24
88	9.89	0.00	0.00	2.69	0.00	2.55
86	10.04	0.00	0.00	2.86	0.00	2.62
84	10.17	0.00	0.00	3.04	0.94	2.75
82	10.29	0.00	0.00	3.40	2.29	2.84
80	10.41	0.29	0.00	3.64	2.67	2.91
78	10.51	0.77	0.10	3.88	2.70	3.02
76	10.59	1.38	0.22	4.09	2.76	3.12
74	10.70	1.92	0.43	4.26	2.80	3.19
72	10.82	2.54	0.64	4.47	2.84	3.25
70	10.91	2.62	0.67	4.64	2.88	3.37
68	11.07	2.65	0.67	4.96	2.93	3.71
66	11.20	2.67	0.68	5.26	2.96	4.04
64	11.30	2.70	0.68	5.39	3.01	4.19
62	12.02	2.72	0.69	5.52	3.05	4.31
60	13.98	2.75	0.70	5.82	3.11	4.48
58	17.17	2.78	0.71	6.13	3.14	4.63
56	19.39	2.81	0.72	6.36	3.18	4.86
54	23.80	2.86	0.73	6.67	3.23	5.02
52	25.69	2.92	0.74	7.02	3.27	5.22
50	29.72	2.96	0.75	7.24	3.32	5.37
48	34.42	2.99	0.77	7.44	3.36	5.61
46	38.91	3.08	0.78	7.75	3.47	5.90
44	42.38	3.14	0.79	8.36	3.61	7.10
42	47.64	3.19	0.81	9.14	3.75	10.90
40	53.38	3.25	0.83	9.74	3.92	13.72
38	58.98	3.33	0.85	10.45	4.03	17.18
36	64.05	3.56	0.88	11.69	4.20	21.20
34	69.47	3.80	0.96	12.43	4.31	25.21
32	75.69	4.04	1.02	13.09	4.48	29.41
30	80.86	4.22	1.09	13.77	4.77	35.59
28	82.41	4.48	1.13	14.37	4.99	39.68
26	83.67	4.75	1.21	15.67	5.18	46.05
24	84.52	5.29	1.29	16.76	5.41	51.29
22	85.96	5.80	1.36	17.88	5.73	56.65
20	87.23	6.21	1.48	18.80	6.05	61.78
18	88.39	7.42	1.82	20.60	6.33	67.17
16	89.84	13.36	3.32	21.95	11.04	70.53
14	91.64	24.99	5.05	22.02	16.94	75.21
12	93.02	29.96	6.53	22.10	23.90	82.24
10	94.23	42.12	8.44	22.20	29.10	90.46
8	95.68	61.81	10.74	22.32	35.04	91.69
6	96.84	75.92	13.52	22.45	40.32	92.10
4	97.88	87.00	16.79	22.53	49.66	92.48
2	98.93	94.19	23.82	23.08	87.31	93.88
0	100.00	100.00	100.00	100.00	100.00	100.00

APPENDIX K-84
PERCENT EXCEEDENCE FOR MAXIMUM WUA, HABITAT REACH B, RACEWAY GUILD, SUMMER
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	300MOD50	MOD55	480MOD55	WET	WETOF
100	3.73	0.11	0.06	49.58	0.03	0.03
98	7.27	0.26	0.28	62.92	0.18	0.21
96	9.29	0.33	0.34	66.29	0.27	0.35
94	10.61	0.40	0.40	66.81	0.39	2.35
92	12.18	1.31	0.87	67.59	0.56	4.37
90	15.40	2.04	1.60	68.33	1.04	10.28
88	17.85	2.78	2.35	68.95	1.89	12.11
86	19.66	3.46	2.90	69.42	3.67	18.04
84	20.62	3.99	3.49	69.89	7.05	28.15
82	22.47	4.69	4.29	71.98	10.18	35.48
80	24.53	5.52	4.83	74.62	13.18	41.27
78	26.05	6.67	5.82	75.97	15.80	50.28
76	27.98	8.09	6.91	77.52	20.11	57.59
74	30.34	9.36	8.86	79.16	23.23	62.60
72	33.72	10.83	10.85	81.05	26.10	65.19
70	36.96	12.44	13.30	81.91	29.59	67.51
68	38.71	14.64	15.04	82.87	32.88	68.16
66	40.54	16.15	17.30	83.88	35.60	68.60
64	42.00	18.87	18.45	84.88	39.56	69.12
62	43.61	20.52	20.44	86.73	42.35	69.60
60	44.85	22.37	23.00	87.79	46.76	70.20
58	46.86	25.23	25.90	88.76	49.17	71.82
56	48.26	27.46	29.65	89.89	52.58	73.23
54	51.04	30.99	33.19	90.87	56.08	74.84
52	52.24	35.71	35.86	91.26	59.40	76.43
50	54.78	39.21	39.51	91.61	63.42	77.27
48	57.74	41.53	44.06	91.87	66.41	77.96
46	60.57	48.03	46.73	92.44	69.18	78.64
44	62.76	52.67	50.39	92.86	70.07	79.44
42	66.08	57.18	55.53	93.24	71.45	80.23
40	69.70	61.41	61.52	93.68	72.61	81.01
38	73.23	65.84	65.83	94.11	74.21	81.94
36	76.68	69.16	69.32	94.33	75.40	82.92
34	80.11	70.42	70.13	94.53	76.87	83.94
32	83.91	71.94	72.80	94.97	78.25	84.81
30	87.30	72.98	74.93	95.42	79.84	85.99
28	88.14	74.29	77.41	95.62	82.18	87.25
26	89.18	76.10	79.13	95.98	83.73	87.84
24	89.88	77.74	80.33	96.23	85.38	88.85
22	90.97	79.56	82.17	96.55	86.58	89.72
20	91.74	80.69	83.90	96.88	87.90	90.71
18	92.59	82.89	85.58	97.22	89.19	91.62
16	93.62	85.70	87.51	97.76	90.40	92.51
14	94.67	88.31	88.96	98.05	91.63	93.60
12	95.42	91.45	90.27	98.29	92.62	94.55
10	96.17	92.37	91.76	98.50	94.11	95.58
8	97.07	94.02	93.84	98.74	95.33	96.58
6	98.06	95.24	94.91	98.93	96.48	97.36
4	98.64	97.81	96.86	99.12	97.72	98.16
2	99.34	99.01	98.52	99.41	98.92	99.06
0	100.00	100.00	100.00	100.00	100.00	100.00

APPENDIX K-85
PERCENT EXCEEDENCE FOR MAXIMUM WUA, HABITAT REACH B, MEDIUM POOL GUILD, SUMMER
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	300MOD50	MOD55	480MOD55	WET	WETOF
100	6.72	1.22	0.66	2.12	1.22	1.21
98	7.73	1.24	1.32	4.52	1.50	1.22
96	8.30	1.46	2.22	4.53	2.85	1.23
94	8.75	1.86	2.69	4.55	3.19	1.24
92	9.28	2.38	3.09	4.59	3.38	1.26
90	9.87	3.10	3.42	4.62	3.60	1.32
88	10.15	3.54	3.70	4.66	3.78	1.55
86	10.38	3.72	3.91	4.70	4.03	1.82
84	11.81	4.15	4.16	4.86	4.25	1.99
82	12.78	4.37	4.38	5.26	5.45	2.12
80	13.41	5.72	9.26	6.30	8.02	2.32
78	14.71	9.47	13.69	6.82	10.96	2.51
76	15.75	14.20	15.99	7.47	13.81	2.71
74	16.85	19.22	19.09	8.10	15.91	2.91
72	17.45	21.66	21.99	8.85	17.72	3.15
70	18.21	24.12	23.51	9.20	19.64	3.30
68	21.78	25.75	26.06	9.59	22.30	3.53
66	29.59	27.99	28.15	9.97	23.86	3.69
64	36.01	30.17	30.92	10.40	24.79	3.84
62	41.70	33.49	31.87	11.11	26.37	3.99
60	47.51	40.18	37.15	11.53	27.32	4.12
58	53.47	45.06	42.68	11.87	28.97	4.23
56	58.93	49.12	49.16	12.32	30.28	4.37
54	62.54	52.01	54.25	12.68	31.44	7.10
52	66.68	55.95	58.07	12.85	33.81	9.81
50	70.06	60.56	60.13	12.97	36.42	12.12
48	72.46	64.27	63.62	13.10	41.17	13.56
46	75.27	66.03	66.15	13.30	44.05	15.43
44	76.81	68.82	69.47	13.47	46.06	16.91
42	78.43	72.08	71.52	13.61	49.08	19.15
40	81.02	75.38	73.46	13.79	52.15	20.58
38	82.51	78.02	76.36	13.96	55.47	22.22
36	83.97	79.78	78.07	14.04	57.89	23.27
34	85.64	81.61	79.90	14.11	61.19	24.68
32	88.08	82.97	81.37	14.28	65.43	27.75
30	89.85	84.21	82.73	14.47	68.22	30.99
28	91.50	85.23	83.90	14.57	71.35	32.61
26	92.38	86.71	85.47	14.69	73.52	36.18
24	93.70	87.81	86.93	14.79	75.67	41.04
22	94.54	88.87	87.85	14.91	77.36	45.51
20	95.25	89.90	89.14	15.04	78.48	50.21
18	95.83	91.10	90.34	15.18	80.47	56.67
16	96.76	92.36	91.61	15.39	82.14	65.36
14	97.03	93.33	92.36	15.49	84.23	71.27
12	97.35	94.15	92.99	15.59	86.83	76.86
10	97.87	95.20	94.08	15.69	89.24	81.86
8	98.49	95.97	94.92	15.77	92.14	87.33
6	98.91	96.95	96.21	15.85	94.59	91.19
4	99.21	97.91	97.26	15.93	96.44	96.25
2	99.71	99.33	98.68	16.05	98.79	98.93
0	100.00	100.00	100.00	100.00	100.00	100.00

APPENDIX K-86
PERCENT EXCEEDENCE FOR MAXIMUM WUA, HABITAT REACH B, DEEP POOL GUILD, SUMMER
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	300MOD50	MOD55	480MOD55	WET	WETOF
100	0.00	0.59	0.13	0.05	0.29	0.29
98	0.00	0.64	0.78	0.73	0.75	0.60
96	0.00	0.78	1.31	0.74	1.39	0.62
94	0.00	1.07	1.57	0.75	1.75	0.63
92	0.00	1.45	1.82	0.78	1.92	0.66
90	0.00	1.79	2.05	0.80	2.12	0.74
88	0.00	2.08	2.31	0.83	2.24	0.84
86	0.00	2.34	2.48	0.84	2.39	1.02
84	0.00	2.45	2.59	0.91	2.52	1.16
82	0.00	2.61	2.73	0.99	2.68	1.24
80	0.00	2.84	2.86	1.17	2.85	1.39
78	0.00	2.95	3.00	1.30	2.99	1.48
76	2.16	3.18	3.33	1.46	3.39	1.59
74	4.51	4.22	4.10	1.62	3.93	1.74
72	8.20	5.42	5.28	1.81	4.52	1.85
70	10.54	6.37	6.29	1.90	5.95	1.99
68	13.42	7.11	7.17	2.00	7.99	2.13
66	17.90	8.10	7.99	2.09	10.26	2.26
64	20.59	8.84	8.88	2.20	13.51	2.38
62	24.17	9.82	9.83	2.38	15.69	2.51
60	26.66	10.71	10.68	2.49	17.77	2.60
58	30.22	11.78	11.93	2.57	20.57	2.72
56	34.01	13.14	13.18	2.69	24.55	2.82
54	37.68	14.31	15.23	2.78	27.83	2.89
52	40.75	16.15	17.66	2.82	31.18	3.00
50	43.50	17.24	20.00	2.85	34.59	4.82
48	45.64	19.62	22.49	2.88	37.24	7.81
46	49.44	21.85	25.23	2.93	40.72	10.52
44	52.68	23.82	26.97	2.98	43.36	14.96
42	55.94	26.82	29.37	3.01	45.52	16.57
40	57.54	29.12	32.12	3.06	48.87	20.44
38	61.72	31.35	34.90	3.10	51.60	24.66
36	64.50	34.20	37.30	3.12	54.76	29.77
34	64.97	37.21	39.78	3.14	56.75	32.57
32	65.58	39.75	43.68	3.18	59.89	36.35
30	66.62	43.70	47.12	3.23	63.46	41.52
28	68.01	48.35	49.86	3.25	66.30	45.12
26	68.80	52.86	53.17	3.28	69.19	50.57
24	69.43	55.73	56.39	3.31	71.02	52.86
22	70.63	59.16	60.19	3.34	72.84	56.18
20	73.31	62.18	64.73	3.37	75.46	59.65
18	75.10	66.23	66.90	3.41	77.87	63.37
16	78.89	70.65	69.49	3.46	80.76	67.07
14	81.38	73.66	72.49	3.49	82.81	70.02
12	84.36	77.06	75.65	3.51	85.04	74.04
10	88.32	80.17	80.52	3.54	87.33	79.19
8	90.10	84.56	84.81	3.56	90.07	85.11
6	92.35	87.51	90.07	3.58	92.74	90.30
4	94.71	92.25	95.06	3.60	95.39	93.78
2	97.55	94.89	97.54	3.63	97.29	97.50
0	100.00	100.00	100.00	100.00	100.00	100.00

APPENDIX K-87
PERCENT EXCEEDENCE FOR MAXIMUM WUA, HABITAT REACH B, LOW GRADIENT GROUP, SUMMER
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	300MOD50	MOD55	480MOD55	WET	WETOF
100	19.84	54.98	14.40	11.48	63.07	40.44
98	32.53	76.03	75.78	62.49	75.80	74.35
96	36.81	76.32	76.26	75.17	76.06	75.90
94	40.26	76.51	76.46	77.12	76.50	76.25
92	44.26	77.07	76.66	80.05	76.68	77.74
90	48.80	77.92	77.29	82.83	77.19	79.81
88	50.91	78.62	78.02	85.16	77.97	81.74
86	52.52	79.12	78.64	86.94	79.43	83.75
84	58.88	79.83	79.17	88.69	82.25	85.70
82	63.15	80.49	79.74	89.84	85.62	86.97
80	65.96	81.34	80.38	90.68	88.63	88.52
78	71.70	82.51	81.05	91.11	89.27	89.02
76	76.31	84.23	82.35	91.63	89.68	89.60
74	81.16	85.44	83.80	92.14	90.43	90.07
72	83.80	86.57	86.04	92.75	90.95	90.65
70	87.15	88.36	88.40	93.03	91.51	91.15
68	88.28	88.88	89.00	93.34	92.11	91.41
66	88.71	89.30	89.46	93.65	92.63	91.74
64	88.96	89.55	89.89	94.00	93.27	92.22
62	89.25	89.73	90.10	94.57	93.59	92.68
60	89.50	90.08	90.45	94.91	94.12	93.15
58	89.78	90.42	90.83	95.18	94.58	93.47
56	90.09	90.71	91.30	95.55	94.84	93.82
54	90.40	90.96	91.78	95.84	95.28	94.28
52	90.65	91.39	92.28	95.98	95.48	94.74
50	91.20	91.75	92.78	96.07	95.86	95.03
48	91.77	92.17	93.17	96.18	96.10	95.56
46	92.14	92.62	93.54	96.34	96.36	95.96
44	92.58	93.27	93.88	96.48	96.75	96.38
42	92.95	93.84	94.42	96.59	97.06	96.77
40	93.30	94.41	94.74	96.73	97.42	97.08
38	93.66	94.69	95.35	96.87	97.81	97.45
36	93.99	95.40	95.64	96.94	98.10	97.74
34	94.27	95.93	96.07	97.00	98.38	97.96
32	94.61	96.30	96.39	97.14	98.59	98.32
30	94.77	96.68	96.76	97.28	98.69	98.54
28	95.18	97.11	97.26	97.37	98.86	98.67
26	95.41	97.74	97.74	97.46	98.98	98.81
24	95.78	98.11	98.16	97.54	99.10	98.91
22	95.97	98.47	98.60	97.64	99.19	98.99
20	96.16	98.57	98.84	97.75	99.30	99.08
18	96.40	98.75	99.00	97.86	99.36	99.15
16	96.57	98.96	99.11	98.03	99.47	99.25
14	96.97	99.14	99.26	98.11	99.54	99.35
12	97.25	99.32	99.42	98.20	99.60	99.43
10	97.75	99.47	99.50	98.27	99.68	99.49
8	98.35	99.57	99.59	98.34	99.73	99.55
6	98.80	99.67	99.70	98.40	99.79	99.66
4	99.22	99.77	99.80	98.47	99.87	99.80
2	99.68	99.89	99.94	98.56	99.94	99.92
0	100.00	100.00	100.00	100.00	100.00	100.00

APPENDIX K-88
PERCENT EXCEEDENCE FOR MAXIMUM WUA, HABITAT REACH B, TRICHOPTERA GROUP, SUMMER
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	300MOD50	MOD55	480MOD55	WET	WETOF
100	18.31	47.78	11.84	8.92	44.29	37.63
98	27.86	54.87	52.64	59.79	51.65	52.13
96	30.96	58.79	58.13	72.58	55.65	56.37
94	33.47	61.73	60.86	74.55	61.13	64.33
92	36.37	64.87	63.13	77.50	63.48	68.82
90	39.66	66.41	64.68	80.31	64.50	71.65
88	41.19	67.92	66.25	82.66	66.17	77.18
86	42.42	69.32	67.61	84.46	69.49	78.54
84	49.27	70.30	68.83	86.22	73.57	79.36
82	53.87	71.74	70.06	87.63	76.85	80.55
80	56.89	72.93	71.52	88.80	79.08	81.75
78	63.09	73.85	72.76	89.39	79.99	82.91
76	67.94	75.29	73.87	90.12	81.31	84.32
74	71.19	76.42	75.22	90.83	82.57	85.89
72	73.01	78.29	76.89	91.67	83.44	87.11
70	74.79	78.91	78.87	92.07	84.39	87.65
68	75.71	79.64	79.63	92.50	85.59	88.43
66	76.88	80.28	80.28	92.93	86.71	89.24
64	78.15	81.07	80.95	93.41	87.39	89.87
62	79.68	81.72	81.45	94.22	88.46	90.28
60	81.12	82.49	82.05	94.68	89.50	90.87
58	82.52	83.04	83.06	95.07	90.70	91.56
56	83.55	83.70	84.06	95.58	91.54	92.19
54	84.80	84.28	85.23	95.98	92.34	92.86
52	85.51	85.23	86.21	96.17	93.41	93.50
50	86.11	86.55	87.21	96.31	94.01	94.22
48	87.13	87.59	88.01	96.45	94.83	94.92
46	87.66	88.00	89.25	96.68	95.27	95.39
44	88.24	88.86	90.59	96.87	95.66	96.13
42	89.05	89.38	91.18	97.03	96.23	96.57
40	89.94	90.64	92.06	97.23	96.72	97.08
38	90.58	91.63	92.68	97.42	97.33	97.61
36	91.33	92.84	93.63	97.51	97.75	98.01
34	91.93	93.73	94.58	97.59	98.41	98.44
32	92.53	94.71	95.48	97.79	98.86	98.80
30	93.32	95.72	96.34	97.99	98.91	98.89
28	93.96	96.40	97.09	98.11	98.97	98.98
26	94.42	96.96	97.70	98.24	99.02	99.09
24	94.98	97.54	98.35	98.35	99.07	99.17
22	95.34	98.79	98.91	98.49	99.12	99.22
20	95.70	98.92	98.94	98.64	99.17	99.26
18	96.33	99.00	99.05	98.80	99.22	99.31
16	96.92	99.09	99.13	99.03	99.28	99.39
14	97.28	99.16	99.23	99.14	99.38	99.45
12	97.88	99.24	99.30	99.26	99.45	99.53
10	98.19	99.35	99.40	99.35	99.53	99.58
8	98.64	99.48	99.51	99.46	99.60	99.64
6	99.03	99.64	99.61	99.54	99.70	99.70
4	99.41	99.80	99.70	99.61	99.84	99.79
2	99.61	99.93	99.85	99.75	99.91	99.89
0	100.00	100.00	100.00	100.00	100.00	100.00

APPENDIX K-89
PERCENT EXCEEDENCE FOR MAXIMUM WUA, HABITAT REACH B, SHALLOW POOL GUILD, FALL
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	300MOD50	MOD55	480MOD55	WET	WETOF
100	4.06	3.67	3.88	4.43	2.28	2.08
98	4.68	4.07	4.09	4.66	3.18	2.94
96	13.90	10.45	11.02	5.09	3.75	3.42
94	18.02	16.99	15.56	5.25	4.24	3.92
92	20.29	19.22	18.09	5.31	4.37	4.00
90	22.94	21.17	19.81	5.37	5.31	4.12
88	24.06	22.04	21.89	5.44	11.77	4.20
86	25.31	22.59	23.73	5.50	19.79	4.31
84	25.70	23.24	24.96	5.55	22.24	4.39
82	26.18	23.57	25.99	5.57	24.46	5.53
80	26.85	24.26	26.50	5.61	25.91	7.97
78	27.69	25.77	27.18	5.63	27.13	12.07
76	28.88	26.52	27.51	5.66	27.66	13.50
74	30.67	27.92	27.87	5.69	28.09	14.61
72	31.72	29.25	28.74	5.71	28.39	15.15
70	33.62	30.37	29.22	5.74	28.74	15.80
68	34.52	31.87	29.91	5.76	29.06	16.80
66	35.88	33.14	30.75	5.77	29.54	17.99
64	36.61	34.33	31.36	5.79	30.02	18.60
62	37.59	35.43	31.77	5.81	30.63	19.68
60	38.20	36.33	32.59	5.83	31.42	20.33
58	38.84	37.25	33.96	5.85	32.23	20.87
56	39.63	37.99	34.81	5.88	33.27	21.68
54	40.94	38.74	35.68	5.91	34.68	22.77
52	41.83	39.51	37.06	5.93	36.25	23.50
50	42.68	40.48	37.60	5.96	38.15	24.76
48	43.14	41.38	38.43	5.98	38.99	25.72
46	43.45	41.98	39.13	6.01	39.48	26.68
44	43.92	42.52	40.19	6.03	40.02	27.90
42	44.57	43.00	41.14	6.04	40.73	29.35
40	44.96	43.36	41.88	6.05	41.50	30.27
38	45.79	43.71	42.73	6.06	42.57	31.19
36	46.48	44.11	43.60	6.09	43.42	33.66
34	46.80	44.68	44.41	6.12	44.26	35.20
32	47.68	45.15	45.65	6.14	45.35	36.34
30	48.33	45.89	47.24	6.16	46.05	37.61
28	48.79	46.63	48.01	6.19	46.38	39.20
26	49.57	47.73	49.35	6.21	47.78	40.75
24	50.22	48.25	50.50	6.24	51.03	42.48
22	51.69	49.15	51.23	6.29	52.72	44.05
20	53.22	50.62	52.18	6.34	54.02	45.00
18	54.52	53.19	53.07	6.42	55.32	45.89
16	57.75	55.20	54.17	6.45	56.30	46.32
14	61.34	56.12	57.22	6.51	57.37	48.85
12	65.31	58.77	58.79	6.56	59.36	54.21
10	67.47	62.38	63.89	9.29	63.56	56.54
8	69.12	65.64	65.48	32.19	72.73	61.40
6	73.80	71.28	66.58	41.27	74.59	65.73
4	82.98	78.73	70.61	59.34	81.94	71.03
2	90.50	83.09	97.57	81.48	89.82	89.82
0	100.00	100.00	100.00	100.00	100.00	100.00

APPENDIX K-90
PERCENT EXCEEDENCE FOR MAXIMUM WUA, HABITAT REACH B, SLOW RIFFLE GUILD, FALL
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	300MOD50	MOD55	480MOD55	WET	WETOF
100	0.75	0.74	0.83	5.11	0.74	2.60
98	2.66	3.62	2.46	16.73	1.62	4.76
96	3.53	4.93	3.02	53.32	2.93	5.65
94	4.64	5.81	3.90	75.94	6.47	7.15
92	5.76	6.84	5.66	78.59	7.11	13.56
90	6.66	8.17	6.19	81.90	10.07	20.68
88	10.61	11.76	6.75	84.22	13.16	34.10
86	13.45	15.31	8.41	86.87	15.11	36.96
84	17.15	20.59	10.61	87.36	17.77	37.93
82	20.80	23.46	13.24	87.95	19.38	39.88
80	22.97	26.18	15.03	88.66	23.88	41.88
78	24.49	27.88	16.97	89.01	28.66	44.69
76	25.97	28.94	21.13	89.76	34.35	48.06
74	27.65	31.11	23.38	90.09	36.86	51.33
72	28.55	32.49	27.42	90.37	37.46	54.69
70	30.53	34.63	29.84	90.62	38.84	58.36
68	31.51	36.22	32.85	90.84	40.86	61.13
66	32.81	37.33	35.01	91.17	43.08	63.21
64	34.15	38.74	37.14	91.44	45.81	65.59
62	36.37	40.05	39.18	91.65	47.31	70.50
60	36.91	40.68	41.51	91.90	49.08	72.30
58	38.60	41.95	44.11	92.05	50.96	73.05
56	39.57	43.24	46.55	92.20	52.59	74.00
54	40.44	44.23	48.40	92.38	54.10	75.44
52	41.61	45.89	50.38	92.56	55.36	76.54
50	44.00	48.27	52.69	92.80	57.57	77.40
48	46.11	50.69	56.10	92.98	61.71	78.31
46	49.27	53.19	58.35	93.21	64.92	79.73
44	51.25	54.61	61.69	93.49	67.99	80.40
42	52.76	56.50	64.19	93.77	70.59	81.21
40	54.41	58.82	66.19	94.01	71.41	82.07
38	55.55	61.21	67.14	94.25	72.16	82.90
36	58.42	64.48	68.86	94.47	72.77	83.40
34	61.59	66.85	70.74	94.70	73.51	84.18
32	63.56	70.15	71.54	94.82	73.99	85.20
30	65.09	72.23	72.07	94.94	74.36	85.83
28	70.05	73.53	73.02	95.02	74.81	87.07
26	71.46	74.82	73.47	95.31	75.03	87.94
24	73.36	76.34	73.86	95.59	75.51	88.77
22	74.74	77.16	74.57	95.80	75.99	89.21
20	75.54	78.80	75.20	95.99	77.09	90.11
18	76.27	79.56	76.33	96.27	77.82	91.35
16	76.79	79.92	77.76	96.49	80.36	92.26
14	77.22	80.62	79.76	96.77	81.48	93.43
12	78.59	81.22	82.10	97.21	83.31	94.37
10	79.81	82.18	83.77	97.76	86.12	95.69
8	82.70	84.30	84.60	98.43	92.23	96.78
6	85.18	86.73	87.23	98.77	96.55	98.02
4	89.68	92.21	92.19	99.39	97.72	98.73
2	97.58	97.24	97.96	99.63	99.27	99.52
0	100.00	100.00	100.00	100.00	100.00	100.00

APPENDIX K-91
PERCENT EXCEEDENCE FOR MAXIMUM WUA, HABITAT REACH B, FAST RIFFLE GUILD, FALL Final Aquatic Impact Analysis Report

% Exceedence	MOD50	300MOD50	MOD55	480MOD55	WET	WETOF
100	0.00	0.00	0.00	0.20	0.00	0.00
98	0.00	0.00	0.00	2.87	0.00	0.00
96	0.00	0.00	0.00	3.32	0.00	0.00
94	0.00	0.00	0.00	4.11	0.00	0.53
92	0.00	0.00	0.00	4.79	0.00	1.76
90	0.00	1.74	0.00	6.52	1.16	2.68
88	0.00	3.97	5.23	8.74	2.37	2.75
86	5.48	5.50	7.73	11.01	2.68	2.90
84	11.10	5.55	12.59	14.09	2.71	2.98
82	14.06	5.68	13.56	15.64	2.74	2.99
80	14.26	5.84	13.71	19.34	2.78	3.02
78	14.51	5.93	13.86	21.76	2.82	3.04
76	14.74	5.99	13.98	23.93	2.87	3.09
74	14.85	6.02	14.16	25.28	2.97	3.14
72	14.97	6.09	14.38	26.47	3.01	3.18
70	15.04	6.14	14.51	27.86	3.02	3.23
68	15.15	6.19	14.76	28.88	3.04	3.27
66	15.29	6.22	14.96	29.63	3.07	3.30
64	15.34	6.25	15.10	31.12	3.09	3.34
62	15.45	6.28	15.24	32.47	3.12	3.54
60	15.58	6.30	15.38	32.90	3.15	3.63
58	15.64	6.32	15.49	33.56	3.17	3.73
56	15.75	6.35	15.65	34.17	3.19	3.89
54	15.82	6.39	15.82	35.25	3.21	4.02
52	15.87	6.42	15.93	36.45	3.22	4.12
50	15.94	6.48	16.07	37.57	3.25	4.23
48	16.08	6.54	16.16	38.86	3.30	4.36
46	16.22	6.59	16.38	40.00	3.35	4.44
44	16.43	6.64	16.52	41.40	3.39	4.56
42	16.56	6.68	16.66	42.53	3.46	4.64
40	16.66	6.74	16.88	43.40	3.55	4.70
38	16.75	6.80	17.01	44.52	3.63	4.77
36	16.91	6.87	17.08	45.57	3.70	4.89
34	17.03	6.94	17.18	46.43	3.75	4.95
32	17.24	7.02	17.37	47.21	3.80	5.08
30	17.39	7.32	17.79	47.97	3.84	5.19
28	17.69	7.58	18.08	49.21	3.88	5.26
26	18.17	7.89	18.60	50.16	3.91	5.31
24	19.22	8.21	18.82	51.58	3.95	5.43
22	19.92	8.38	19.01	53.28	4.01	5.59
20	20.41	8.73	19.42	54.33	4.14	6.03
18	20.80	8.90	19.73	55.88	4.30	6.29
16	21.09	8.97	20.34	56.86	4.54	8.61
14	21.32	9.12	21.08	59.61	4.81	13.68
12	22.06	9.25	22.18	62.21	5.68	21.44
10	22.71	9.45	23.43	65.41	6.38	26.86
8	24.27	9.91	24.46	68.23	10.09	35.07
6	25.60	10.42	25.97	71.26	18.49	40.31
4	28.03	11.94	28.69	78.83	52.57	74.63
2	36.63	42.10	37.95	99.19	91.53	95.53
0	100.00	100.00	100.00	100.00	100.00	100.00

APPENDIX K-92
PERCENT EXCEEDENCE FOR MAXIMUM WUA, HABITAT REACH B, RACEWAY GUILD, FALL
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	300MOD50	MOD55	480MOD55	WET	WETOF
100	0.10	0.11	0.05	5.31	0.15	0.15
98	0.21	0.31	0.08	19.72	0.26	0.26
96	0.30	0.36	0.41	53.21	0.35	3.02
94	0.44	1.53	2.26	69.67	1.14	6.08
92	2.50	4.65	2.89	71.95	2.12	8.96
90	3.41	6.86	3.81	75.69	7.52	15.12
88	4.60	9.37	7.23	78.33	10.32	20.37
86	7.30	11.54	8.37	79.44	13.24	32.45
84	9.80	13.71	10.59	80.50	15.63	38.14
82	14.53	18.46	12.33	81.35	17.85	39.11
80	17.58	24.50	14.52	82.18	20.78	41.12
78	21.19	27.98	16.84	82.93	23.71	43.27
76	24.67	30.11	18.63	83.67	27.52	46.81
74	26.20	31.34	21.47	84.14	34.84	50.71
72	28.03	33.92	24.77	84.57	38.00	54.19
70	29.12	35.68	26.66	85.02	38.74	57.78
68	30.65	37.42	30.55	85.44	40.33	60.63
66	32.72	38.52	33.59	85.93	42.78	62.93
64	33.48	39.87	35.60	86.30	44.68	65.19
62	35.09	40.82	37.74	86.70	46.60	68.09
60	37.07	41.64	39.81	86.97	49.00	69.58
58	37.99	42.49	41.63	87.21	50.75	70.74
56	39.50	43.61	43.97	87.50	52.33	71.65
54	40.61	44.90	46.57	87.80	53.55	72.61
52	41.36	46.30	48.29	88.01	54.65	74.17
50	42.42	48.42	50.34	88.41	56.55	75.53
48	44.45	50.72	51.66	88.74	60.84	76.60
46	46.55	52.53	55.06	89.08	64.25	77.59
44	49.62	54.30	57.20	89.50	66.69	78.97
42	51.49	56.05	59.27	89.99	68.89	79.79
40	53.01	58.21	62.64	90.34	69.58	80.97
38	54.43	60.35	64.65	90.75	70.38	81.83
36	56.74	62.94	65.66	91.11	71.13	82.33
34	58.46	65.73	67.16	91.43	71.76	83.00
32	61.66	68.75	69.05	91.63	72.30	83.89
30	63.79	70.84	69.89	91.83	72.82	84.60
28	68.27	72.13	70.47	91.94	73.12	85.73
26	69.89	73.67	71.51	92.41	73.50	86.65
24	71.95	75.29	71.95	92.86	73.79	87.57
22	73.31	76.15	72.34	93.19	74.35	88.24
20	74.29	77.89	73.16	93.50	74.80	88.76
18	75.06	78.69	73.77	93.95	75.89	89.46
16	75.61	79.07	75.01	94.30	76.90	90.10
14	76.06	79.82	76.49	94.74	79.21	91.11
12	77.51	80.45	78.69	95.51	80.46	92.60
10	78.80	81.46	81.20	96.35	83.25	93.56
8	81.85	83.71	83.27	97.44	89.21	95.60
6	84.47	86.28	86.31	98.03	95.33	97.19
4	89.22	90.08	91.76	98.94	96.56	98.50
2	96.39	95.57	97.16	99.54	98.97	99.24
0	100.00	100.00	100.00	100.00	100.00	100.00

APPENDIX K-93
PERCENT EXCEEDENCE FOR MAXIMUM WUA, HABITAT REACH B, MEDIUM POOL GUILD, FALL
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	300MOD50	MOD55	480MOD55	WET	WETOF
100	3.95	2.91	3.94	1.23	1.22	1.22
98	4.85	3.91	4.43	1.24	1.36	1.25
96	14.32	10.72	11.87	1.94	2.76	1.94
94	18.54	17.39	16.72	2.21	3.98	3.19
92	20.87	19.66	19.44	2.31	4.28	3.38
90	23.58	21.65	21.28	2.41	5.28	3.67
88	24.73	22.54	23.51	2.52	11.64	3.87
86	26.02	23.10	25.48	2.62	19.53	4.15
84	26.42	23.76	26.65	2.71	21.93	4.34
82	26.91	24.10	27.63	2.75	24.11	5.51
80	27.59	24.80	28.16	2.80	25.54	7.92
78	28.46	26.34	28.53	2.84	26.74	11.95
76	29.68	27.10	29.20	2.90	27.26	13.36
74	31.51	28.53	29.55	2.95	27.69	14.46
72	33.09	29.89	29.92	2.98	27.98	14.98
70	38.13	31.03	30.81	3.02	28.33	15.62
68	39.78	33.09	31.30	3.05	28.63	16.61
66	41.59	36.51	32.08	3.08	29.11	17.78
64	44.98	39.24	34.06	3.11	29.58	18.38
62	47.10	42.53	35.91	3.14	30.18	19.44
60	49.29	45.08	36.87	3.18	30.96	20.09
58	51.01	47.56	39.02	3.21	31.75	20.62
56	52.65	49.58	41.70	3.25	33.71	21.41
54	54.65	51.08	45.27	3.30	37.44	22.49
52	57.38	53.70	47.69	3.34	40.50	23.21
50	58.77	55.88	51.35	3.39	45.18	24.45
48	60.75	58.02	53.82	3.43	48.33	25.40
46	62.33	59.50	55.95	3.47	49.35	26.34
44	64.12	60.84	57.32	3.51	51.12	27.54
42	64.94	61.75	59.90	3.53	52.36	28.97
40	65.80	63.04	62.86	3.55	54.20	29.88
38	67.36	64.18	65.33	3.57	55.39	30.78
36	68.70	64.90	67.34	3.61	57.36	34.78
34	70.24	65.88	69.16	3.66	59.24	38.87
32	72.26	66.92	71.83	3.69	61.89	41.71
30	74.02	68.23	74.06	3.73	64.19	43.92
28	74.75	69.48	76.20	3.78	66.04	47.79
26	77.13	71.13	78.50	3.82	67.49	51.03
24	78.16	73.31	82.37	3.86	68.20	54.35
22	80.14	75.87	83.89	3.94	71.23	56.49
20	81.91	77.20	84.63	4.02	76.64	61.05
18	83.15	78.47	85.84	4.15	79.65	63.28
16	84.14	80.58	88.36	4.21	81.44	65.79
14	85.77	83.83	90.55	4.32	83.80	67.99
12	87.95	88.12	92.31	4.40	87.60	70.89
10	90.26	91.35	93.90	6.26	90.57	82.86
8	91.43	93.16	95.42	21.52	92.91	88.33
6	94.03	94.99	96.45	27.57	94.88	92.35
4	95.56	97.64	97.83	51.39	97.11	94.52
2	98.03	98.93	98.73	91.08	98.85	96.94
0	100.00	100.00	100.00	100.00	100.00	100.00

APPENDIX K-94
PERCENT EXCEEDENCE FOR MAXIMUM WUA, HABITAT REACH B, DEEP POOL GUILD, FALL
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	300MOD50	MOD55	480MOD55	WET	WETOF
100	0.84	0.89	0.39	0.59	0.59	0.59
98	1.80	2.36	0.65	0.61	0.74	0.64
96	2.55	2.63	2.79	1.13	1.30	1.14
94	2.77	2.83	3.47	1.33	2.13	1.84
92	3.63	3.24	6.10	1.41	2.59	2.13
90	6.64	7.81	7.11	1.48	2.76	2.24
88	7.94	10.03	8.21	1.57	2.95	2.39
86	9.68	12.50	11.10	1.64	3.06	2.54
84	12.38	15.41	13.66	1.71	4.68	2.78
82	14.99	17.74	15.06	1.73	6.16	2.93
80	19.69	22.48	17.33	1.78	11.49	3.28
78	24.58	26.33	18.94	1.80	15.27	7.38
76	28.79	34.39	22.90	1.85	16.56	10.26
74	32.14	39.30	25.49	1.89	20.32	12.11
72	36.32	42.38	27.97	1.91	24.40	14.72
70	38.41	44.52	31.35	1.94	26.88	20.19
68	40.93	46.35	35.06	1.97	30.70	24.88
66	42.00	49.27	38.21	1.99	34.27	29.36
64	44.19	51.19	43.17	2.01	39.25	32.66
62	46.20	52.59	45.91	2.04	45.21	36.05
60	48.05	54.35	48.78	2.07	52.04	38.99
58	50.22	55.87	51.22	2.09	55.70	40.51
56	51.47	57.29	53.61	2.12	56.54	43.53
54	53.73	58.56	55.45	2.16	58.21	46.24
52	55.23	59.85	56.90	2.19	60.61	49.59
50	56.15	60.88	59.14	2.22	63.02	51.46
48	58.08	62.16	61.39	2.25	64.63	53.69
46	59.26	63.08	63.20	2.28	67.18	55.71
44	60.30	64.56	66.26	2.31	68.56	56.30
42	61.62	65.66	68.67	2.33	71.52	57.59
40	63.82	66.77	70.49	2.34	72.70	58.94
38	66.82	67.60	72.48	2.36	74.49	59.82
36	68.91	69.57	74.06	2.39	76.31	61.87
34	70.45	70.42	76.08	2.43	77.39	63.08
32	72.69	71.07	78.67	2.45	78.68	64.87
30	74.47	72.21	80.76	2.48	79.87	66.68
28	75.85	73.64	82.38	2.52	81.51	68.43
26	77.12	74.87	84.25	2.55	82.62	71.08
24	78.86	77.00	85.80	2.58	83.85	73.07
22	79.48	79.01	87.04	2.64	84.90	75.63
20	80.28	80.31	88.86	2.70	85.60	77.46
18	81.62	81.71	90.06	2.80	86.85	79.31
16	83.58	83.49	90.91	2.84	87.60	81.86
14	84.62	85.36	91.95	2.93	89.14	83.70
12	86.16	87.27	93.39	2.99	90.13	86.38
10	89.13	88.80	94.69	9.22	92.19	88.45
8	90.31	91.31	95.63	28.16	93.51	90.29
6	92.20	93.27	96.06	52.75	94.90	92.05
4	94.61	95.00	97.70	69.00	96.85	93.73
2	98.44	97.79	98.92	82.87	98.40	95.80
0	100.00	100.00	100.00	100.00	100.00	100.00

APPENDIX K-95
PERCENT EXCEEDENCE FOR MAXIMUM WUA, HABITAT REACH B, LOW GRADIENT GROUP, FALL
Final Aquatic Impact Analysis Report

% Exceedence	MOD50	300MOD50	MOD55	480MOD55	WET	WETOF
100	75.55	75.57	75.37	81.44	65.43	59.89
98	75.94	76.27	75.47	88.17	76.04	75.97
96	76.25	76.45	76.64	89.91	76.36	78.27
94	76.66	77.70	78.40	91.00	76.77	80.65
92	78.61	80.60	78.99	91.83	77.62	82.62
90	79.47	83.34	79.85	92.09	80.75	85.13
88	80.58	86.56	83.90	92.42	86.86	88.65
86	83.97	88.83	85.37	92.72	88.49	89.67
84	87.18	89.25	88.23	92.93	89.24	90.67
82	89.42	90.17	89.01	93.25	89.64	92.72
80	90.02	91.33	89.43	93.42	90.03	93.74
78	90.72	92.00	89.89	93.55	90.56	94.11
76	91.39	92.41	90.23	93.70	90.83	94.44
74	91.69	92.65	90.79	93.82	91.58	94.64
72	92.04	93.15	91.43	93.94	92.02	95.01
70	92.25	93.49	91.80	94.09	93.44	95.23
68	92.55	93.82	92.55	94.19	94.00	95.53
66	92.95	94.02	93.14	94.32	94.15	96.05
64	93.10	94.24	93.53	94.39	94.46	96.36
62	93.41	94.42	93.95	94.48	94.92	96.66
60	93.80	94.58	94.35	94.58	95.18	97.11
58	93.98	94.76	94.71	94.67	95.65	97.51
56	94.27	94.96	95.16	94.78	96.07	97.80
54	94.48	95.18	95.67	94.88	96.28	98.10
52	94.63	95.42	96.00	94.99	96.61	98.30
50	94.84	95.74	96.40	95.12	96.85	98.49
48	95.23	96.09	96.66	95.27	97.08	98.61
46	95.64	96.45	97.11	95.38	97.25	98.74
44	96.23	96.88	97.56	95.50	97.42	98.89
42	96.59	97.05	97.94	95.61	97.83	98.97
40	96.89	97.32	98.25	95.72	98.23	99.02
38	97.15	97.71	98.61	95.78	98.51	99.05
36	97.35	97.90	98.85	95.84	98.71	99.08
34	97.81	98.32	99.00	95.88	99.04	99.13
32	98.05	98.81	99.17	96.03	99.23	99.17
30	98.56	99.08	99.27	96.17	99.40	99.23
28	98.89	99.21	99.32	96.27	99.48	99.27
26	99.01	99.30	99.40	96.37	99.58	99.31
24	99.18	99.40	99.44	96.51	99.65	99.34
22	99.33	99.46	99.57	96.62	99.70	99.37
20	99.46	99.49	99.65	96.76	99.73	99.42
18	99.54	99.53	99.71	96.98	99.75	99.47
16	99.61	99.54	99.75	97.21	99.77	99.52
14	99.67	99.57	99.79	97.60	99.79	99.58
12	99.69	99.61	99.82	97.76	99.81	99.62
10	99.71	99.70	99.85	98.07	99.83	99.67
8	99.75	99.76	99.87	98.27	99.86	99.74
6	99.79	99.81	99.90	98.56	99.89	99.81
4	99.86	99.87	99.94	99.35	99.93	99.86
2	99.95	99.92	99.96	99.72	99.97	99.91
0	100.00	100.00	100.00	100.00	100.00	100.00

APPENDIX K-96
PERCENT EXCEEDENCE FOR MAXIMUM WUA, HABITAT REACH B, TRICHOPTERA GROUP, FALL
Final Aquatic Impact Analysis Report

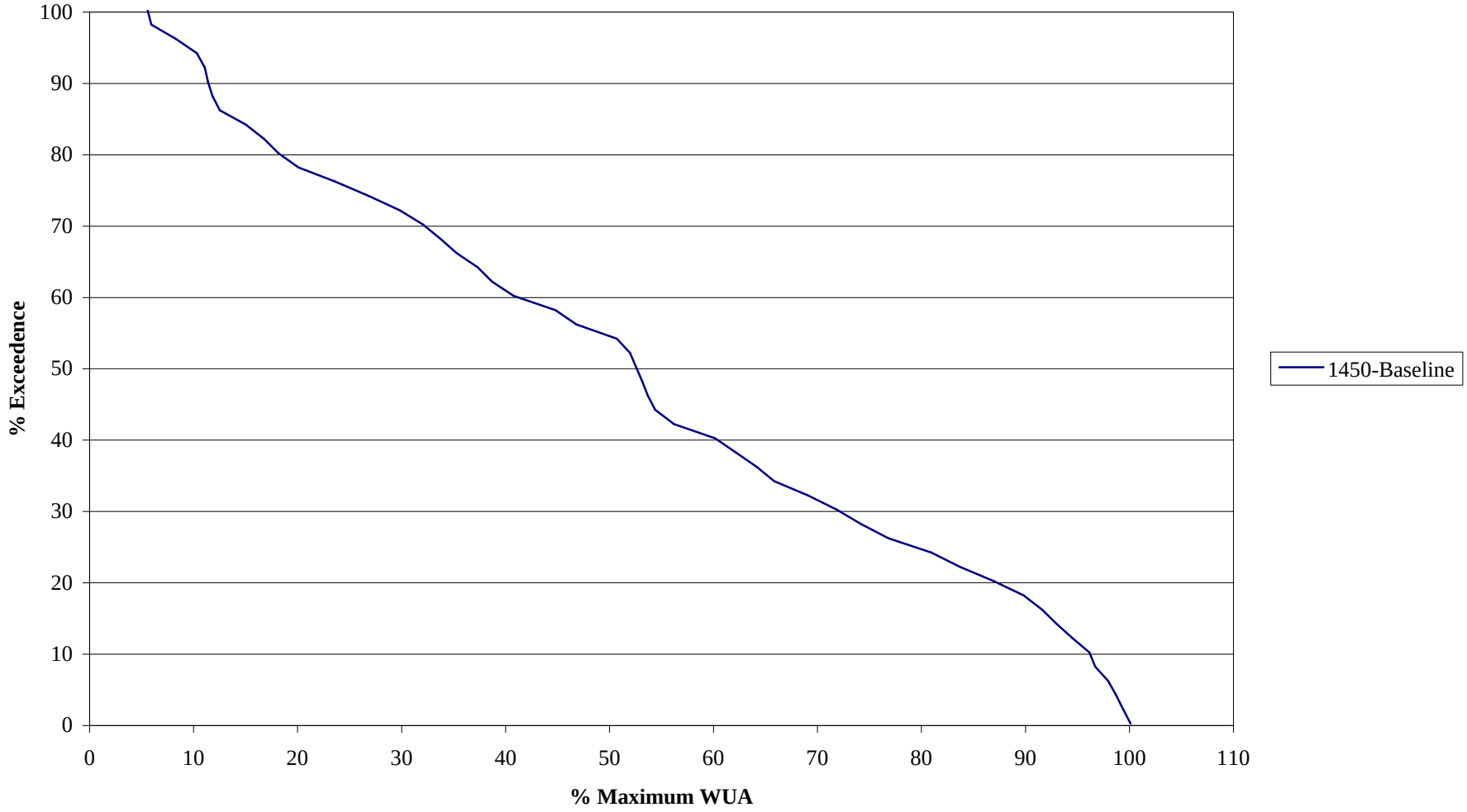
% Exceedence	MOD50	300MOD50	MOD55	480MOD55	WET	WETOF
100	47.48	47.89	44.87	72.85	49.82	49.82
98	53.01	57.70	46.35	81.72	55.51	55.50
96	57.39	60.23	62.73	85.13	59.90	68.25
94	62.76	65.65	67.03	87.95	64.50	72.51
92	67.55	72.05	68.33	90.11	66.35	74.73
90	69.42	74.56	70.23	90.82	73.48	78.31
88	71.88	77.13	74.84	91.29	77.53	80.33
86	74.92	79.03	76.00	91.77	78.77	81.74
84	77.48	79.78	78.28	92.06	79.71	85.28
82	79.94	81.42	79.16	92.59	80.72	87.07
80	81.00	83.51	79.92	92.83	81.39	88.18
78	82.25	84.71	80.73	92.97	82.38	88.57
76	83.46	85.45	81.35	93.20	83.78	89.23
74	84.00	85.88	82.34	93.34	85.13	89.94
72	84.63	86.77	83.49	93.56	87.06	91.17
70	85.01	87.38	84.14	93.77	88.04	92.17
68	85.54	87.98	85.50	93.91	88.33	93.19
66	86.26	88.36	86.56	94.09	88.67	94.11
64	86.52	88.83	87.26	94.20	89.29	95.02
62	87.08	89.15	88.00	94.31	89.93	95.44
60	87.77	89.44	88.72	94.43	90.59	95.77
58	88.09	89.73	89.35	94.58	91.24	96.38
56	88.62	90.12	90.17	94.74	91.96	96.92
54	89.00	90.57	91.07	94.87	92.61	97.33
52	89.26	91.05	91.67	95.03	93.11	98.00
50	89.63	91.79	92.38	95.22	93.52	98.70
48	90.33	92.58	92.85	95.39	93.91	98.90
46	91.06	93.21	94.03	95.57	94.57	98.94
44	92.13	93.82	94.77	95.73	95.61	98.98
42	92.78	94.28	95.49	95.88	96.89	99.04
40	93.31	95.01	96.67	96.05	97.83	99.08
38	93.80	95.58	97.37	96.15	98.32	99.12
36	94.60	96.25	97.72	96.25	98.84	99.16
34	95.20	97.12	98.21	96.31	98.87	99.21
32	96.31	97.84	98.65	96.48	98.90	99.25
30	97.05	98.70	98.86	96.67	98.93	99.29
28	98.37	99.09	98.89	96.81	98.96	99.32
26	98.89	99.14	98.92	96.93	98.98	99.34
24	98.95	99.20	98.95	97.08	98.99	99.37
22	99.00	99.25	98.96	97.29	99.01	99.40
20	99.05	99.29	98.99	97.51	99.02	99.42
18	99.09	99.36	99.01	97.73	99.04	99.46
16	99.11	99.39	99.04	98.01	99.06	99.51
14	99.13	99.41	99.08	98.60	99.09	99.54
12	99.17	99.43	99.16	98.83	99.13	99.57
10	99.22	99.46	99.24	99.01	99.23	99.60
8	99.27	99.48	99.33	99.16	99.28	99.64
6	99.38	99.53	99.40	99.36	99.38	99.69
4	99.50	99.63	99.51	99.52	99.64	99.80
2	99.66	99.74	99.73	99.86	99.87	99.91
0	100.00	100.00	100.00	100.00	100.00	100.00

APPENDIX L

HABITAT DURATION CURVES

% EXCEEDENCE OF % MAXIMUM WUA FOR HABITAT REACH L SHALLOW POOL SPRING

Final Aquatic Impact Analysis Report



% EXCEEDENCE OF % MAXIMUM WUA FOR HABITAT REACH L SLOW RIFFLE SPRING

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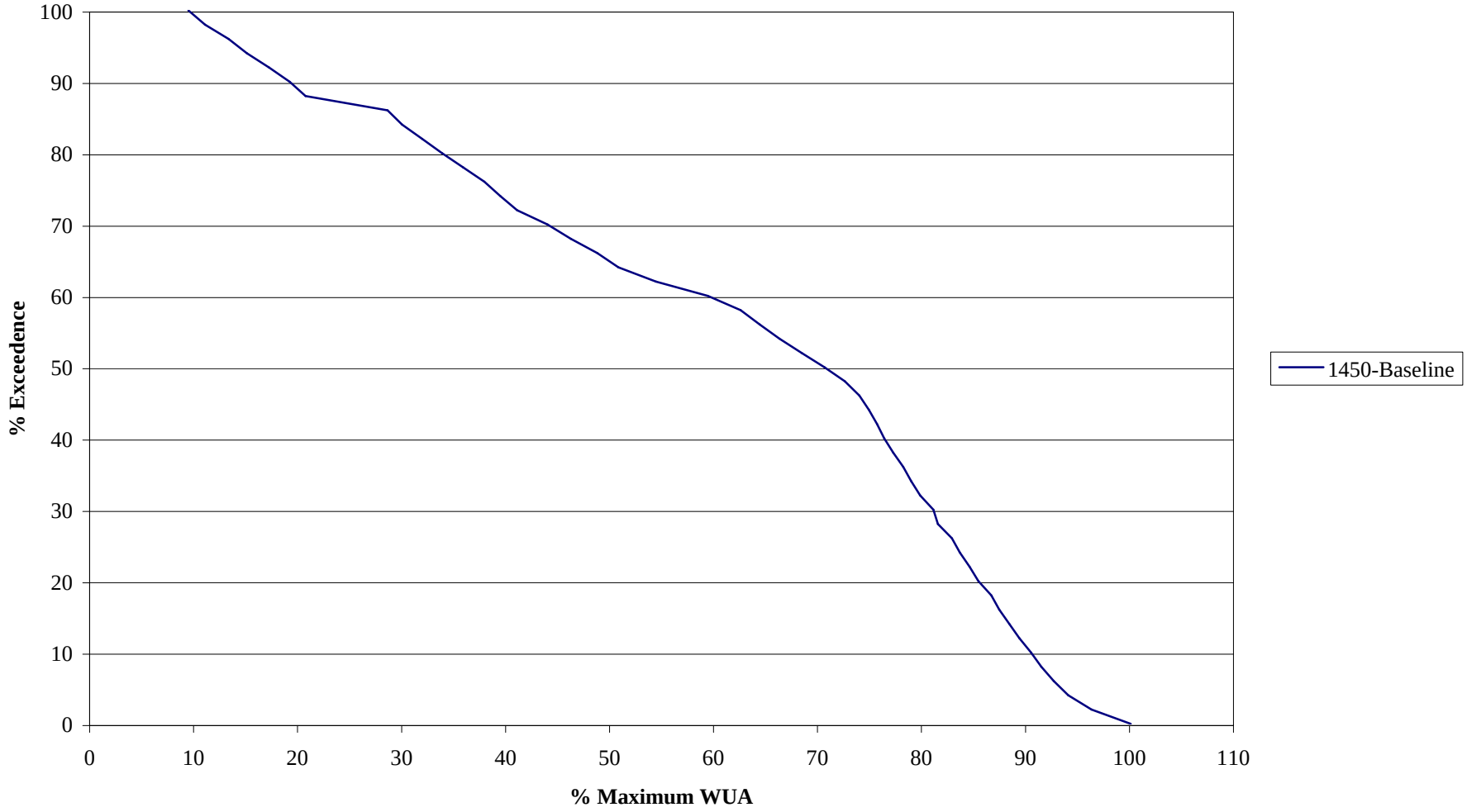

% EXCEEDENCE OF % MAXIMUM WUA FOR HABITAT REACH L FAST RIFFLE SPRING

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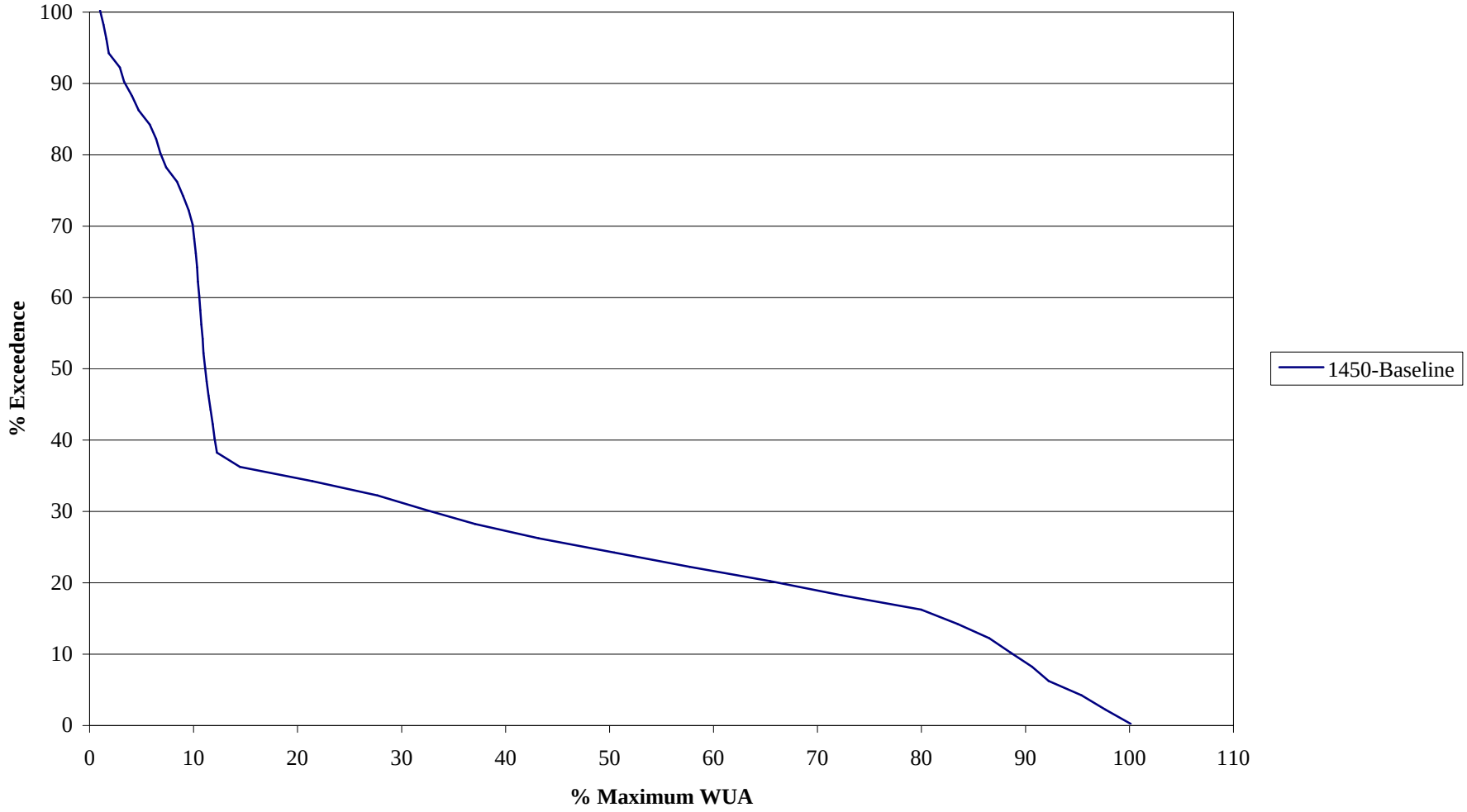

% EXCEEDENCE OF % MAXIMUM WUA FOR HABITAT REACH L RACEWAY SPRING

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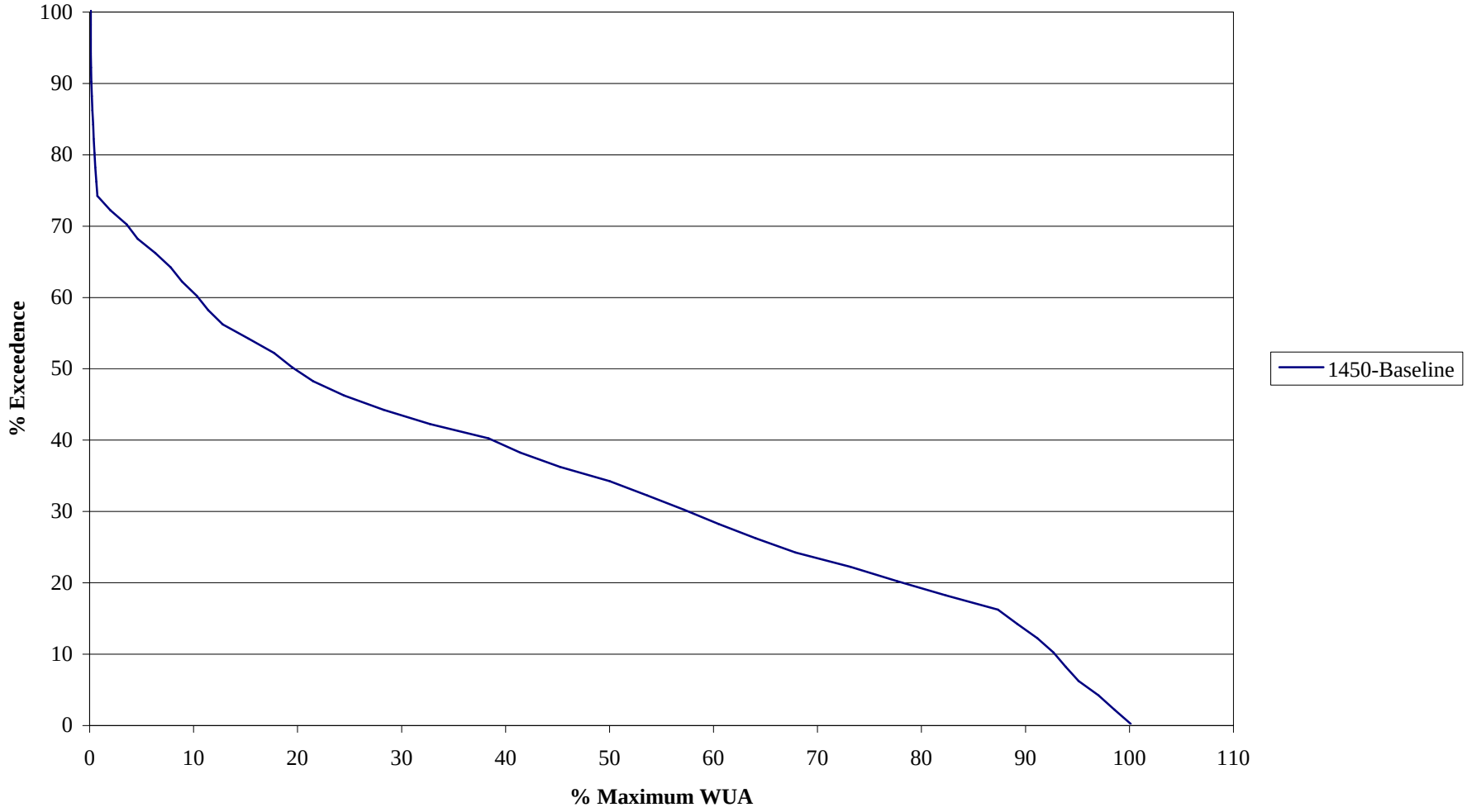

% EXCEEDENCE OF % MAXIMUM WUA FOR HABITAT REACH L MEDIUM POOL SPRING

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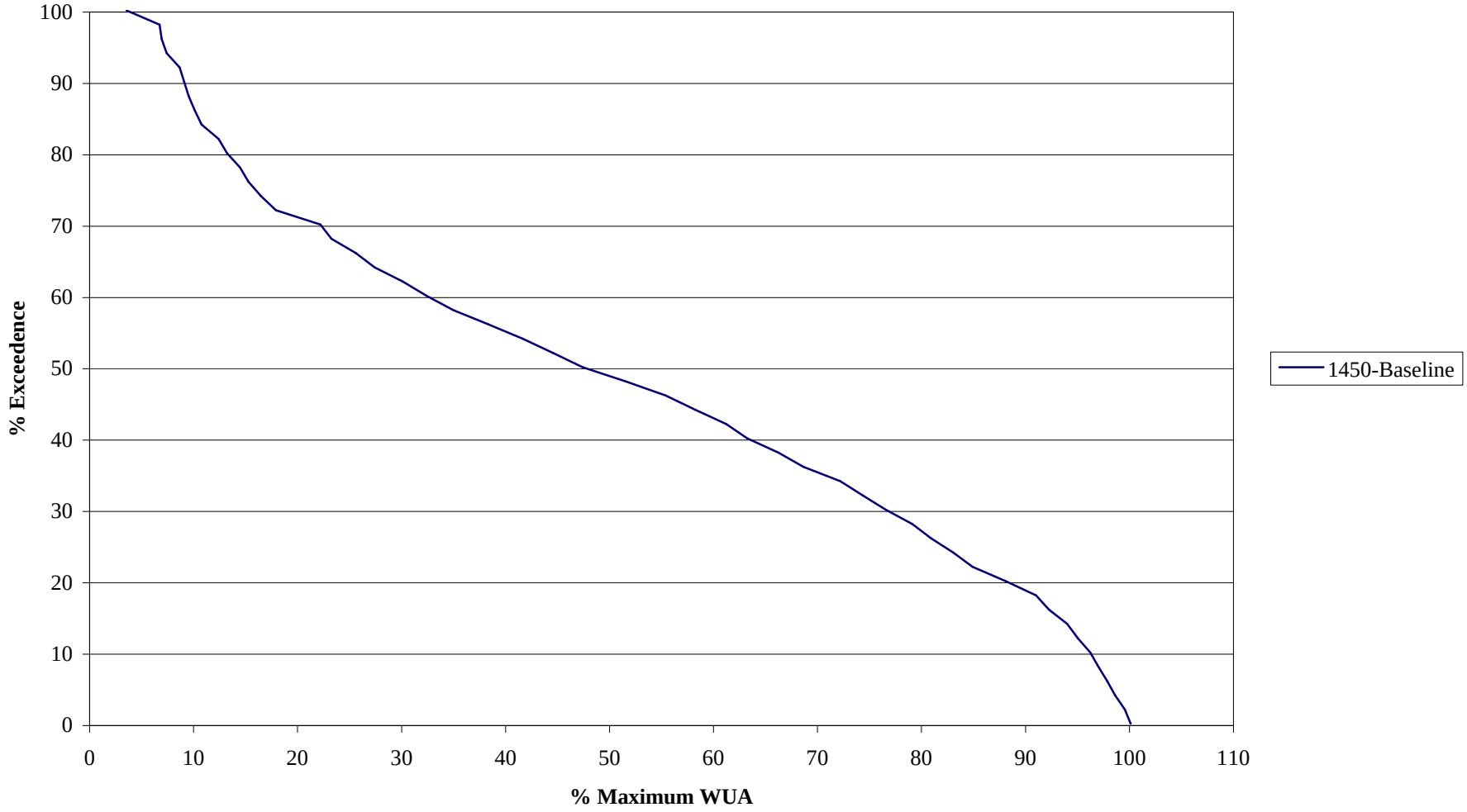

% EXCEEDENCE OF % MAXIMUM WUA FOR HABITAT REACH L DEEP POOL SPRING

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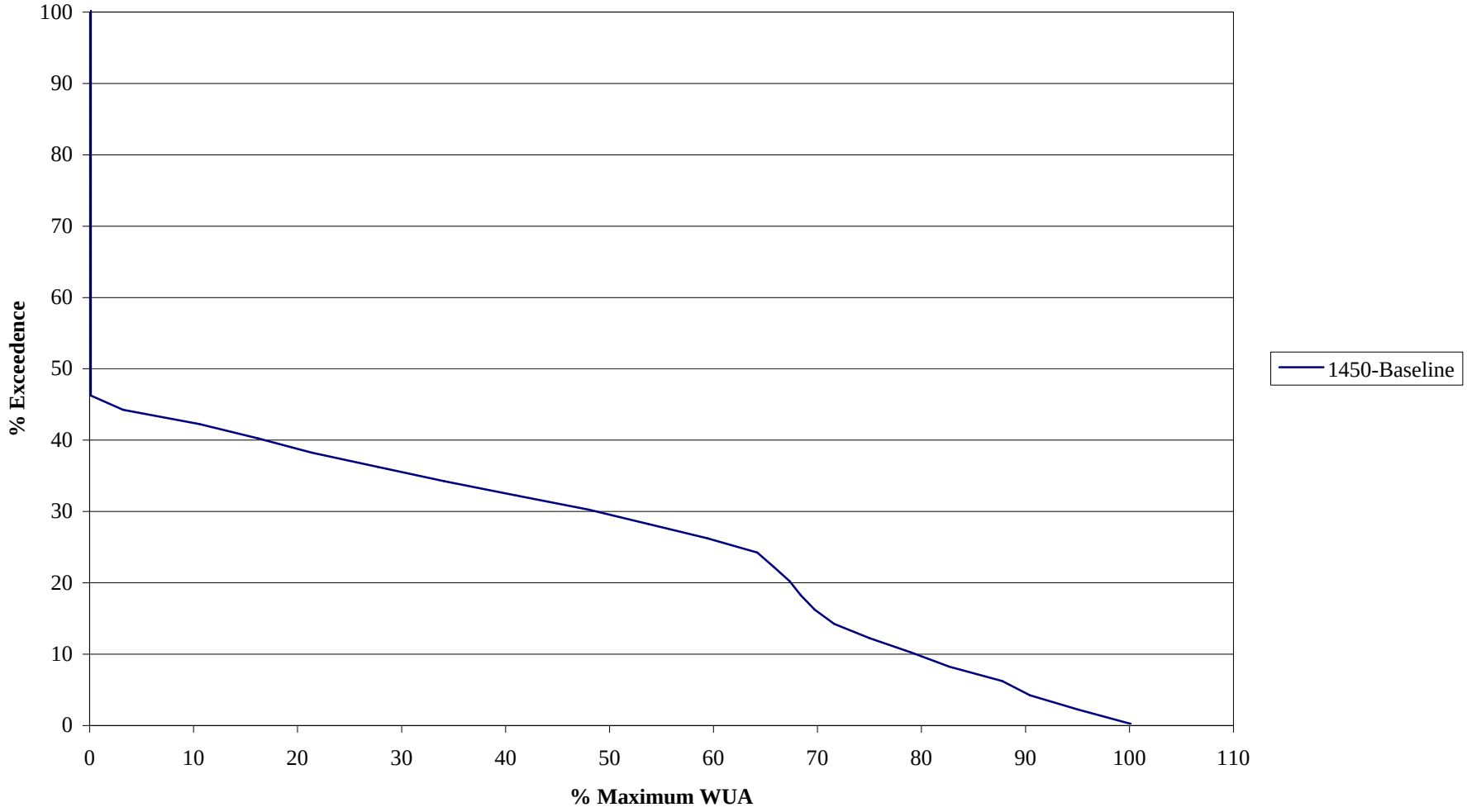

% EXCEEDENCE OF % MAXIMUM WUA FOR HABITAT REACH L LOW GRADIENT SPRING

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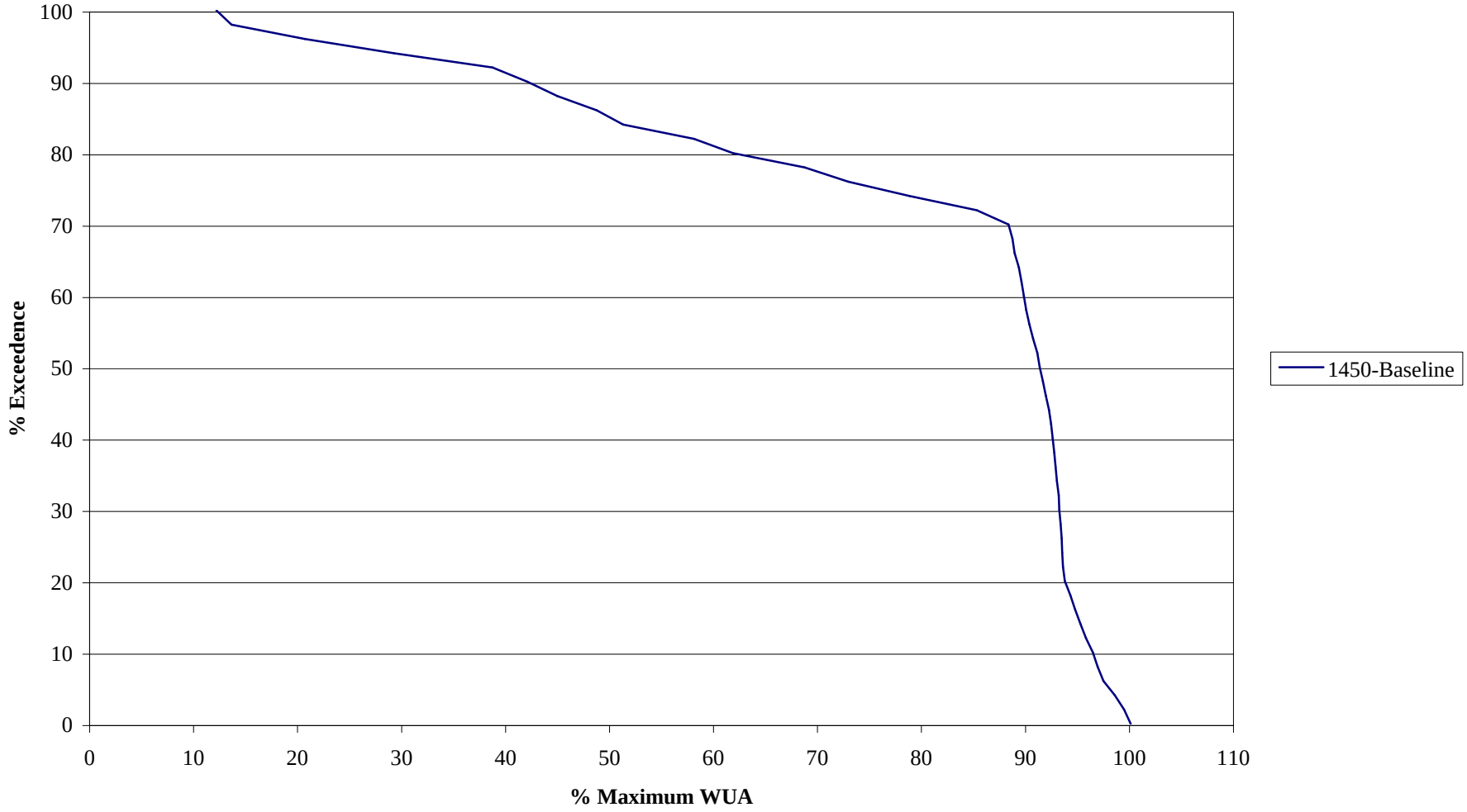
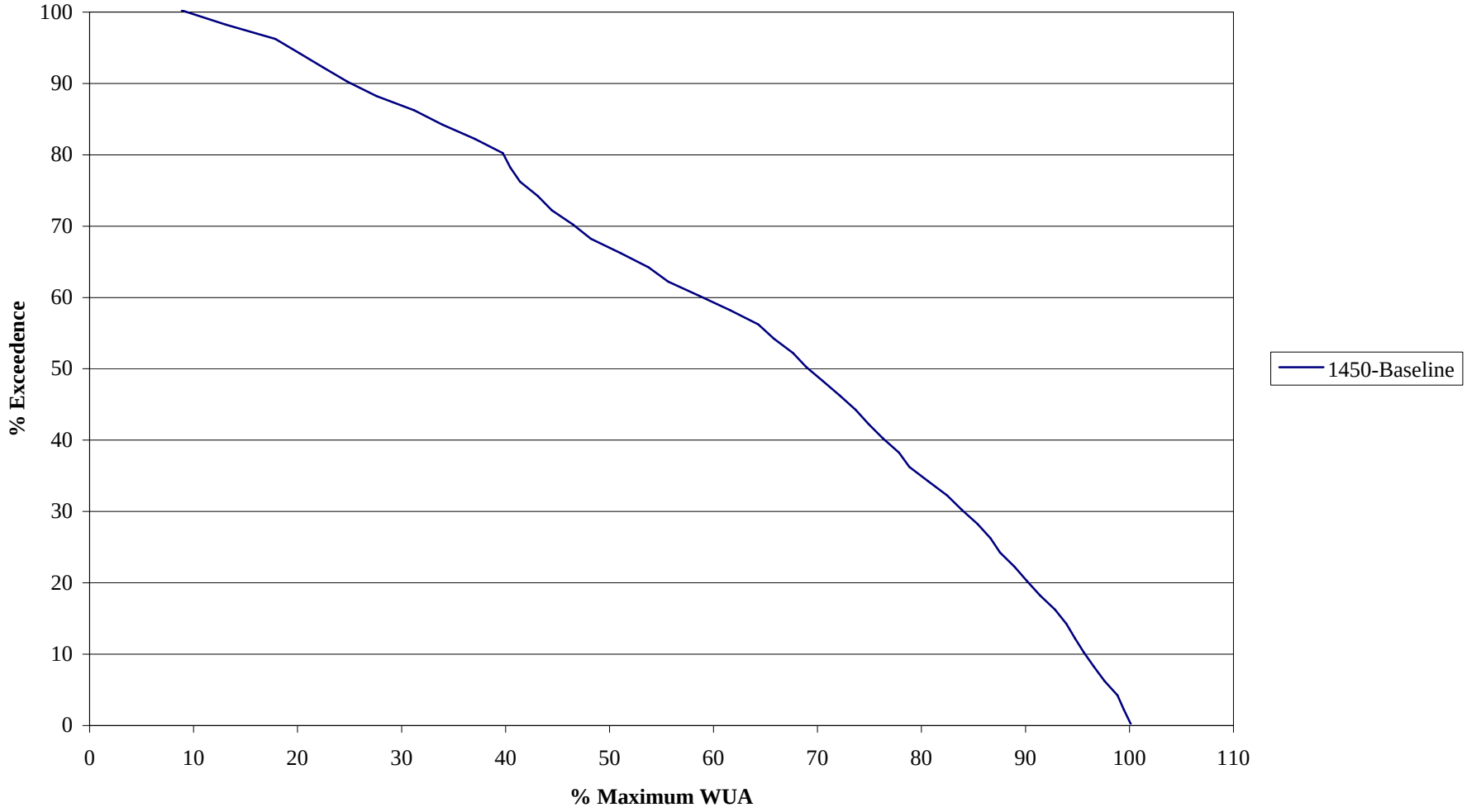


% EXCEEDENCE OF % MAXIMUM WUA FOR HABITAT REACH L TRICHOPTERA SPRING

Final Aquatic Impact Analysis Report



% EXCEEDENCE OF % MAXIMUM WUA FOR HABITAT REACH L SHALLOW POOL SUMMER

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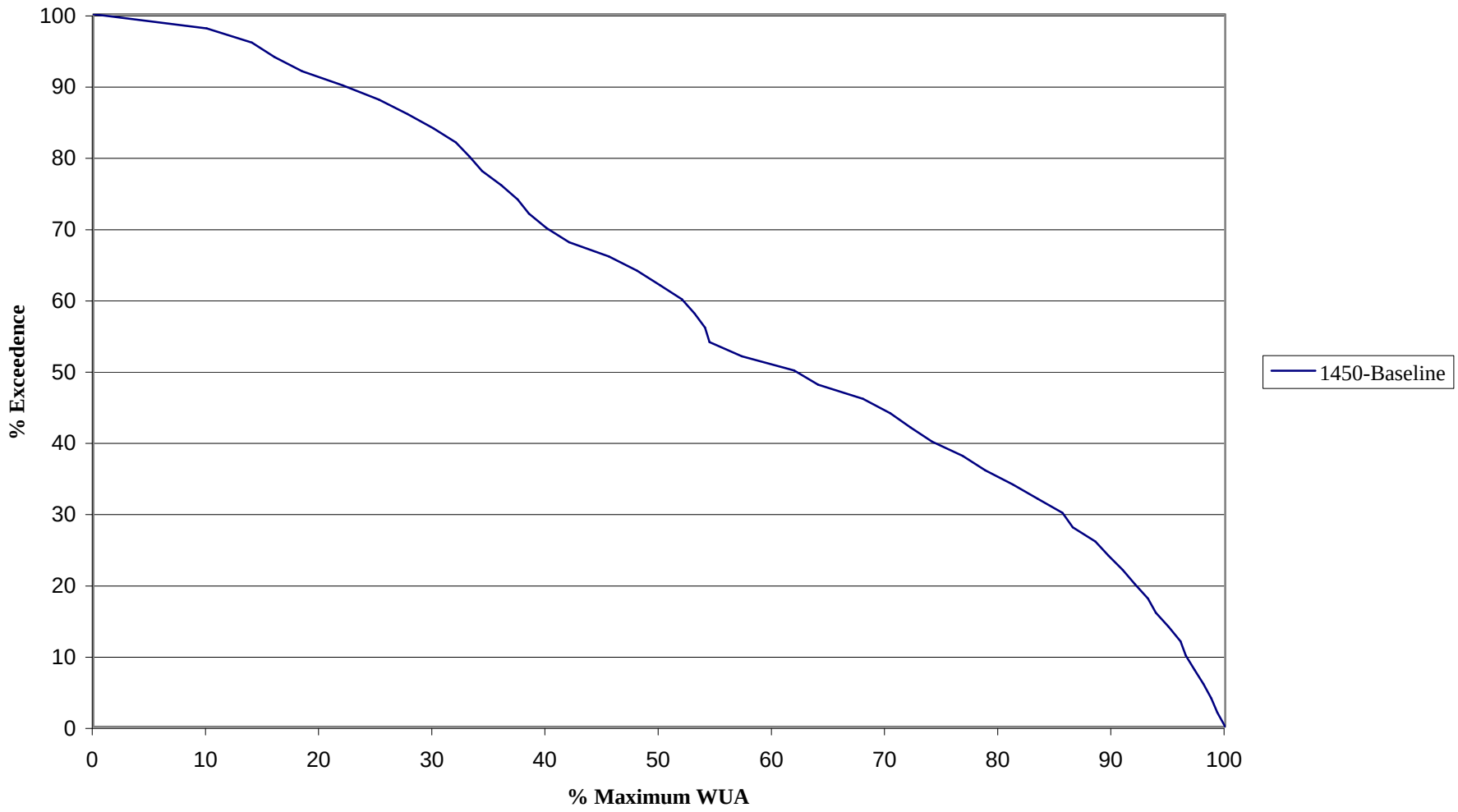

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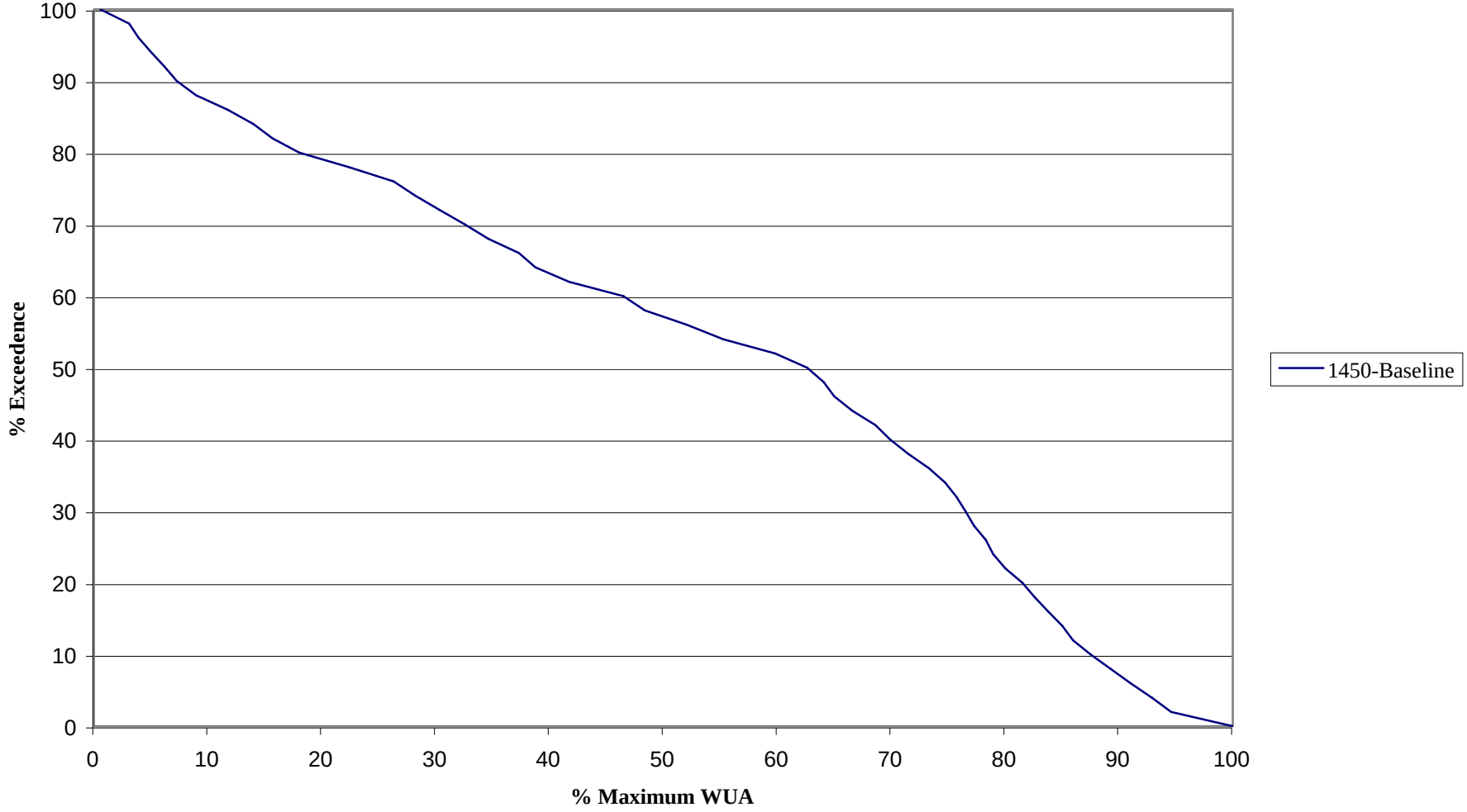

% EXCEEDENCE OF % MAXIMUM WUA FOR HABITAT REACH L FAST RIFFLE SUMMER

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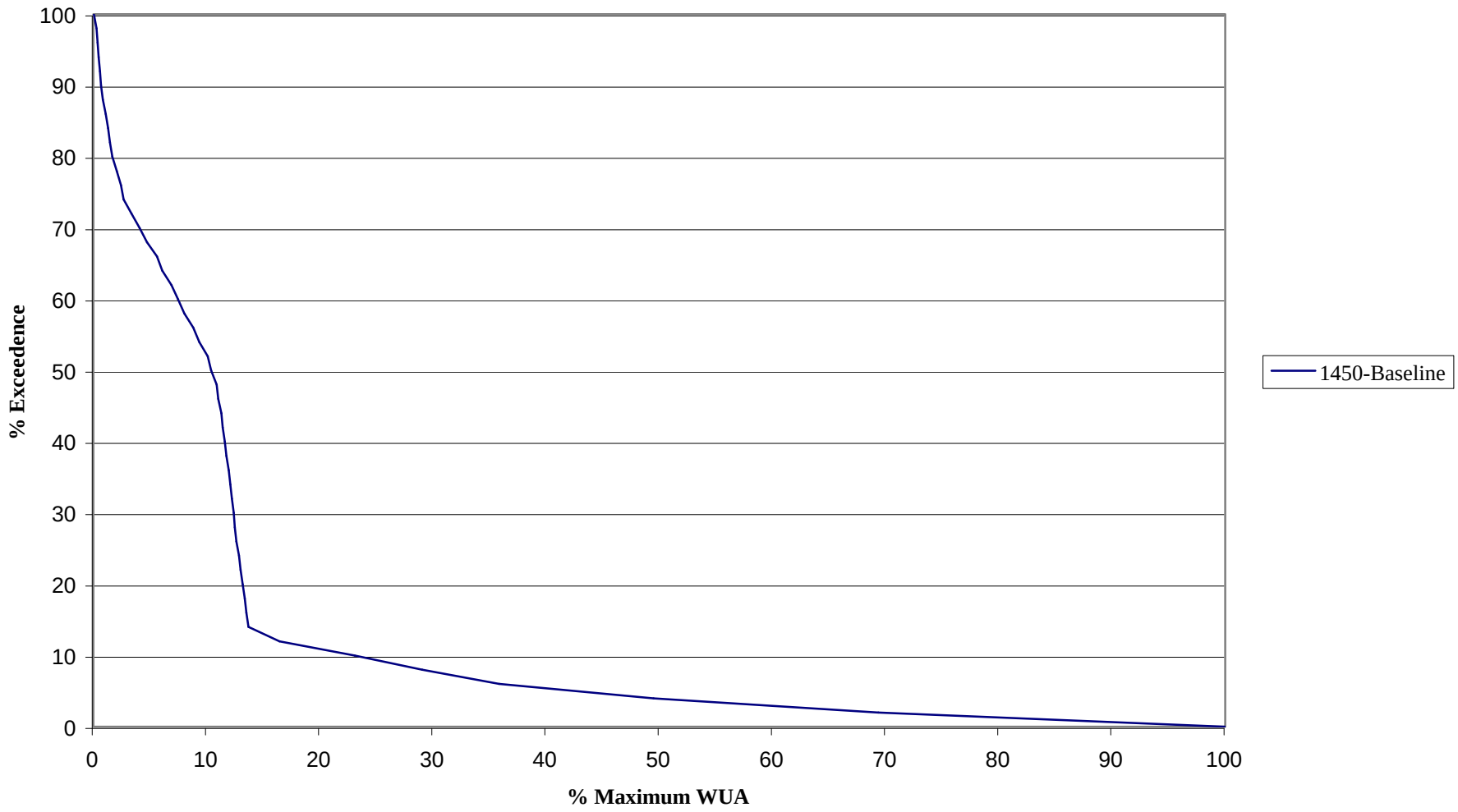

% EXCEEDENCE OF % MAXIMUM WUA FOR HABITAT REACH L RACEWAY SUMMER

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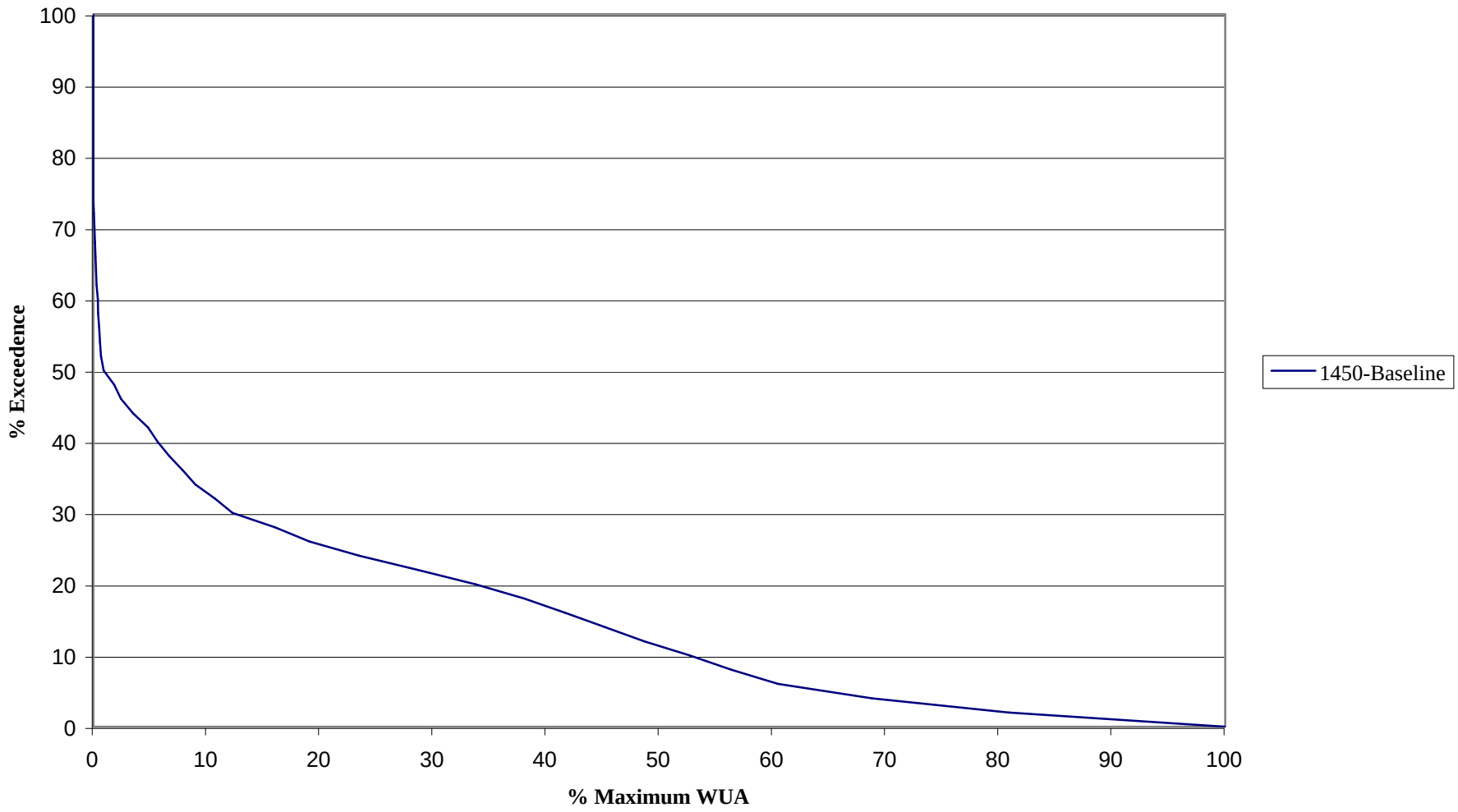

% EXCEEDENCE OF % MAXIMUM WUA FOR HABITAT REACH L MEDIUM POOL SUMMER

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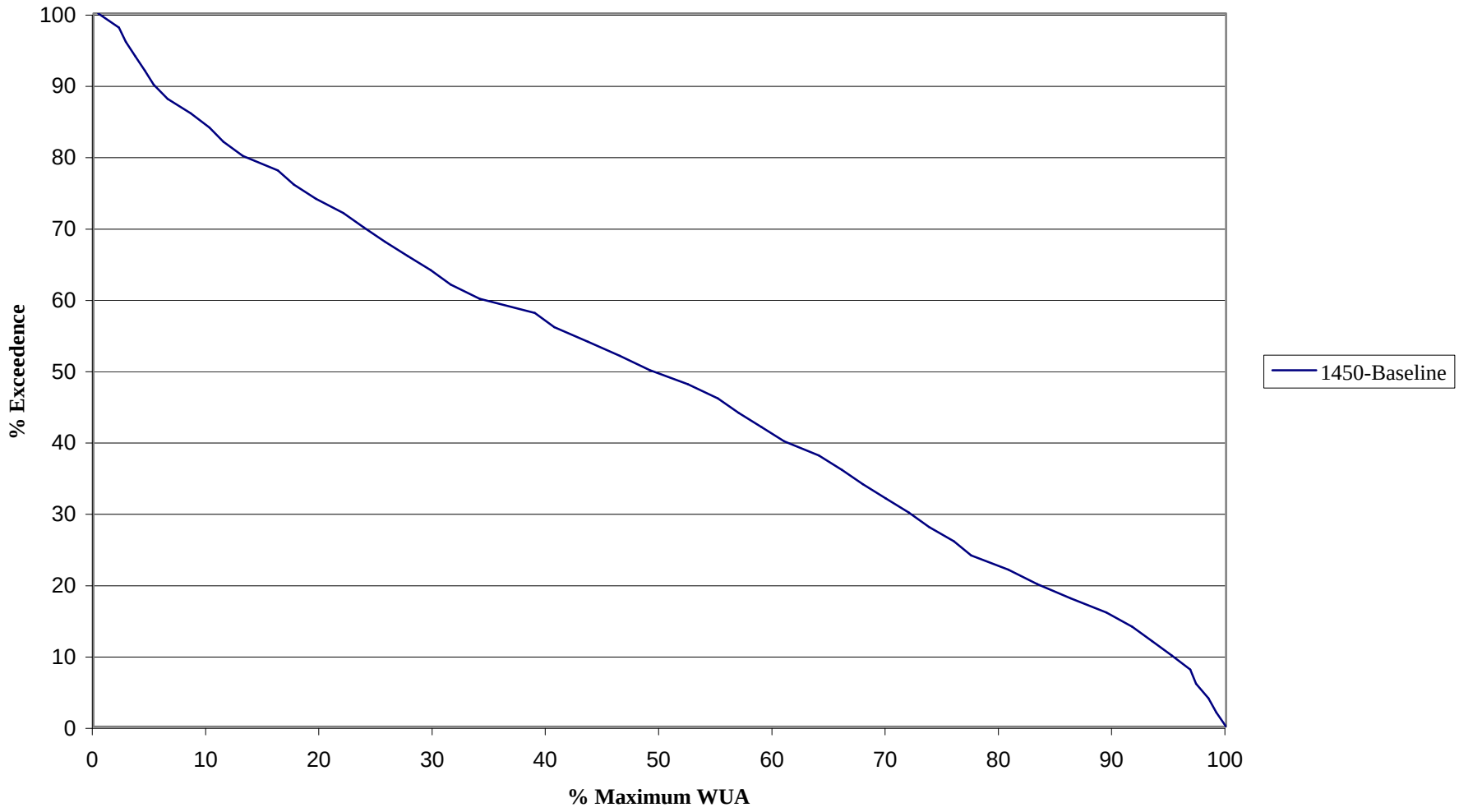

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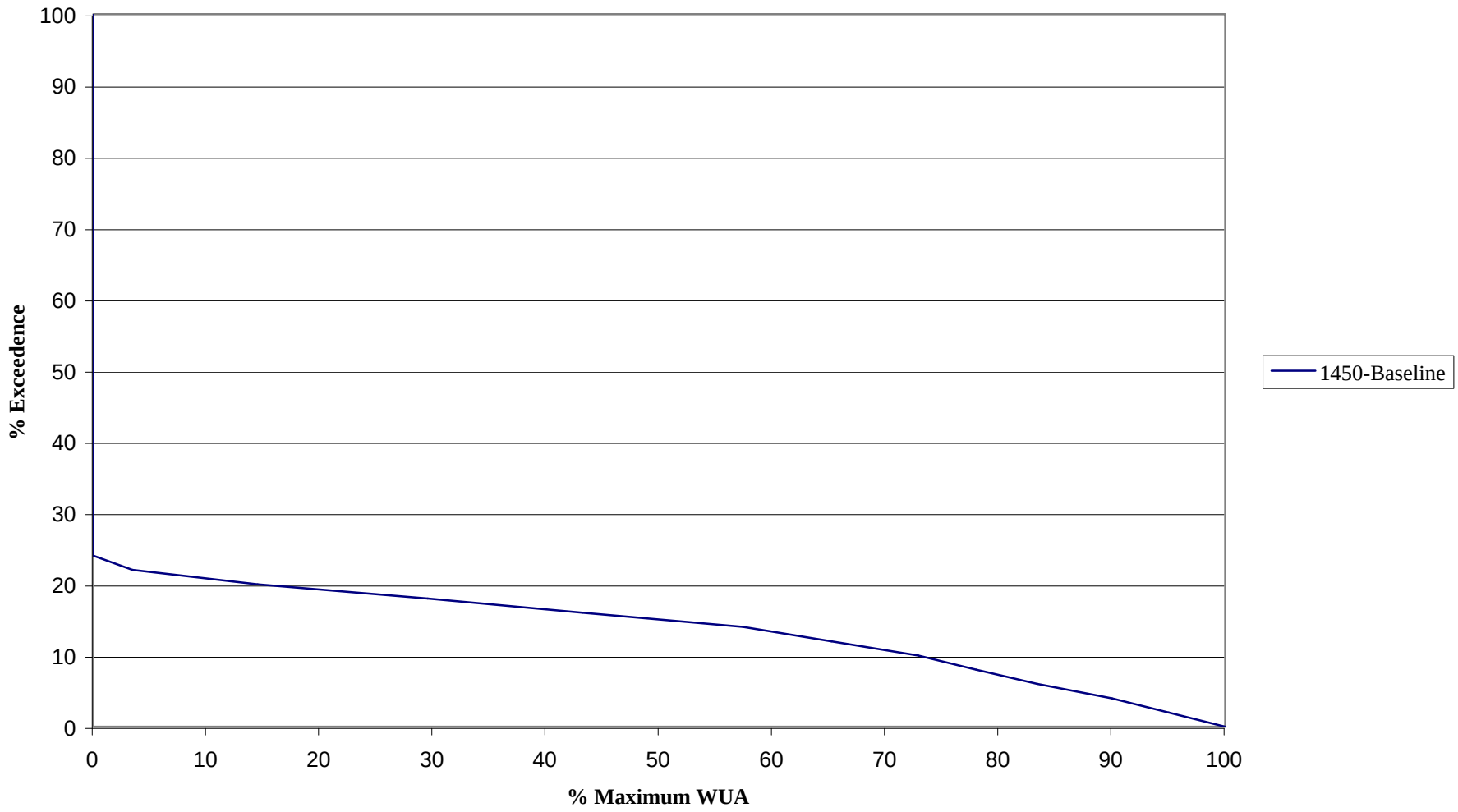

% EXCEEDENCE OF % MAXIMUM WUA FOR HABITAT REACH L LOW GRADIENT SUMMER

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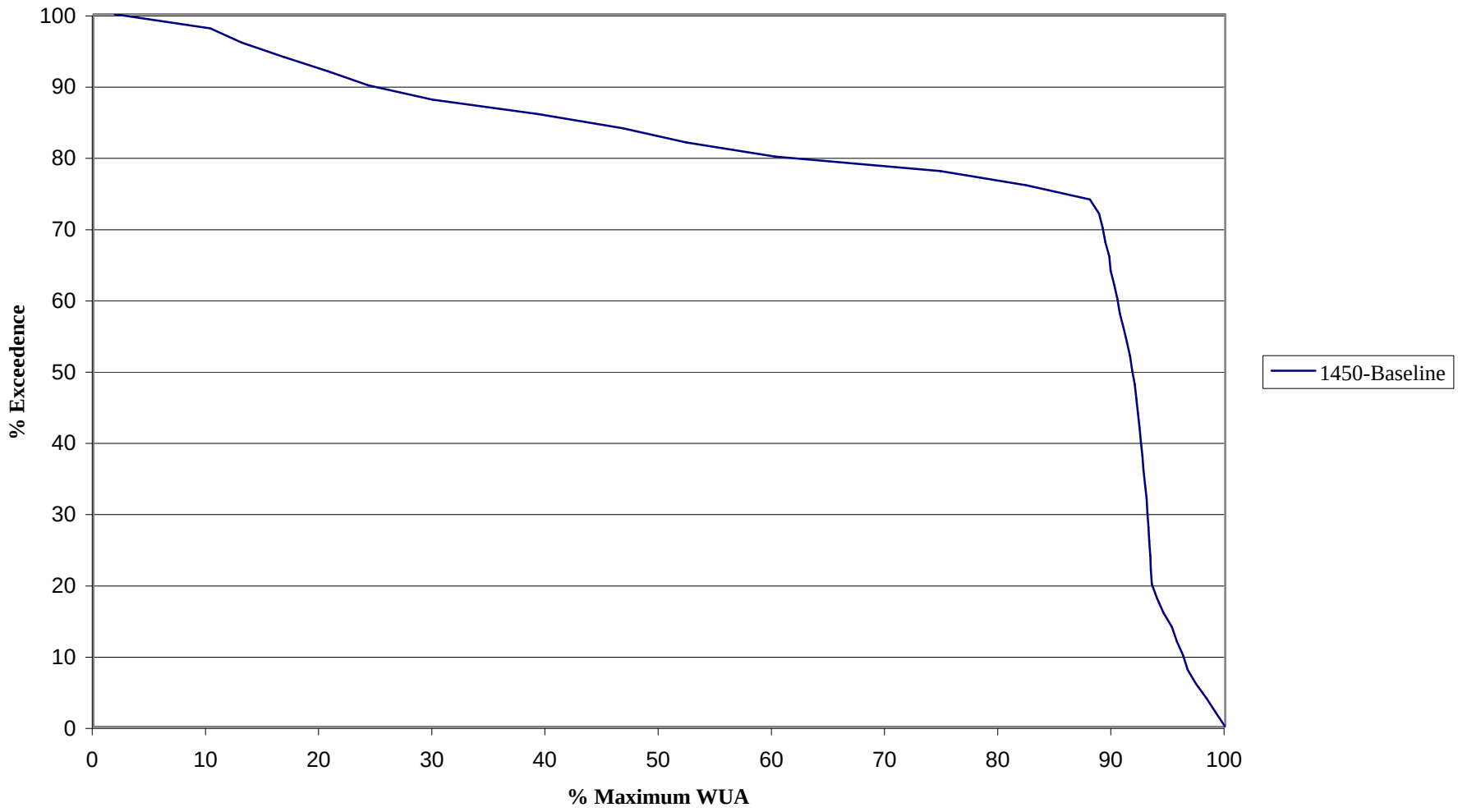

% EXCEEDENCE OF % MAXIMUM WUA FOR HABITAT REACH L TRICHOPTERA SUMMER

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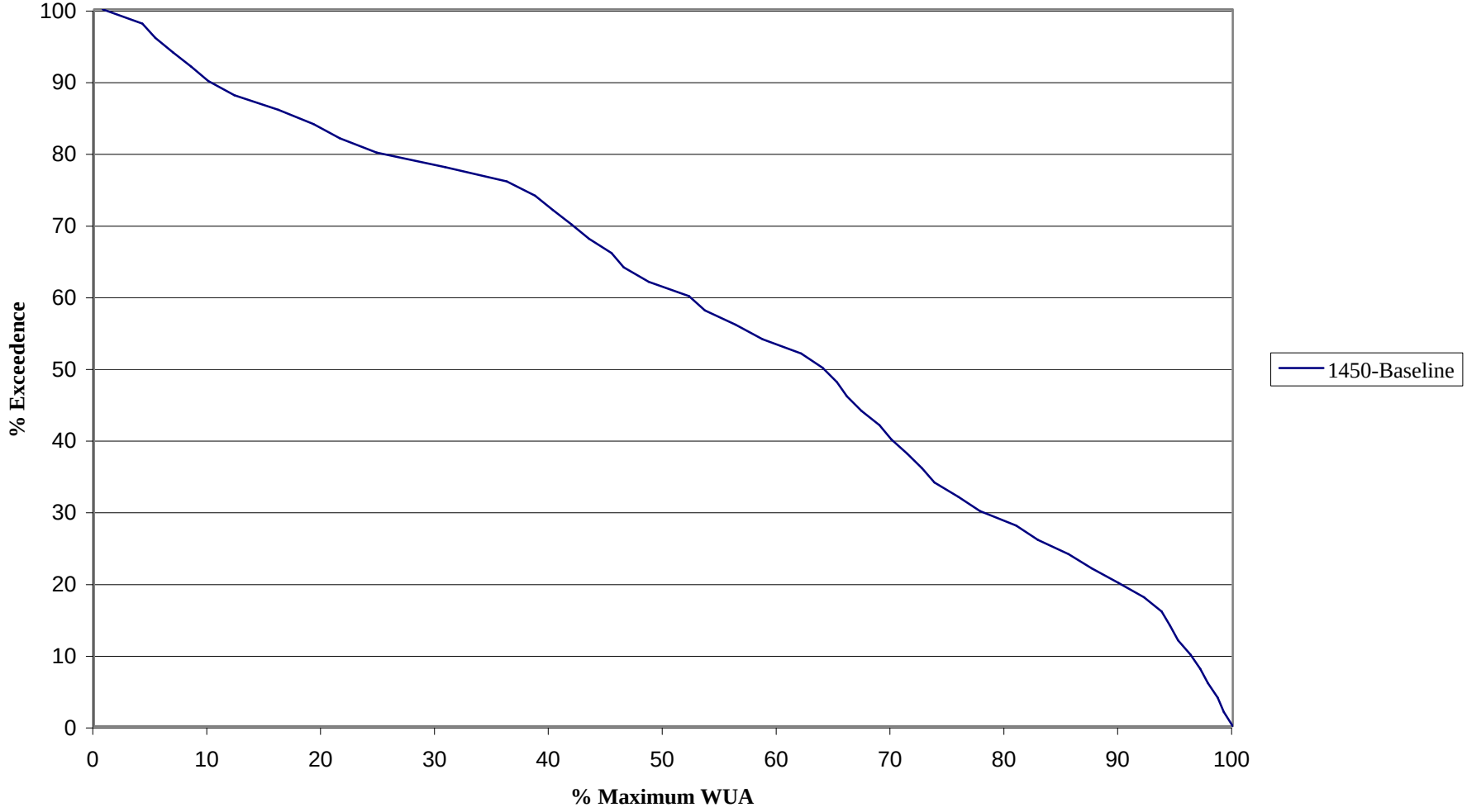

% EXCEEDENCE OF % MAXIMUM WUA FOR HABITAT REACH L SHALLOW POOL FALL

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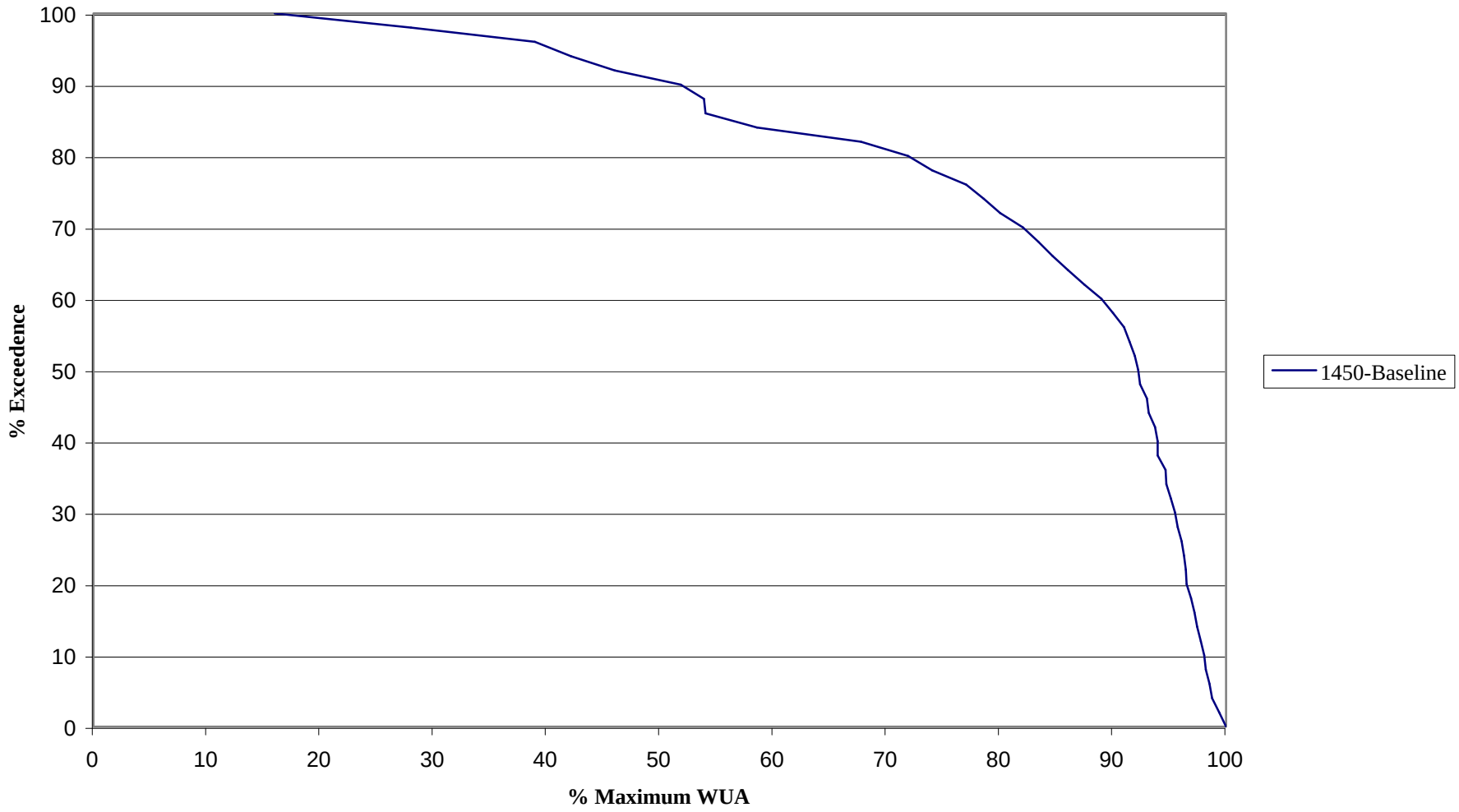

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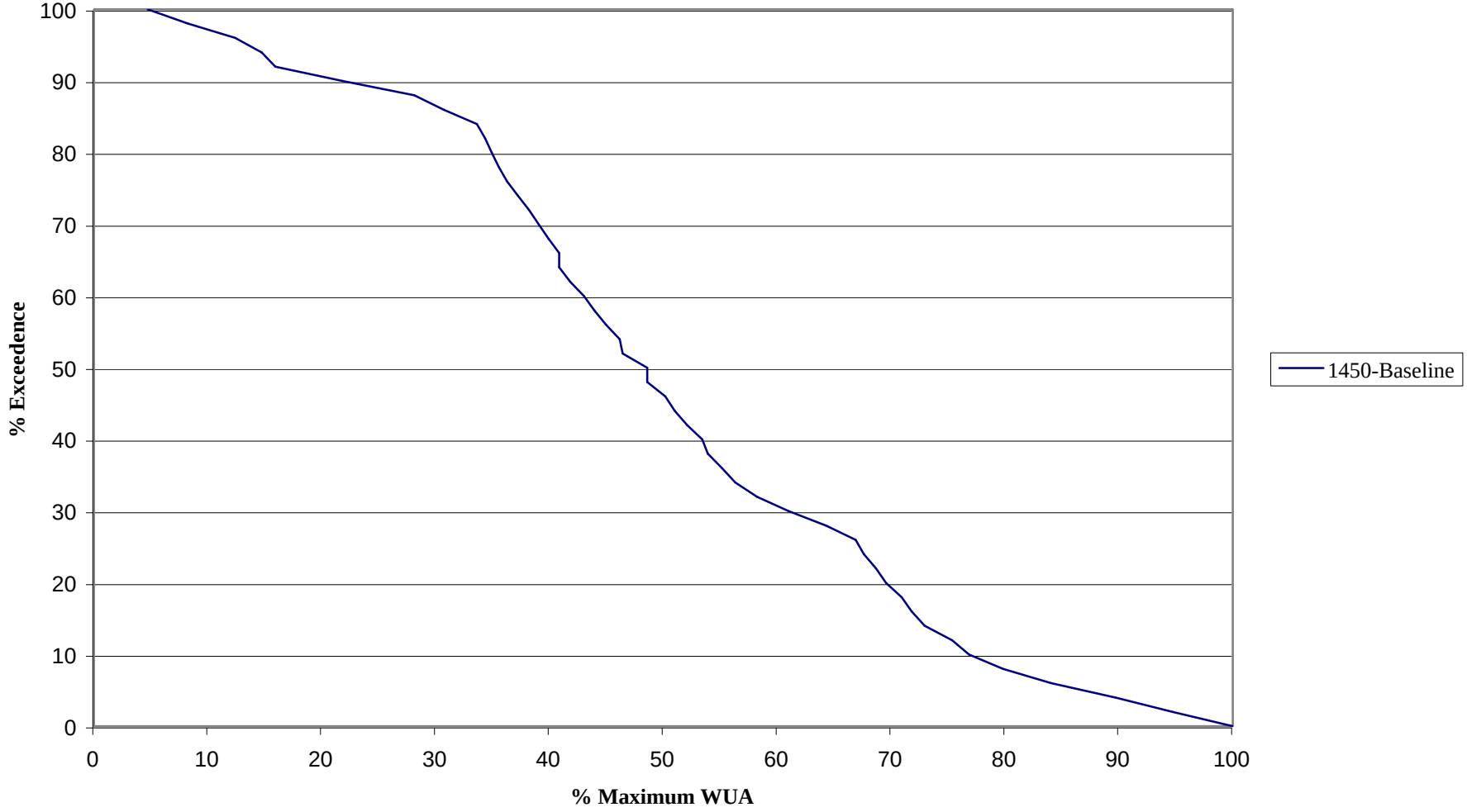

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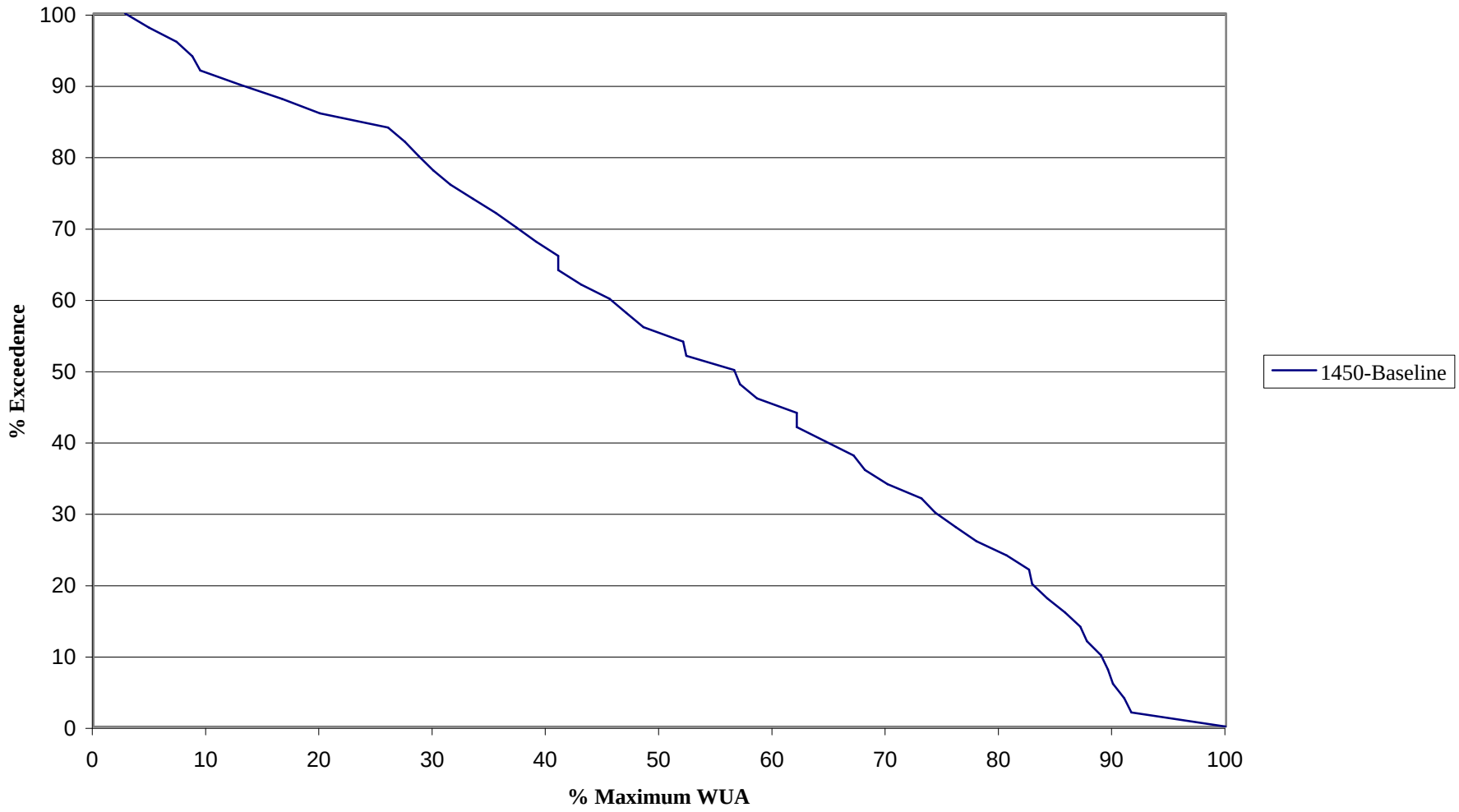

% EXCEEDENCE OF % MAXIMUM WUA FOR HABITAT REACH L RACEWAY FALL

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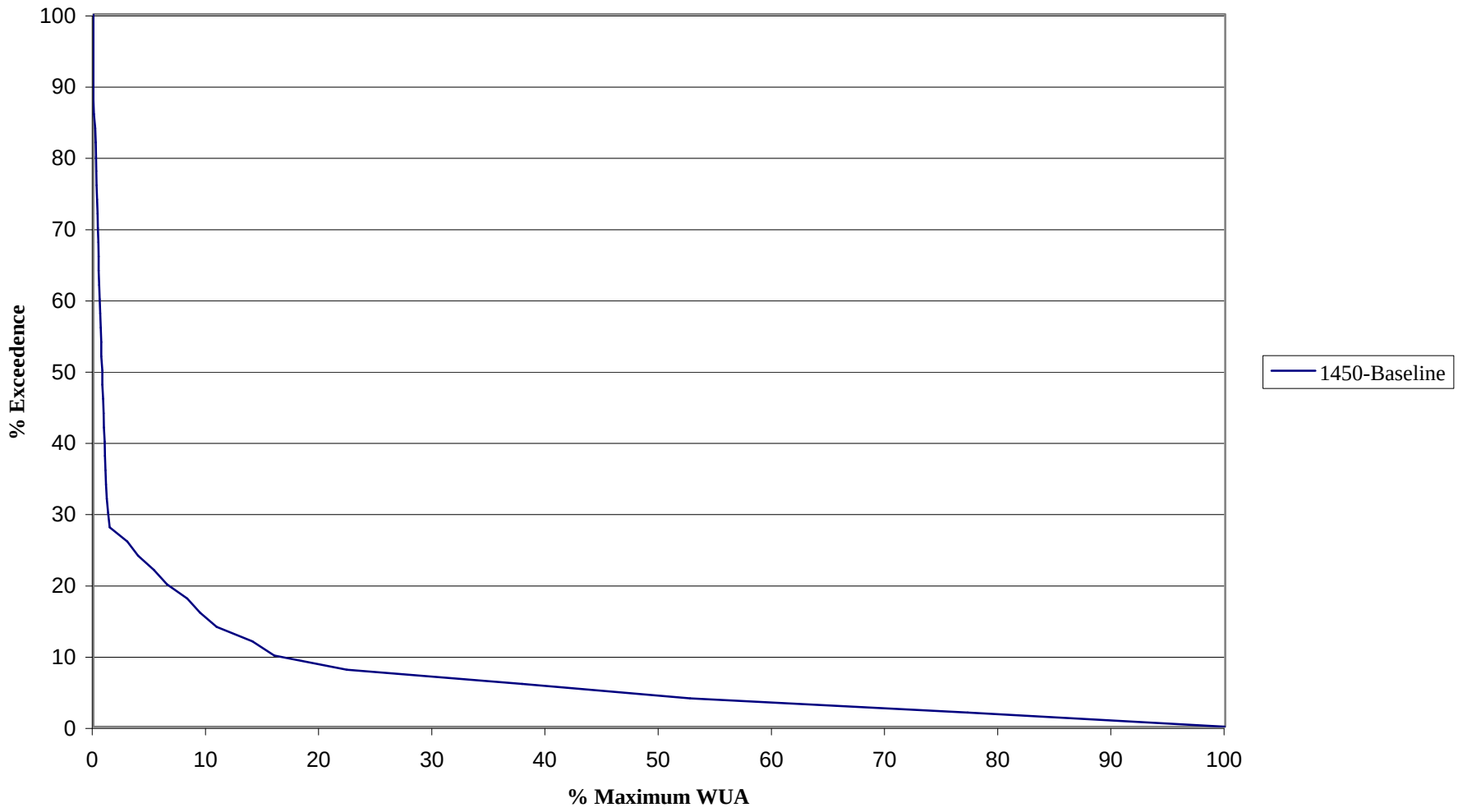
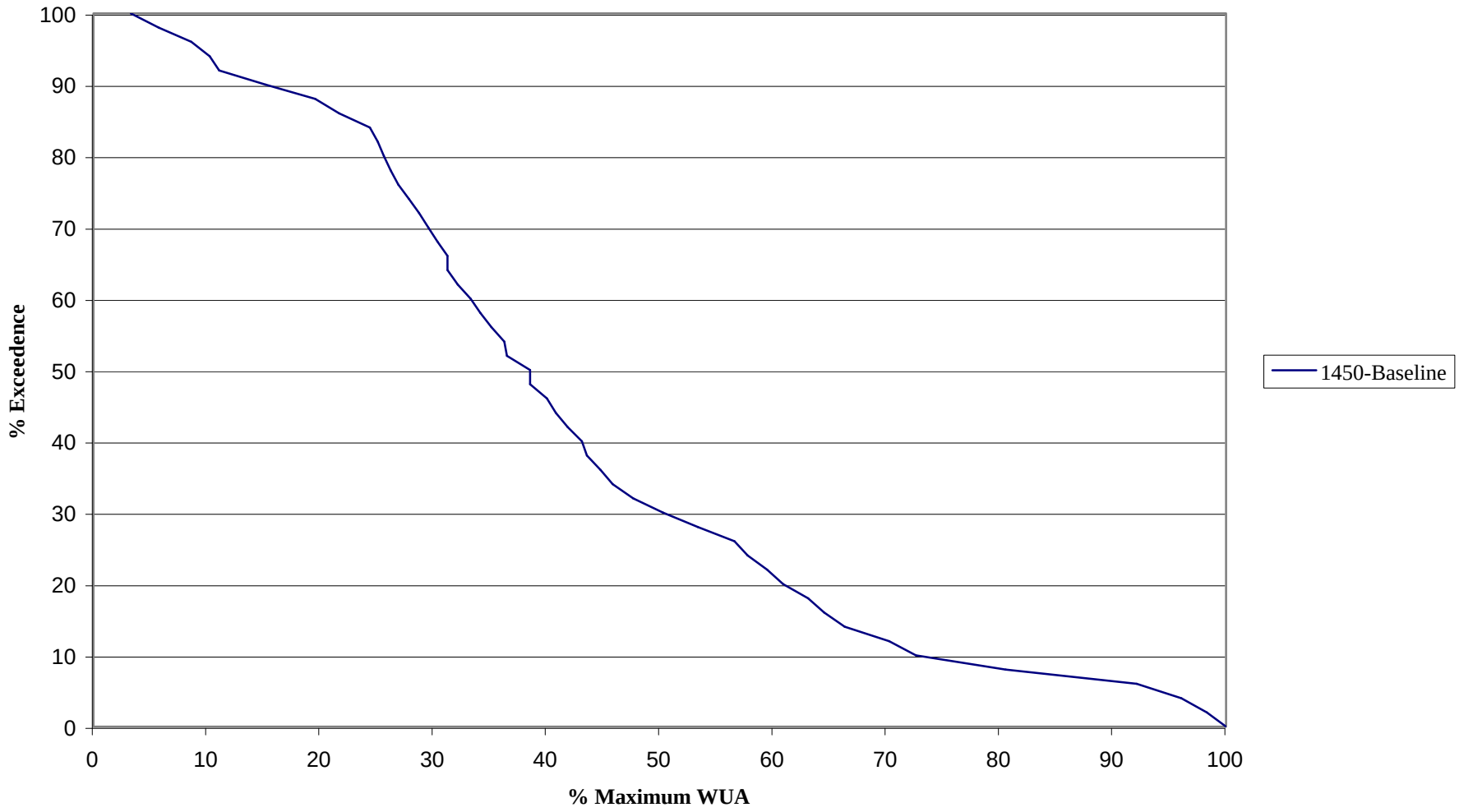


% EXCEEDENCE OF % MAXIMUM WUA FOR HABITAT REACH L1 MEDIUM POOL FALL

Final Aquatic Impact Analysis Report



% EXCEEDENCE OF % MAXIMUM WUA FOR HABITAT REACH L DEEP POOL FALL

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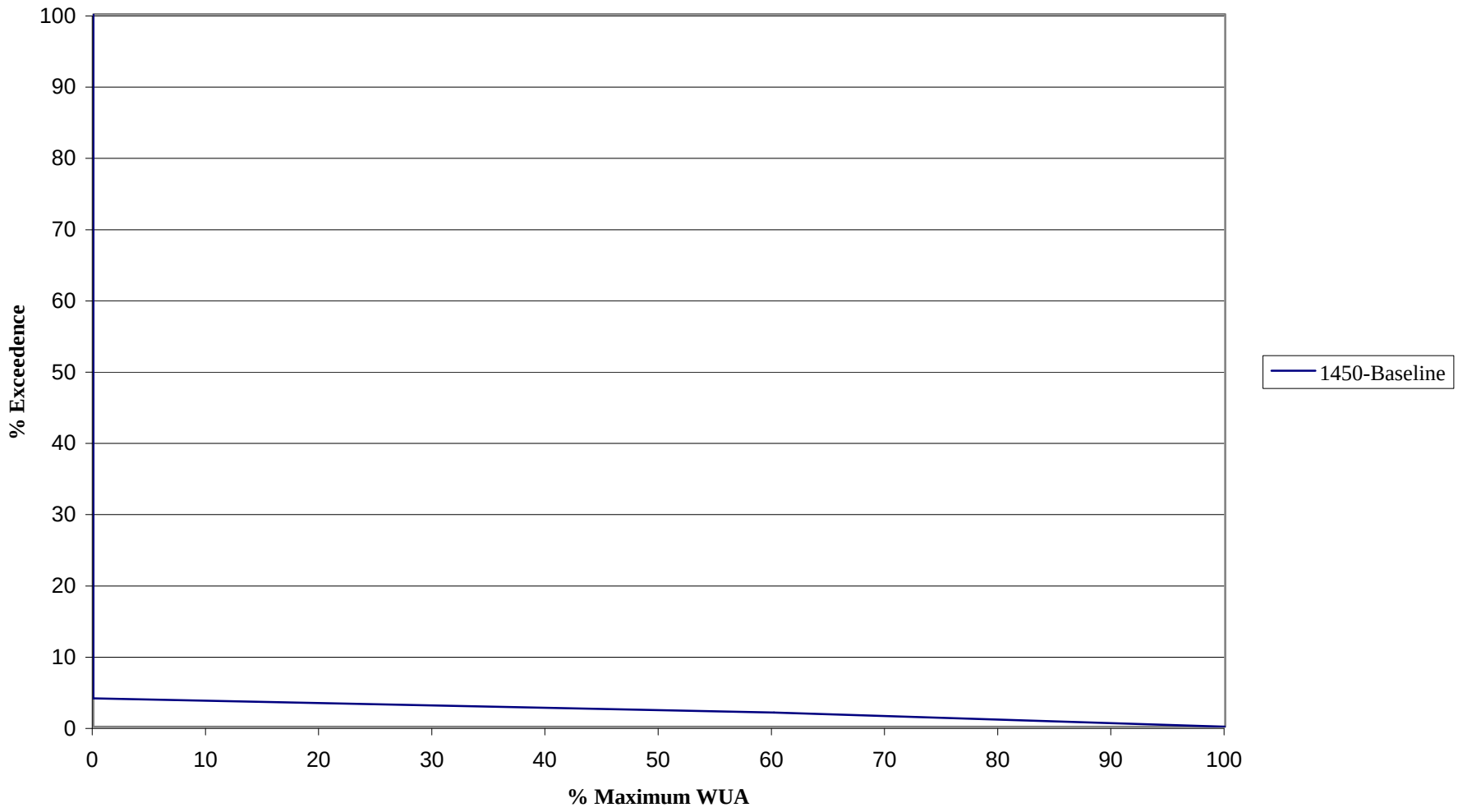

% EXCEEDENCE OF % MAXIMUM WUA FOR HABITAT REACH L LOW GRADIENT FALL

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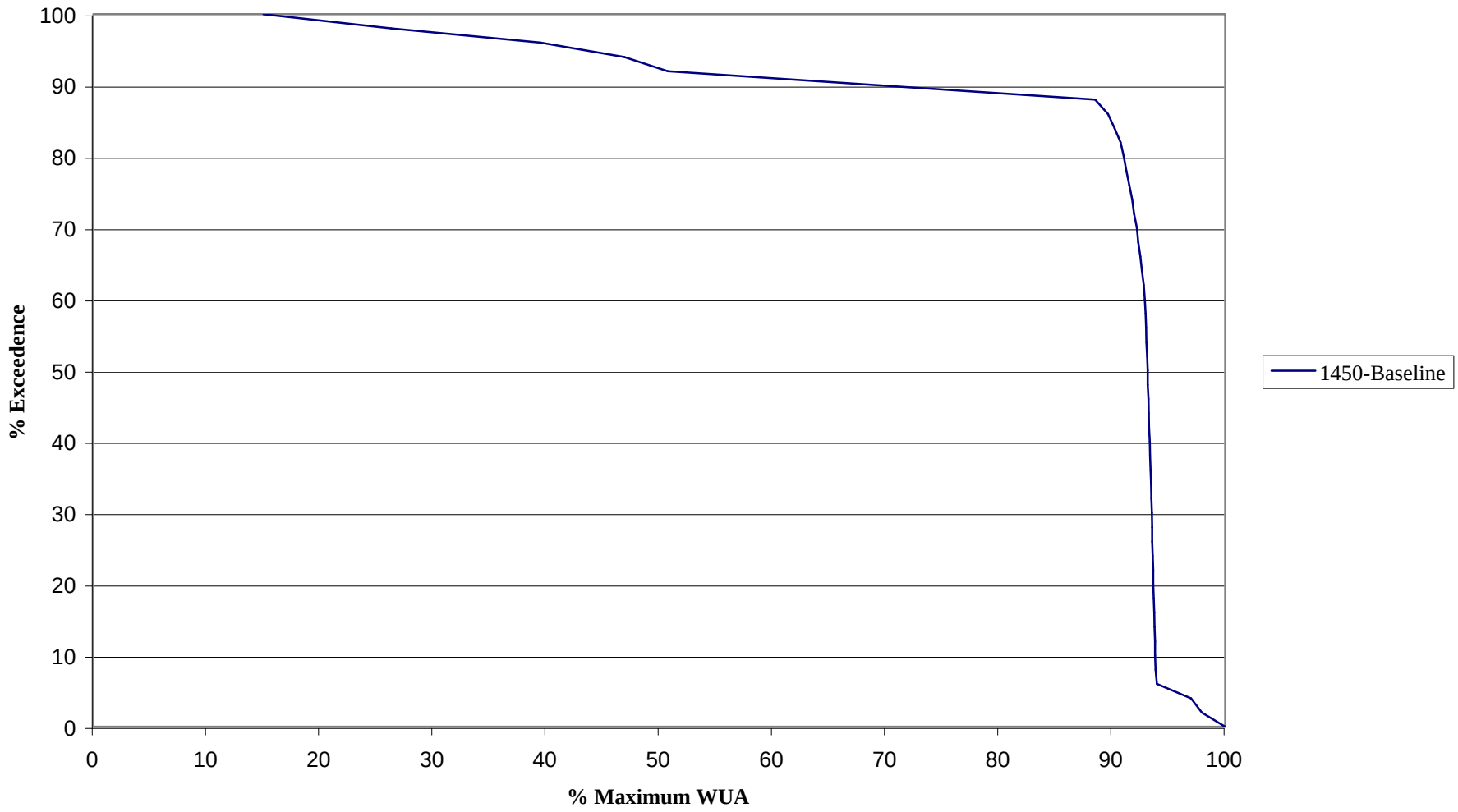

% EXCEEDENCE OF % MAXIMUM WUA FOR HABITAT REACH L TRICHOPTERA FALL

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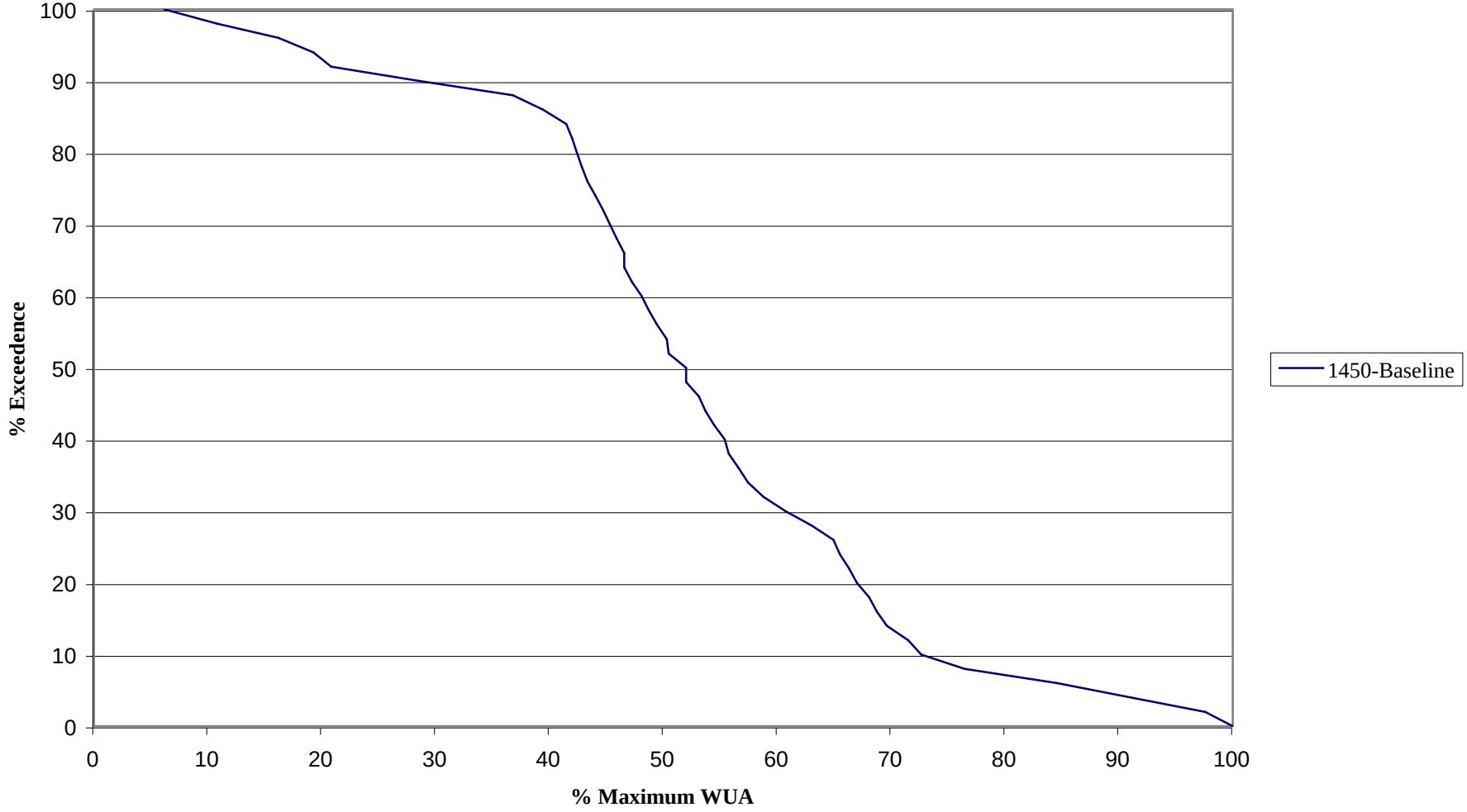
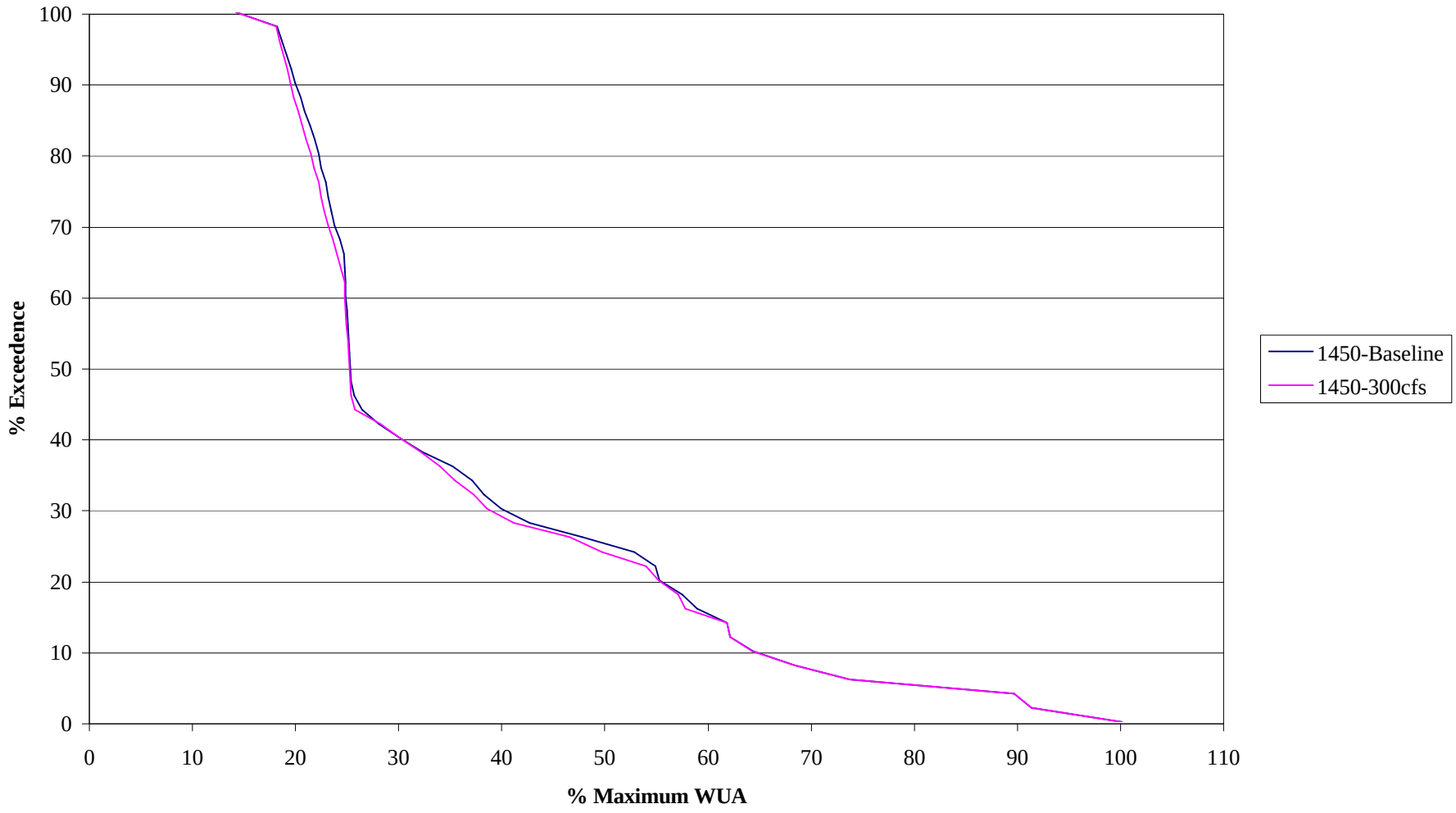


% EXCEEDENCE OF % MAXIMUM WUA FOR HABITAT REACH H SHALLOW POOL SPRING
Final Aquatic Impact Analysis Report



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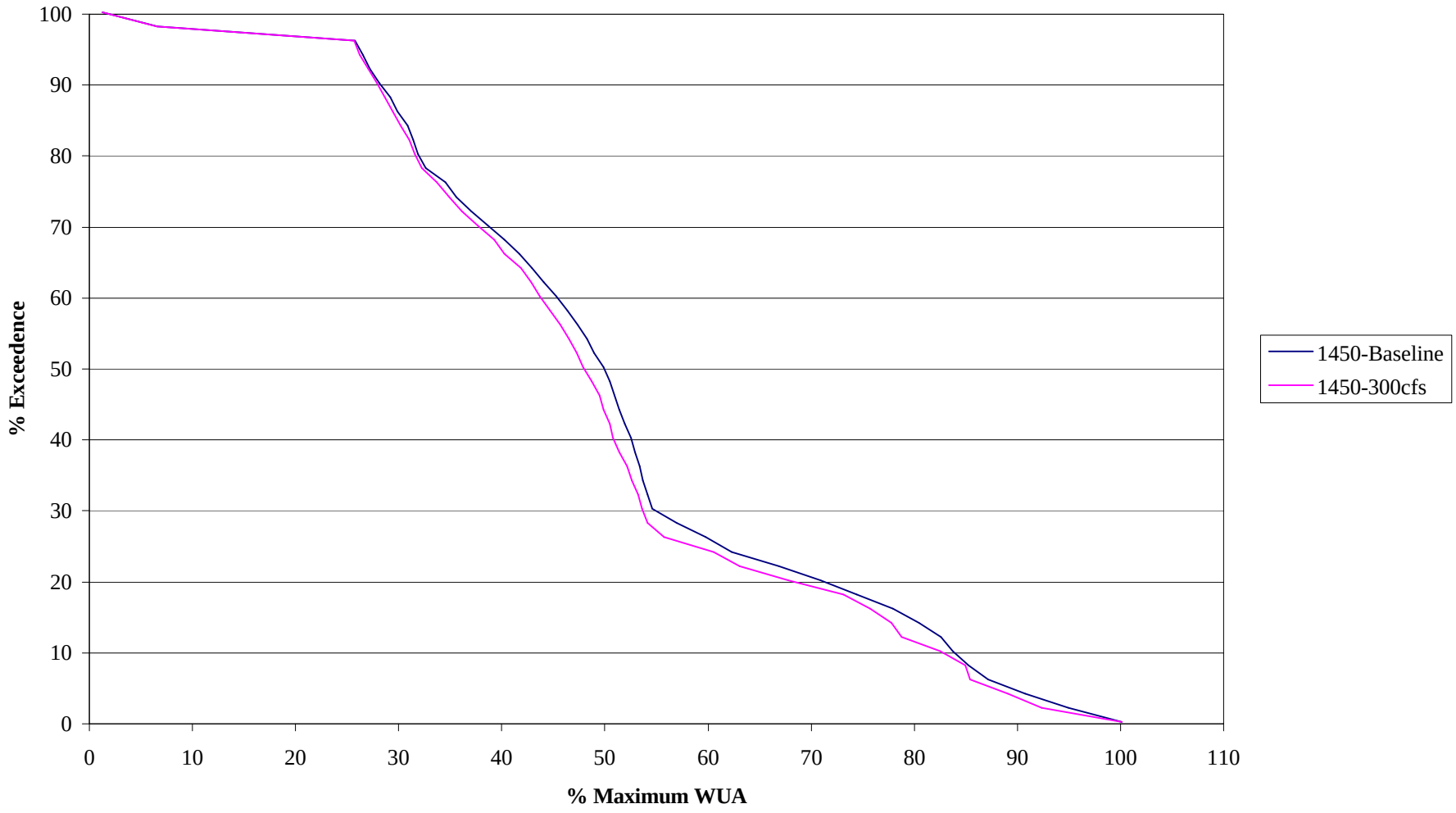

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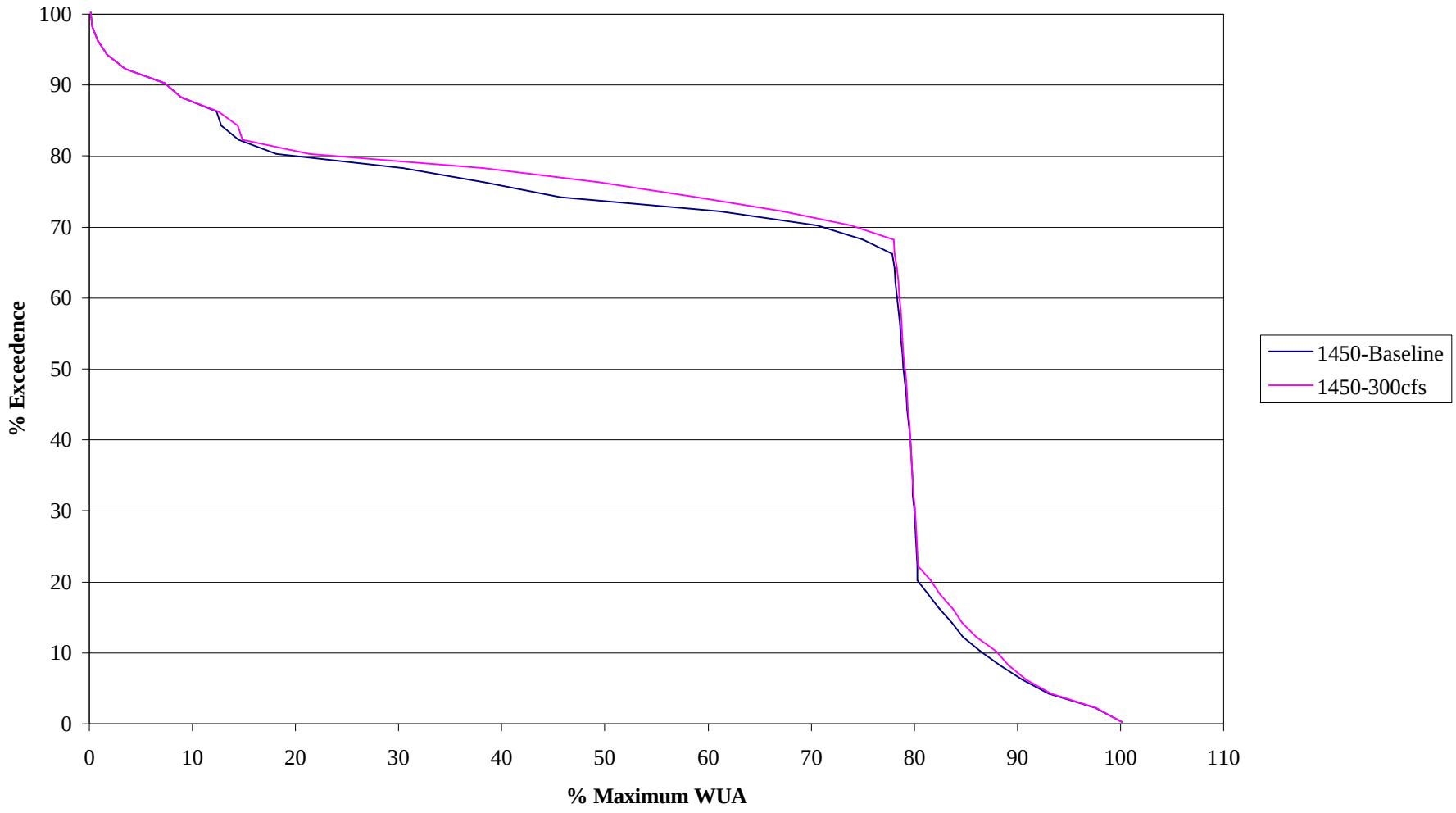

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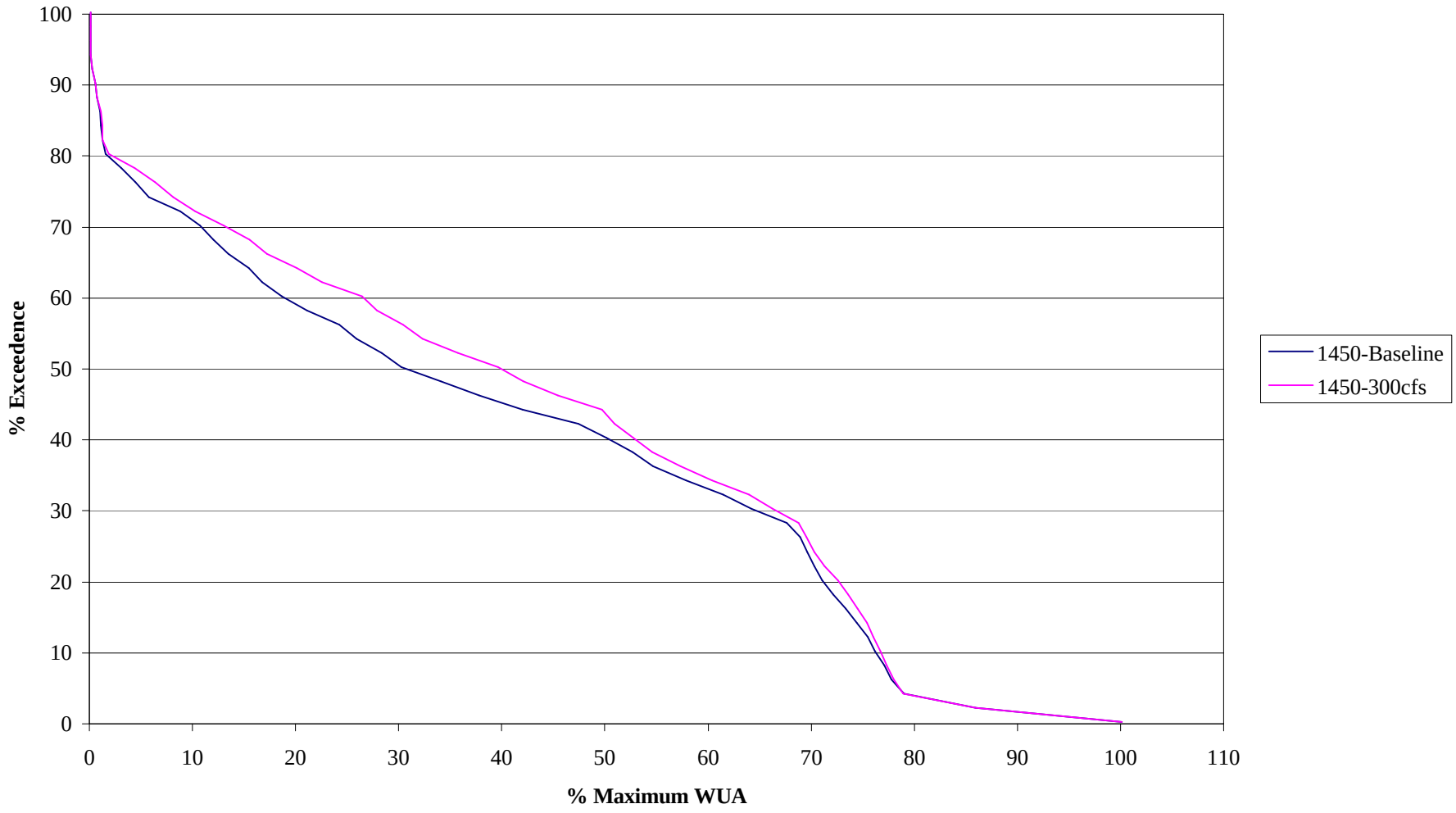

% EXCEEDENCE OF % MAXIMUM WUA FOR HABITAT REACH H MEDIUM POOL SPRING

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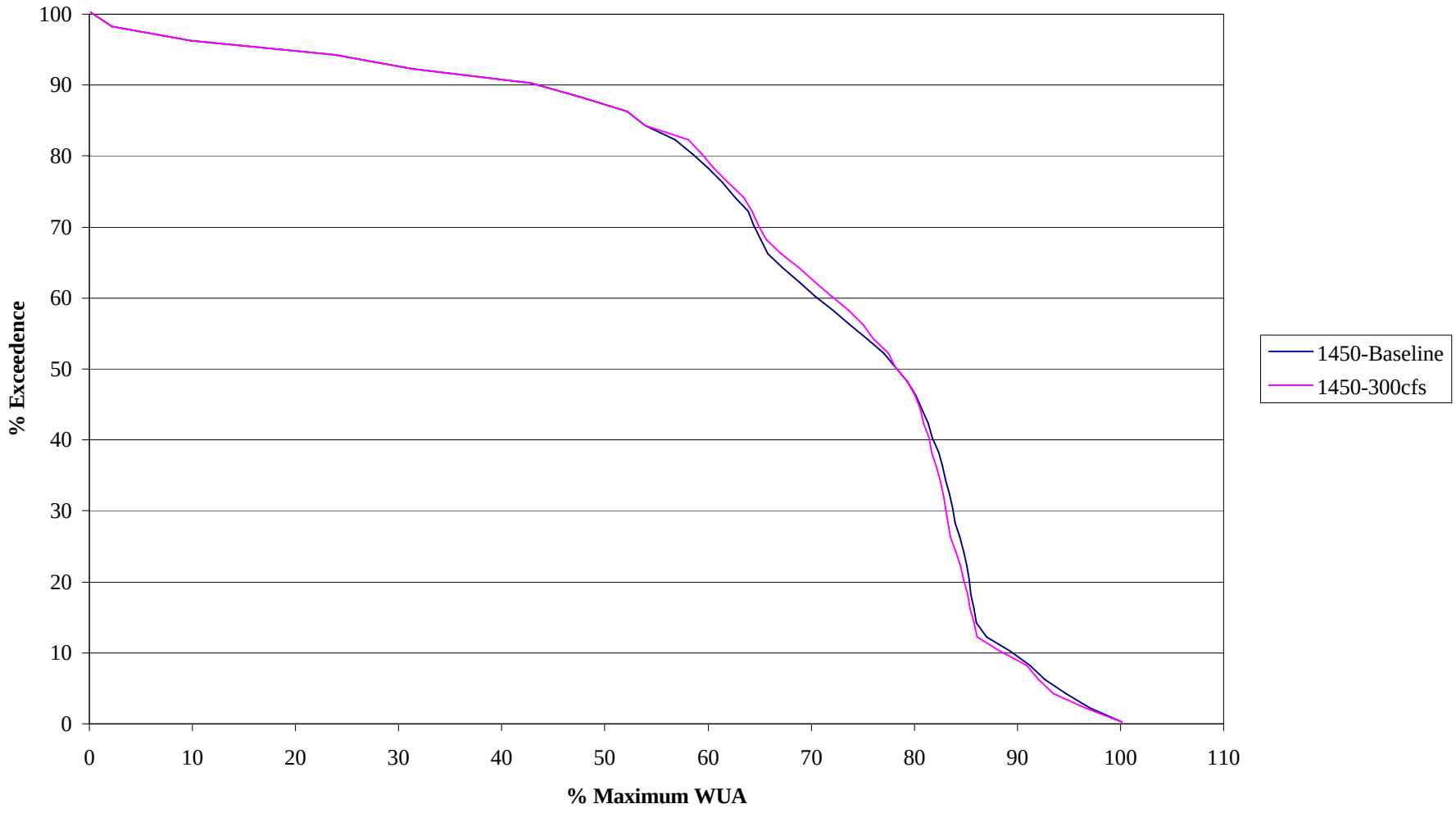

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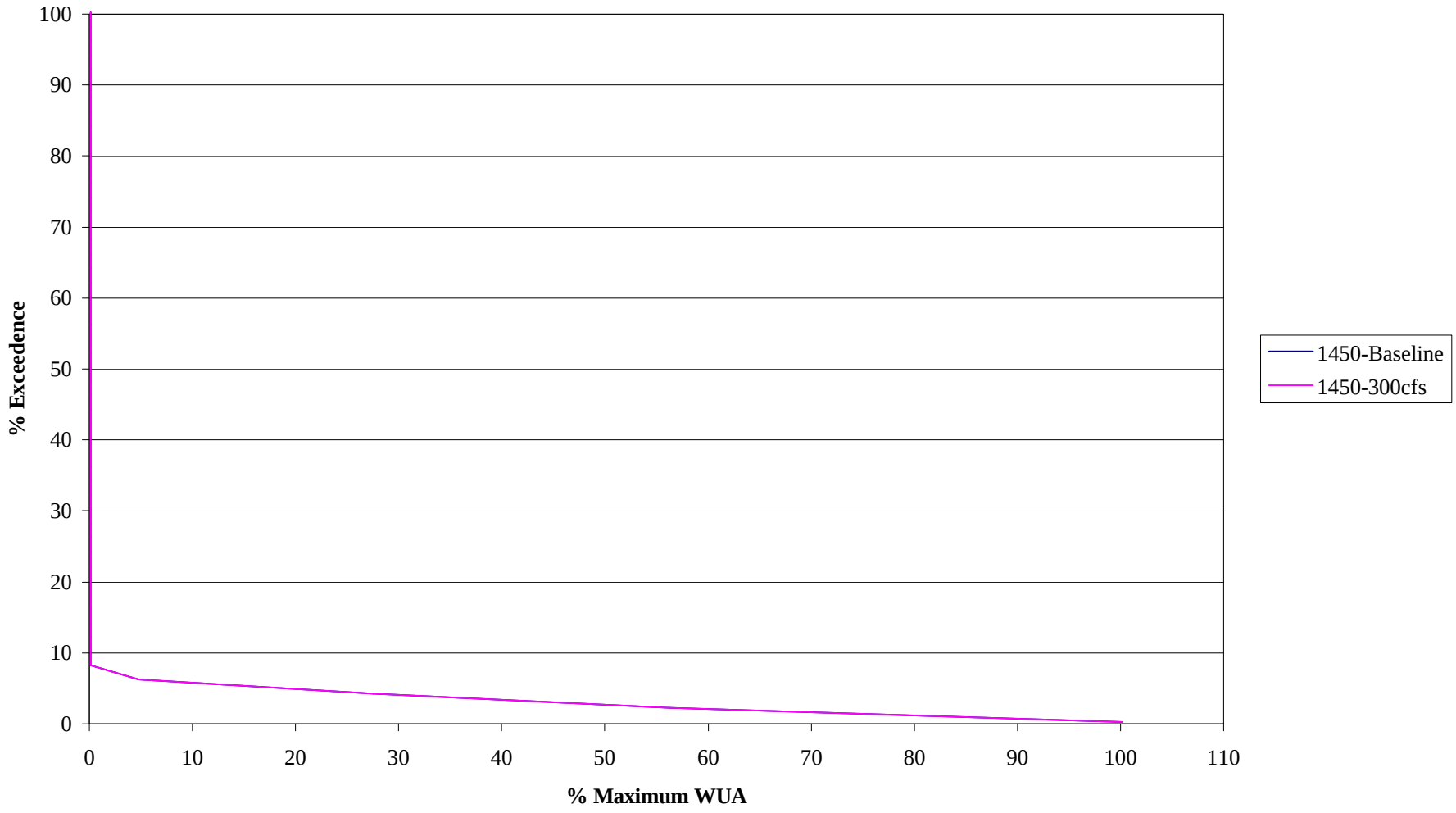

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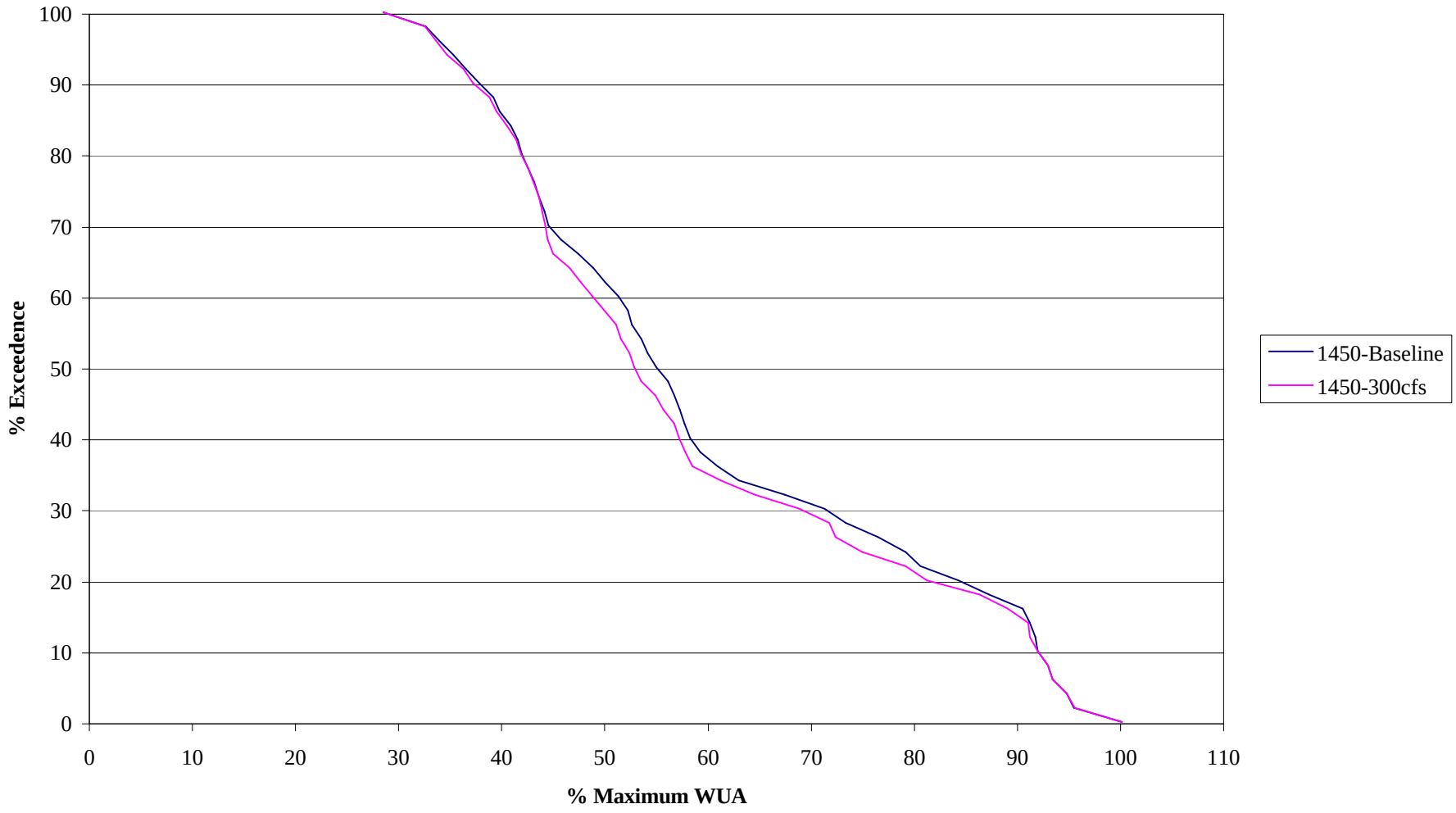

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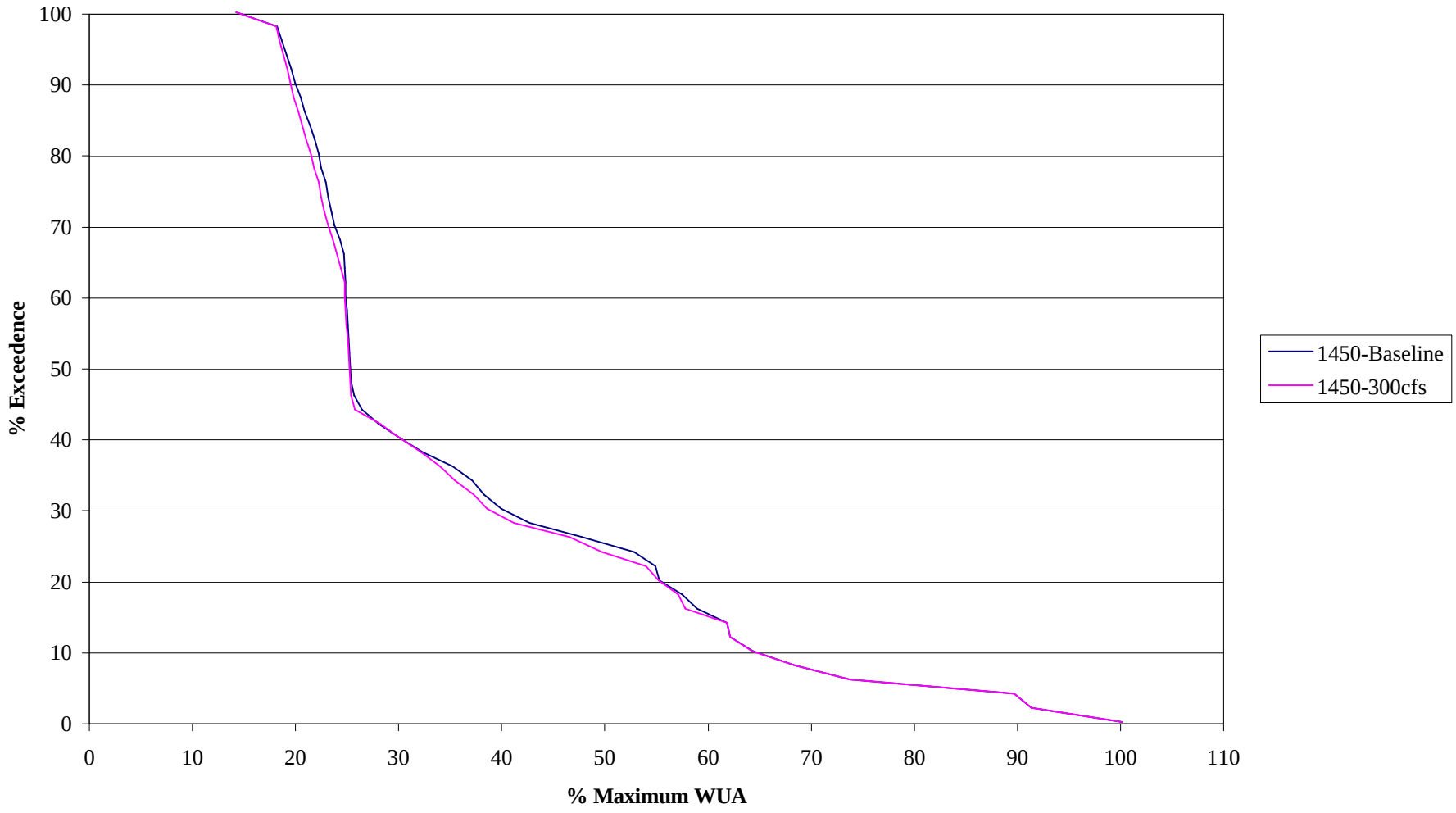
Final Aquatic Impact Analysis Report



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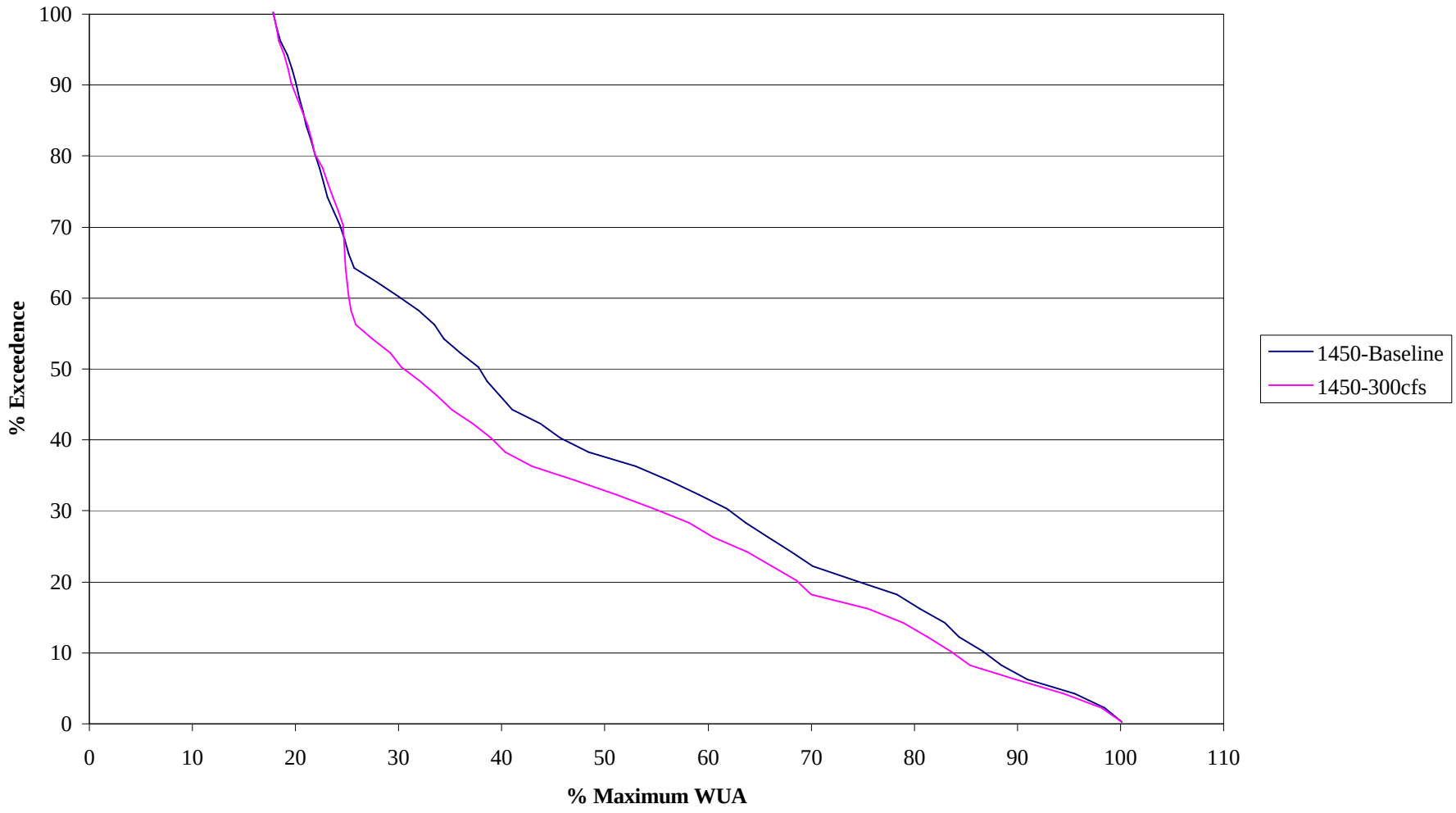

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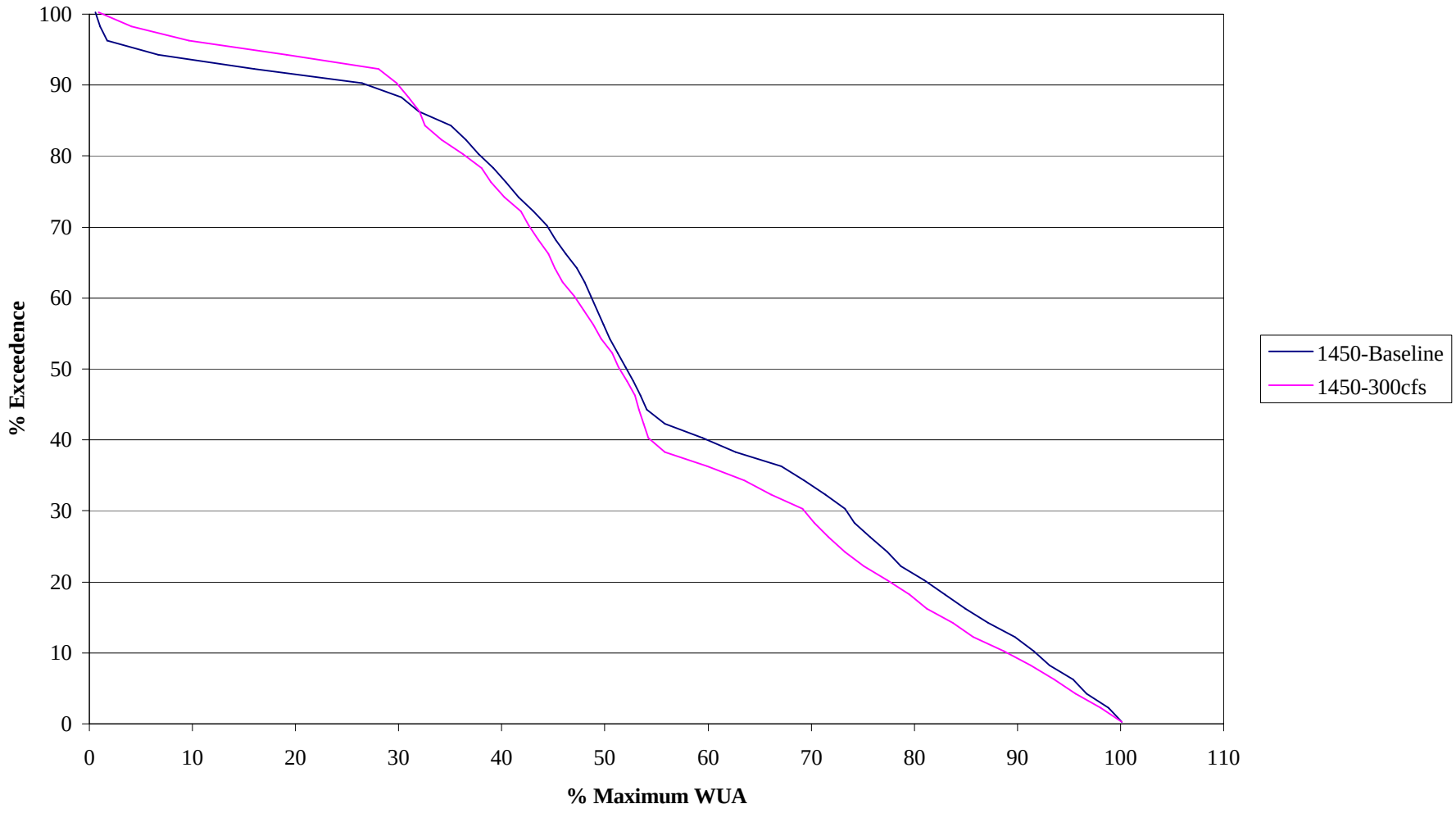

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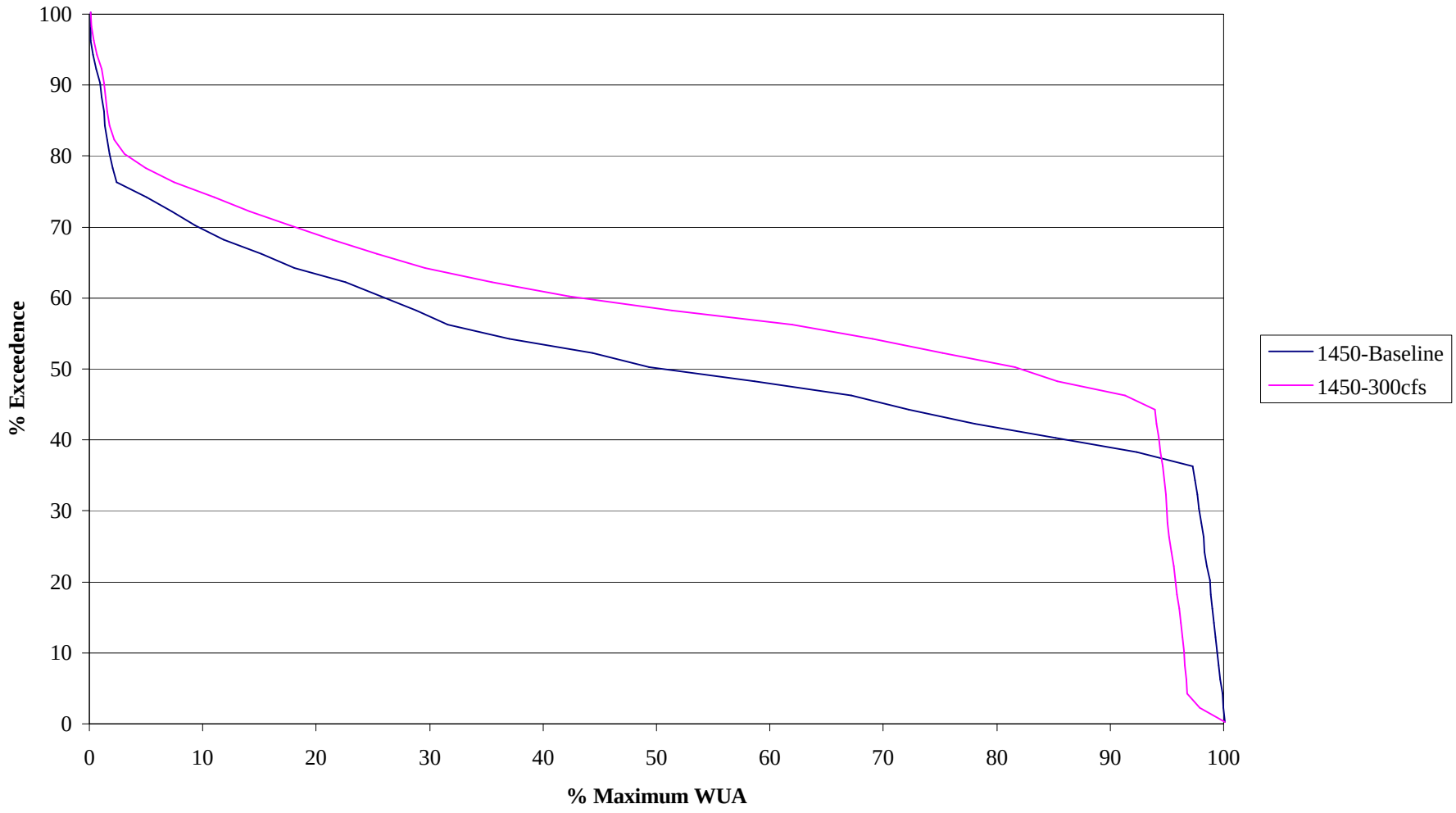

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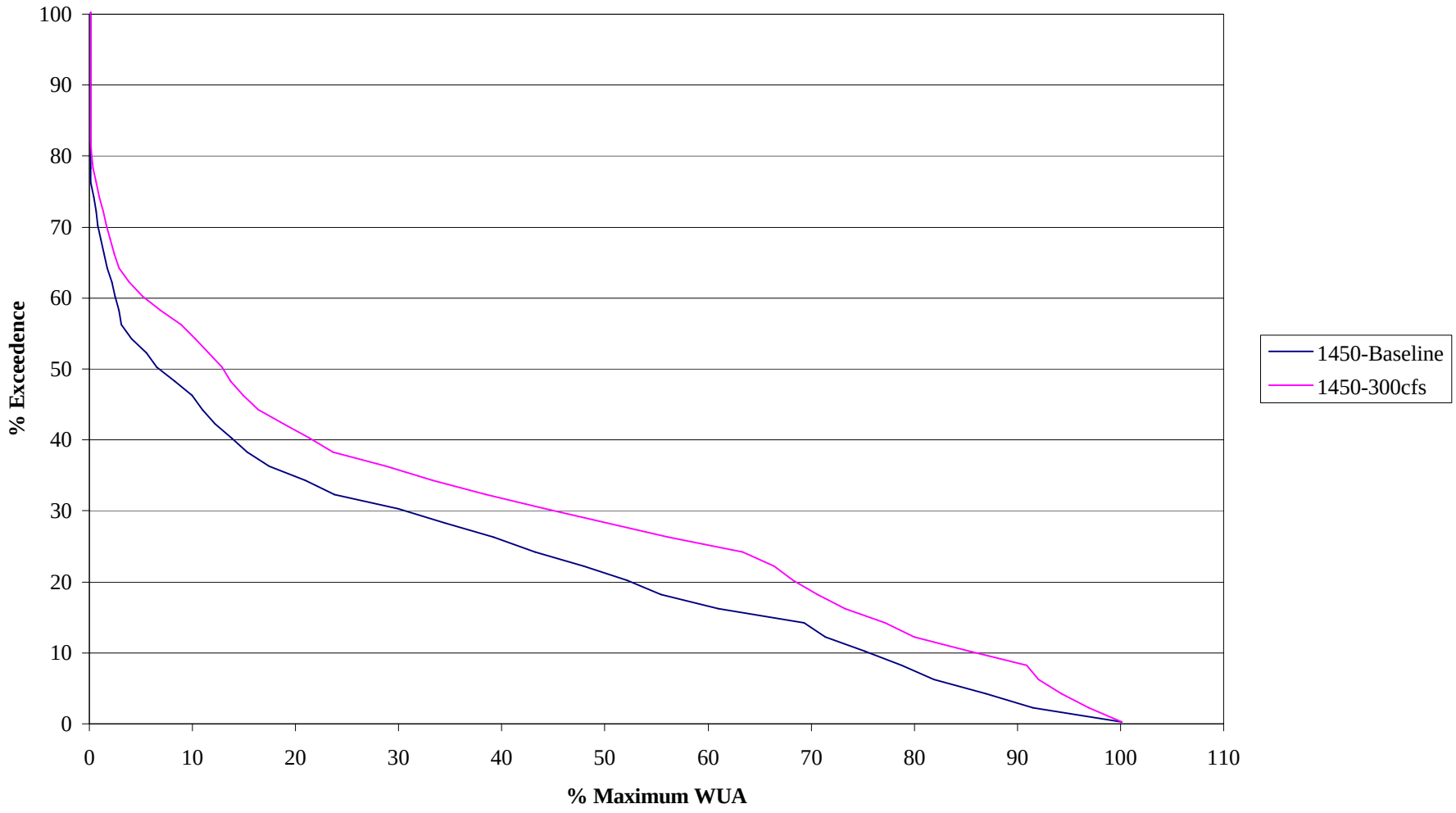
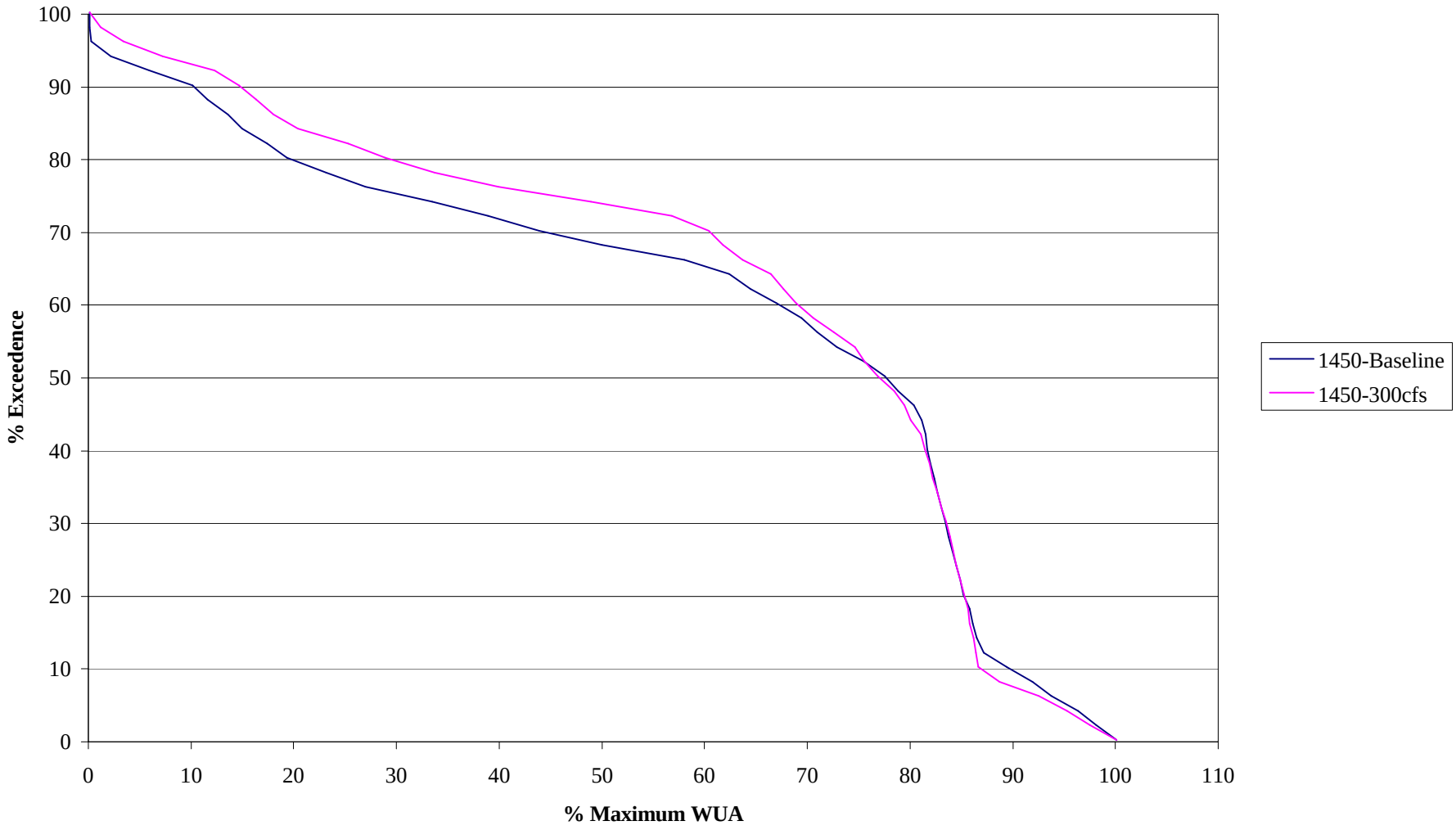
Final Aquatic Impact Analysis Report



% EXCEEDENCE OF % MAXIMUM WUA FOR HABITAT REACH H MEDIUM POOL SUMMER
Final Aquatic Impact Analysis Report



% EXCEEDENCE OF % MAXIMUM WUA FOR HABITAT REACH H DEEP POOL SUMMER

Final Aquatic Impact Analysis Report

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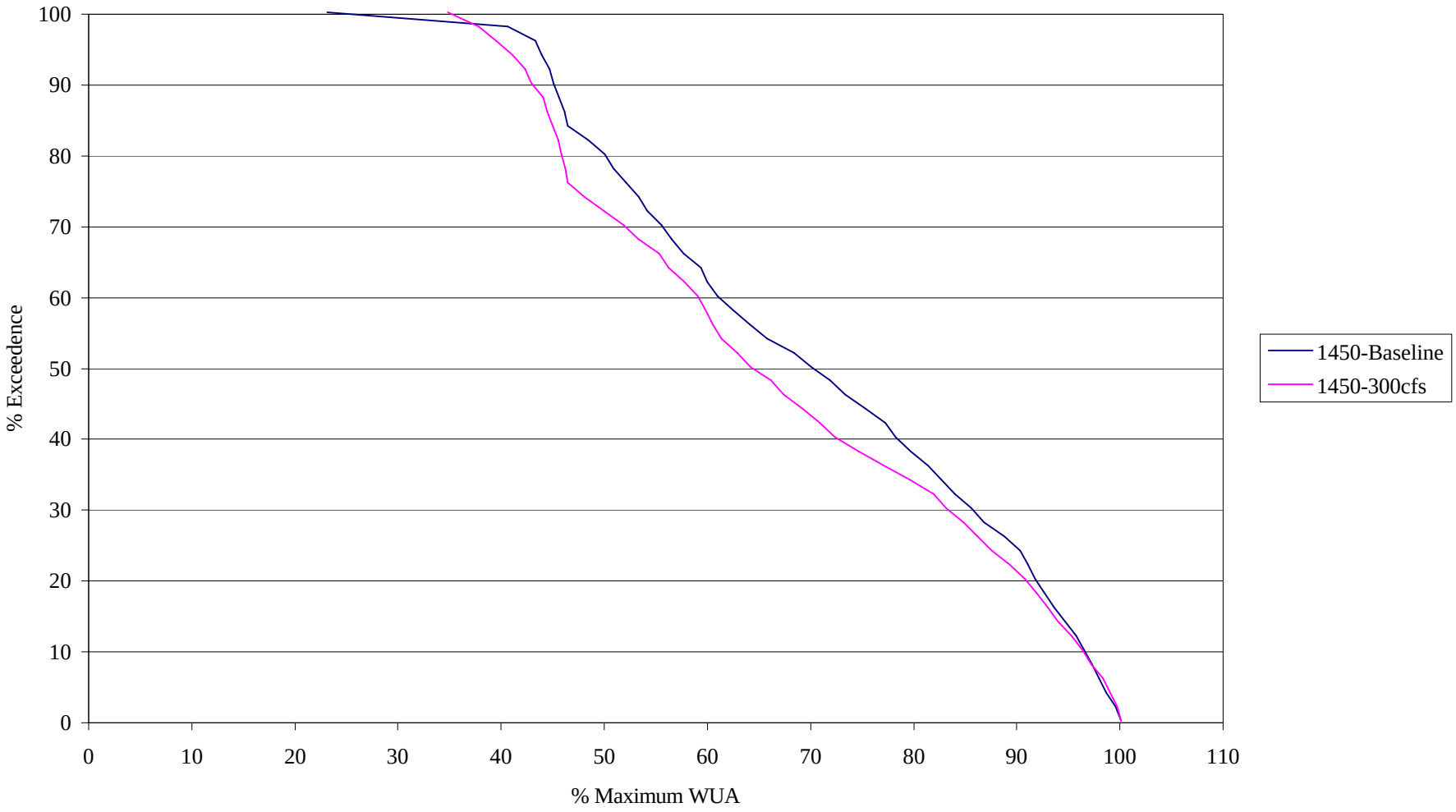
Final Aquatic Impact Analysis Report



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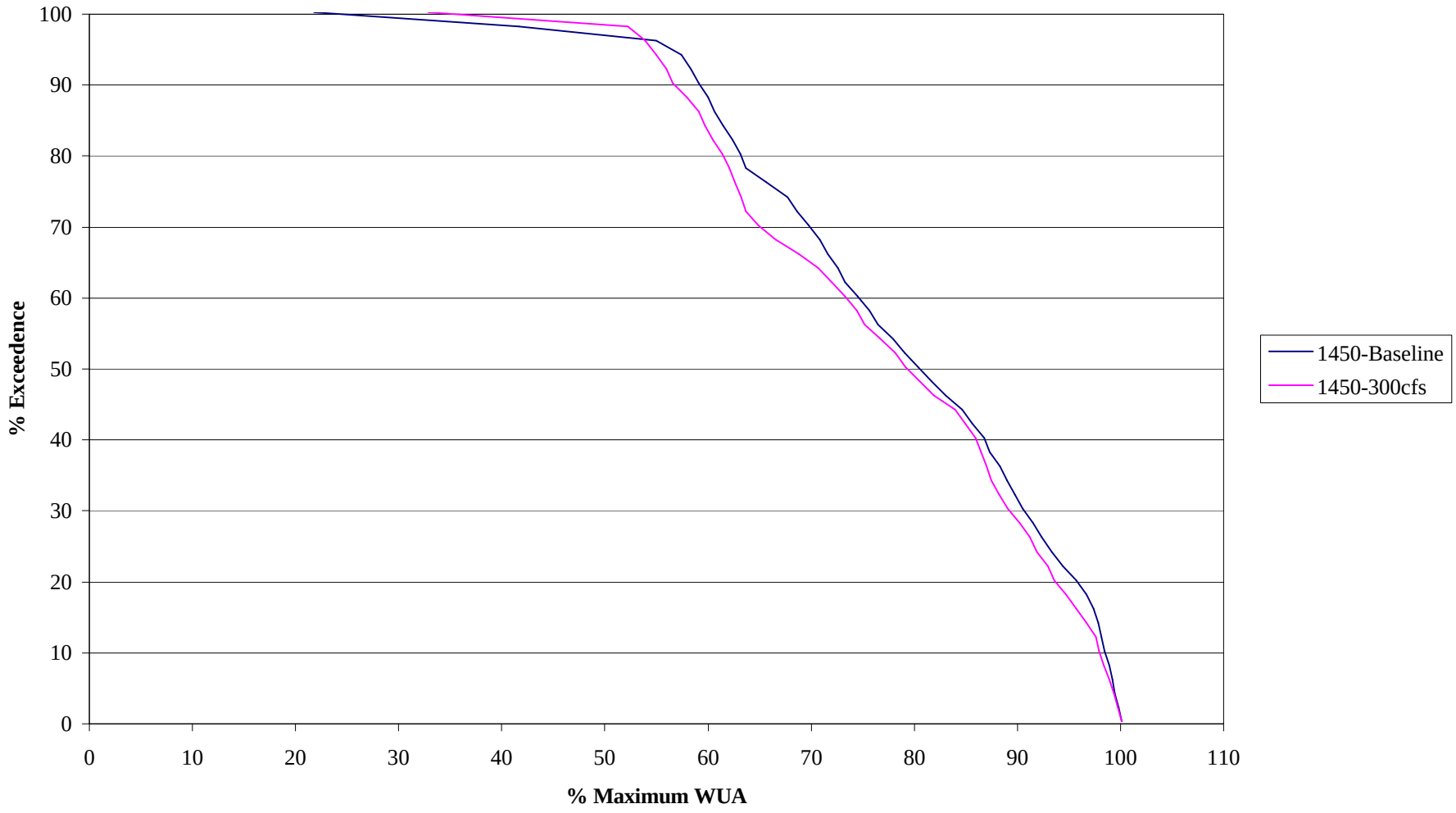

% EXCEEDENCE OF % MAXIMUM WUA FOR HABITAT REACH H SHALLOW POOL FALL
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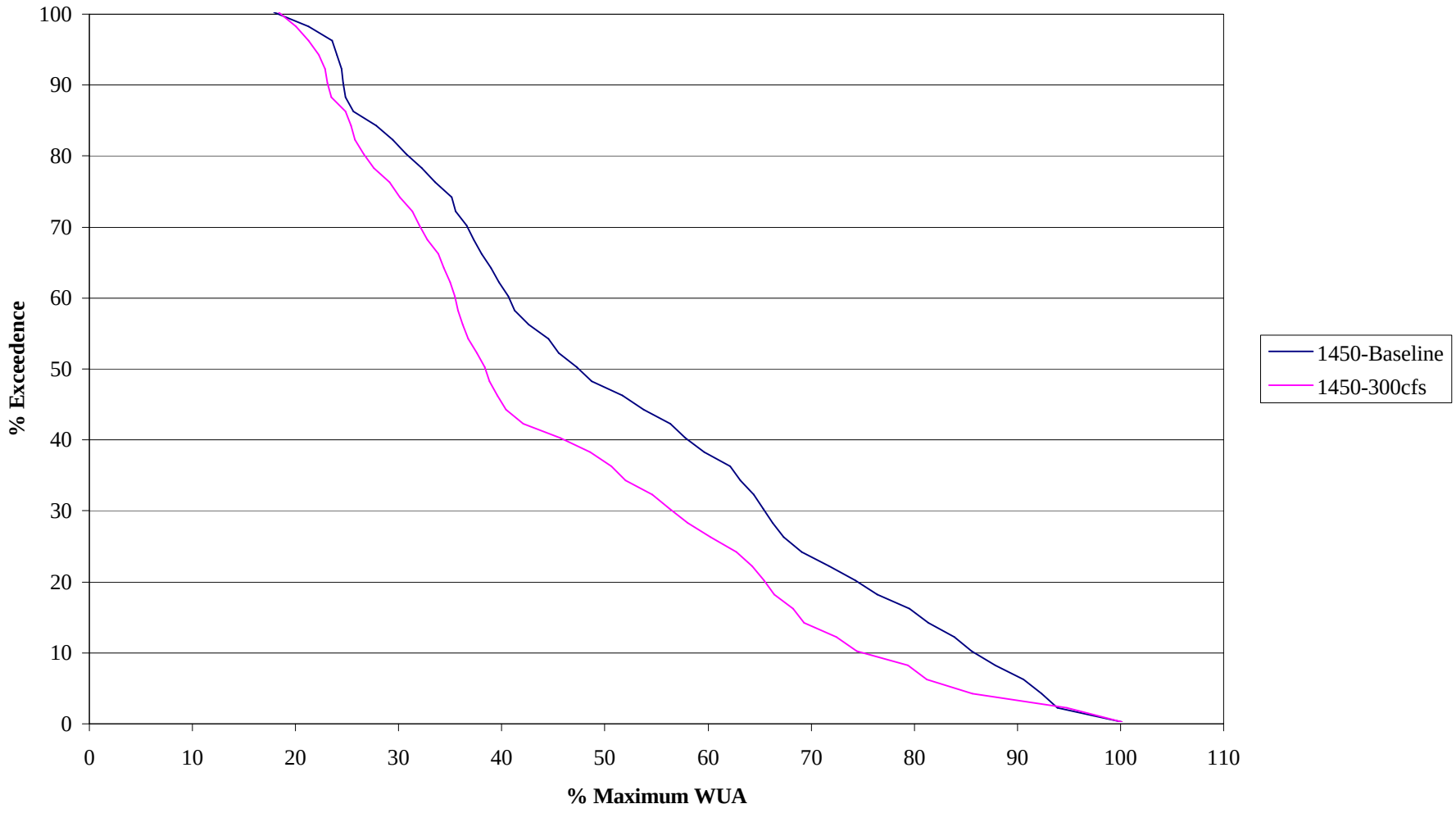

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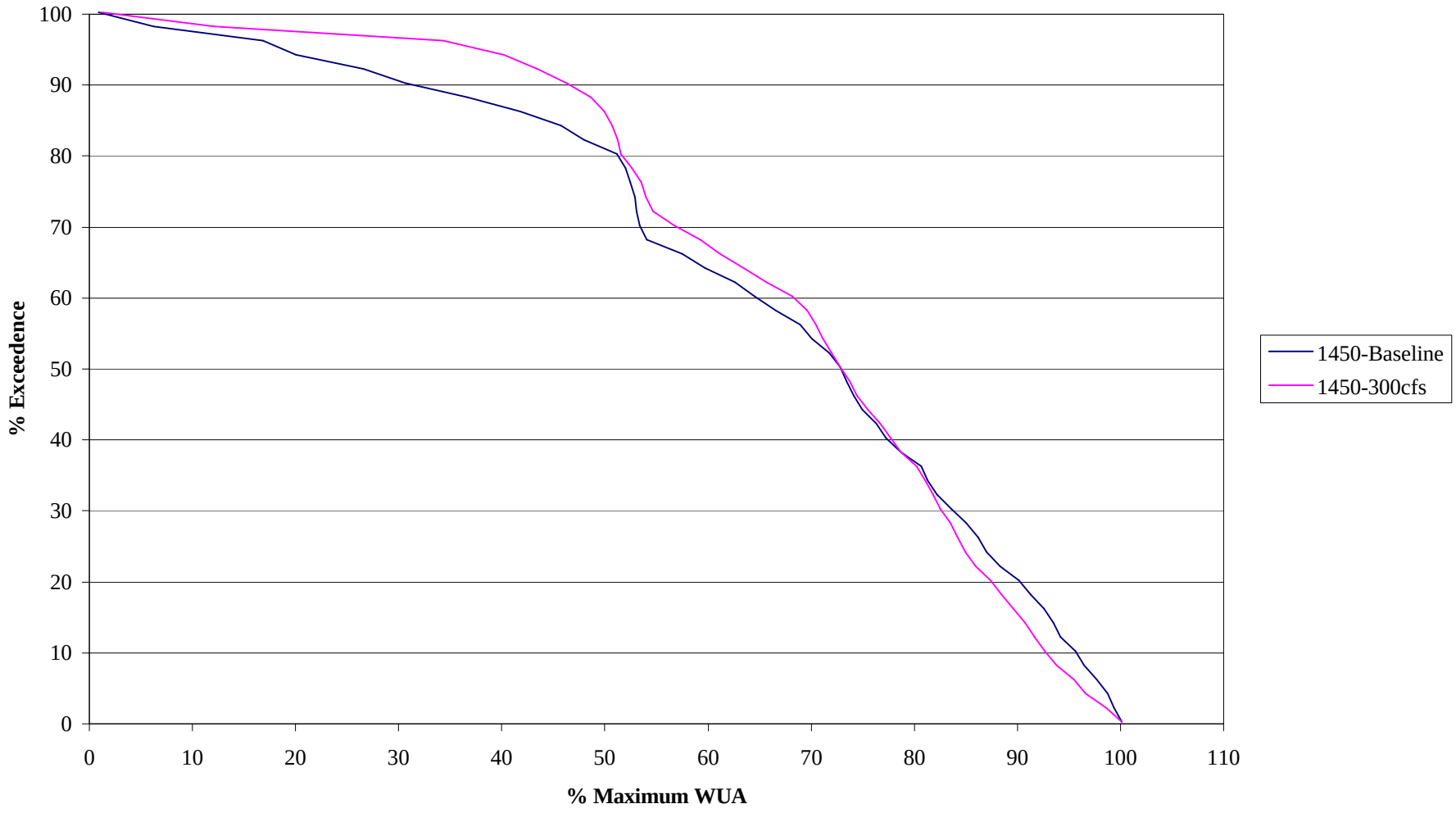
Final Aquatic Impact Analysis Report



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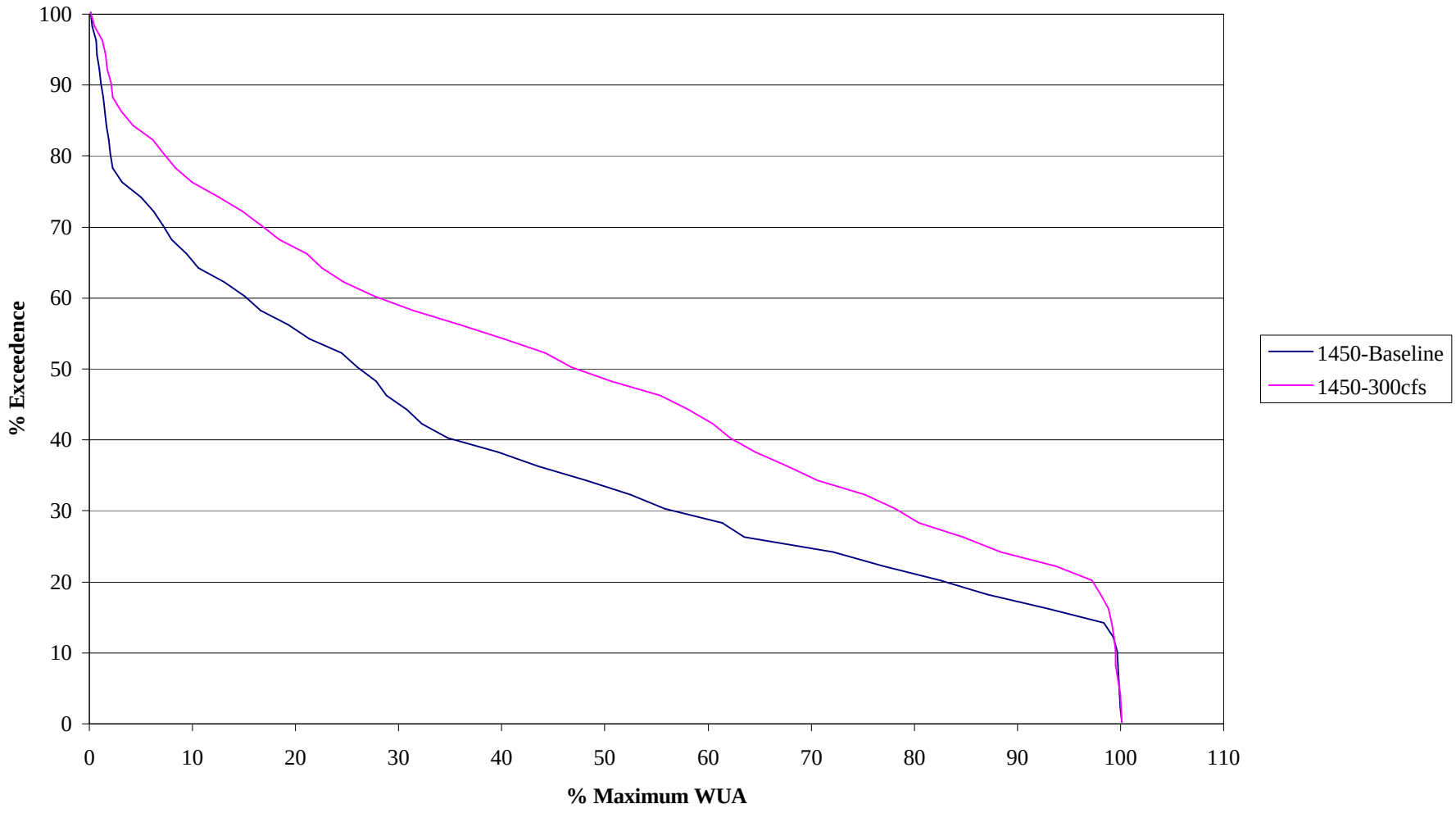
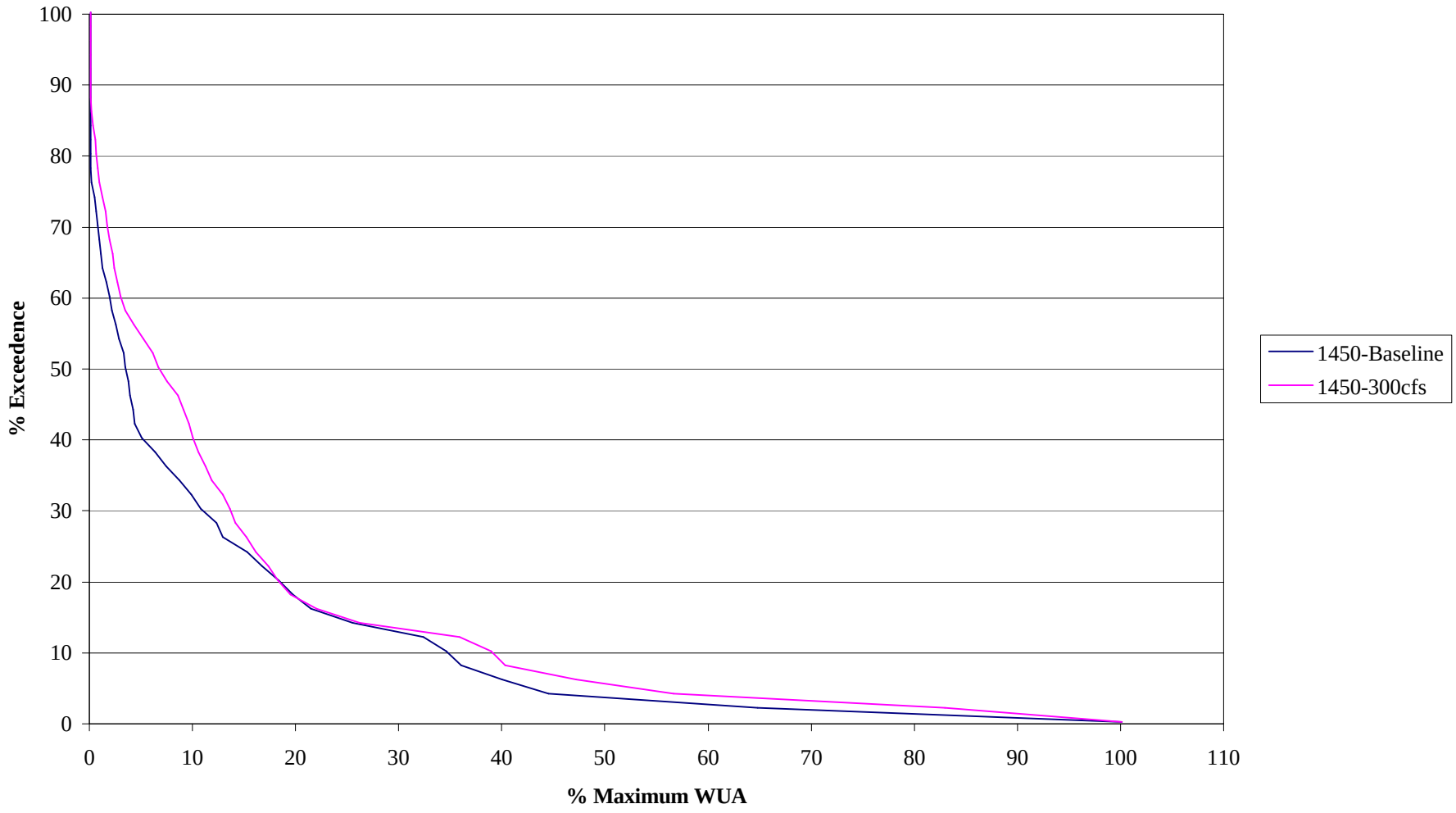
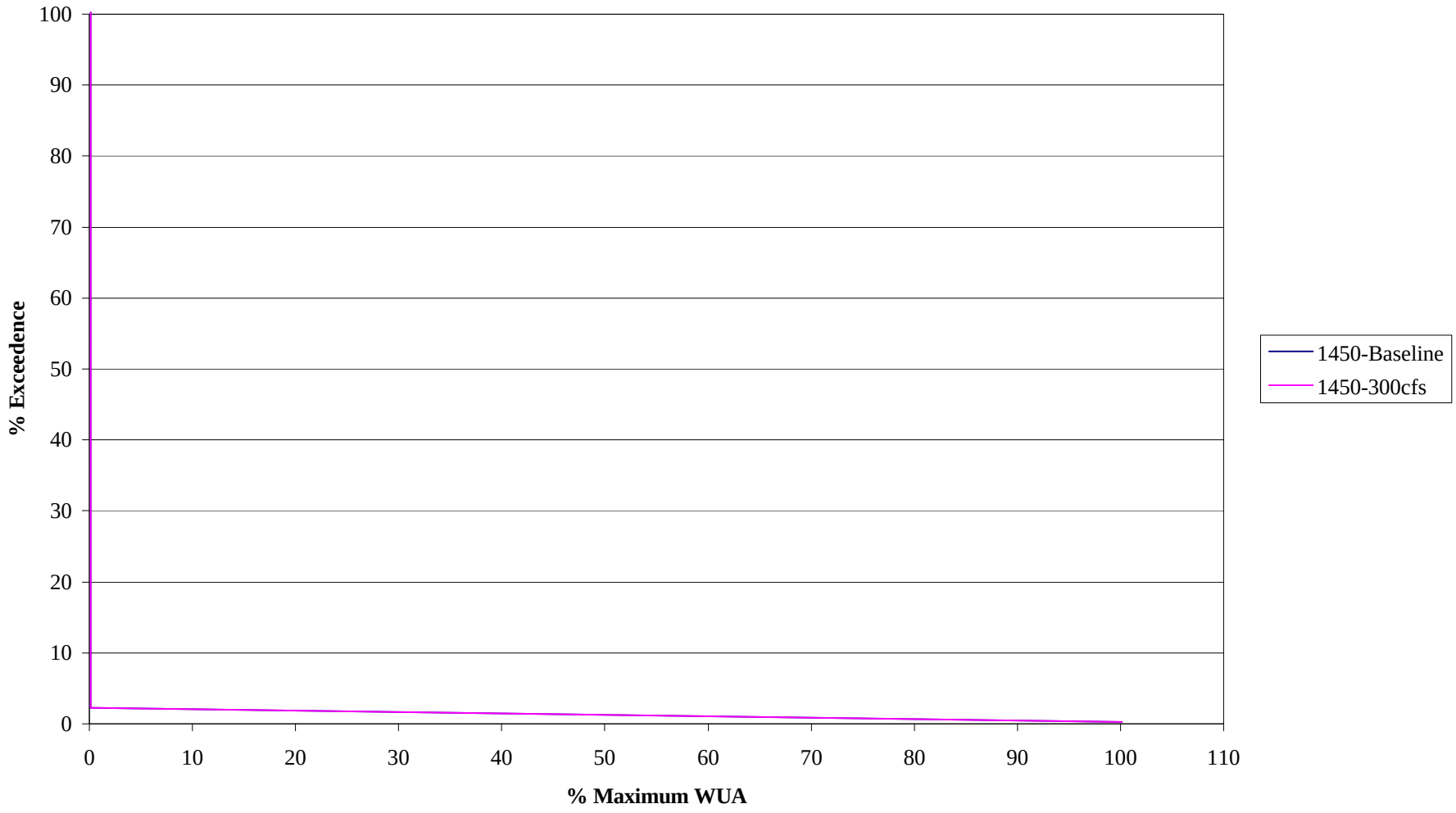


% EXCEEDENCE OF % MAXIMUM WUA FOR HABITAT REACH H RACEWAY
FALL
Final Aquatic Impact Analysis Report

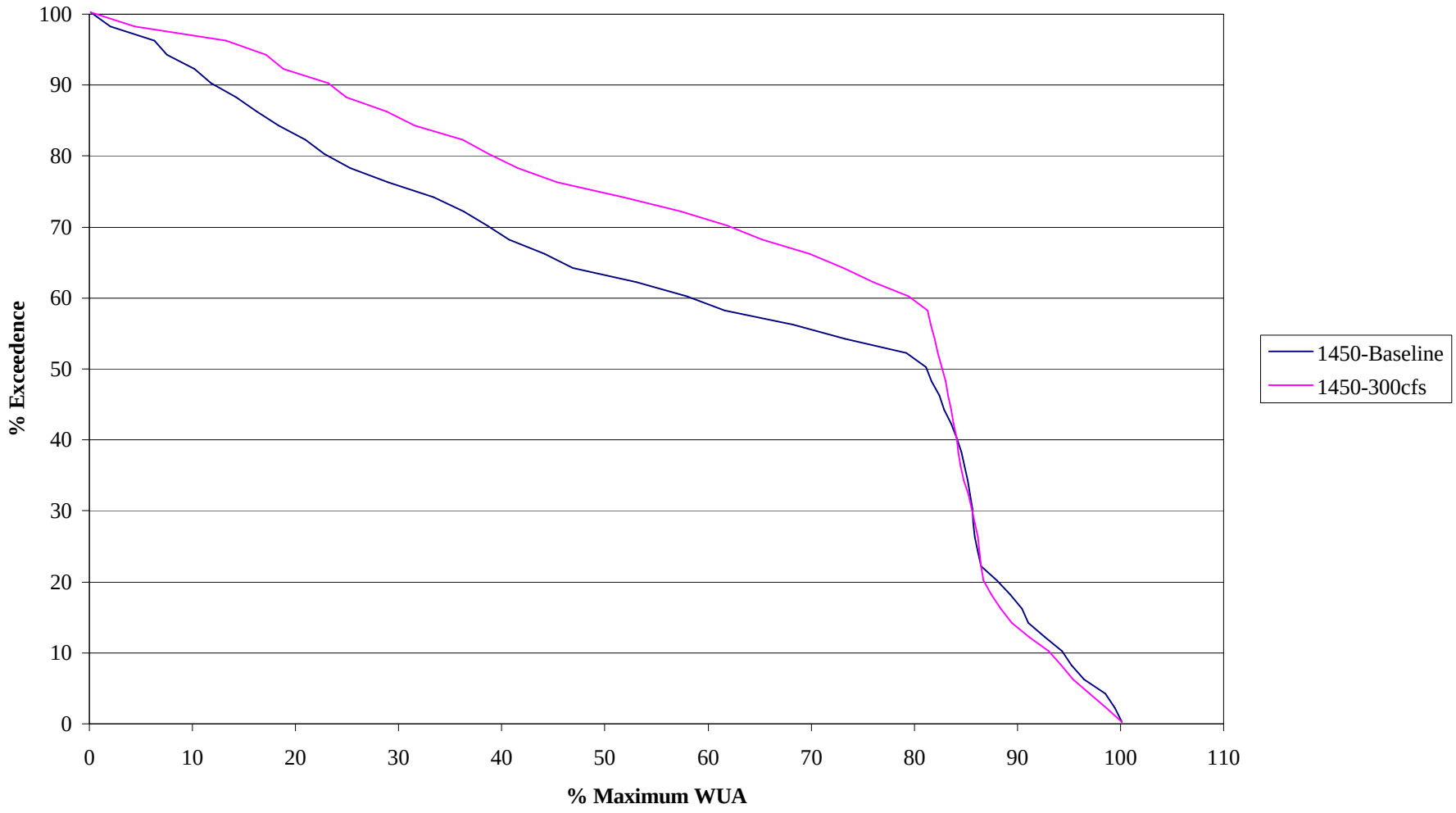


% EXCEEDENCE OF % MAXIMUM WUA FOR HABITAT REACH H DEEP POOL FALL

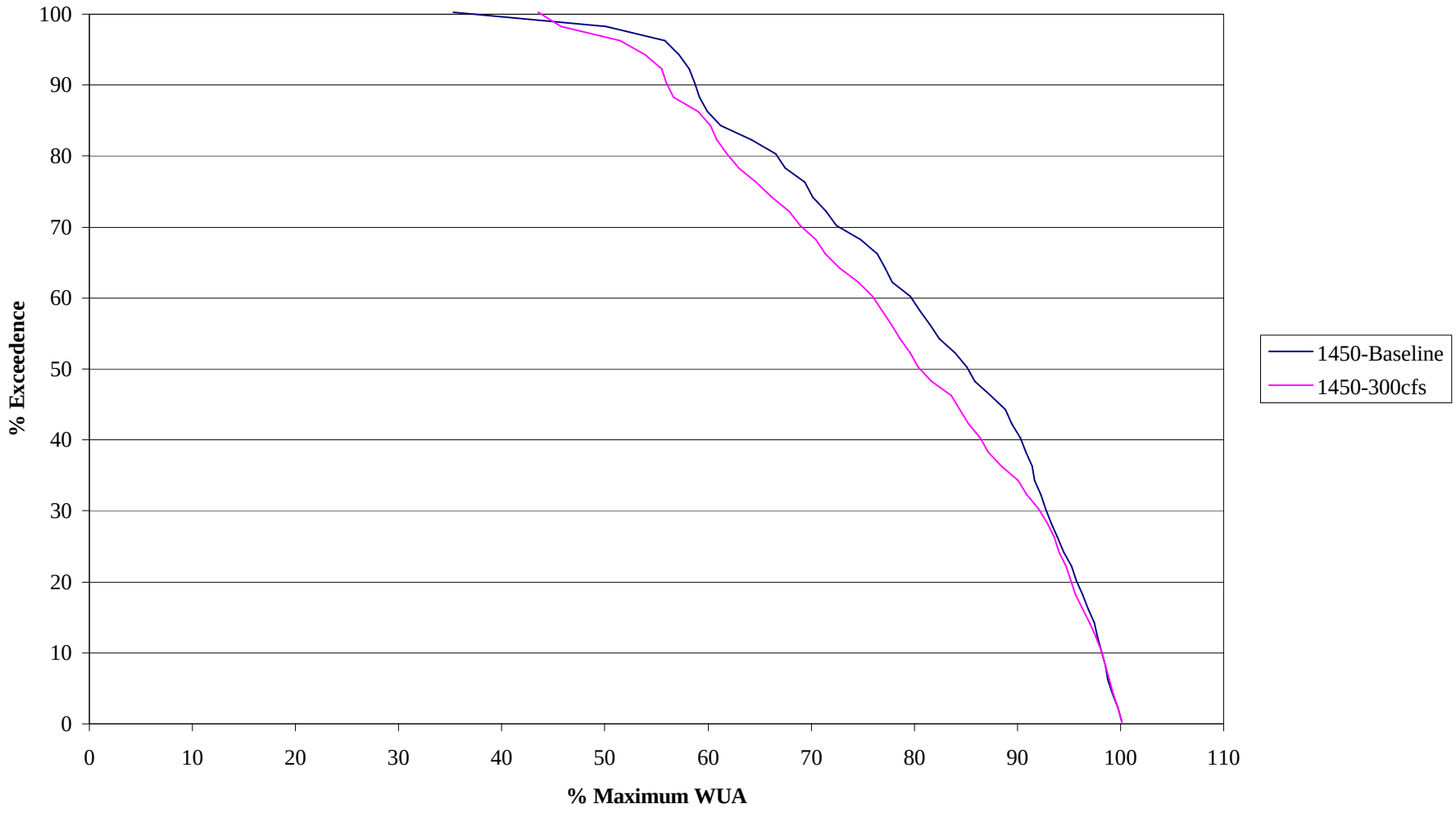
Final Aquatic Impact Analysis Report



% EXCEEDENCE OF % MAXIMUM WUA FOR HABITAT REACH H MEDIUM POOL FALL
Final Aquatic Impact Analysis Report



% EXCEEDENCE OF % MAXIMUM WUA FOR HABITAT REACH H LOW GRADIENT FALL
Final Aquatic Impact Analysis Report



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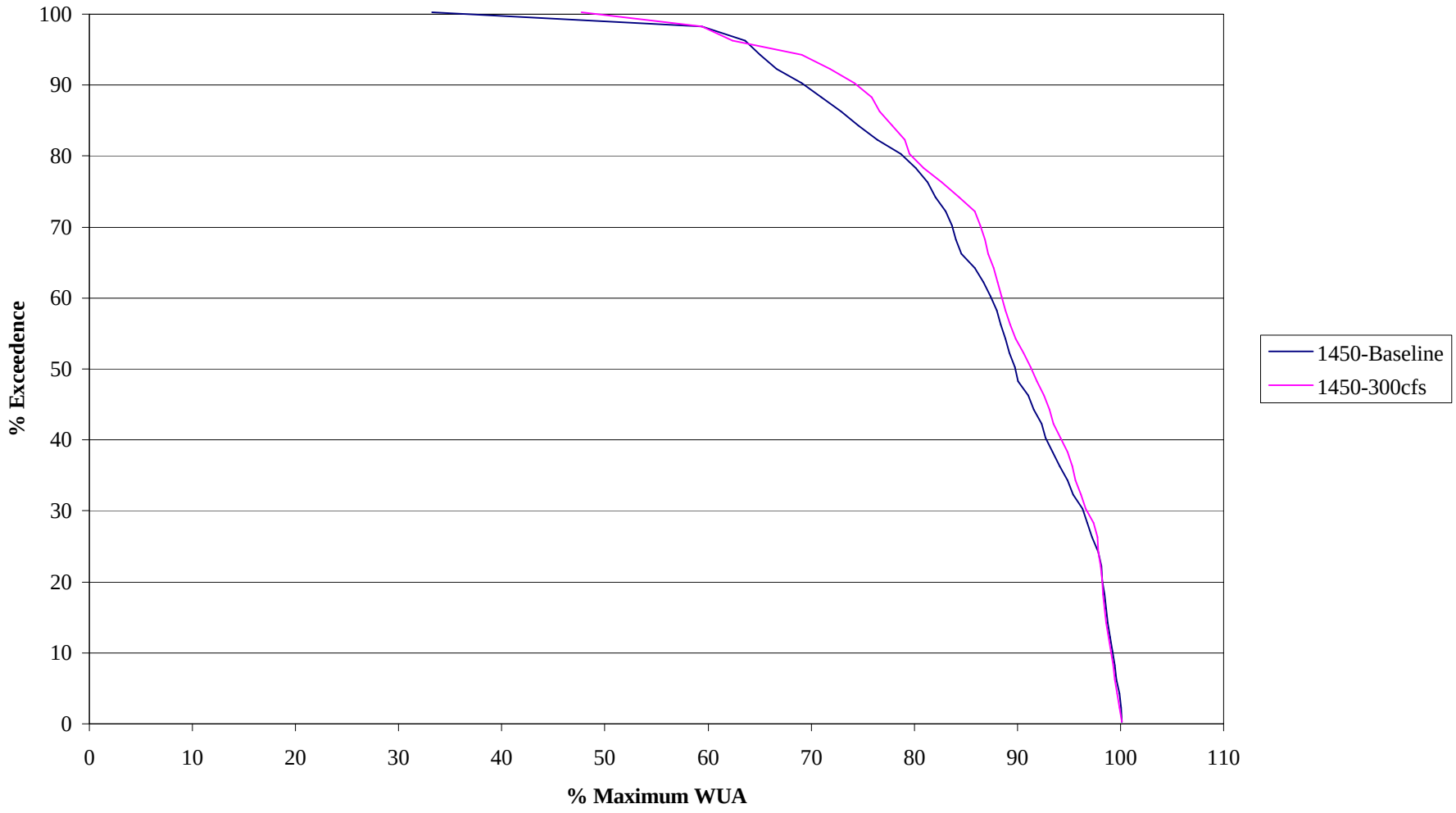
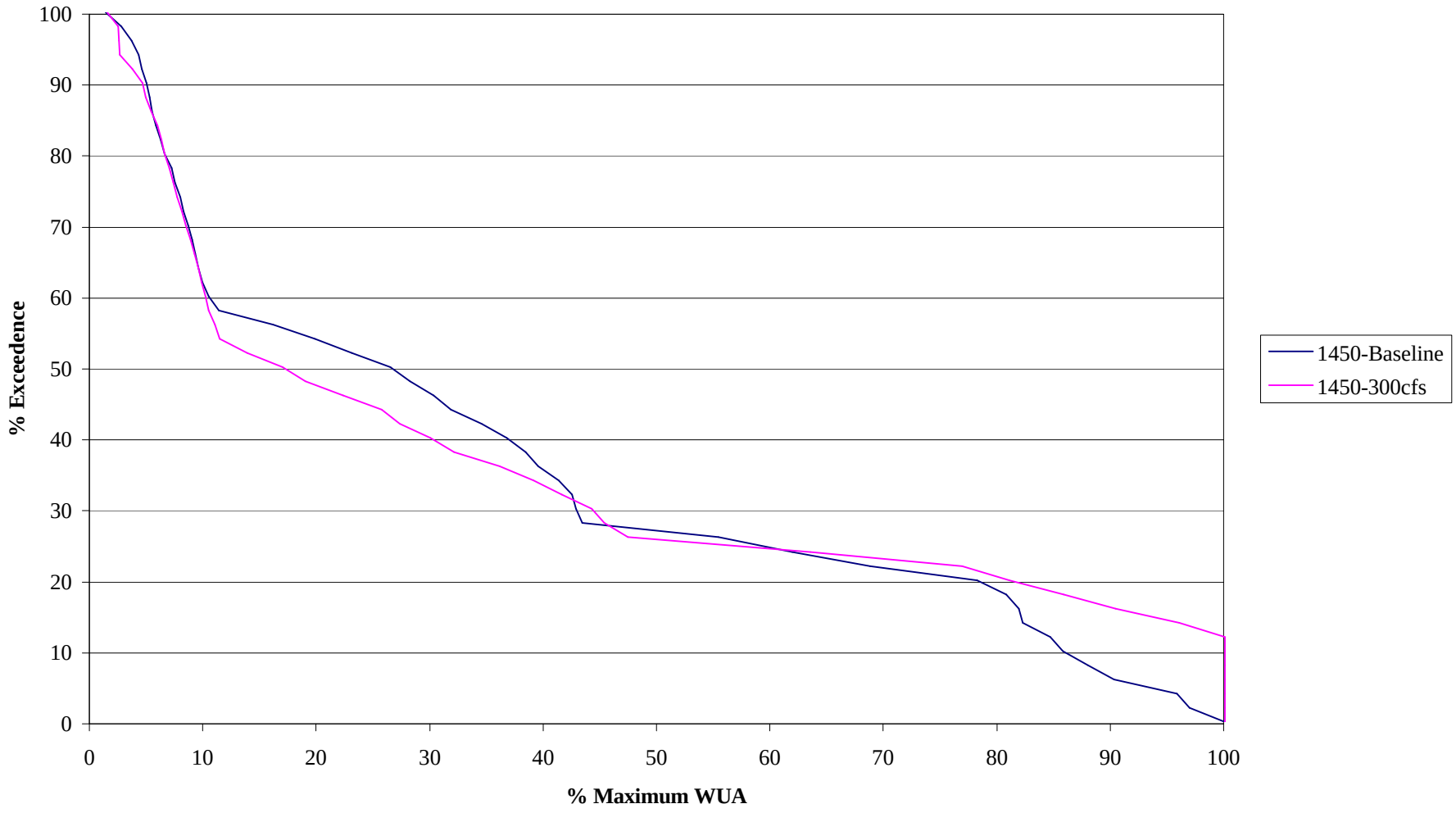
Final Aquatic Impact Analysis Report



% EXCEEDENCE OF % MAXIMUM WUA FOR HABITAT REACH E SHALLOW POOL SPRING

Final Aquatic Impact Analysis Report



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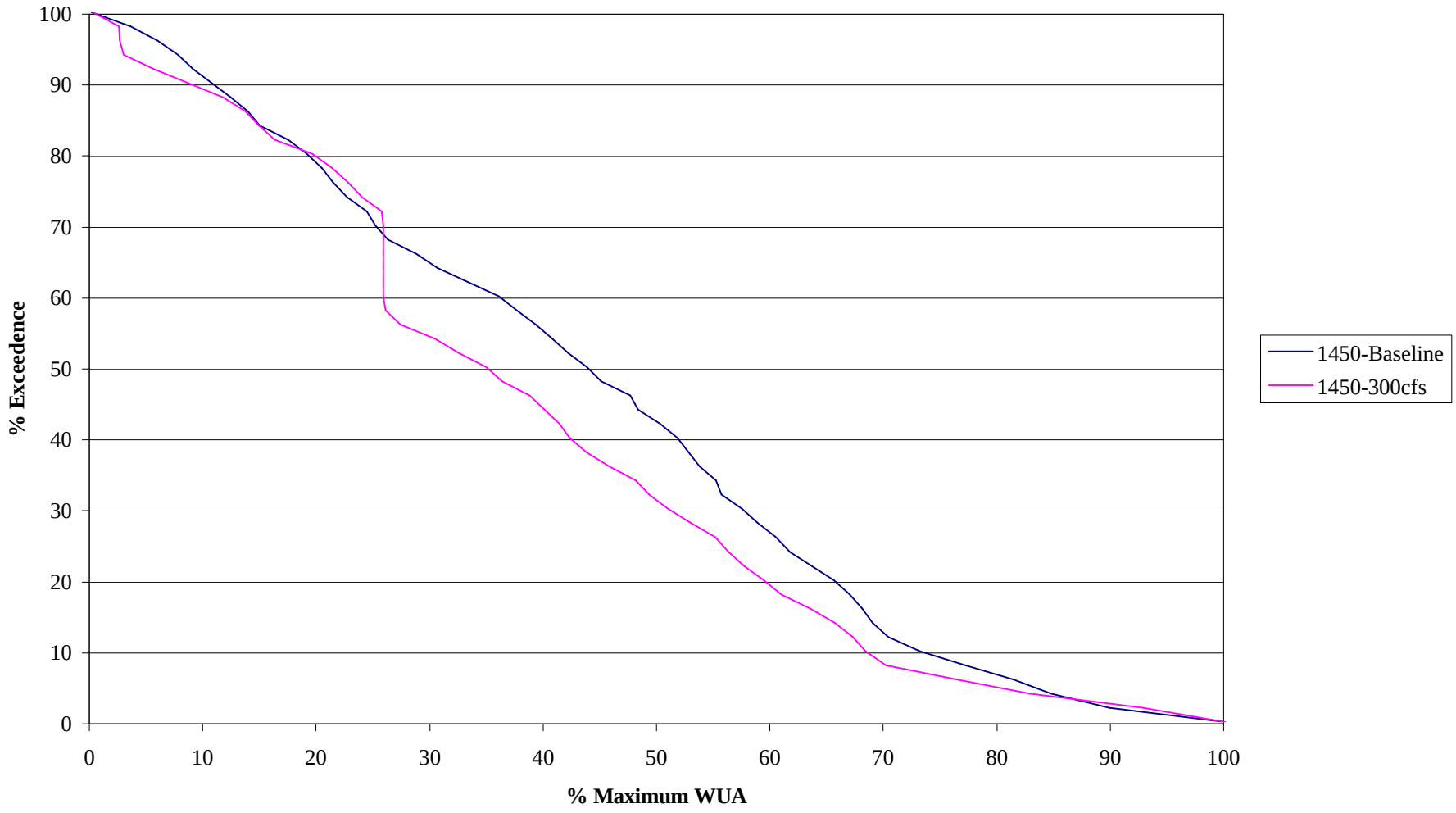

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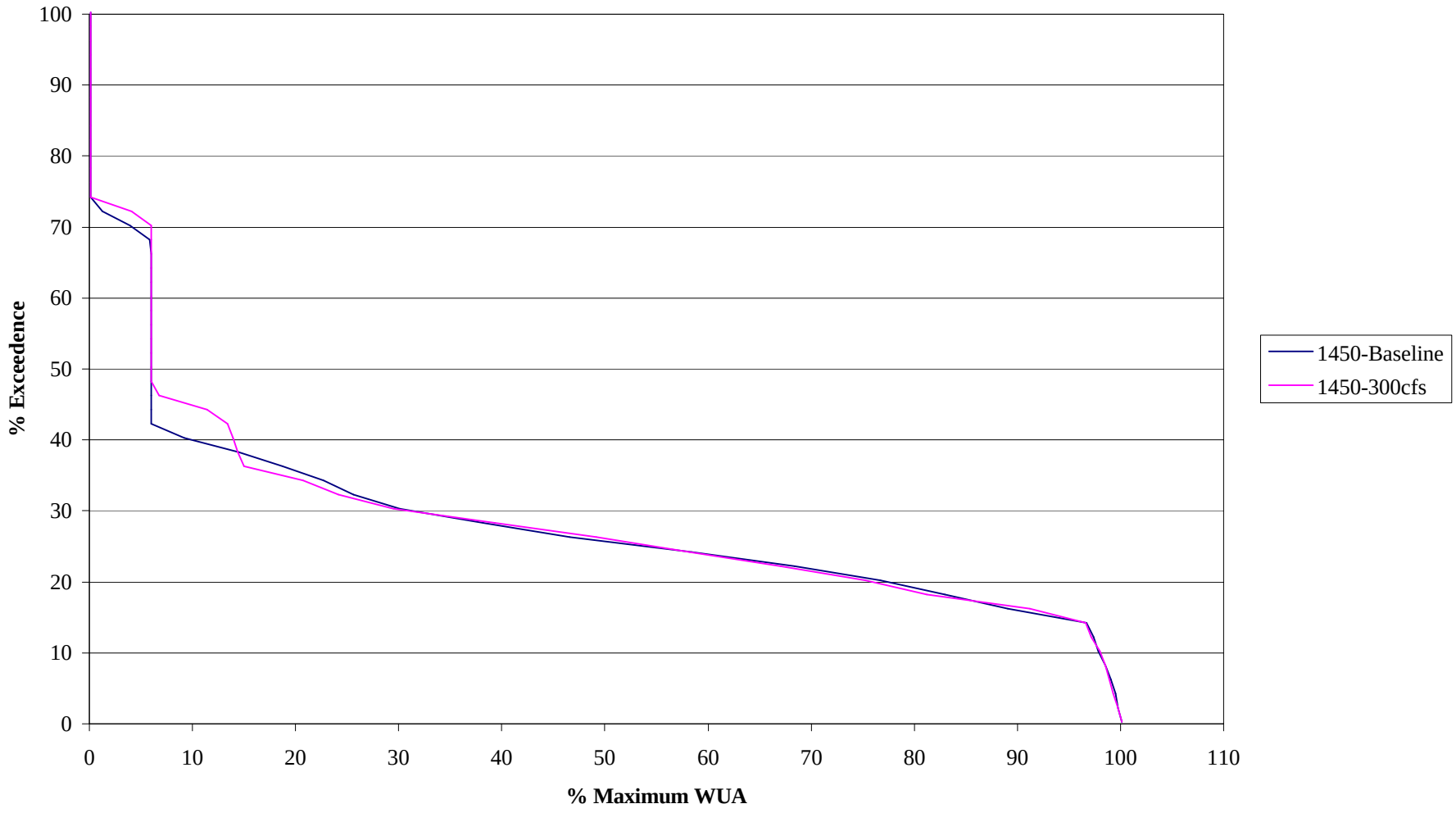

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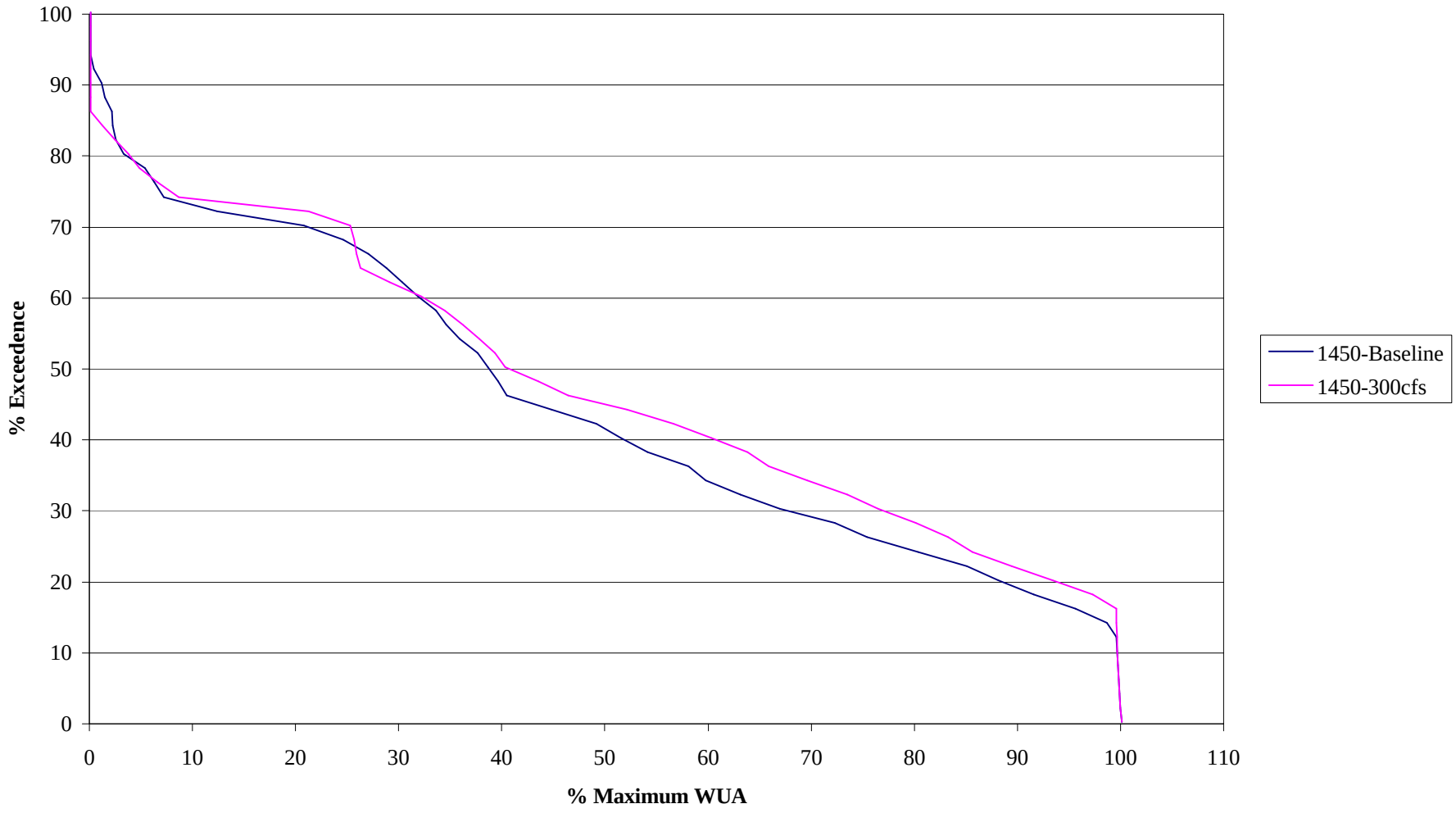

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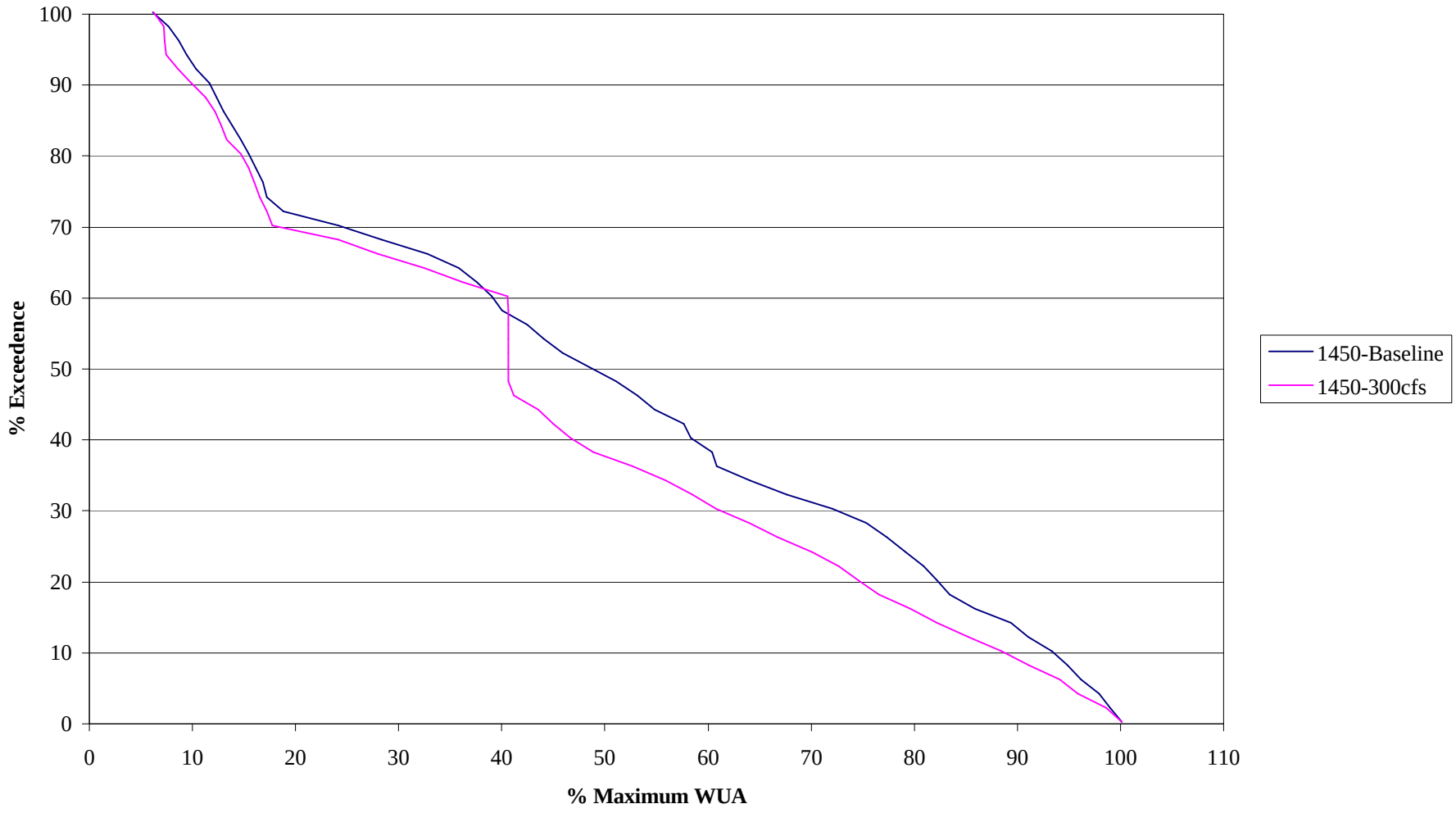

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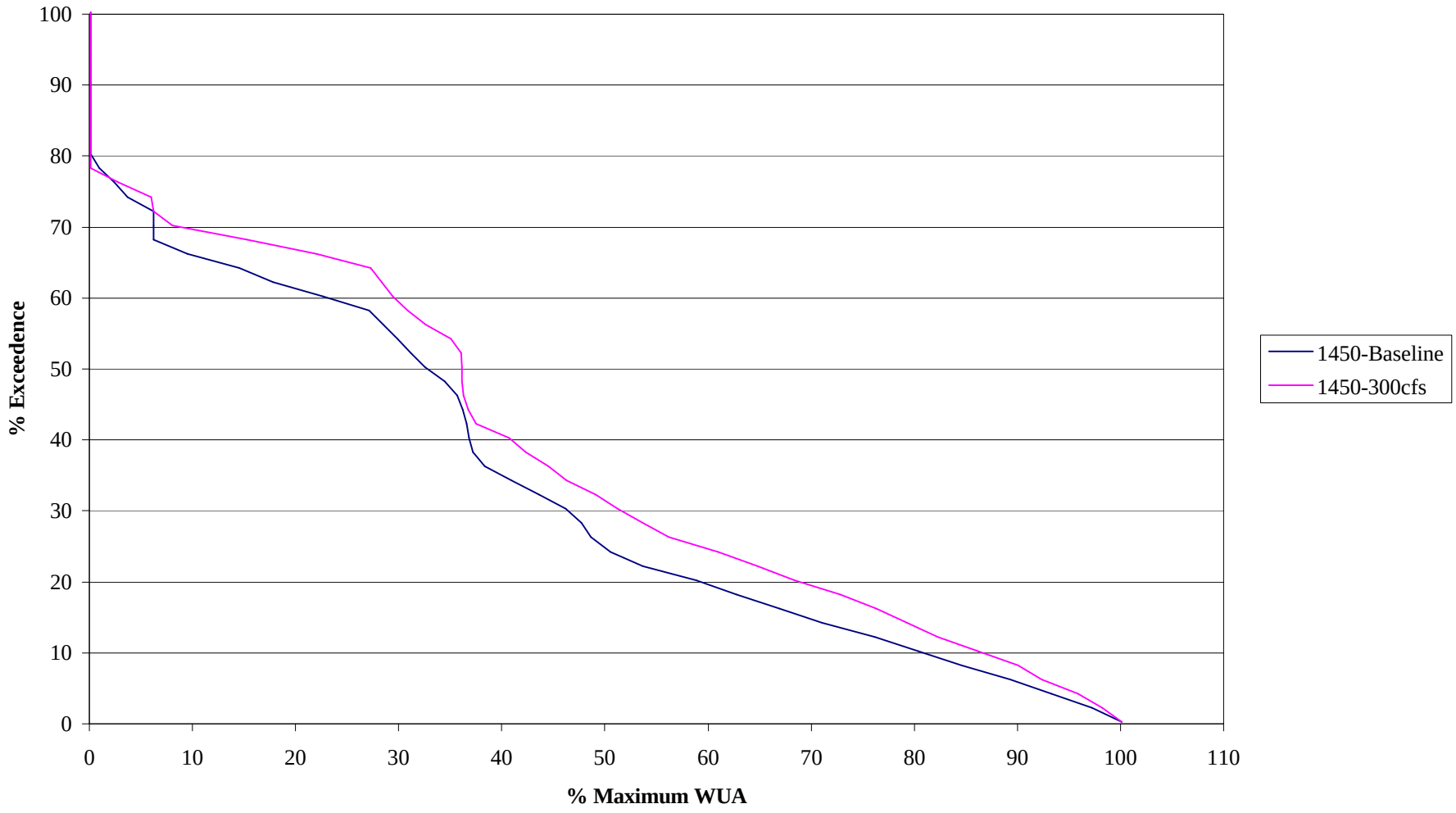

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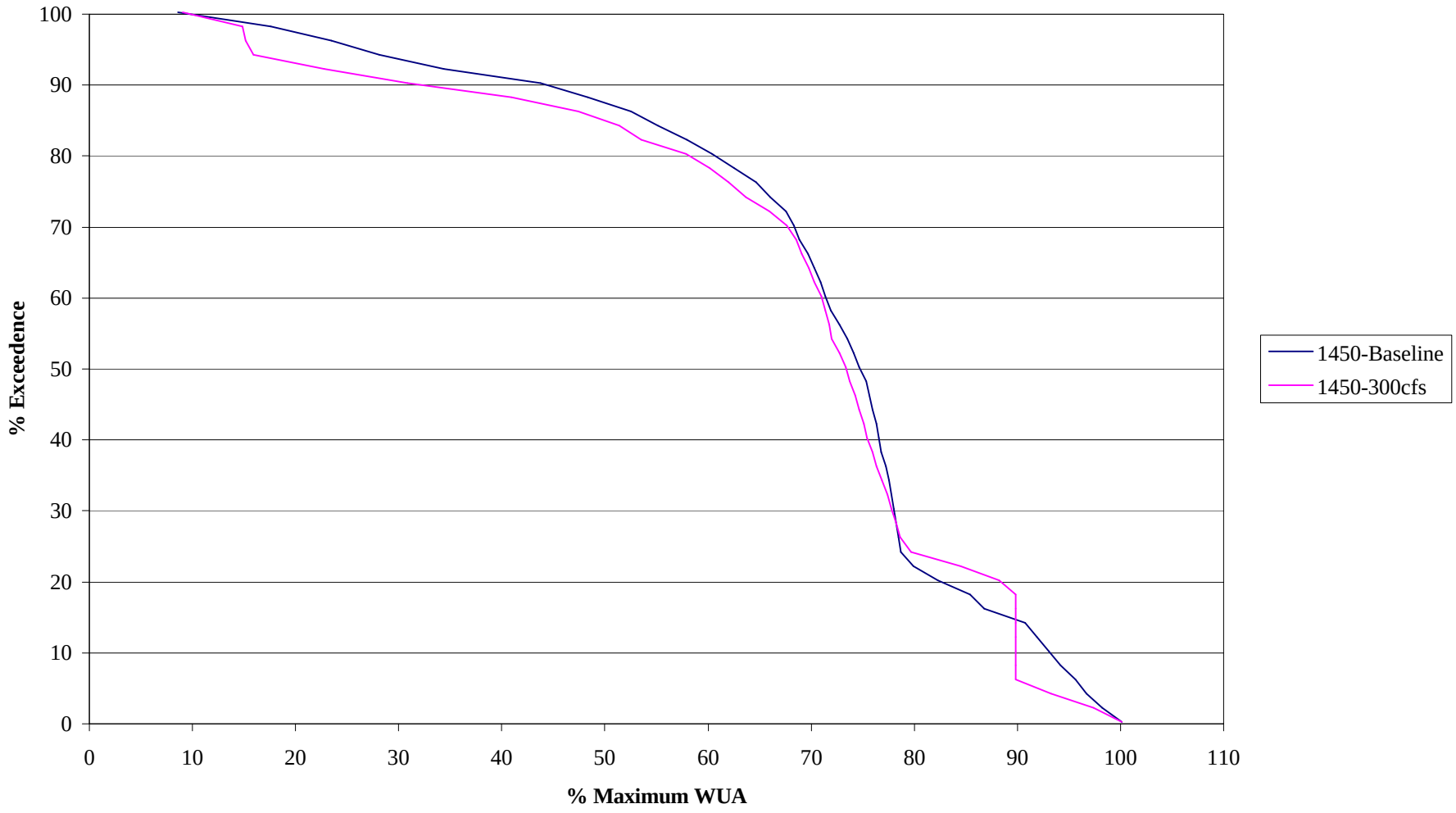

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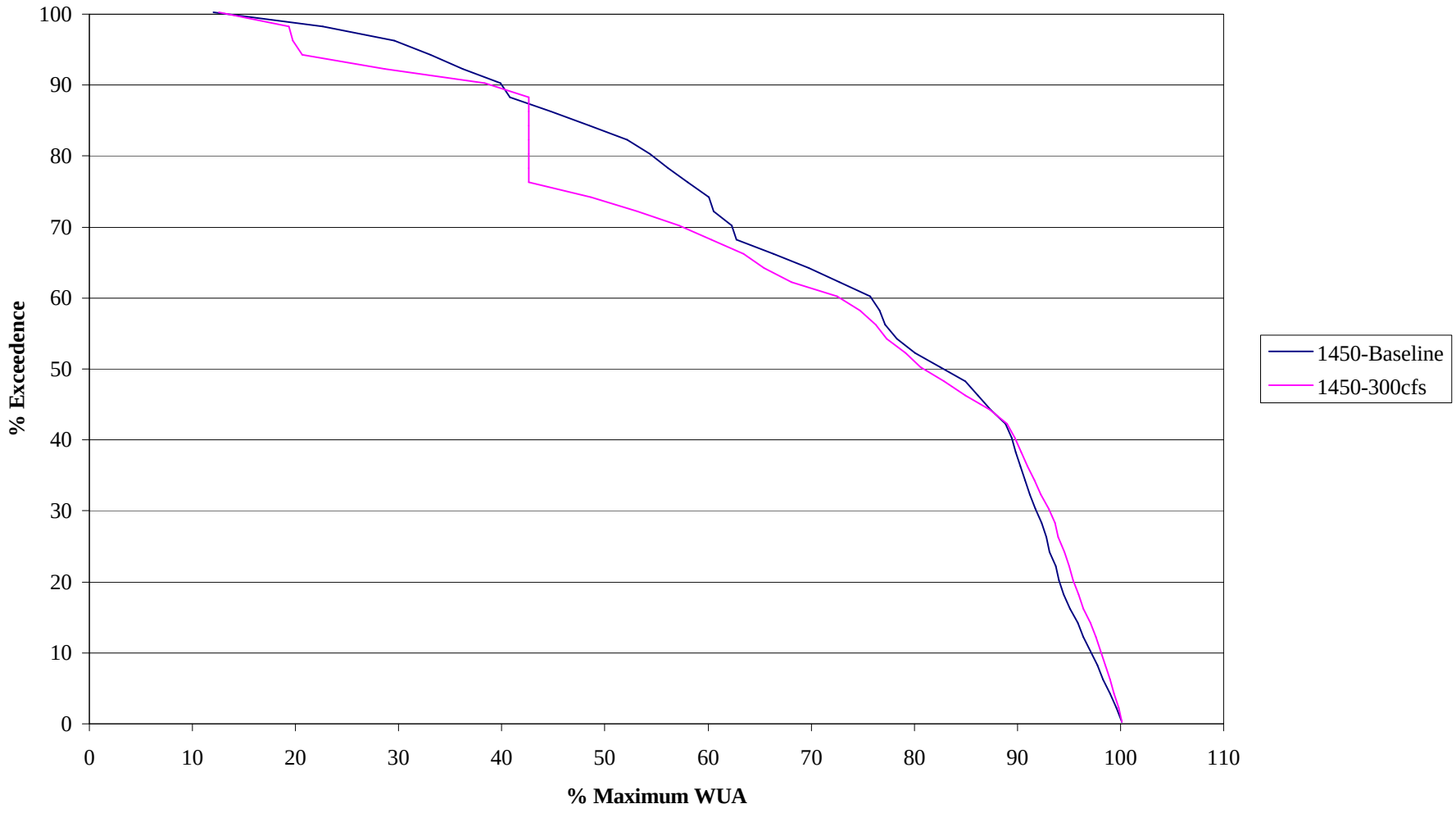

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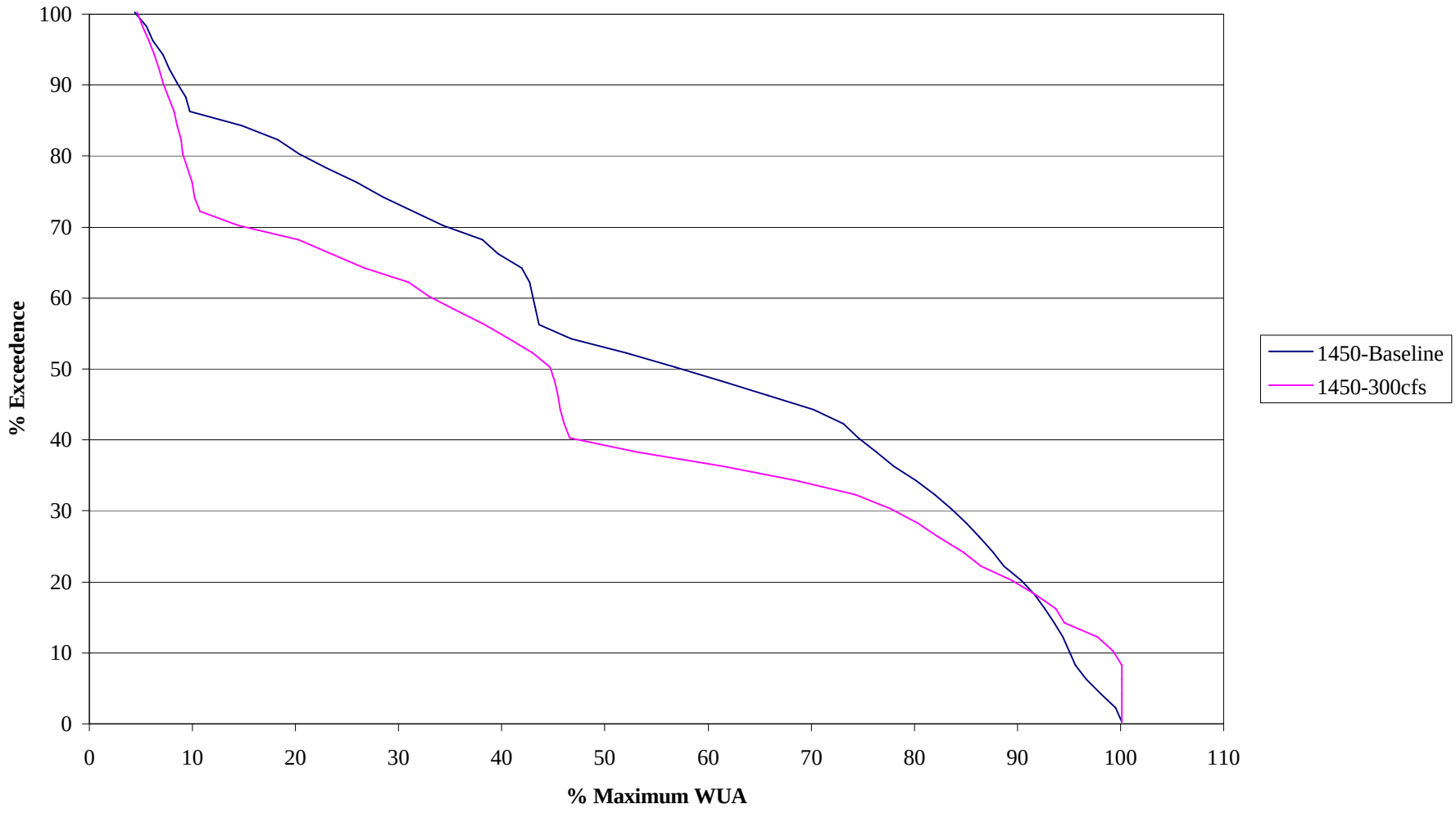

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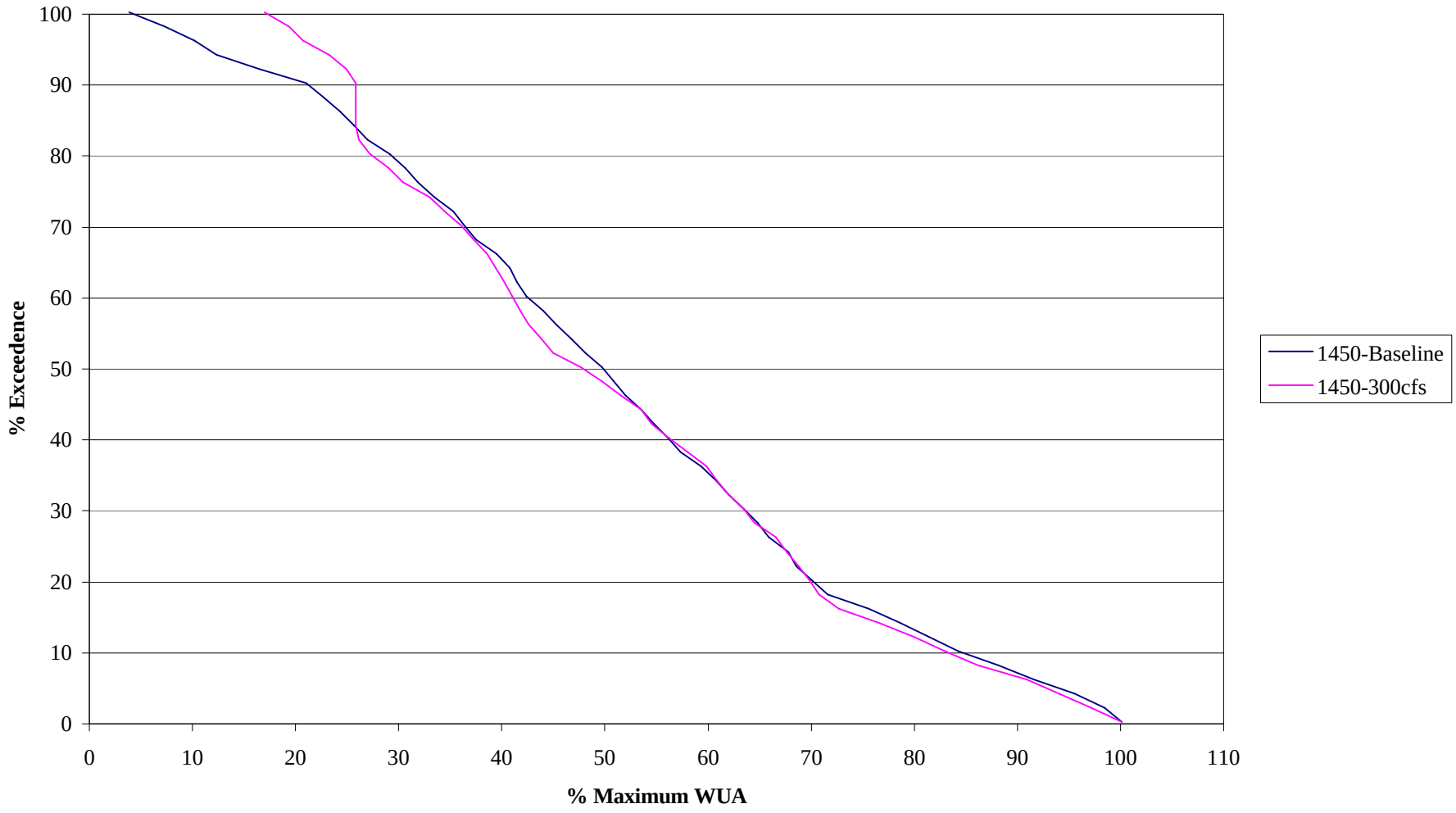

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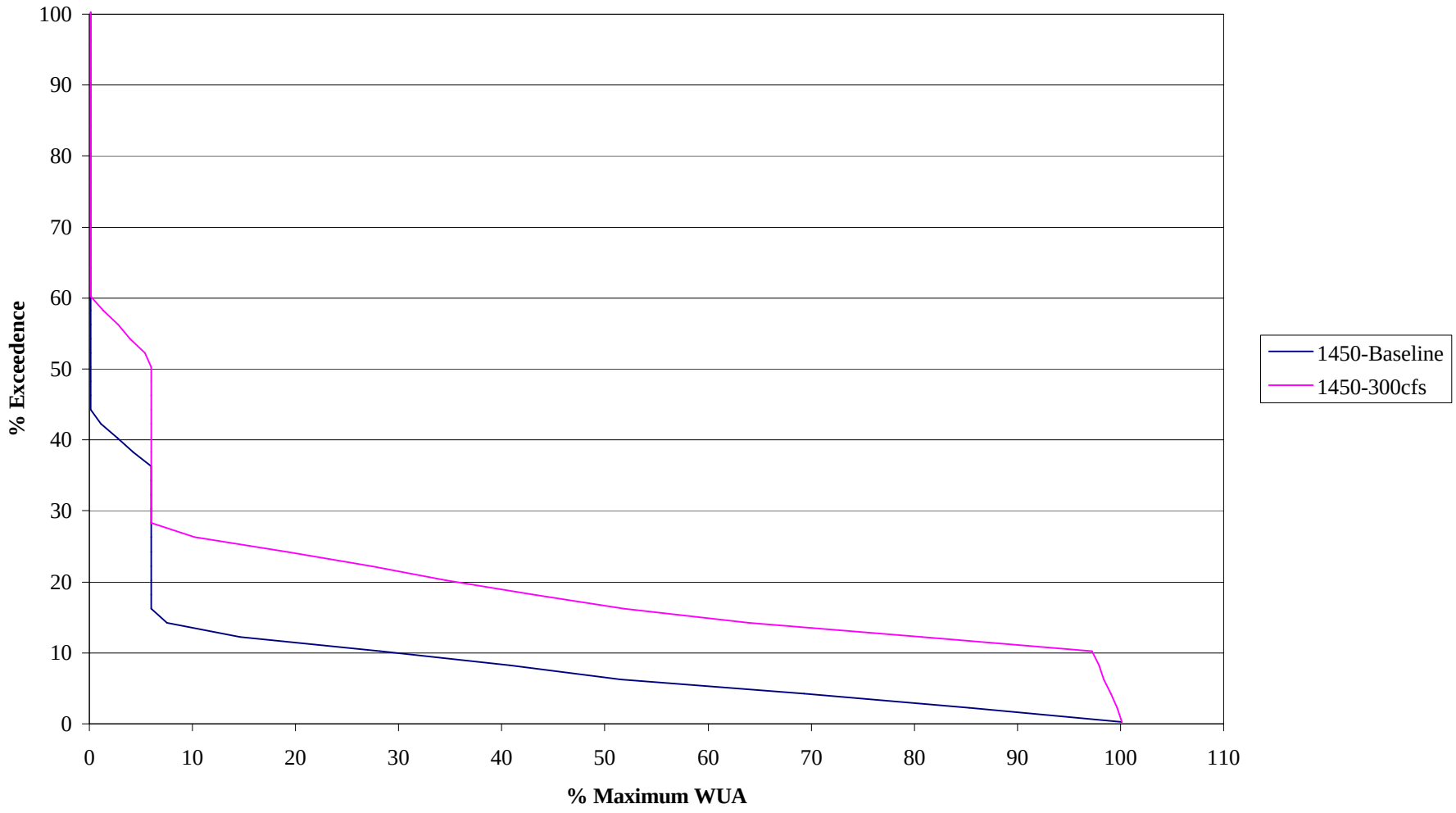

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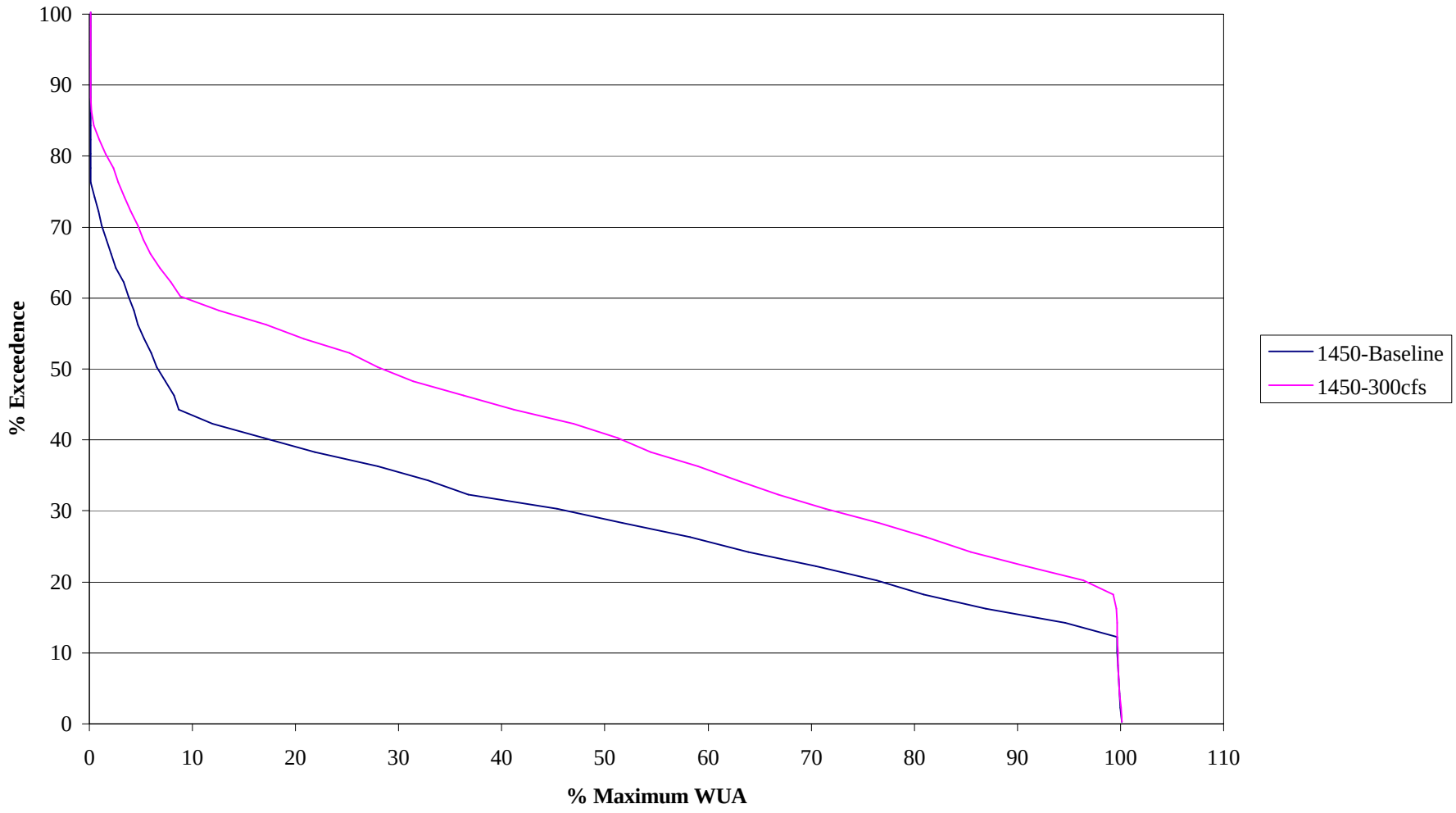

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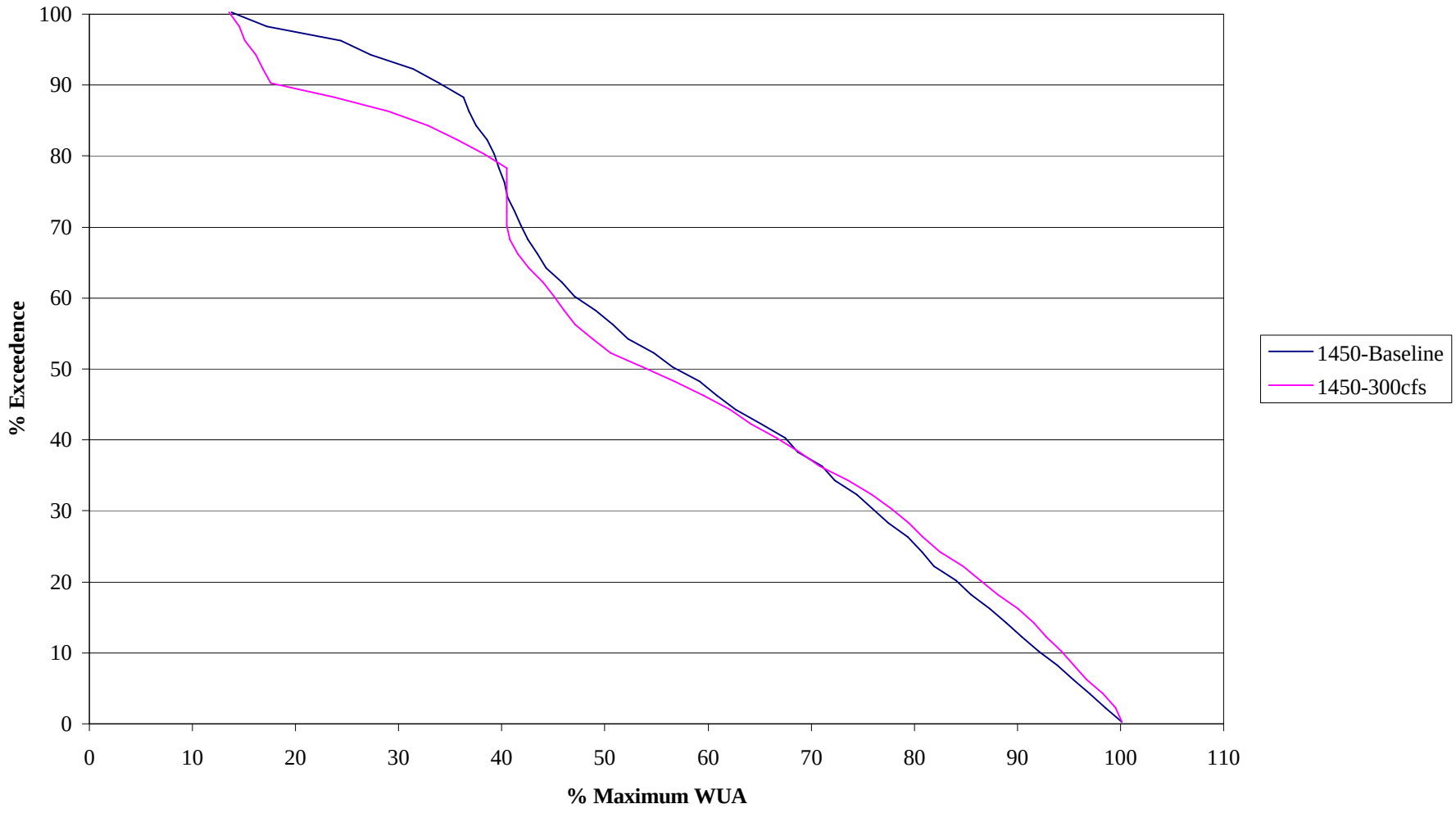

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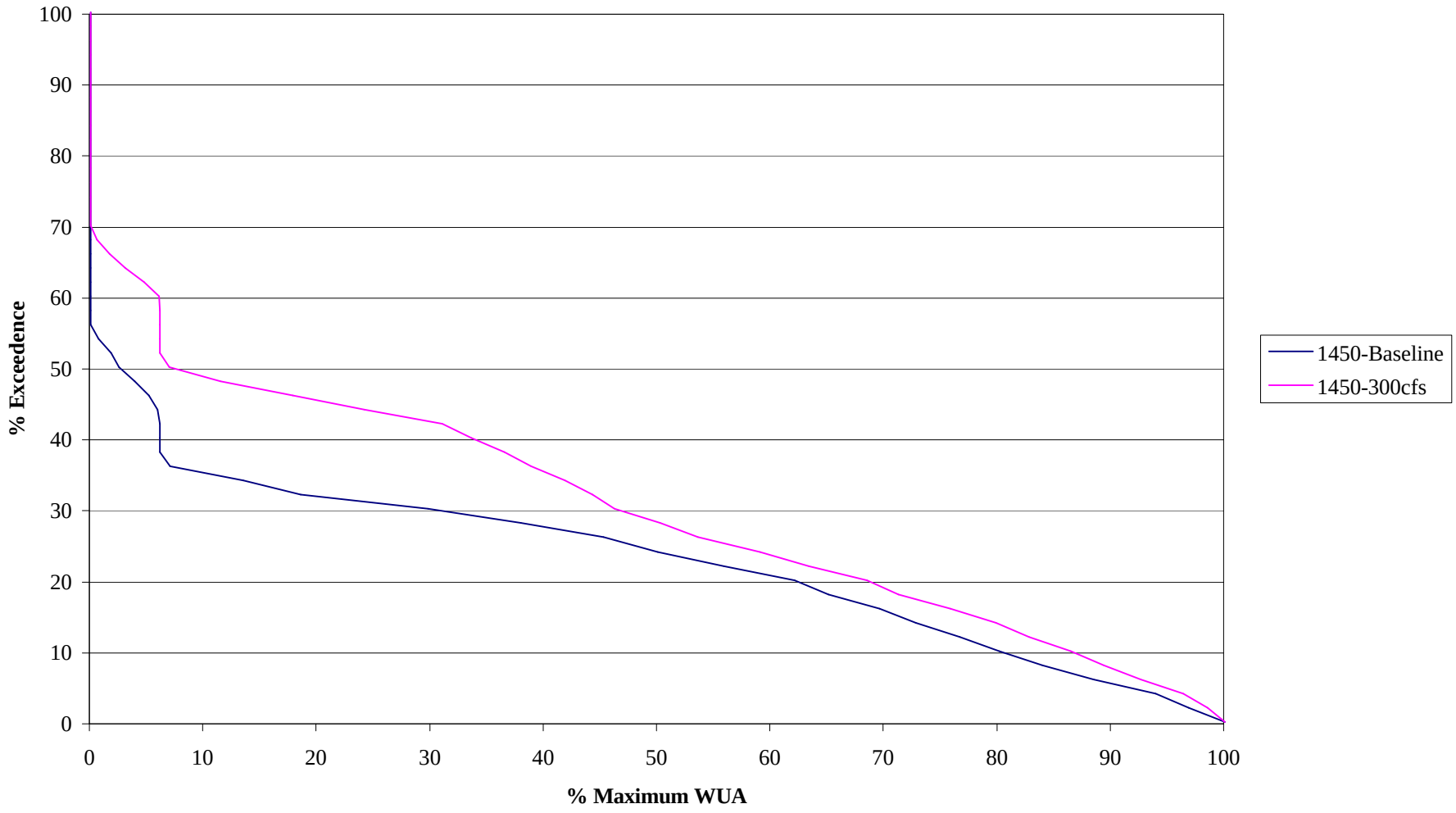

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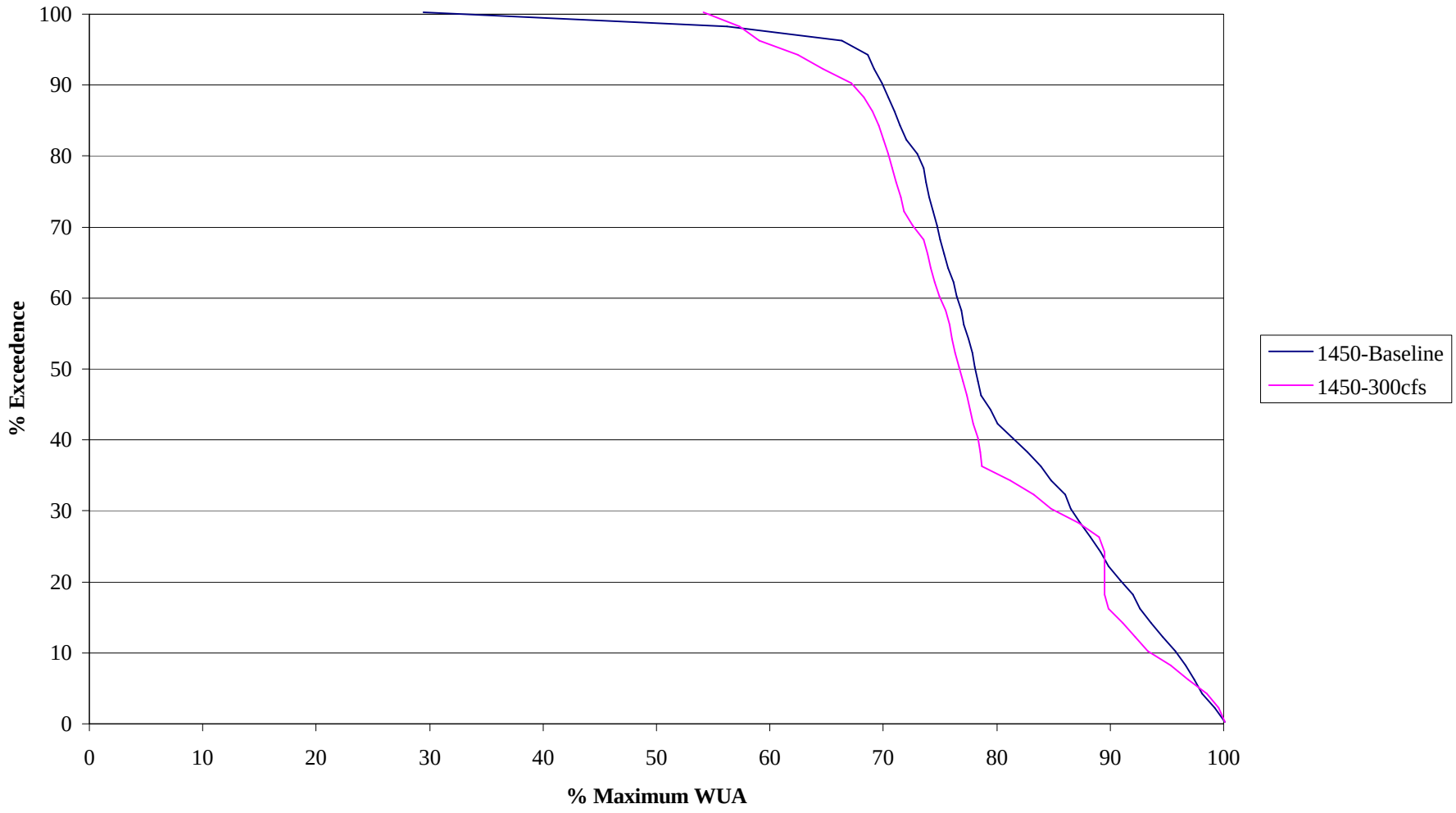

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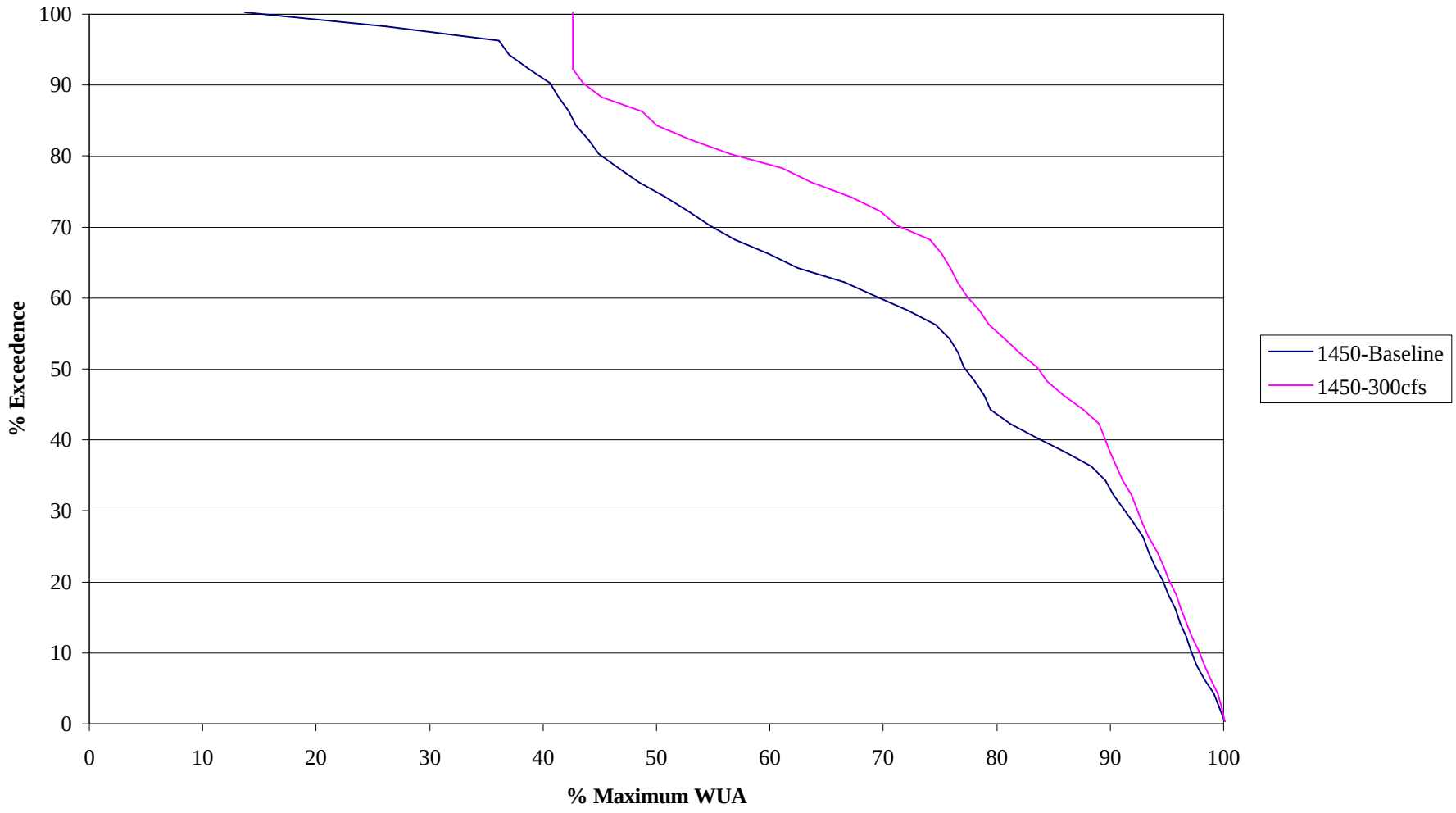

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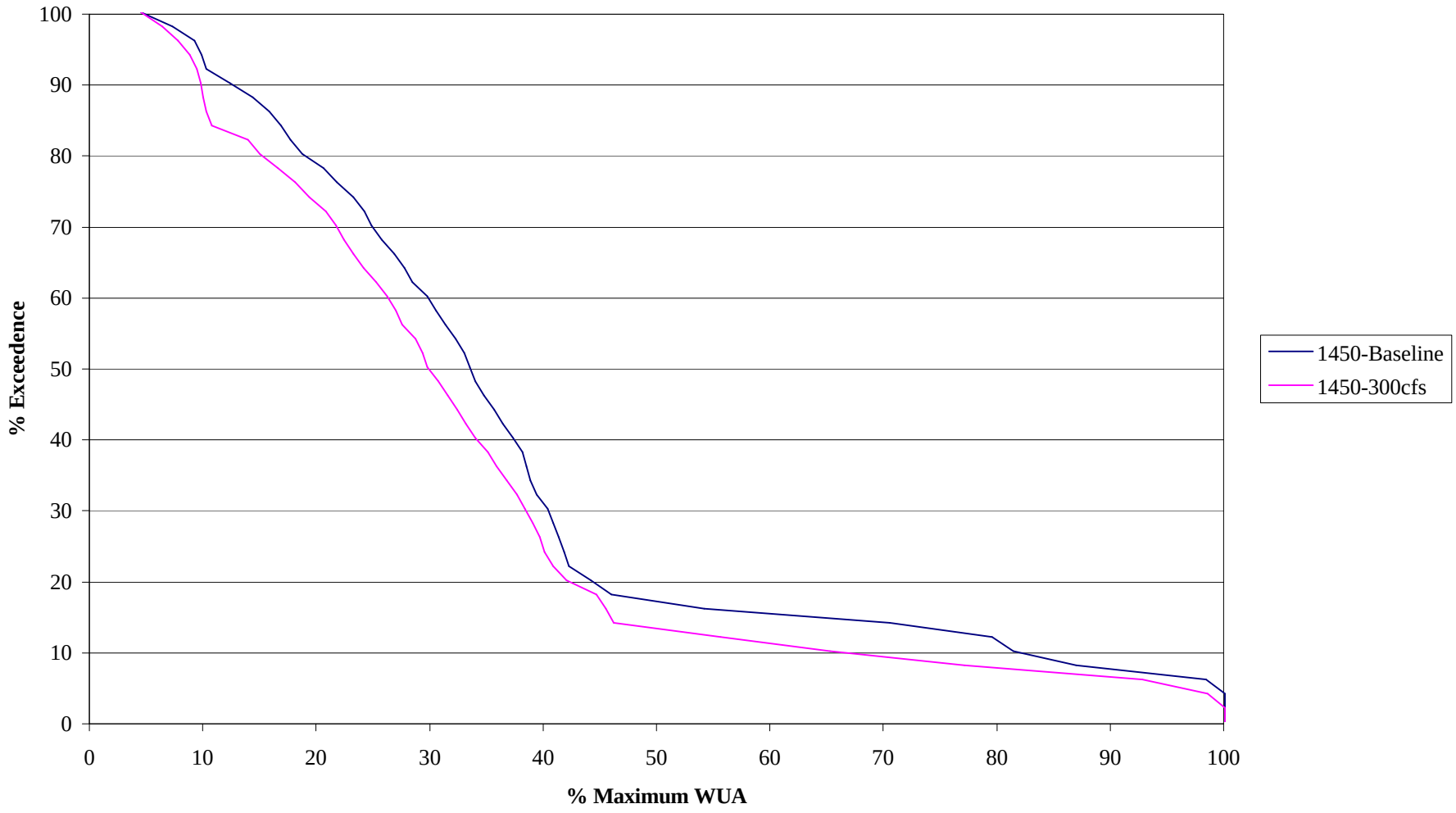

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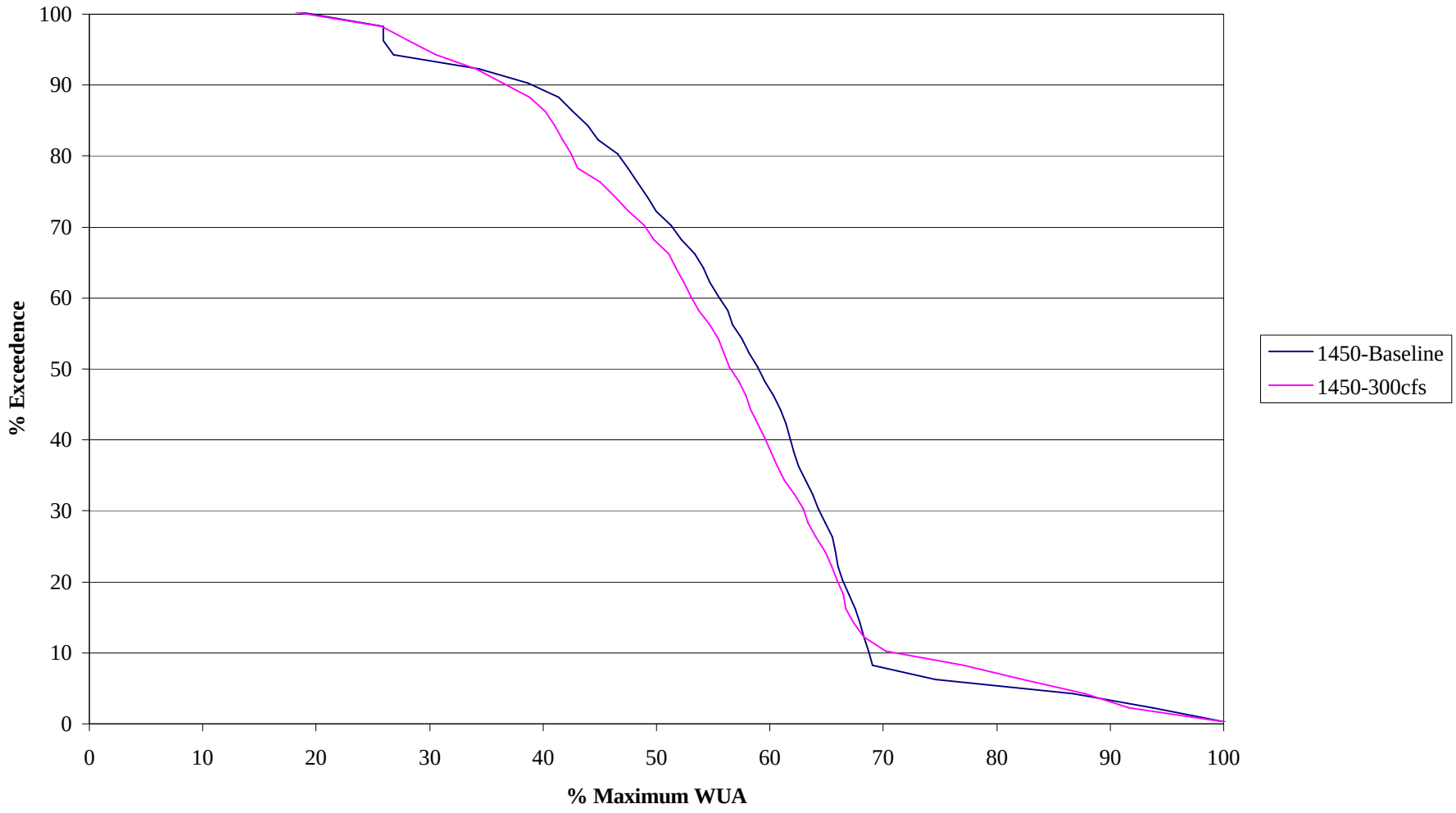

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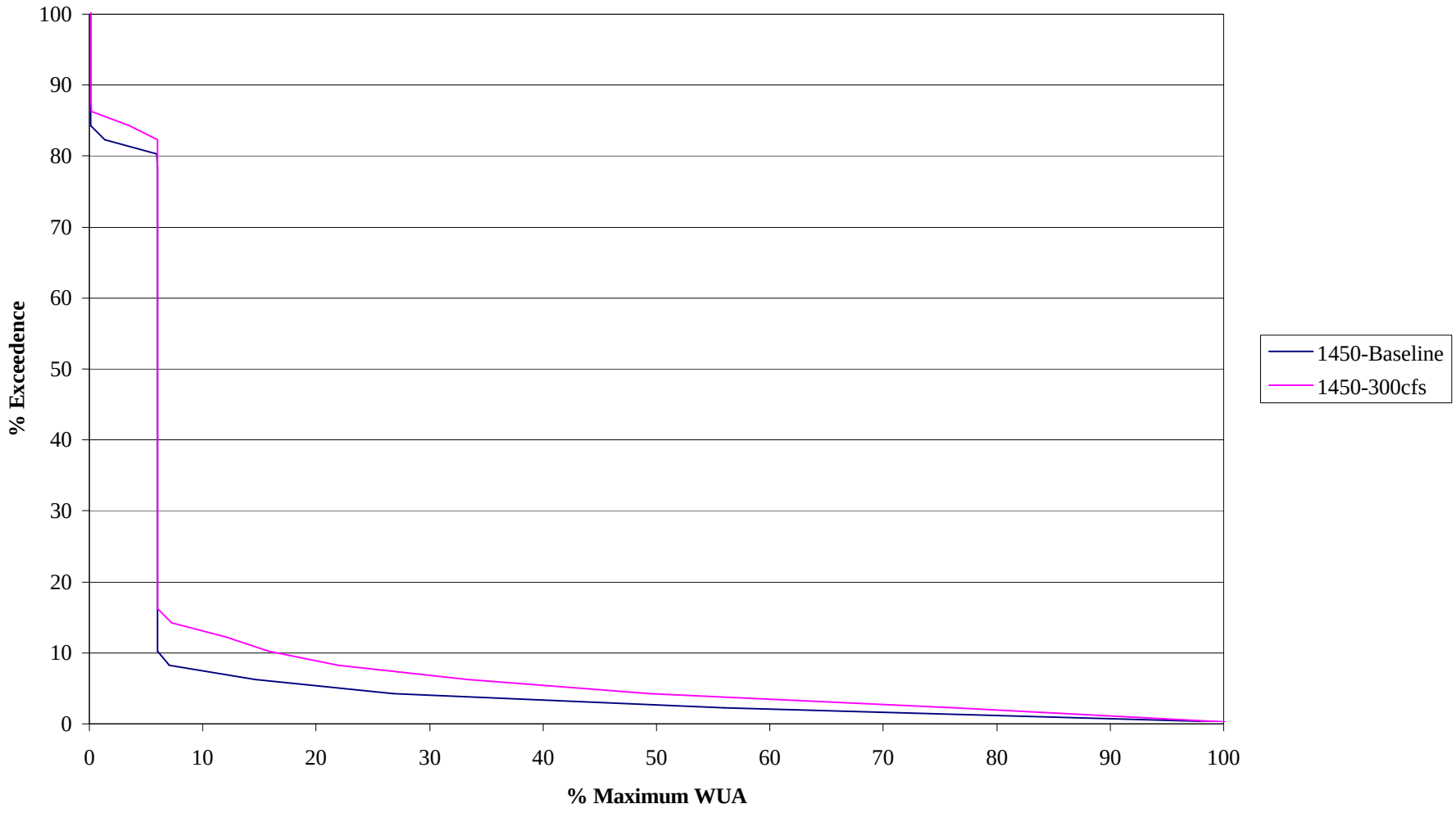

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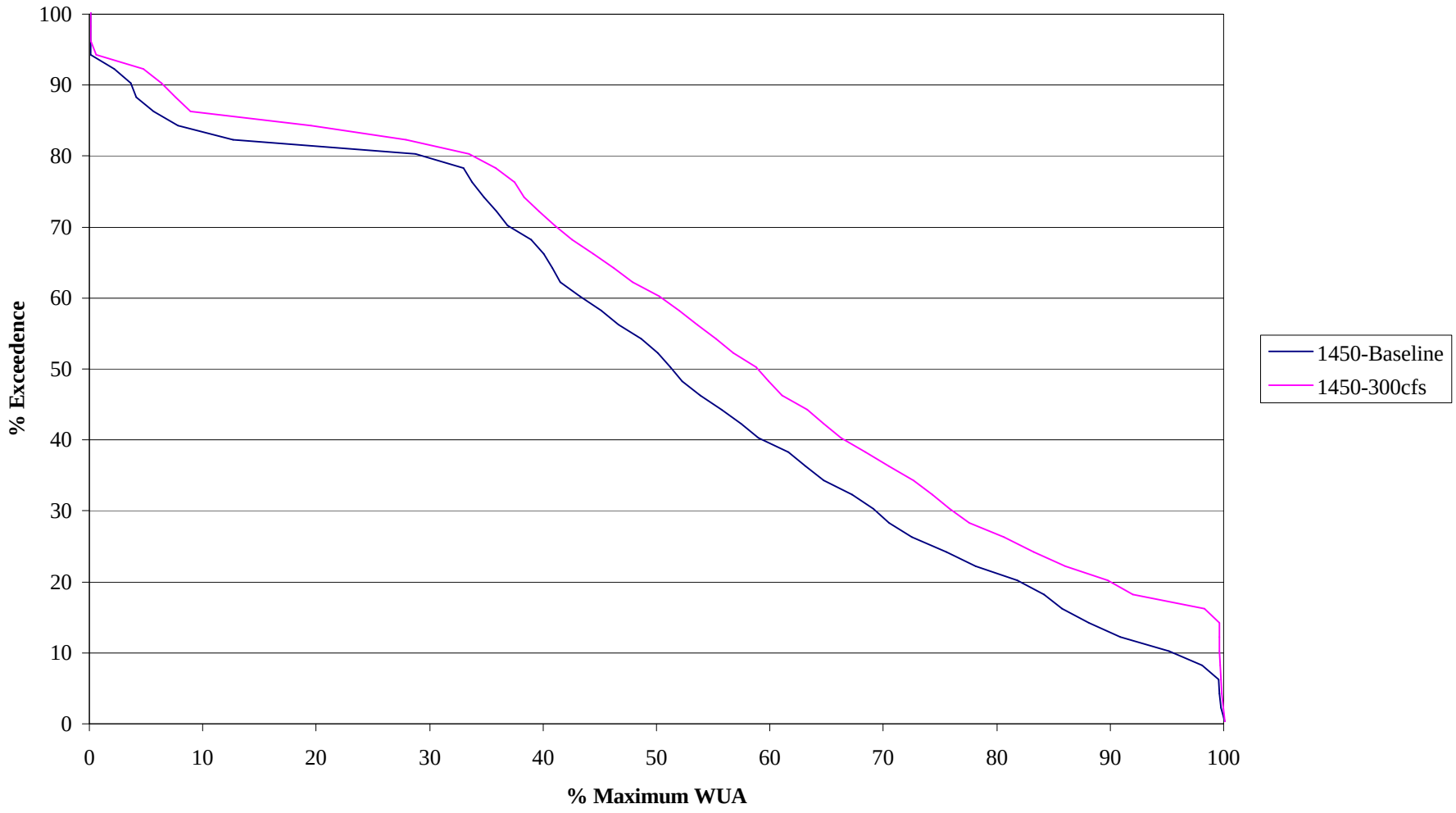

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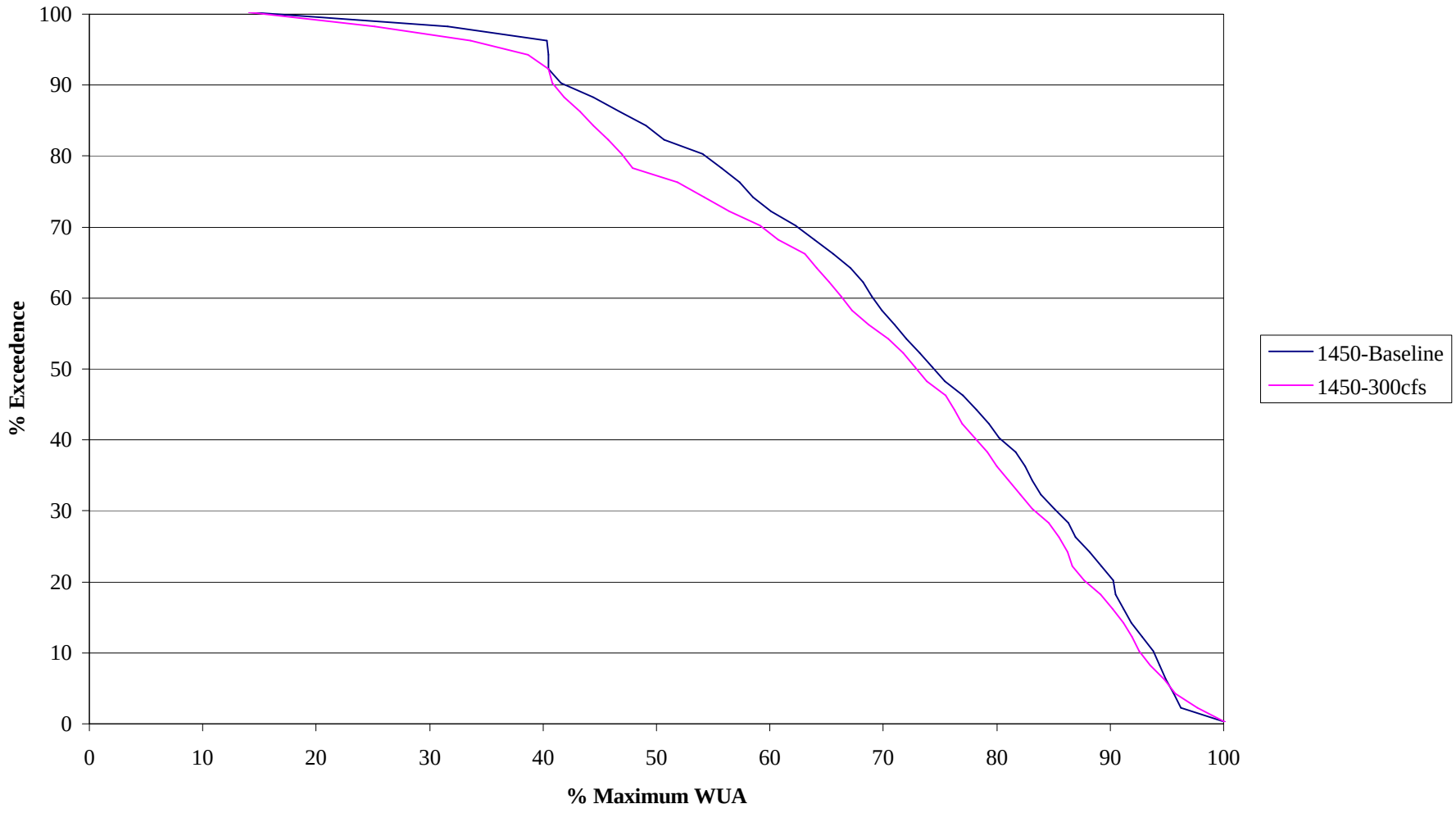

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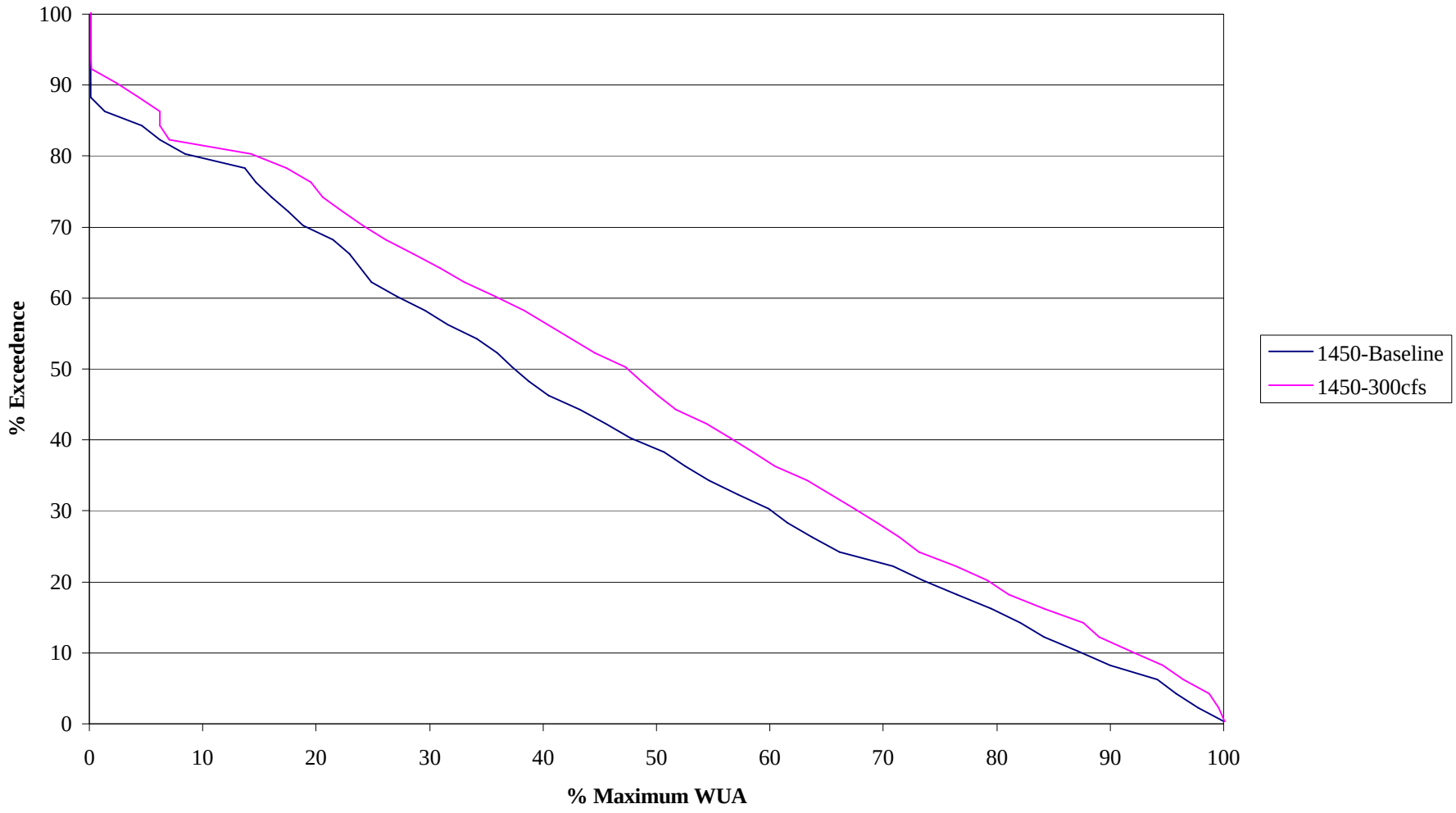

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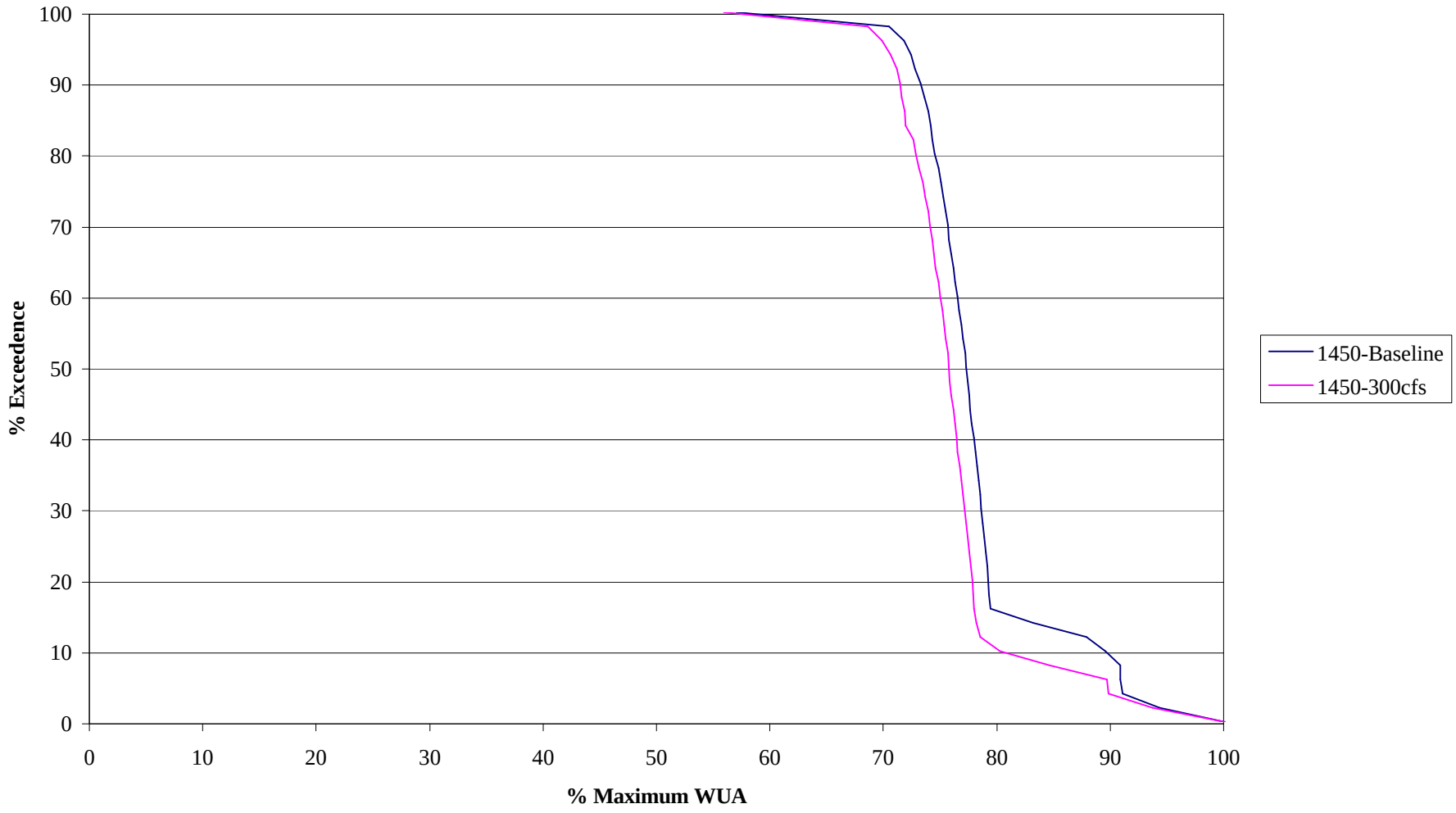

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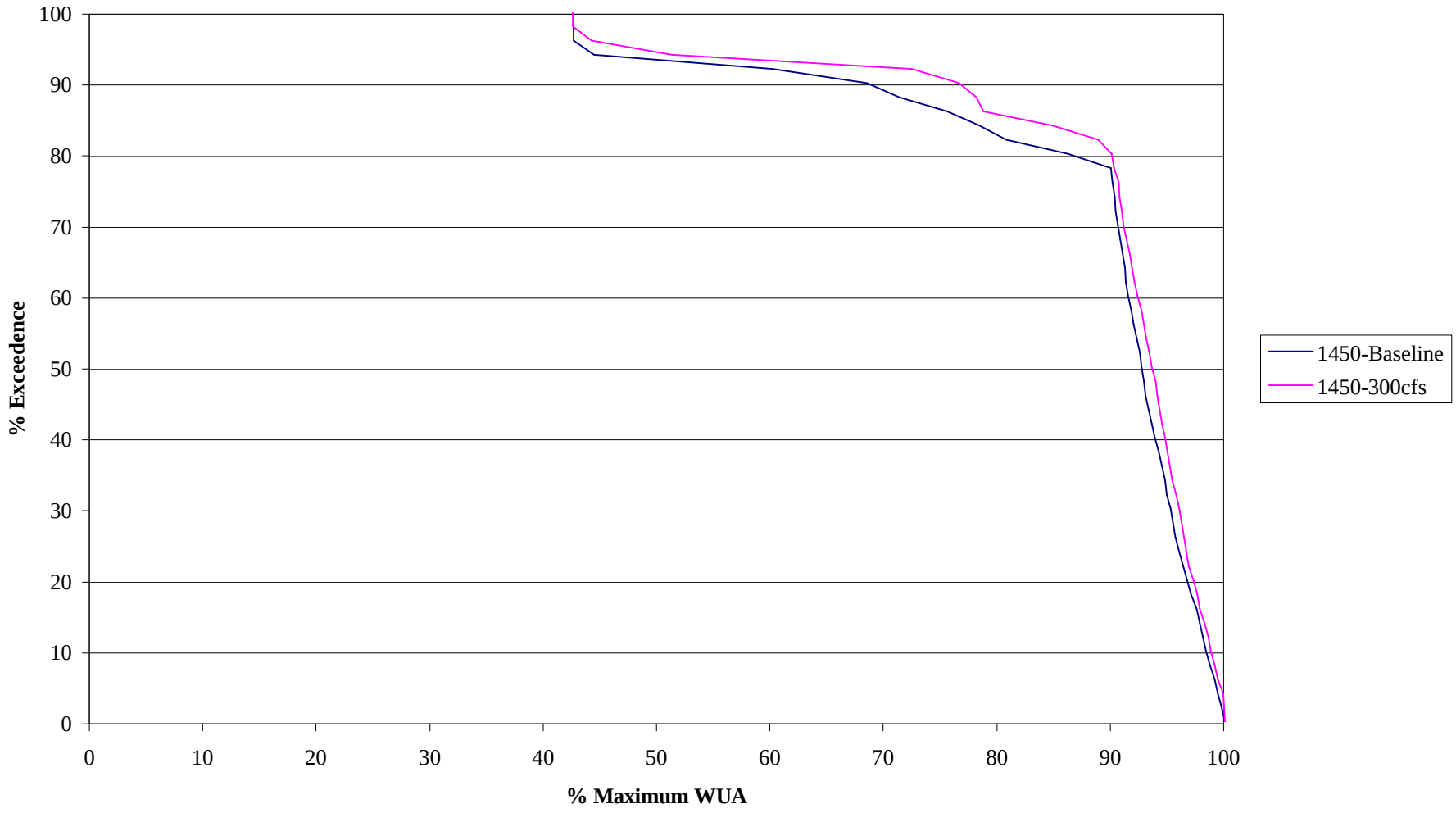

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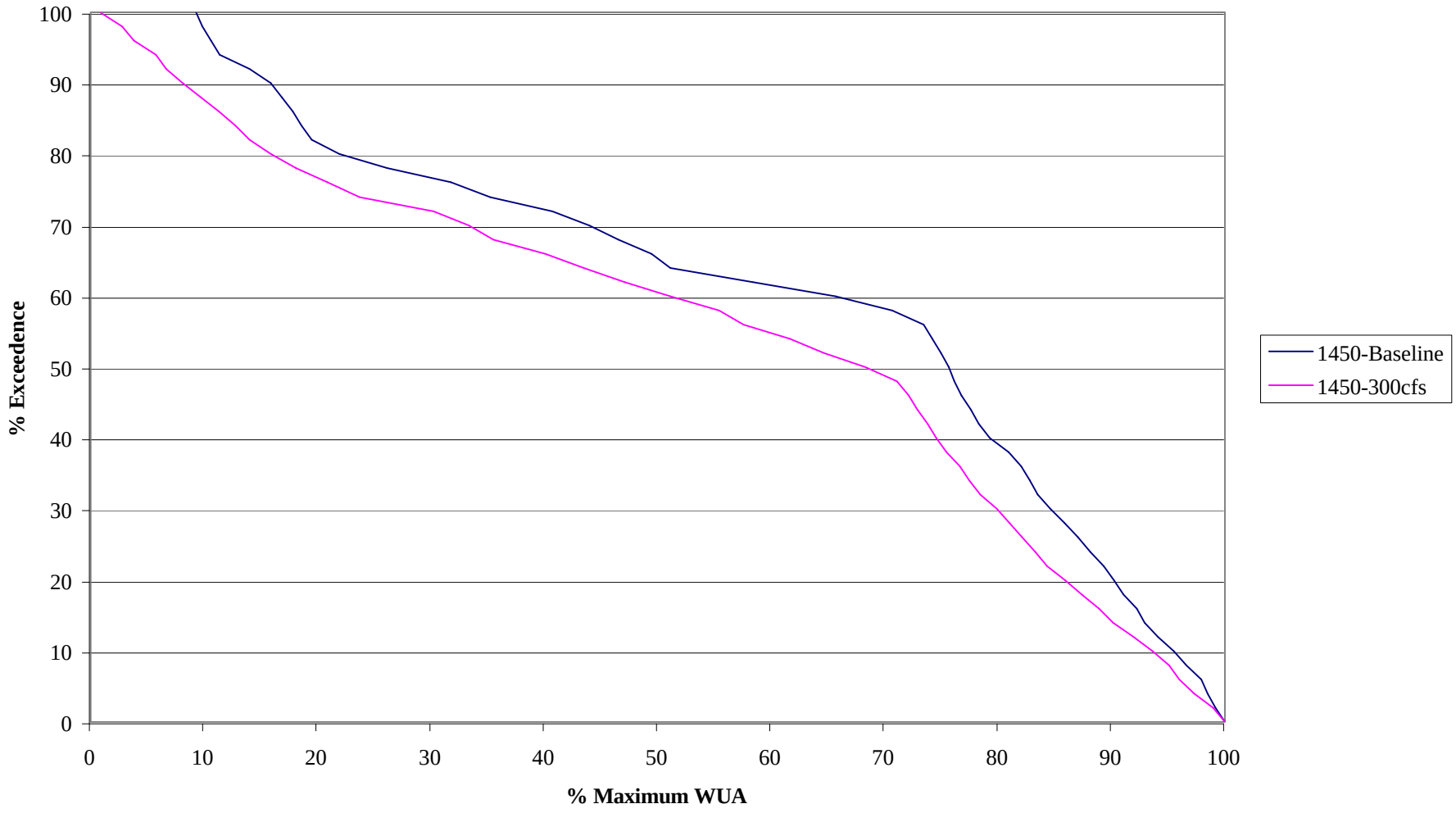

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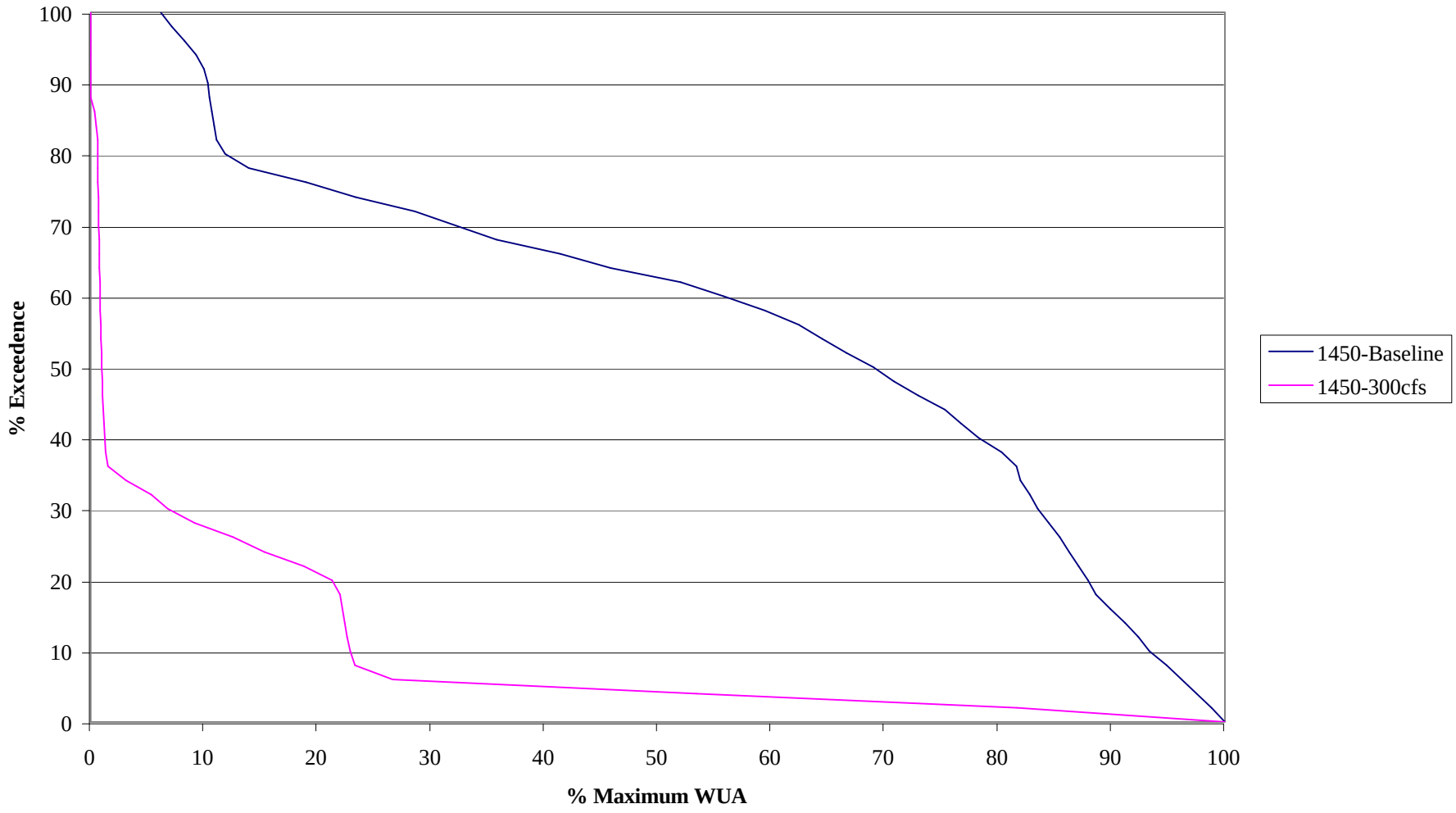

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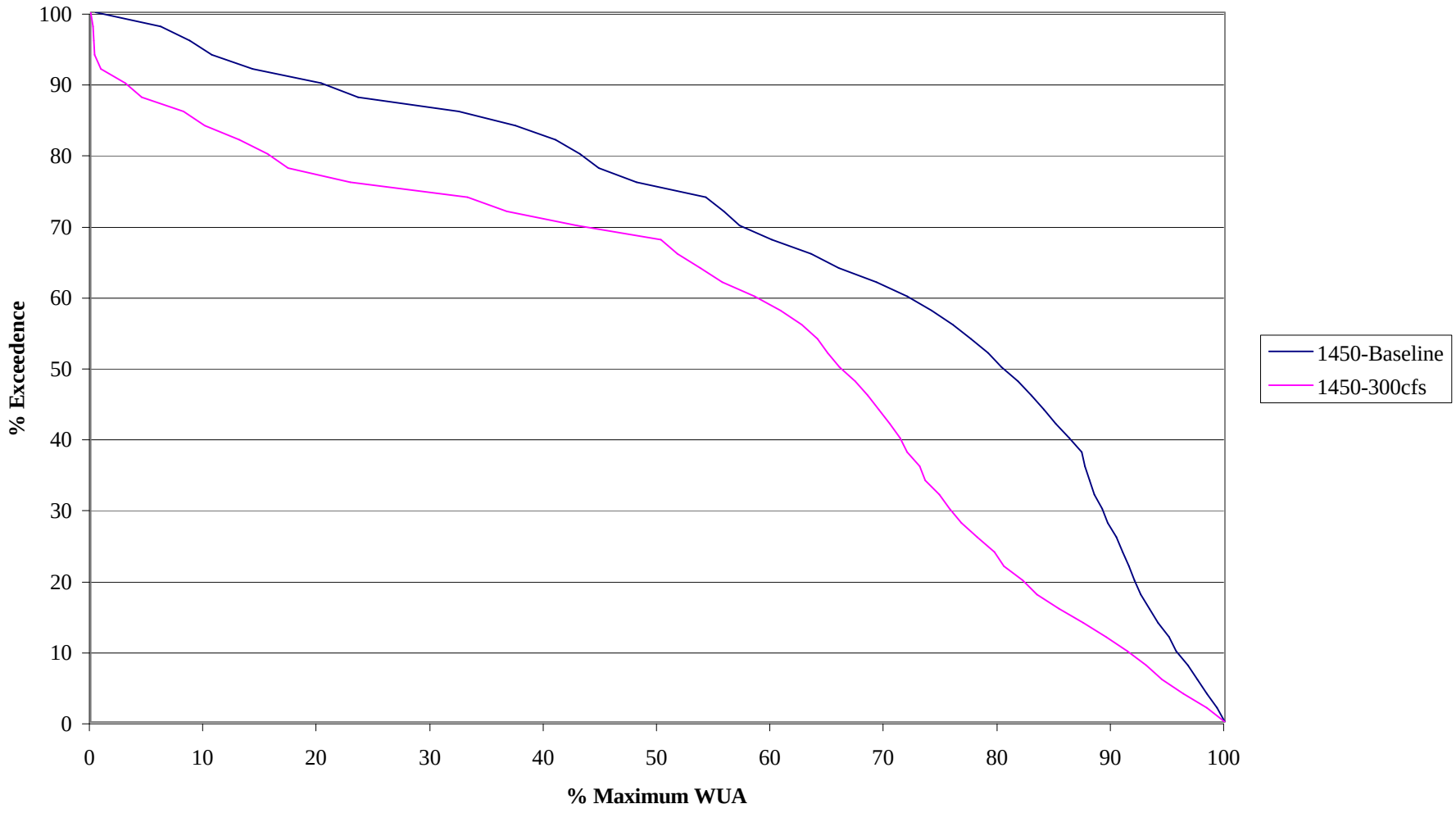

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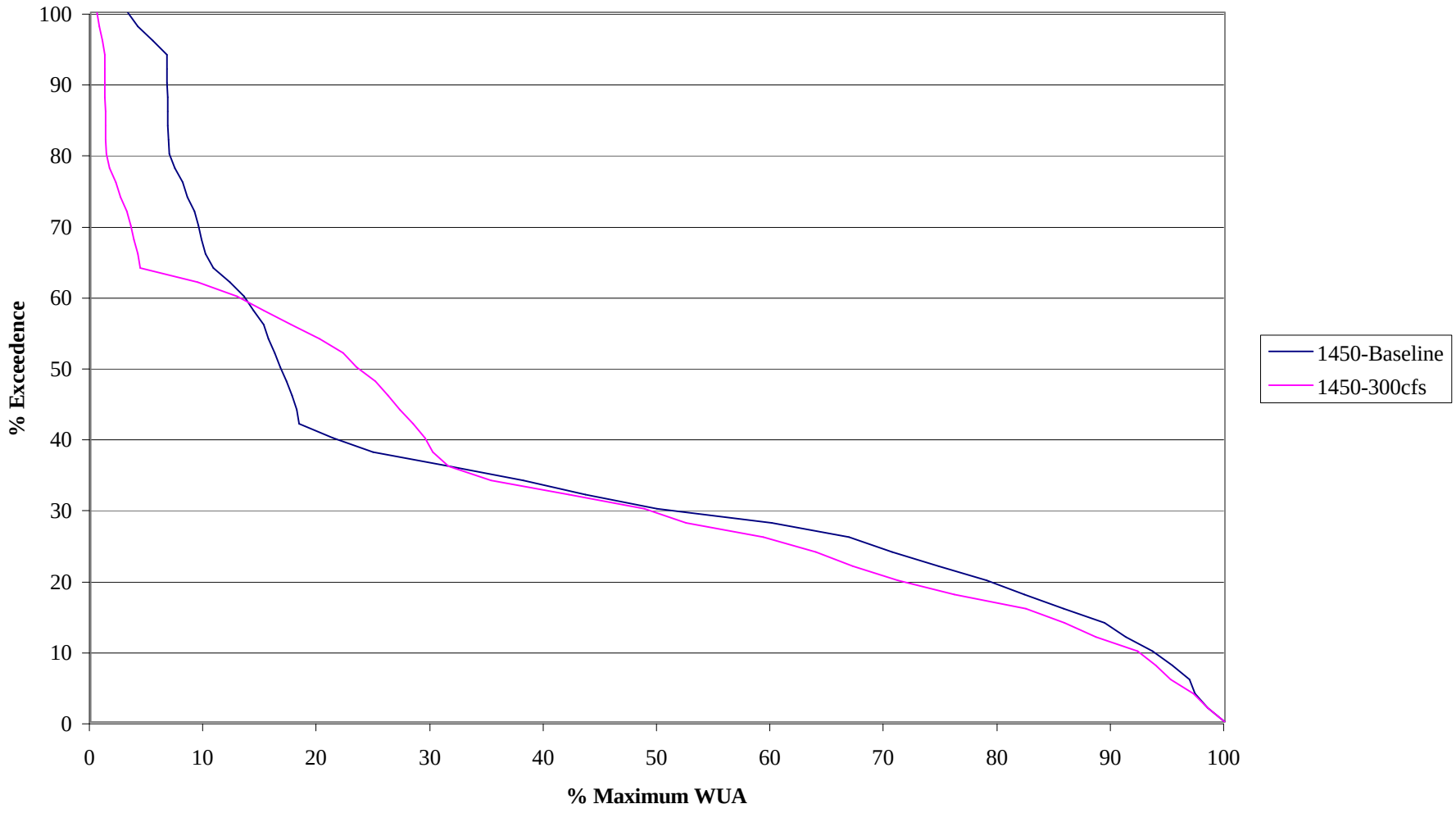

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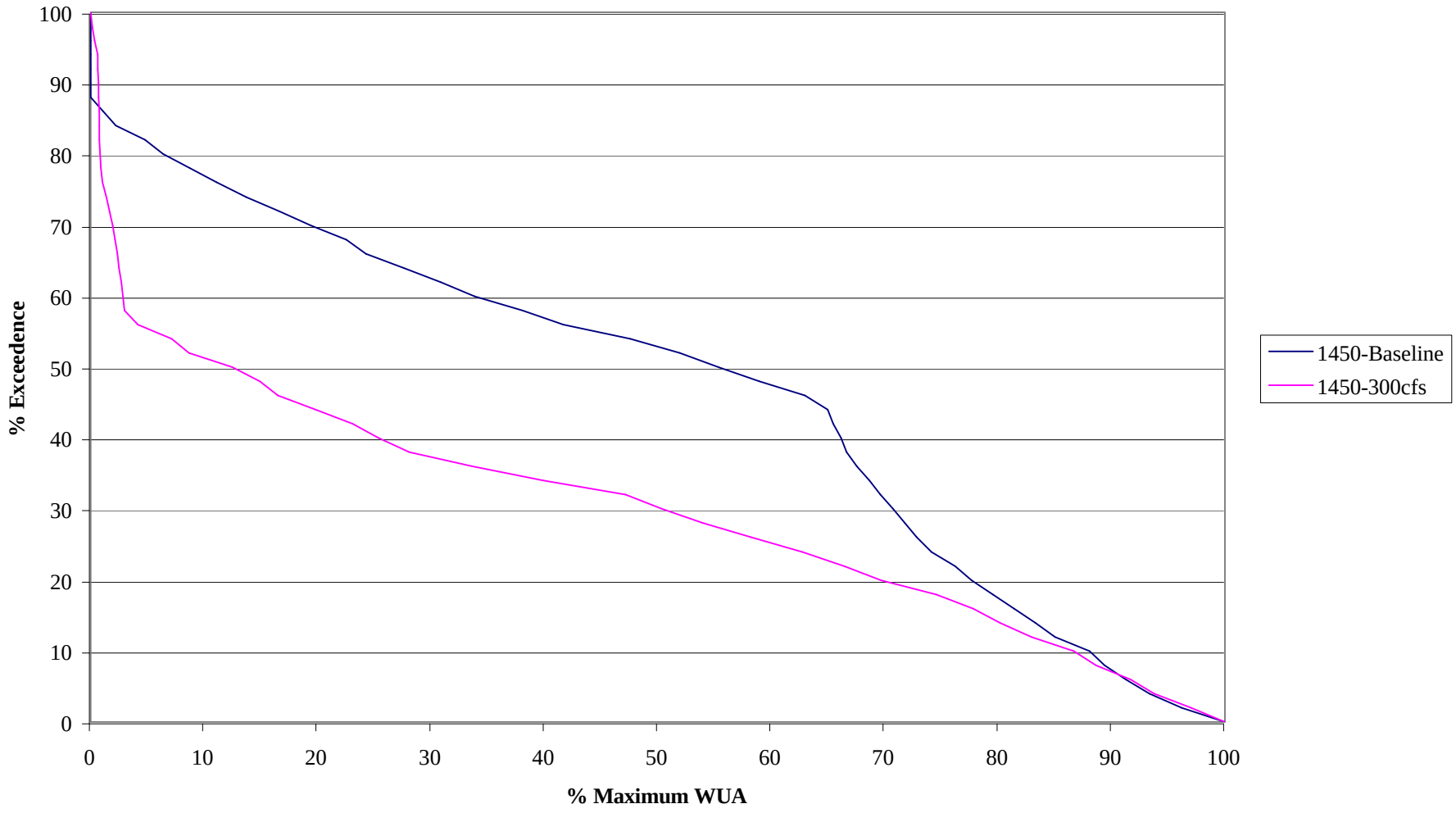

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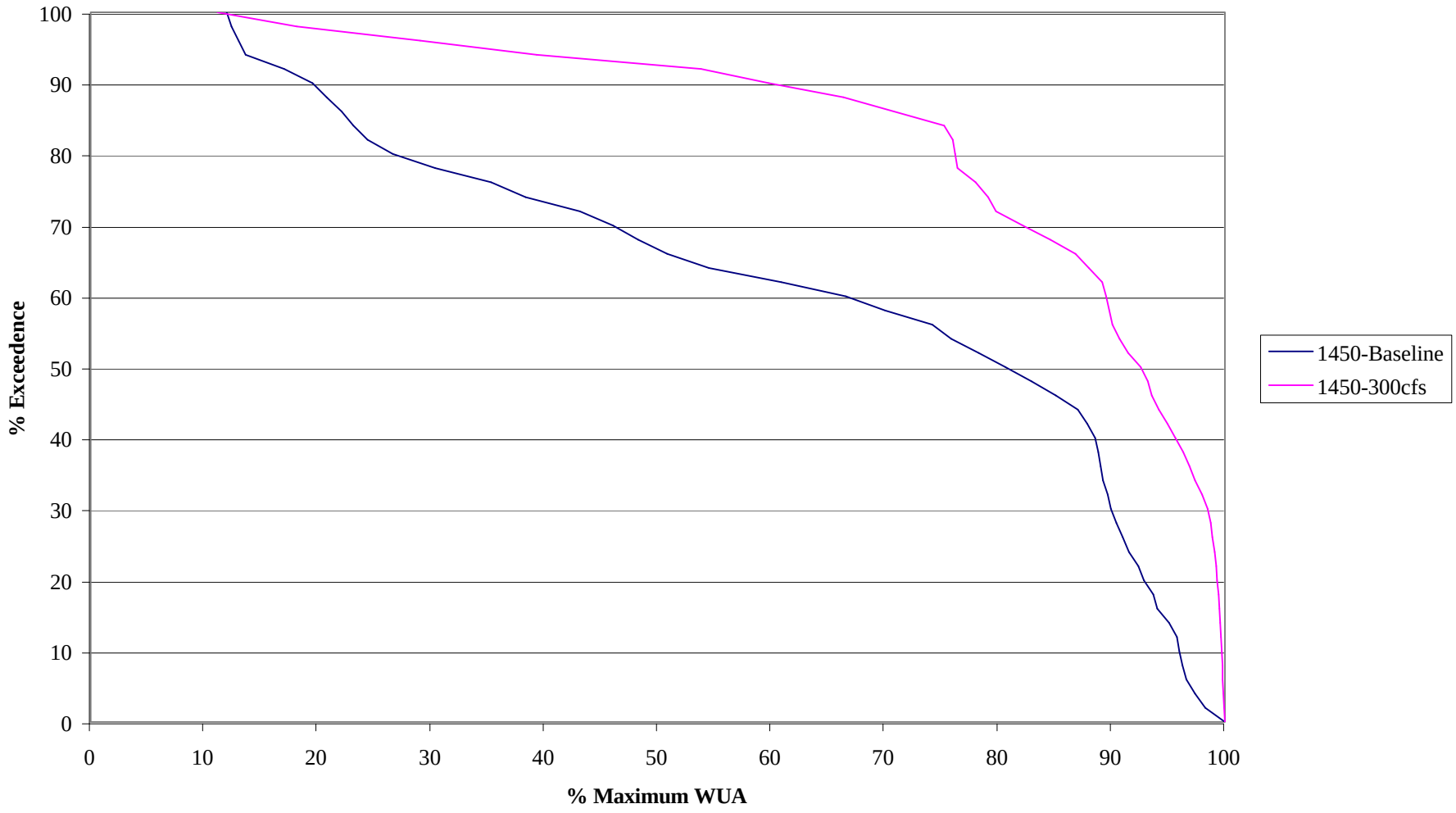

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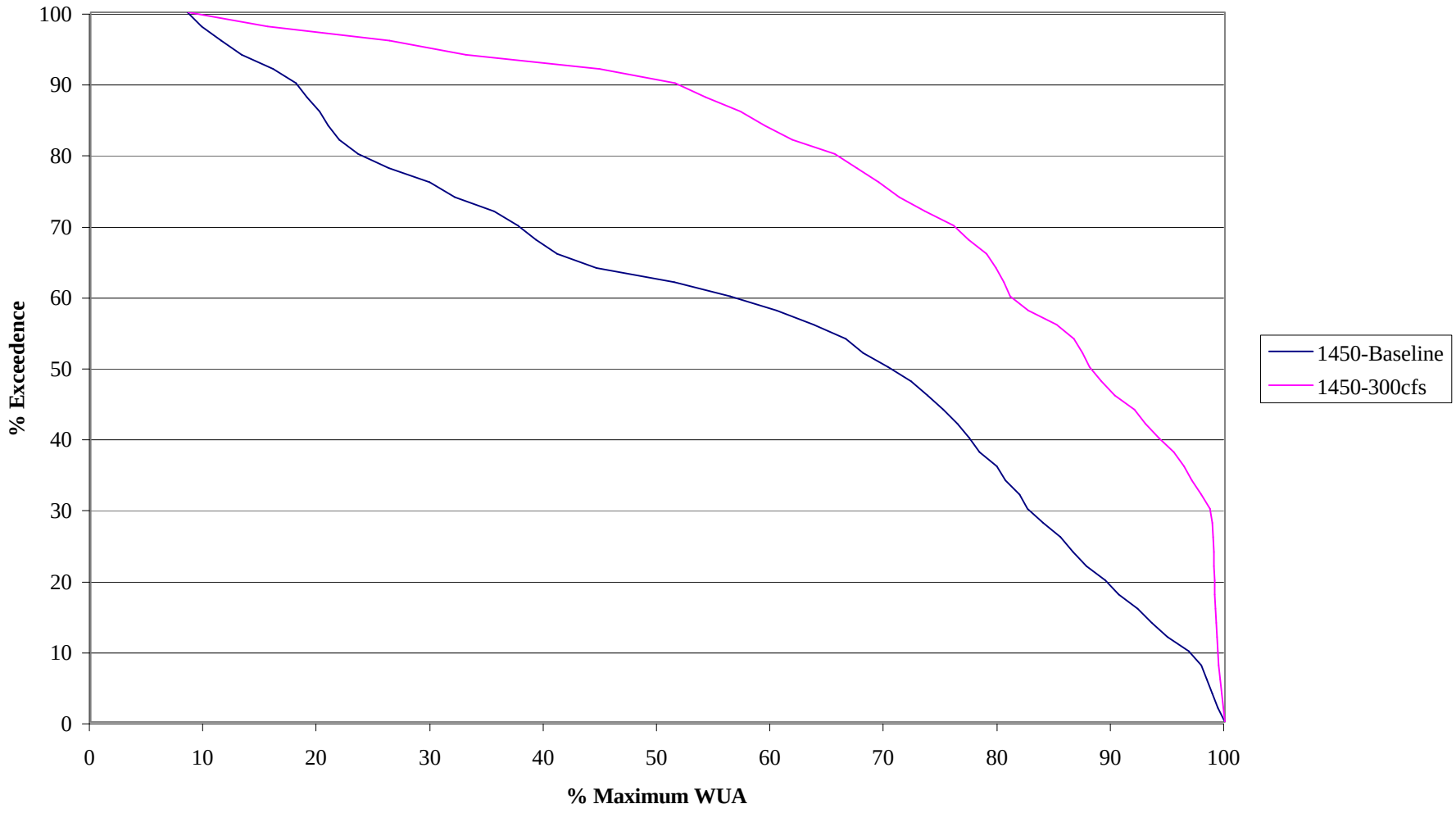

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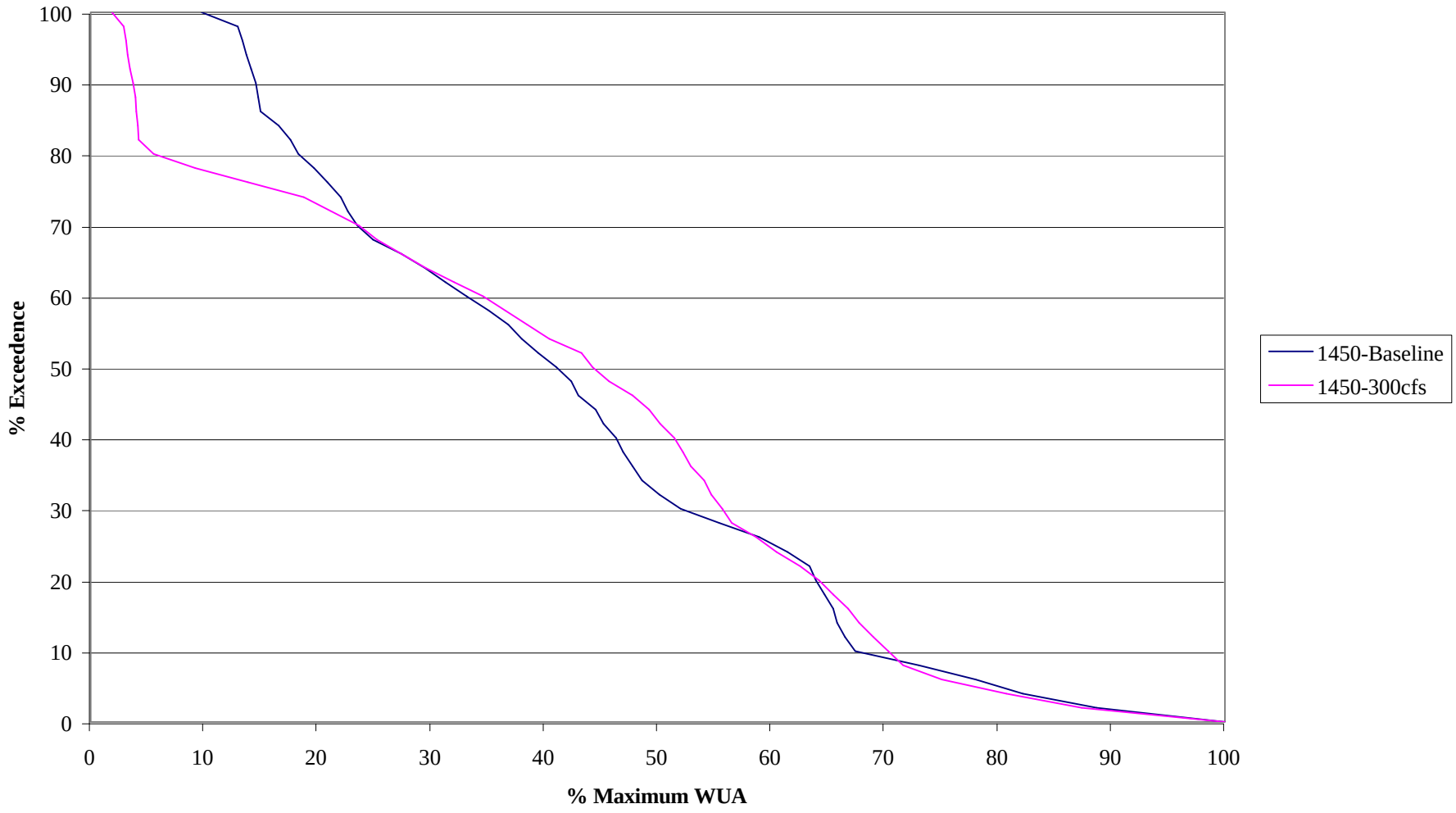

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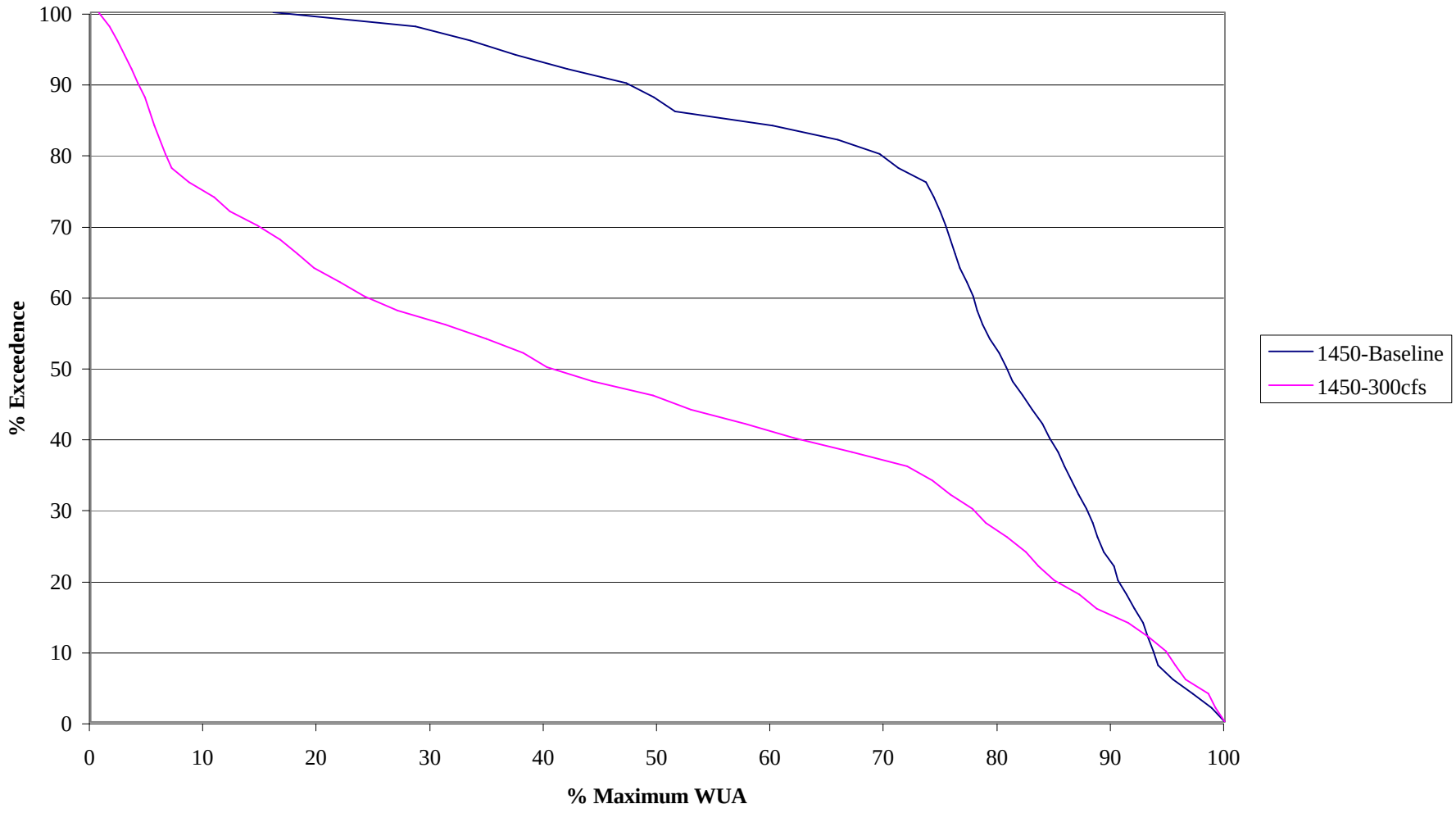

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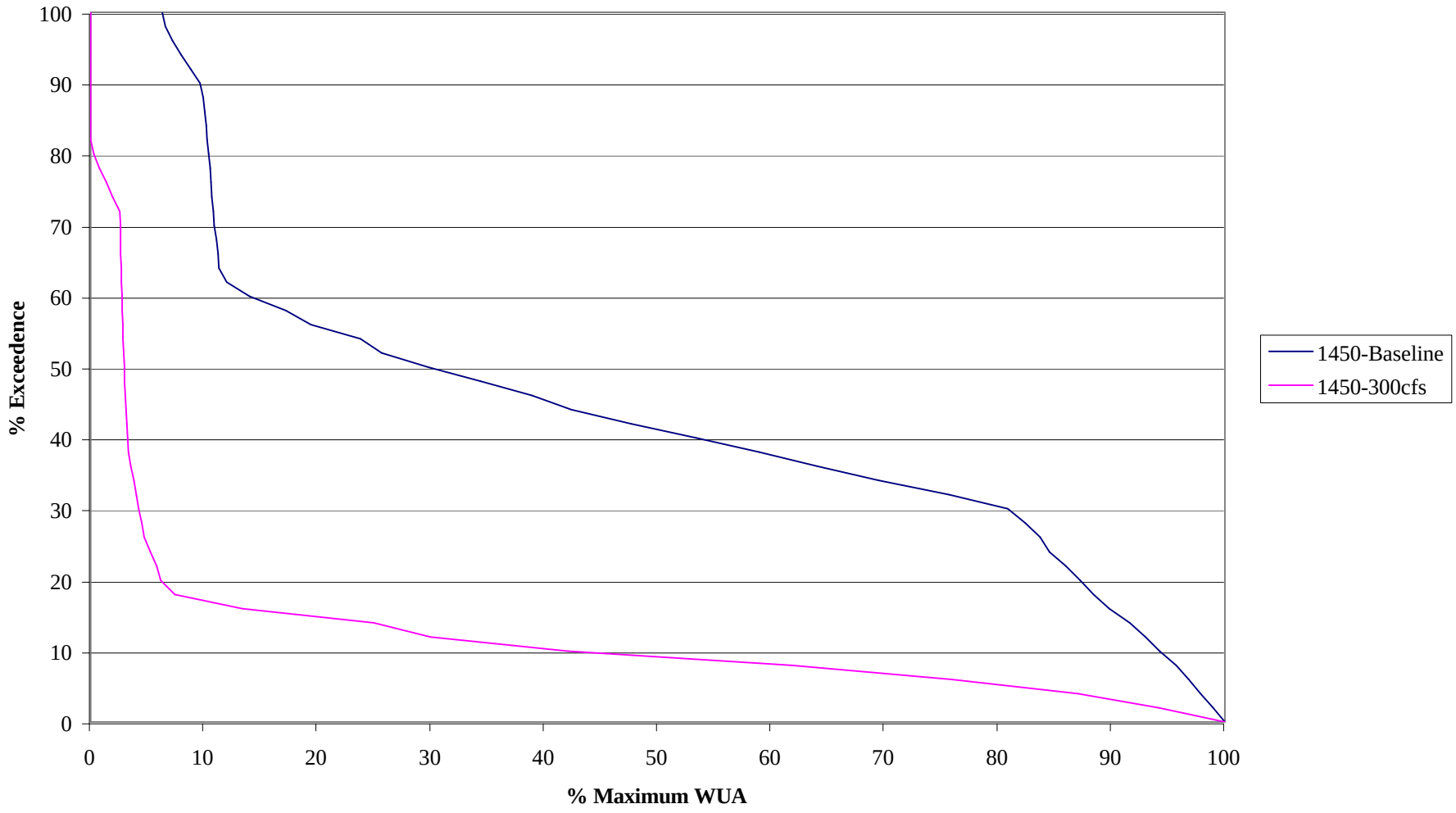

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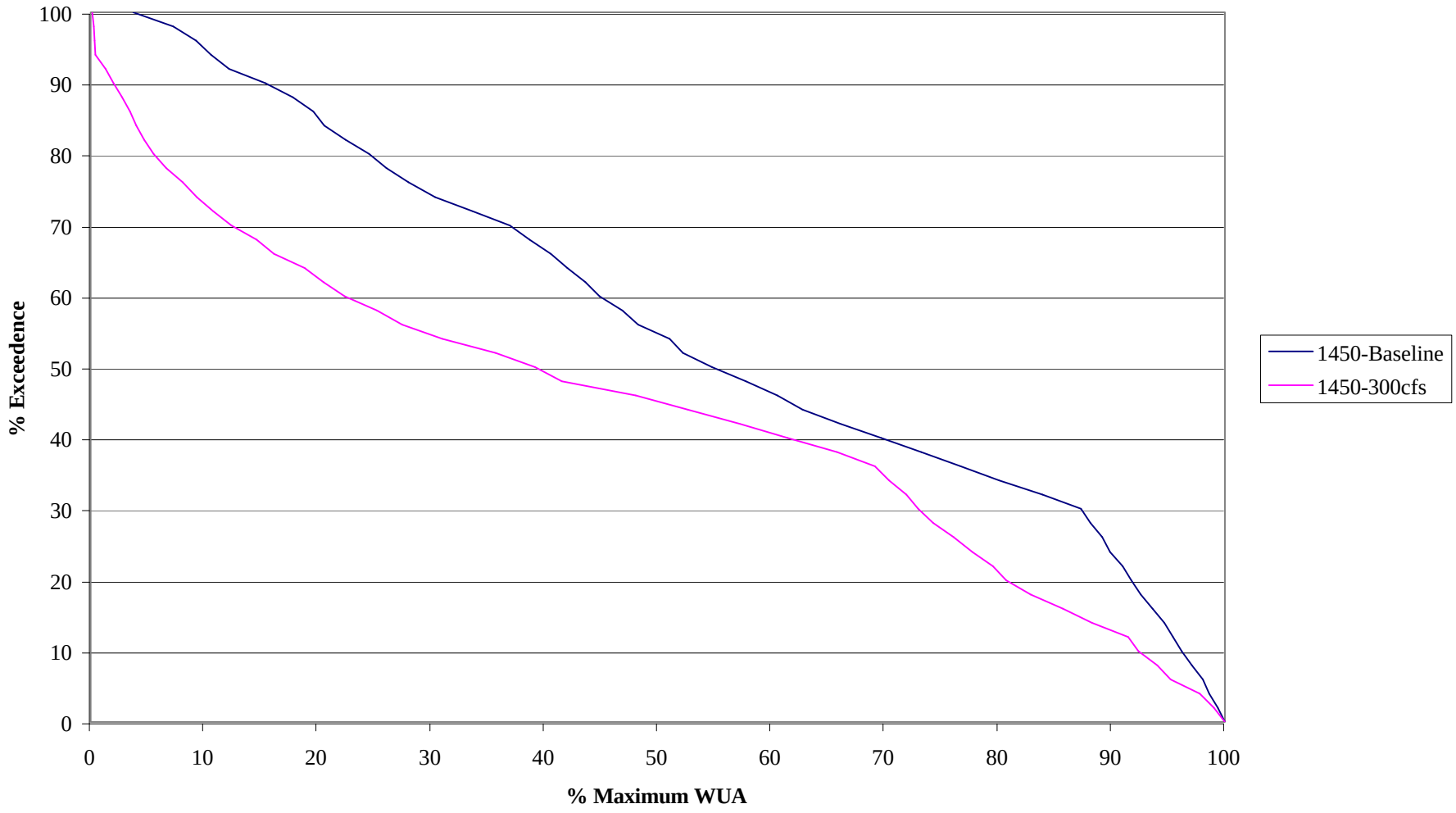

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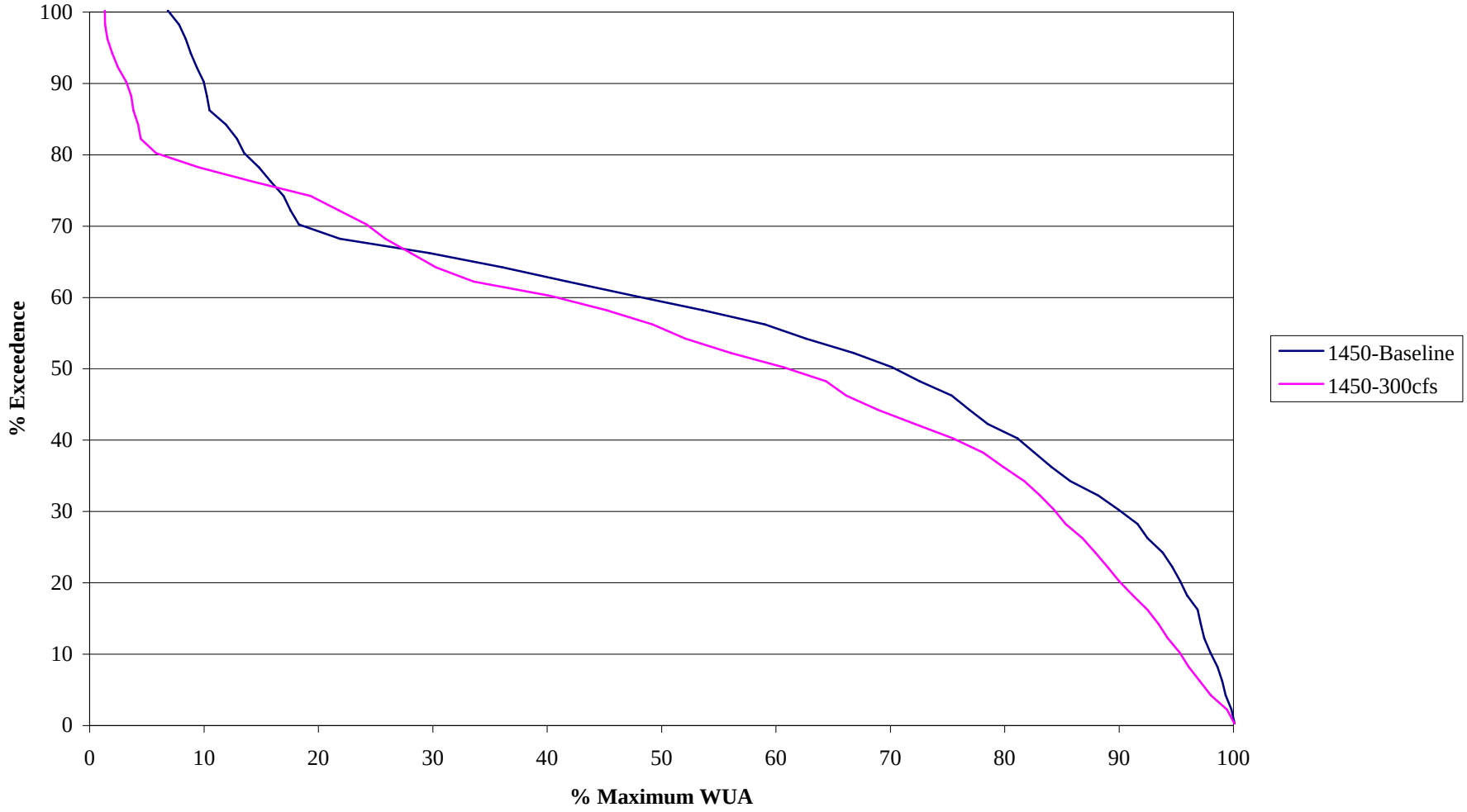

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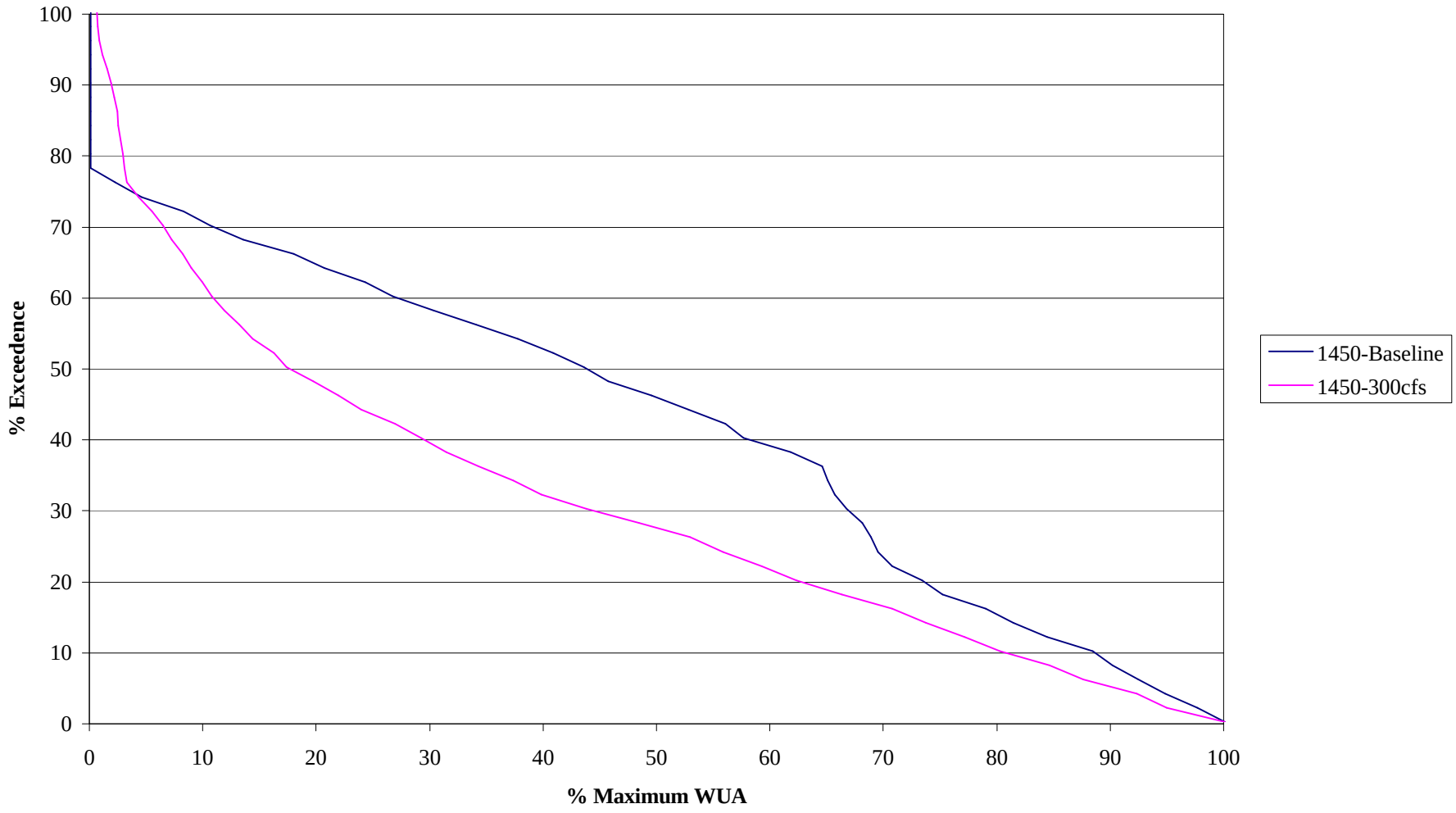

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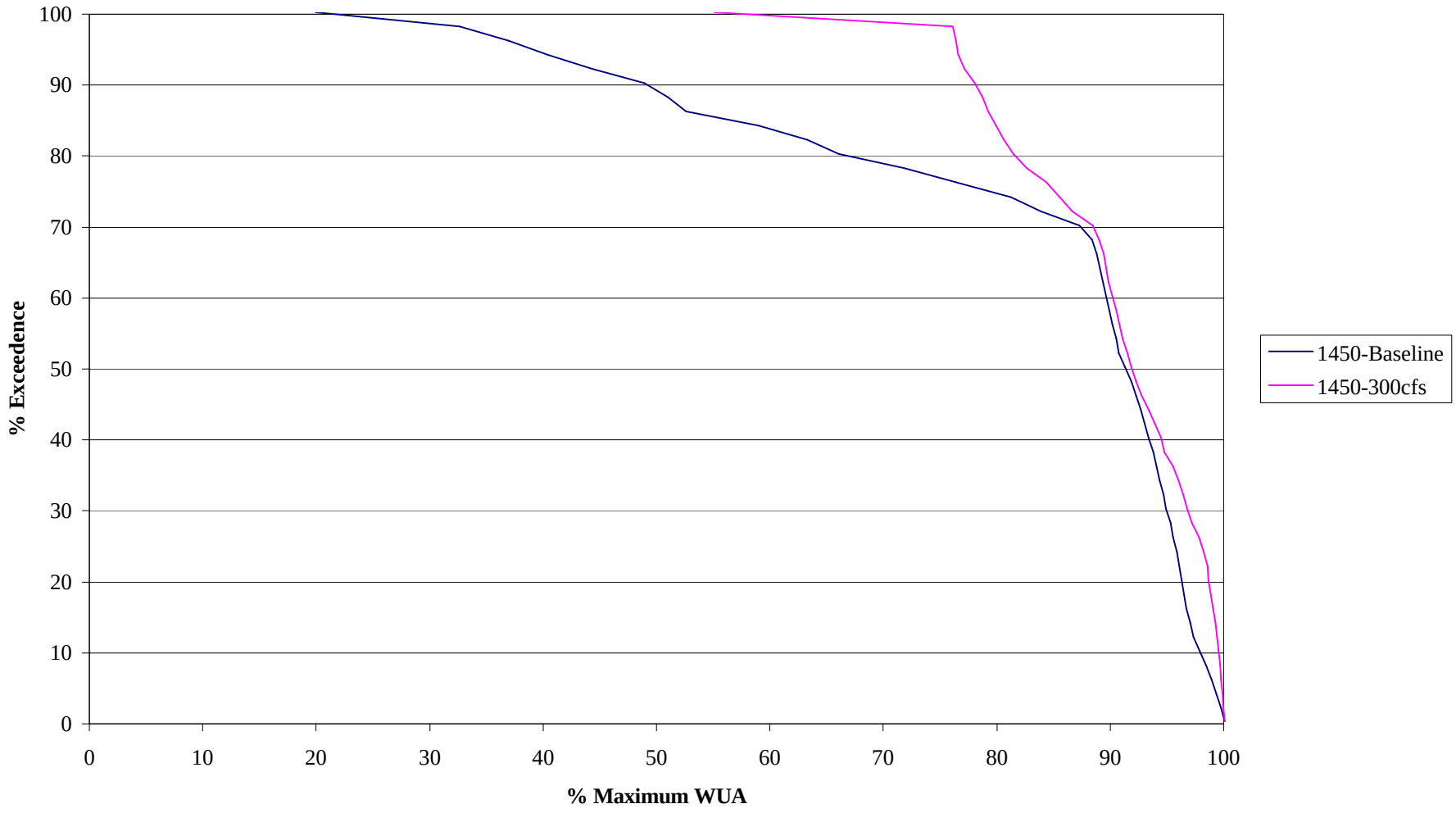

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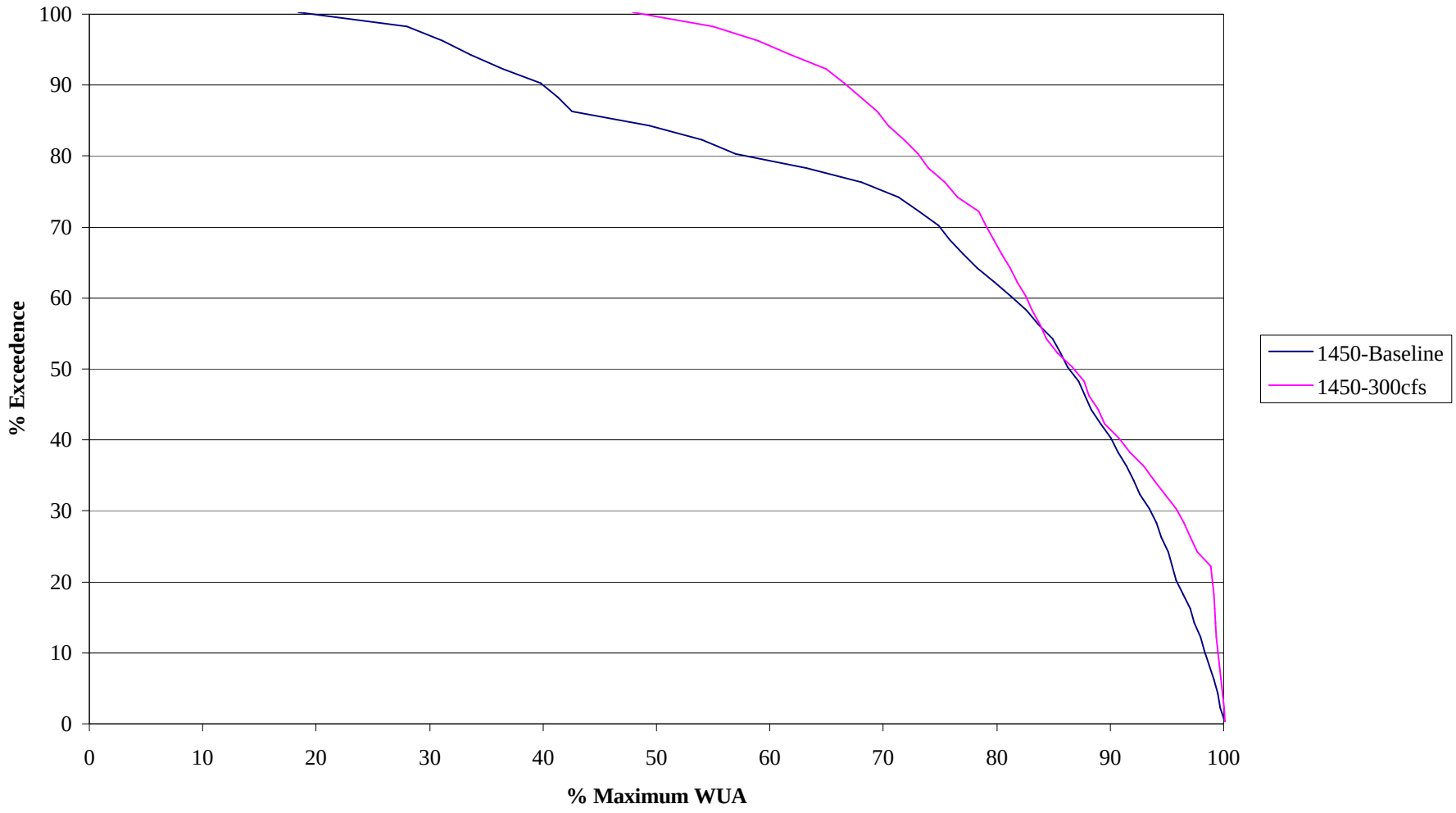

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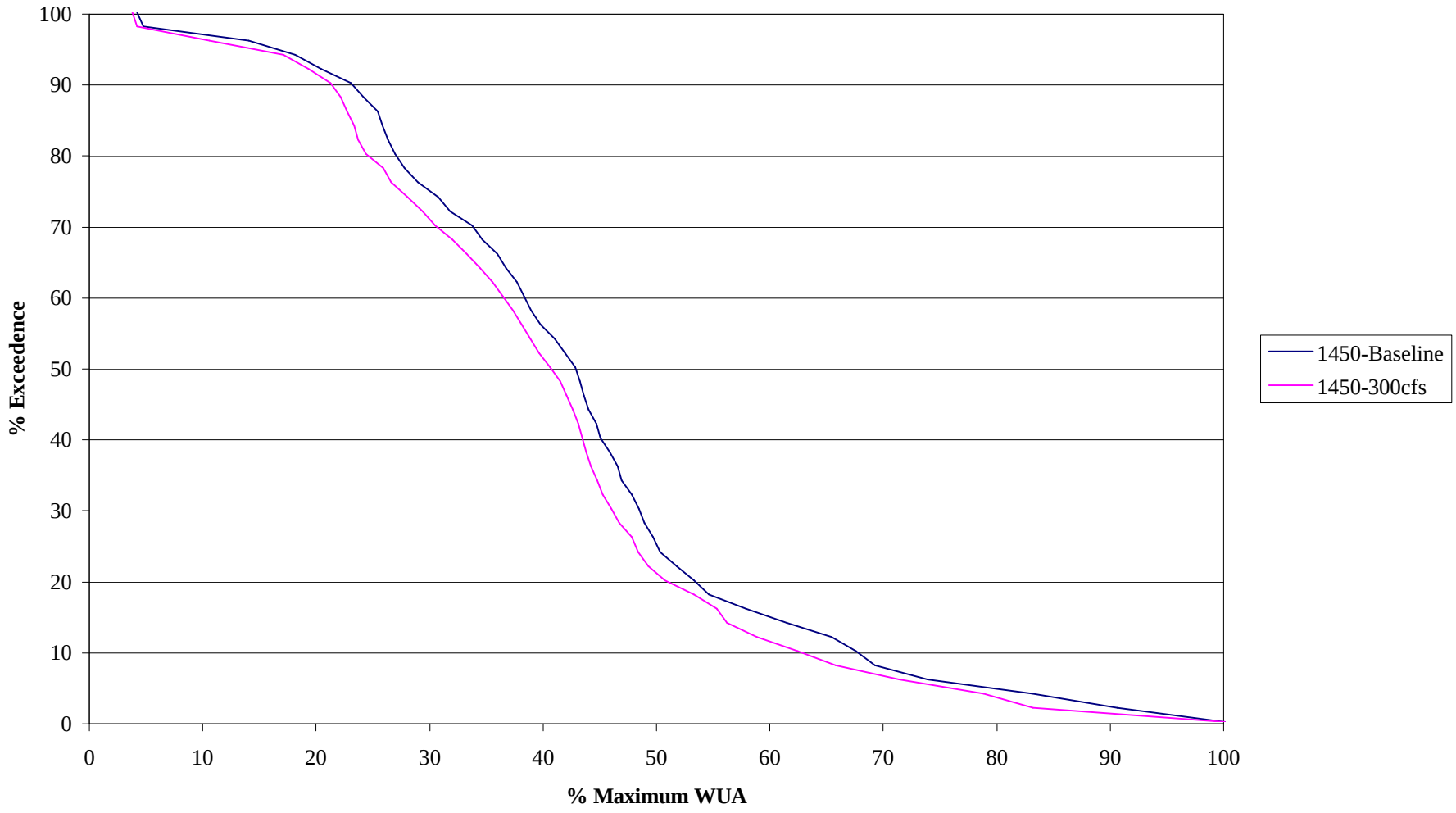

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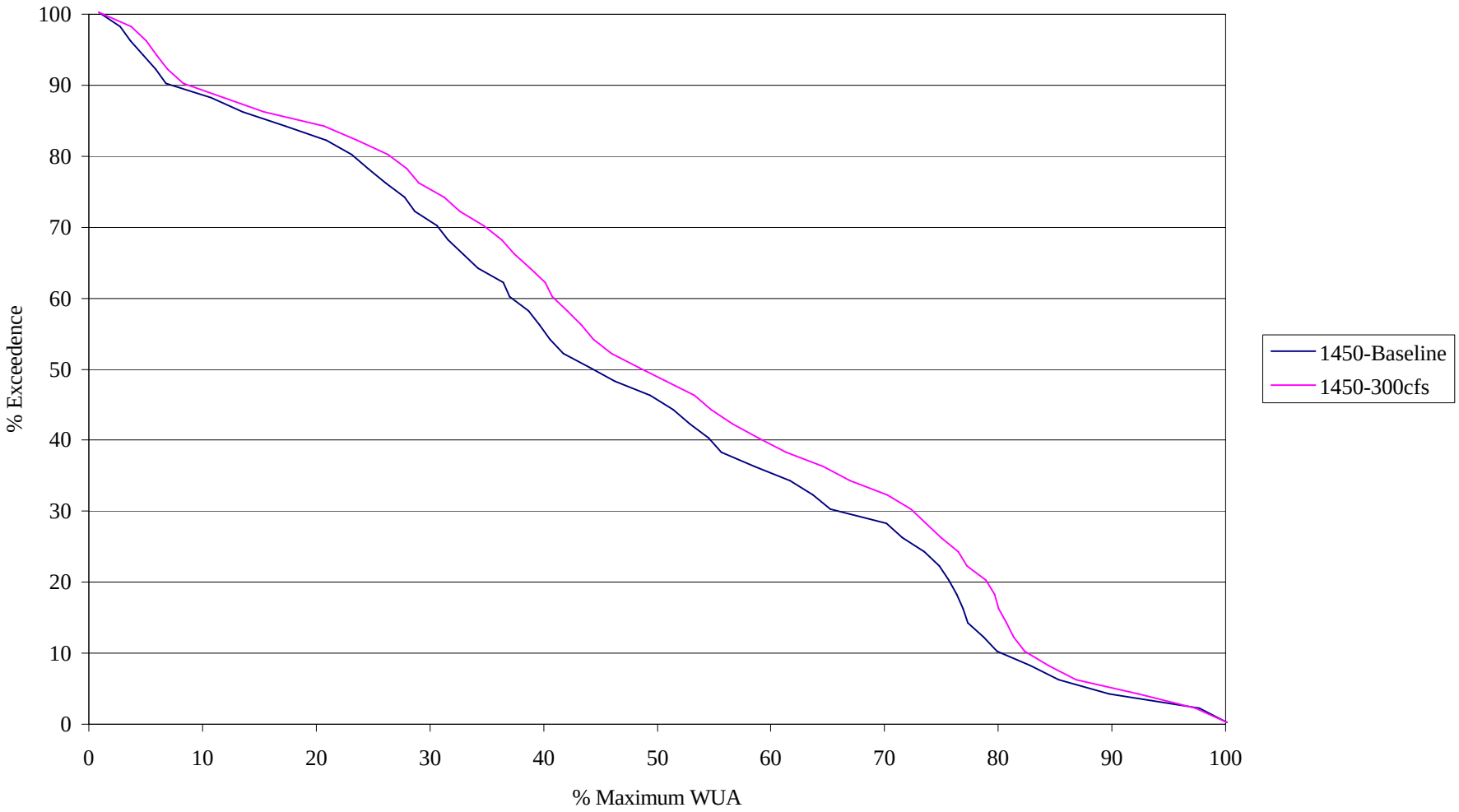

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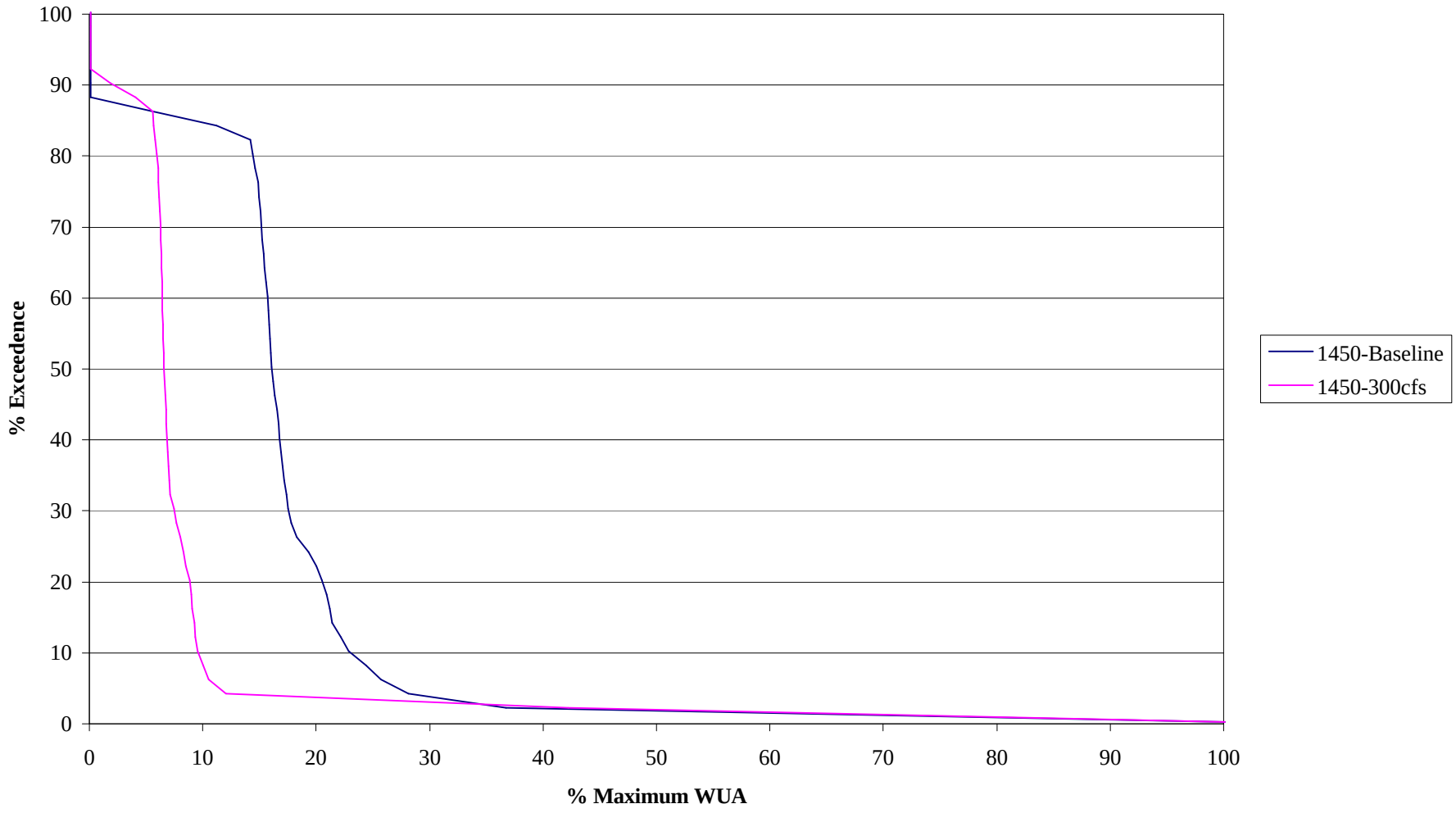

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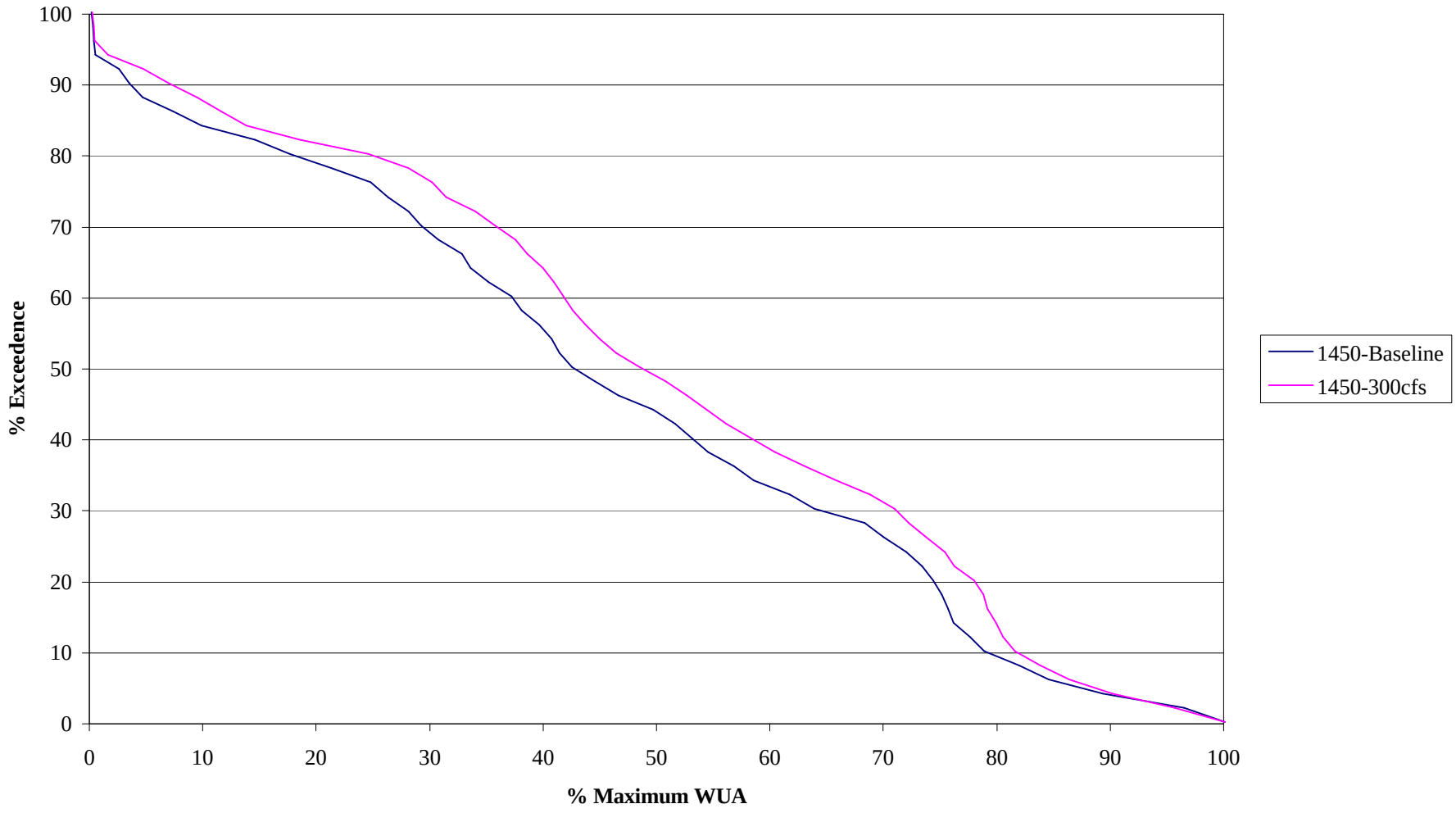

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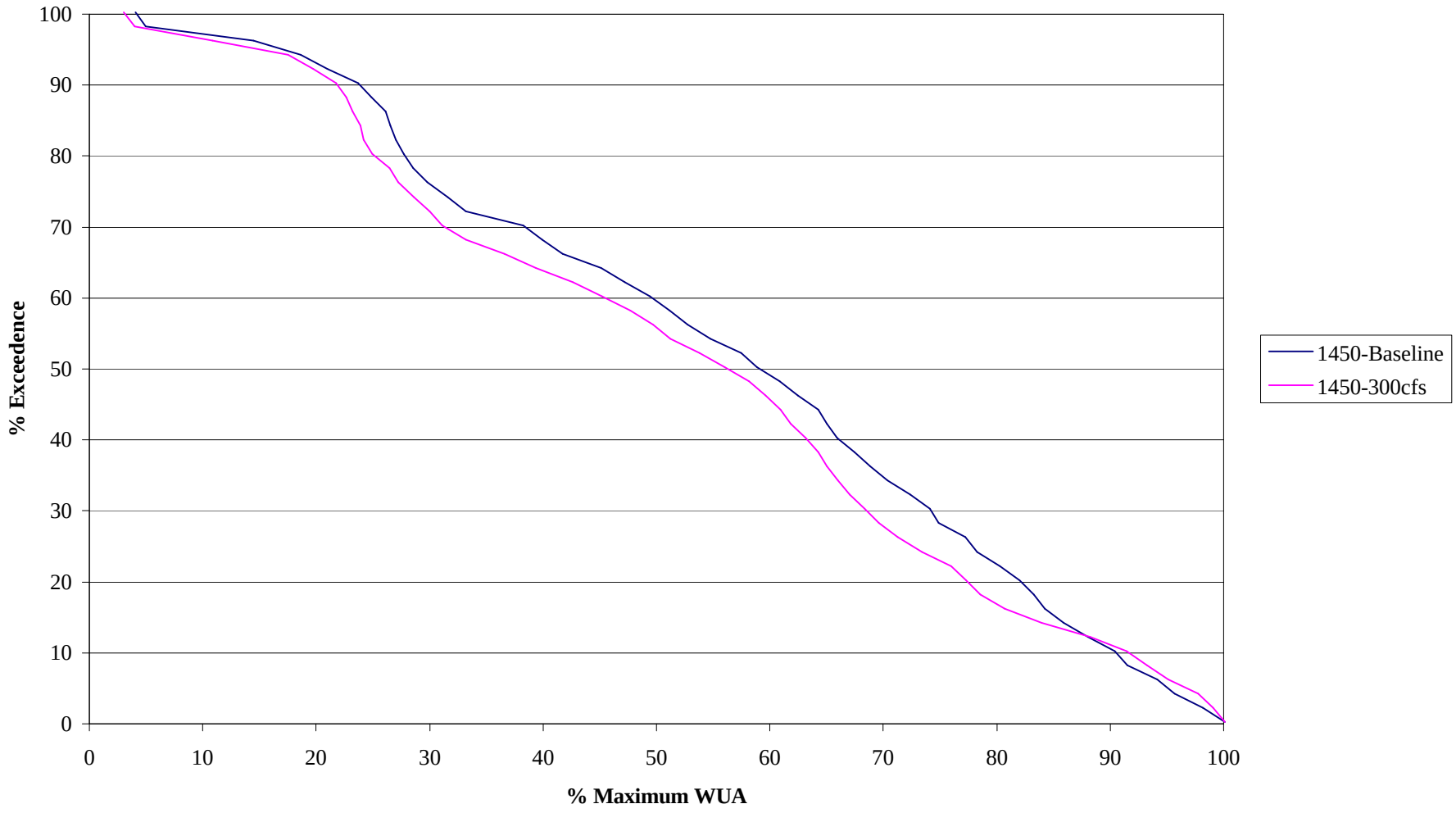

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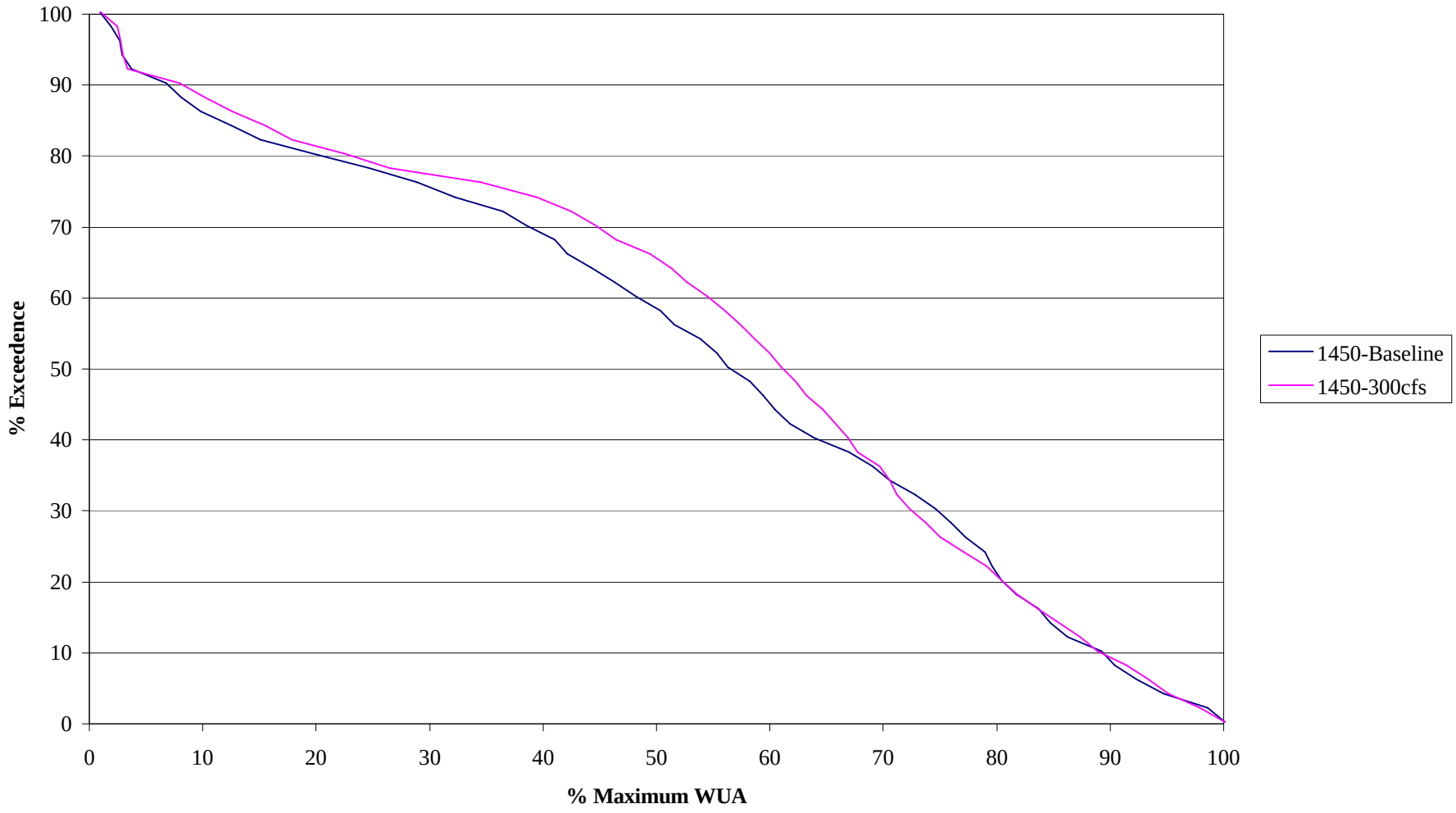

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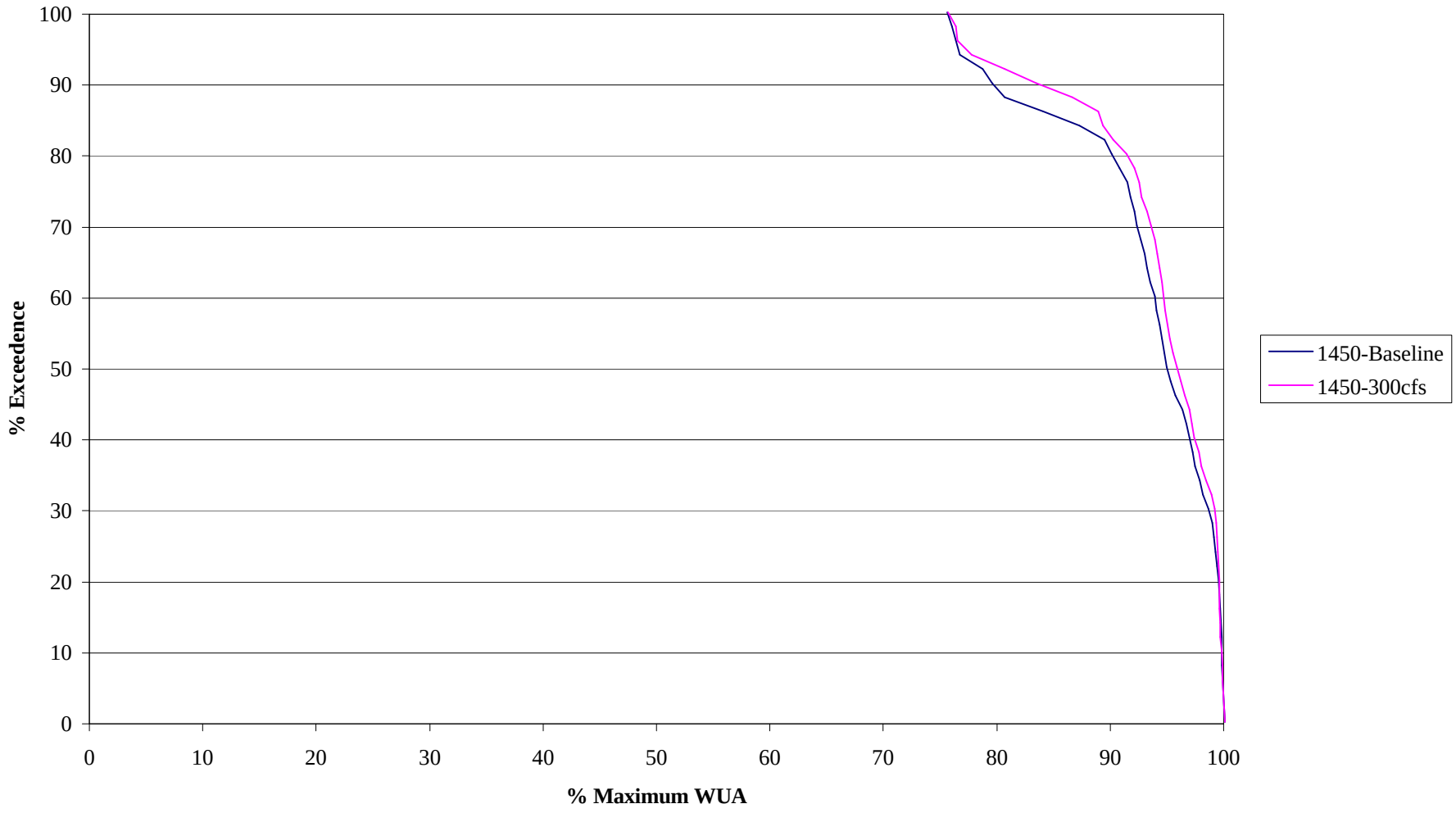

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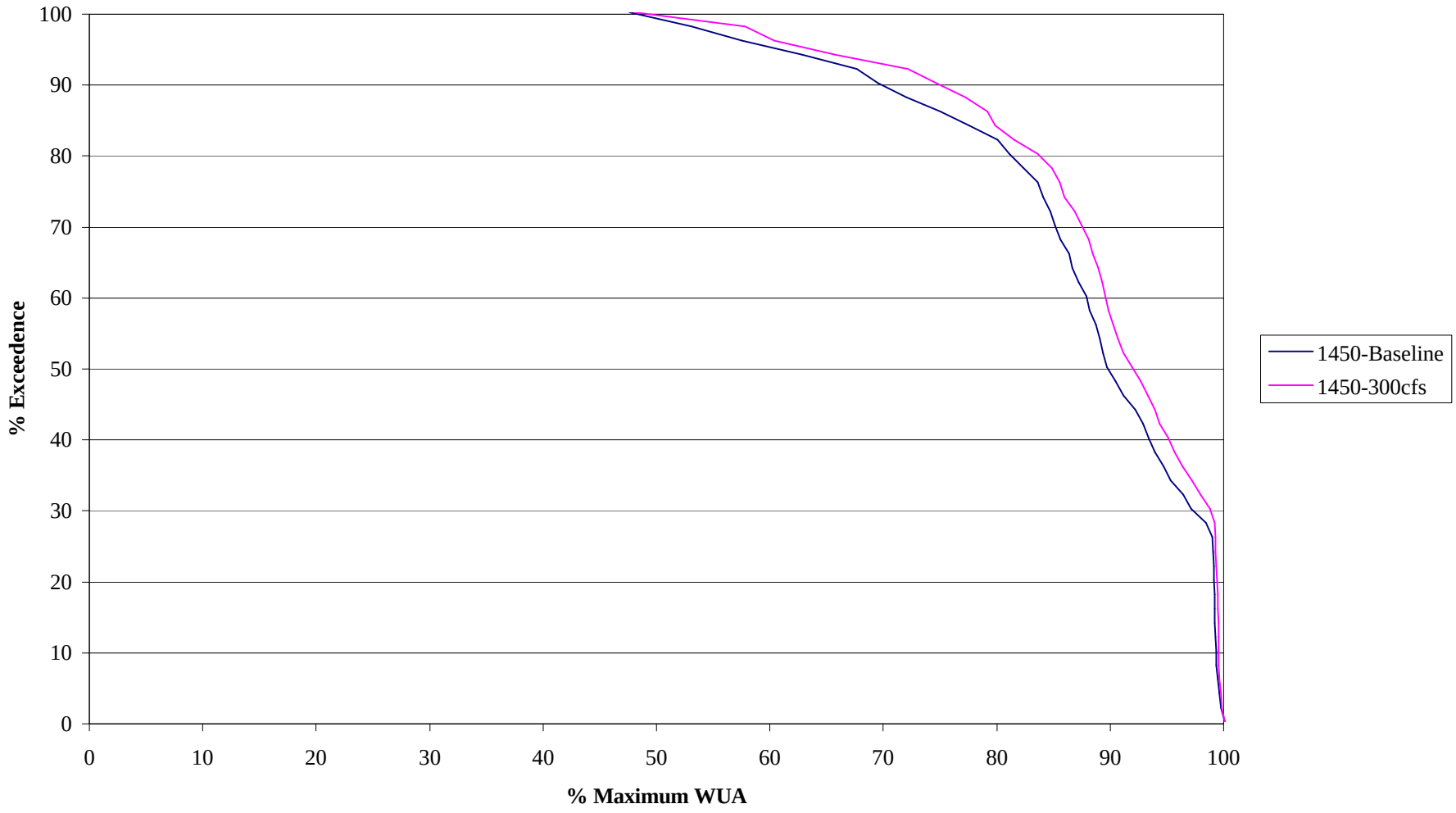

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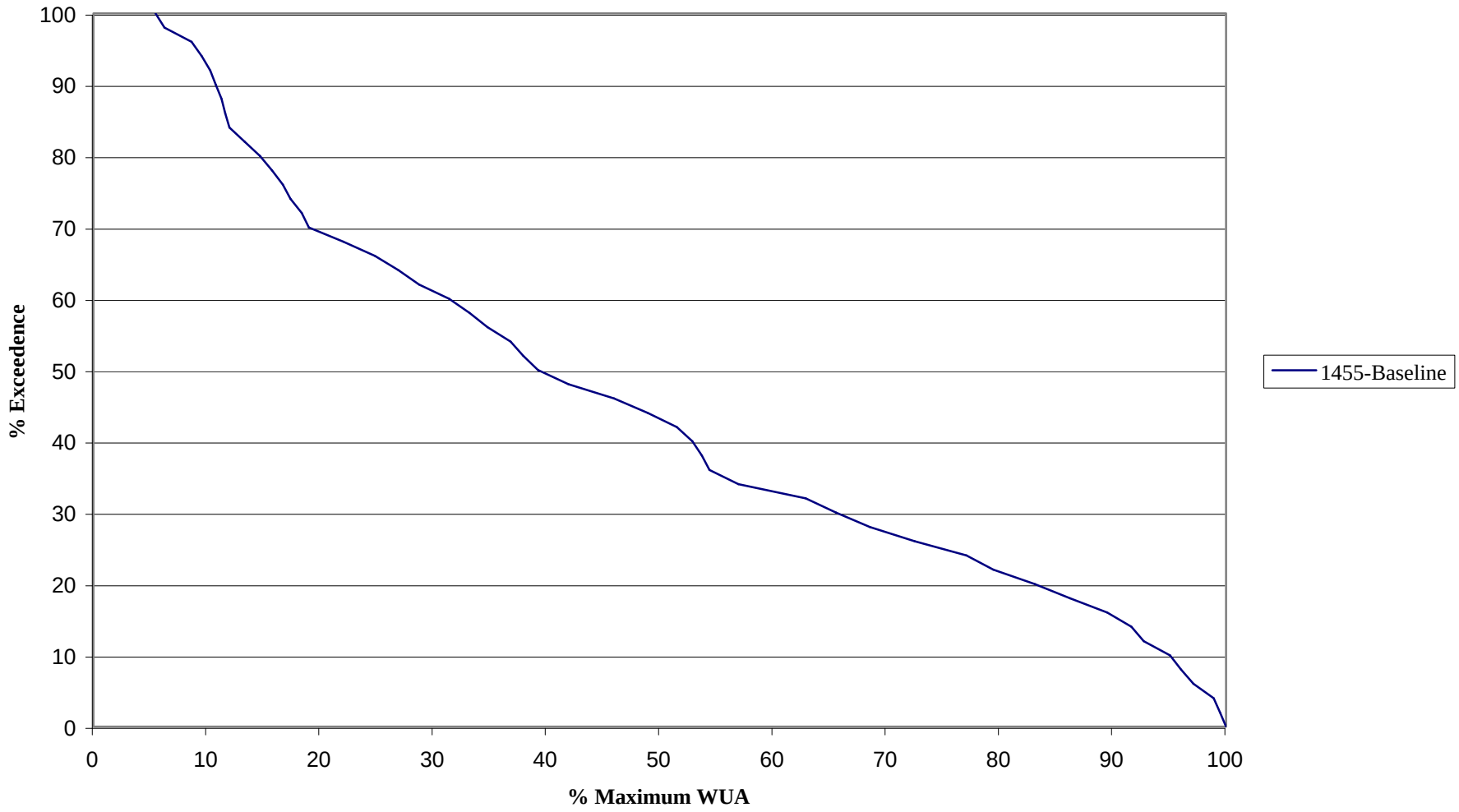

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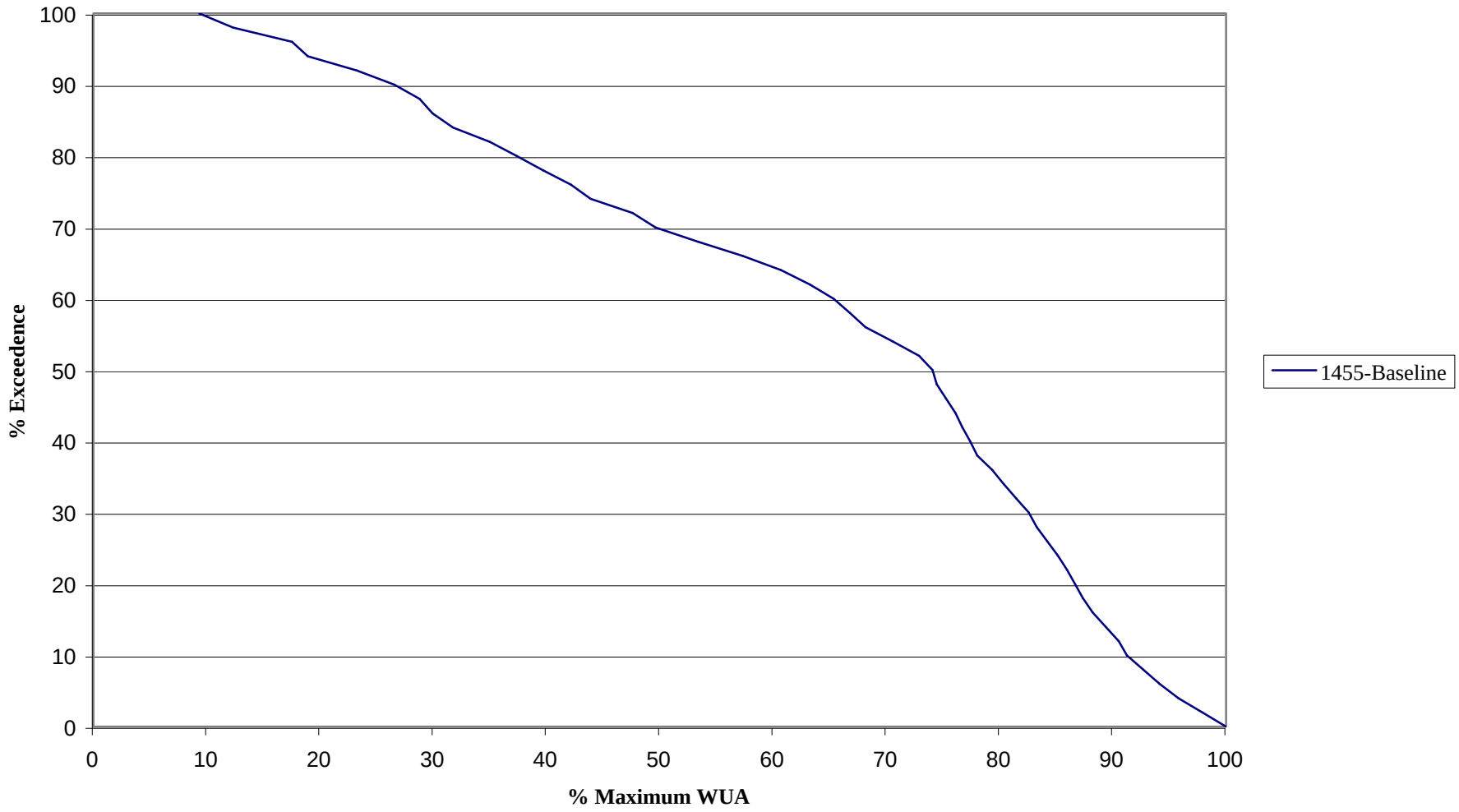

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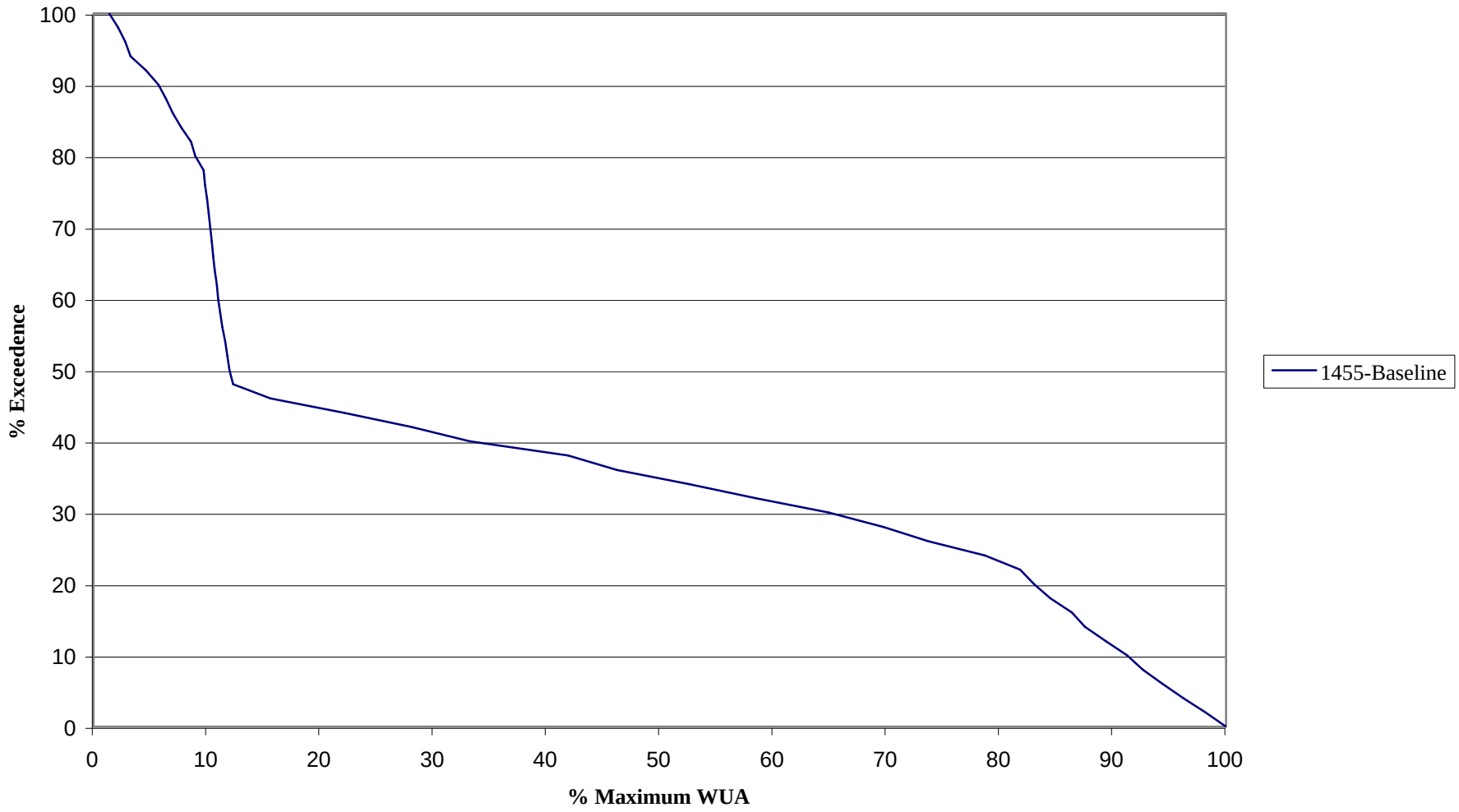
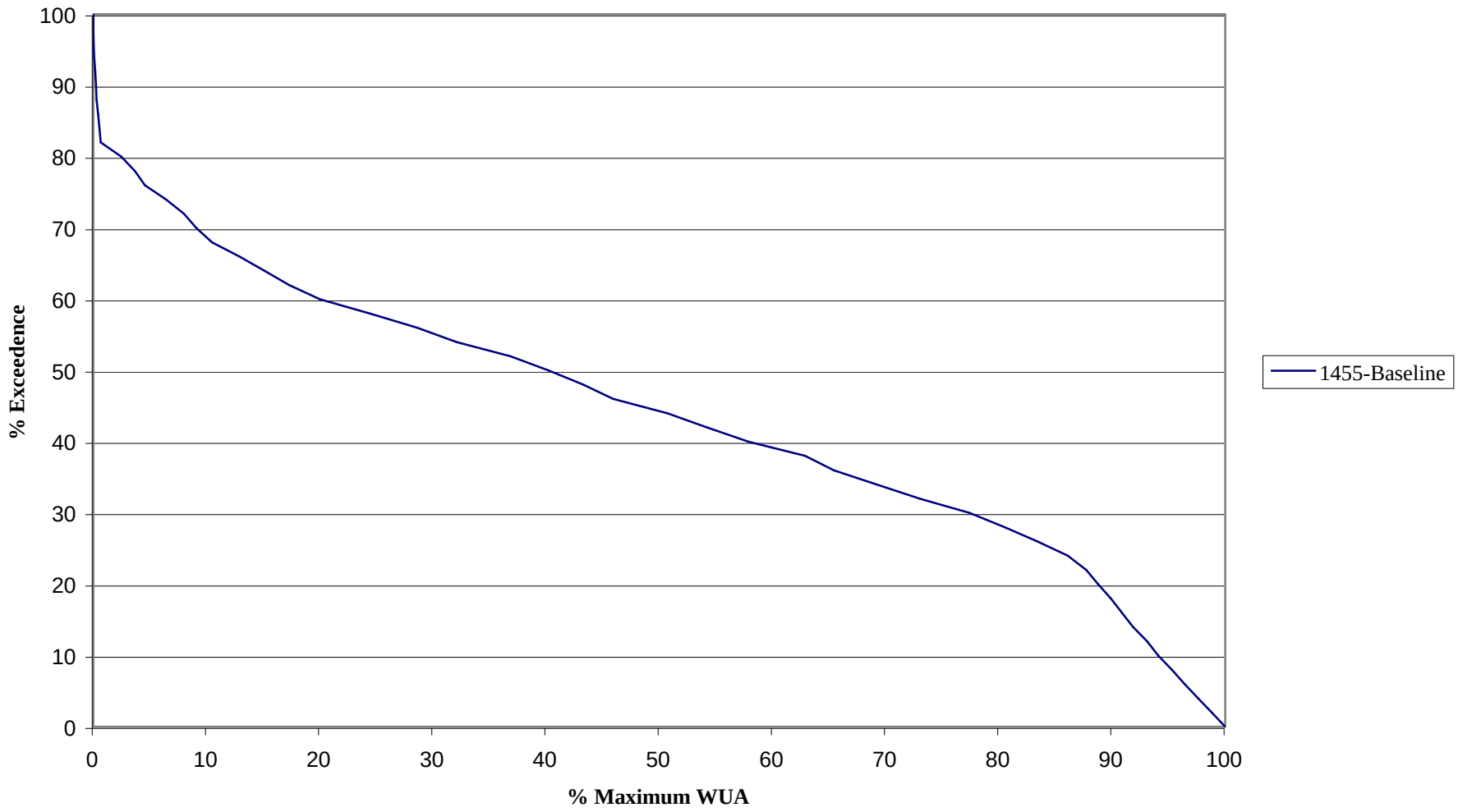


% EXCEEDENCE OF % MAXIMUM WUA FOR HABITAT REACH L RACEWAY SPRING

Final Aquatic Impact Analysis Report



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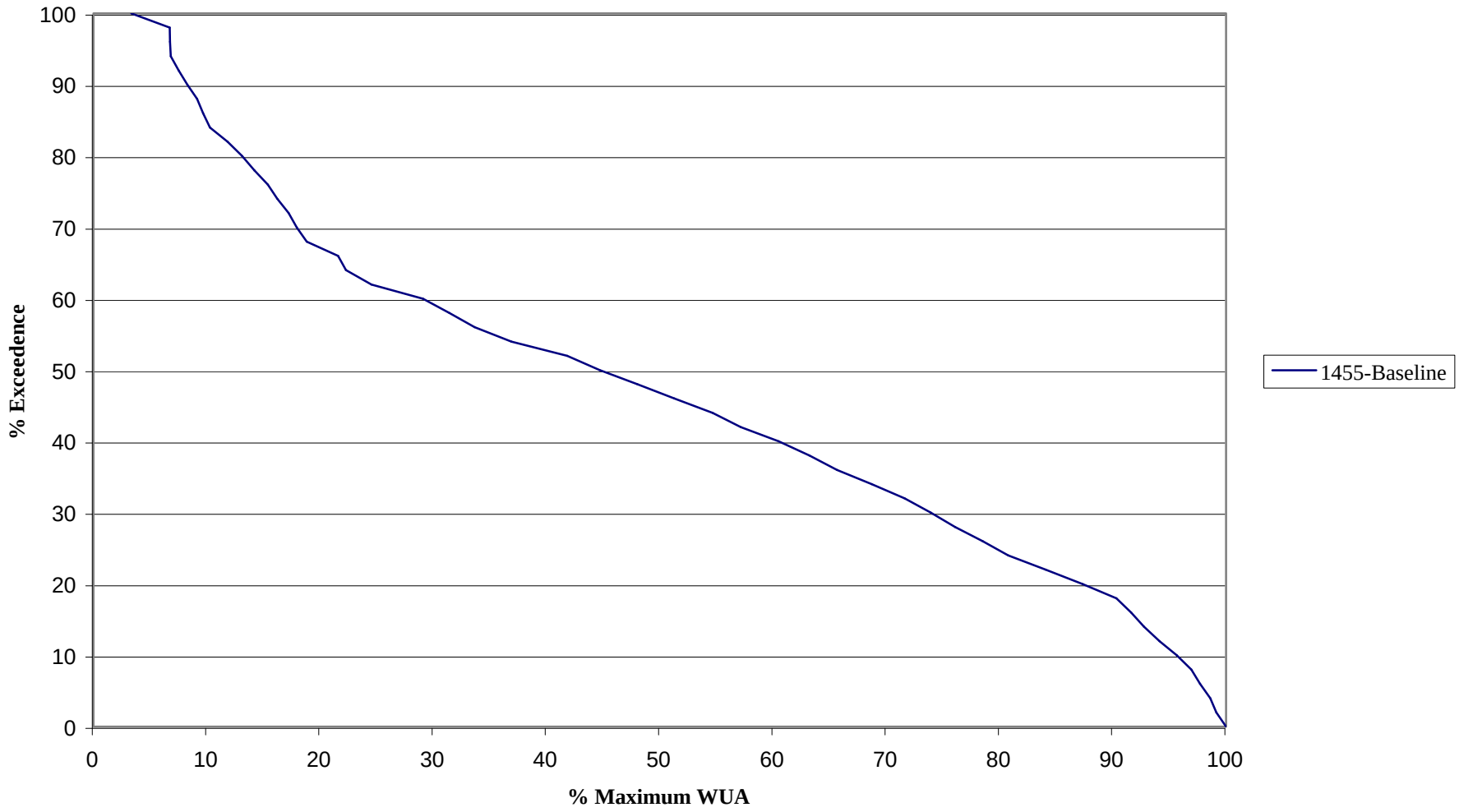

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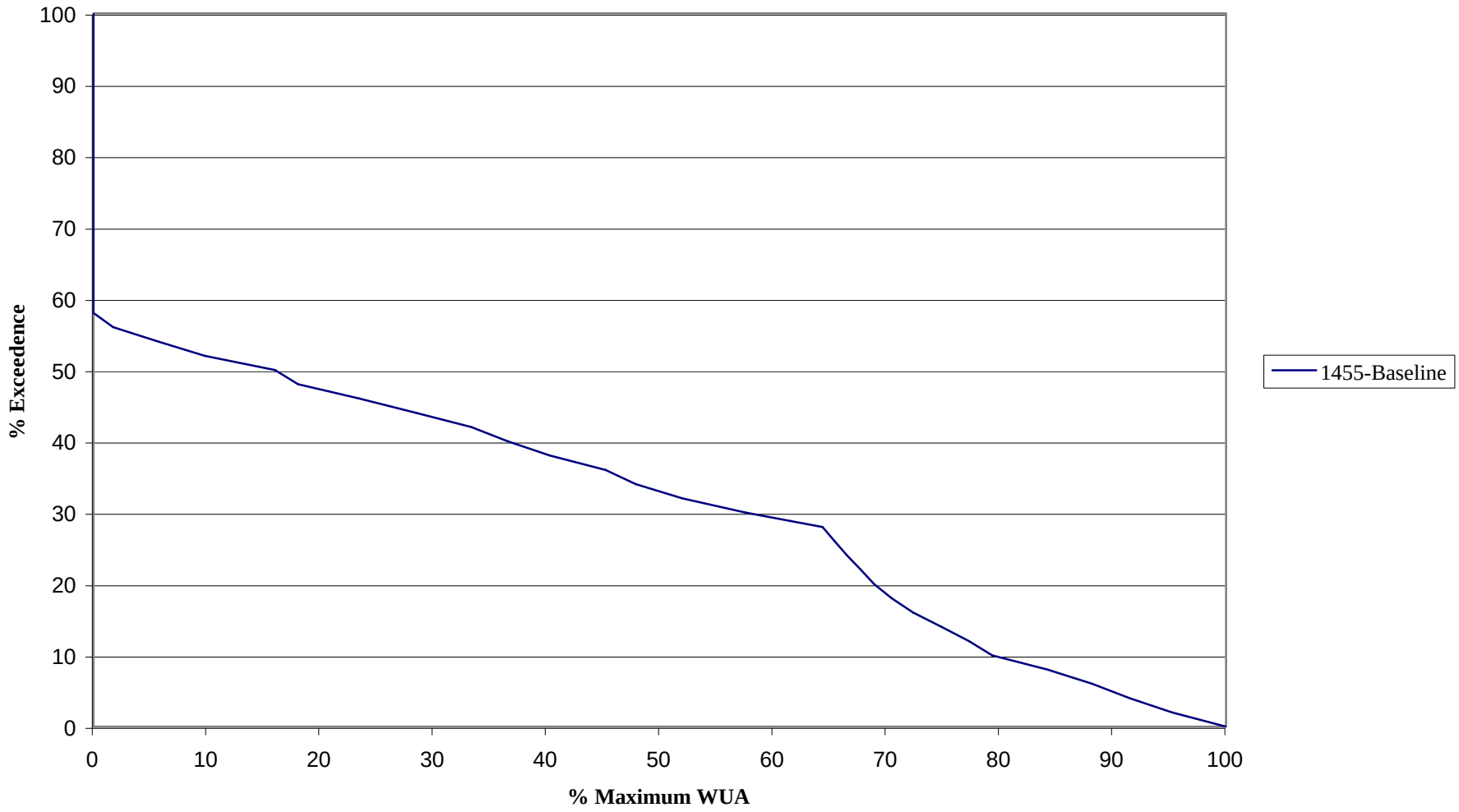

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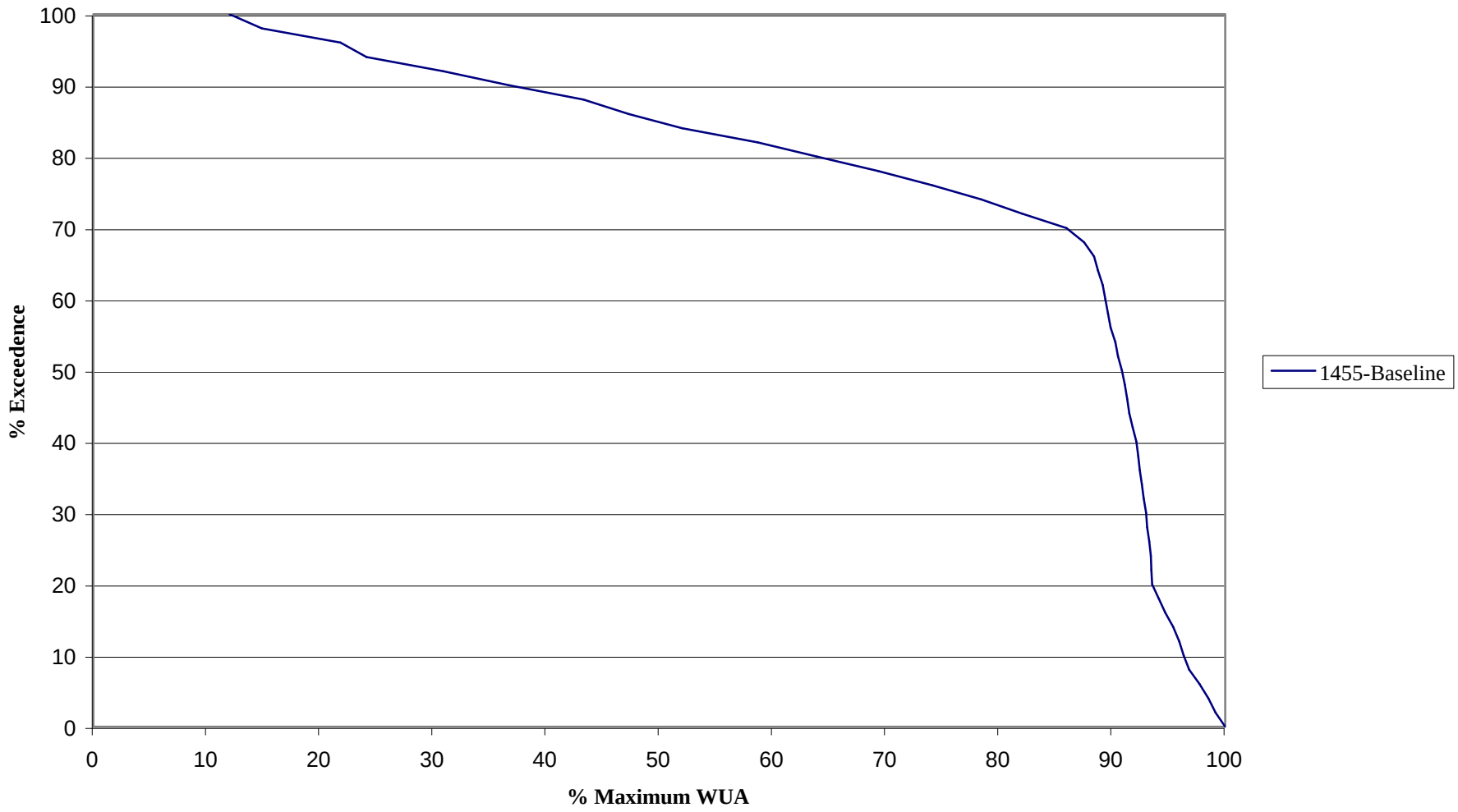

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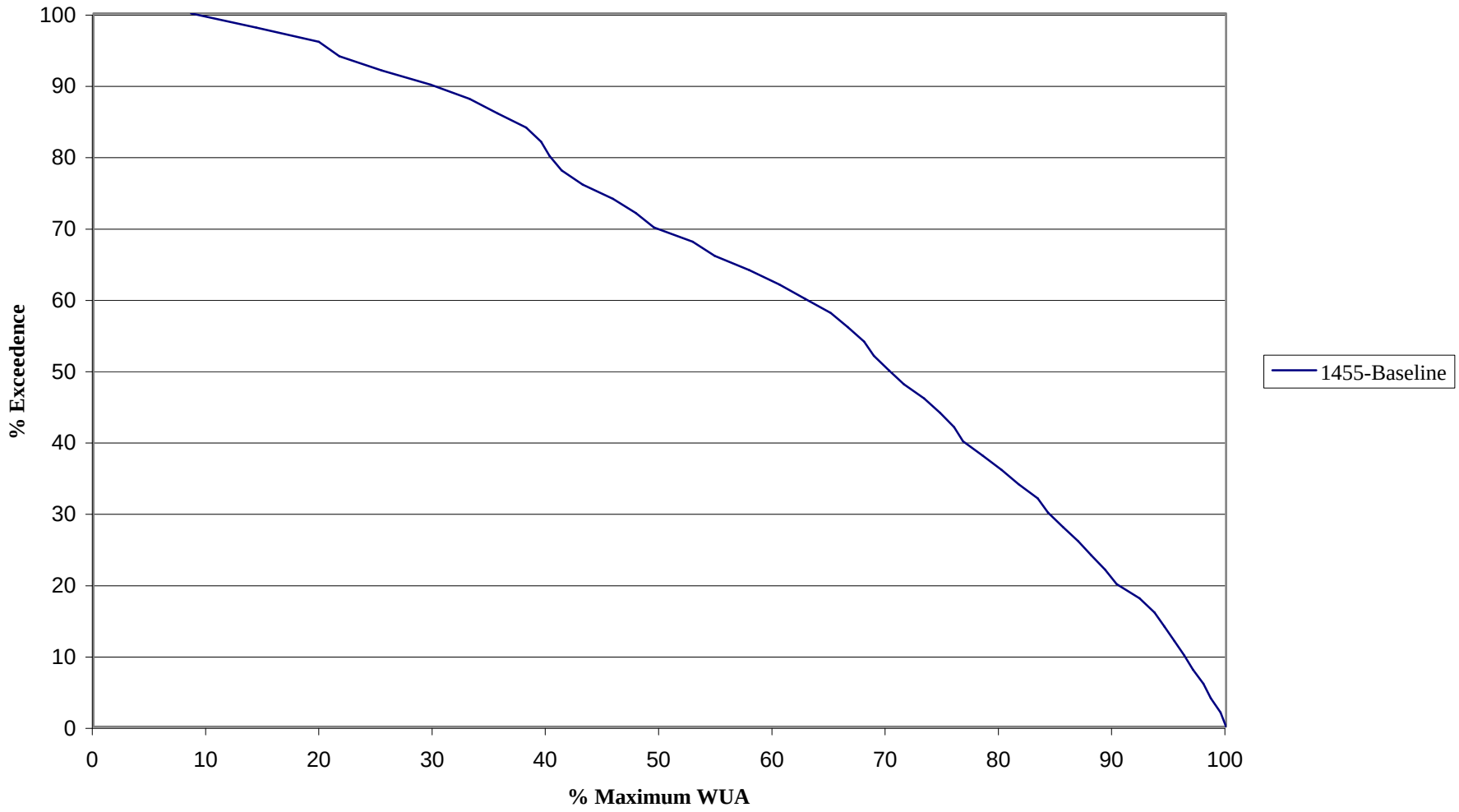

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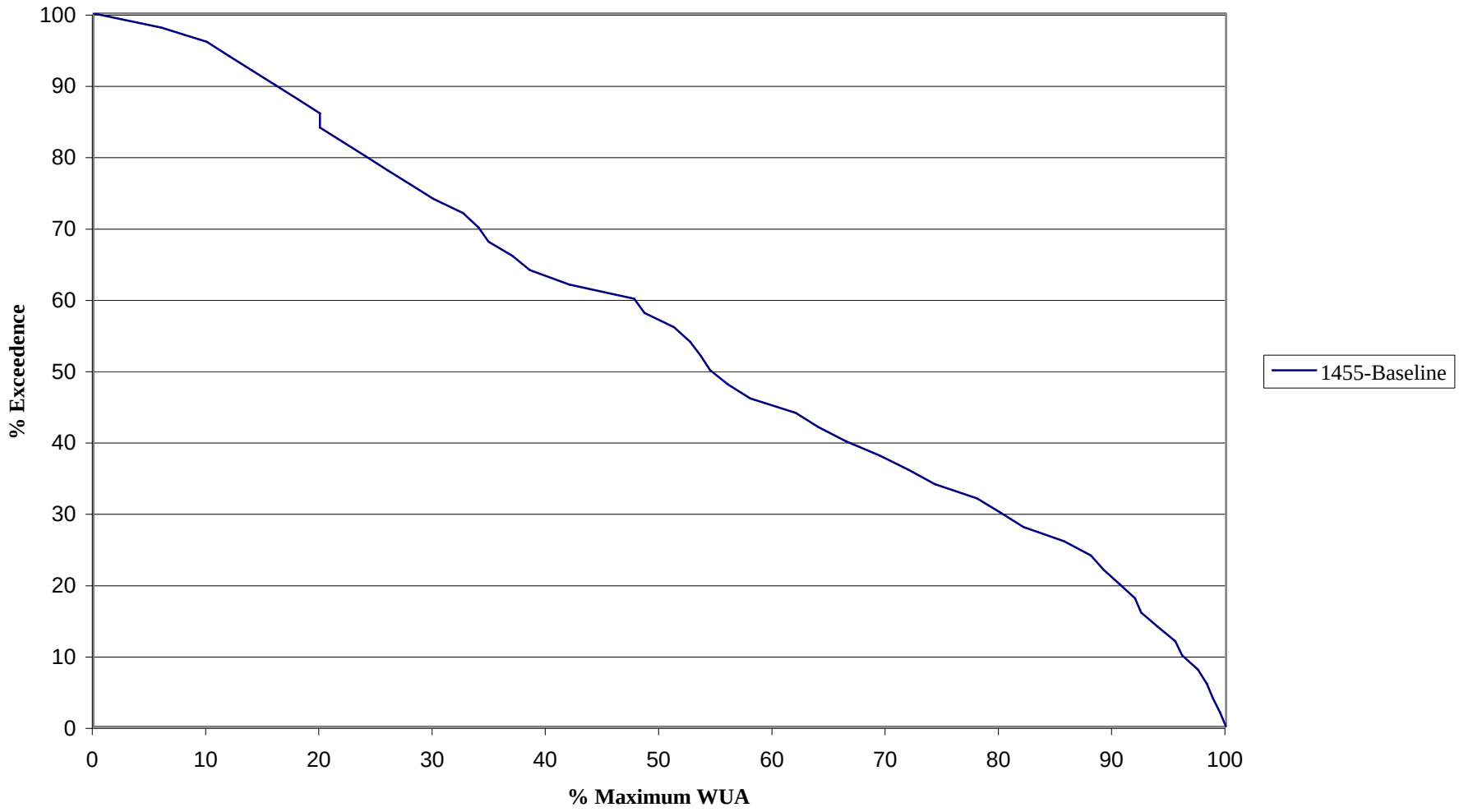

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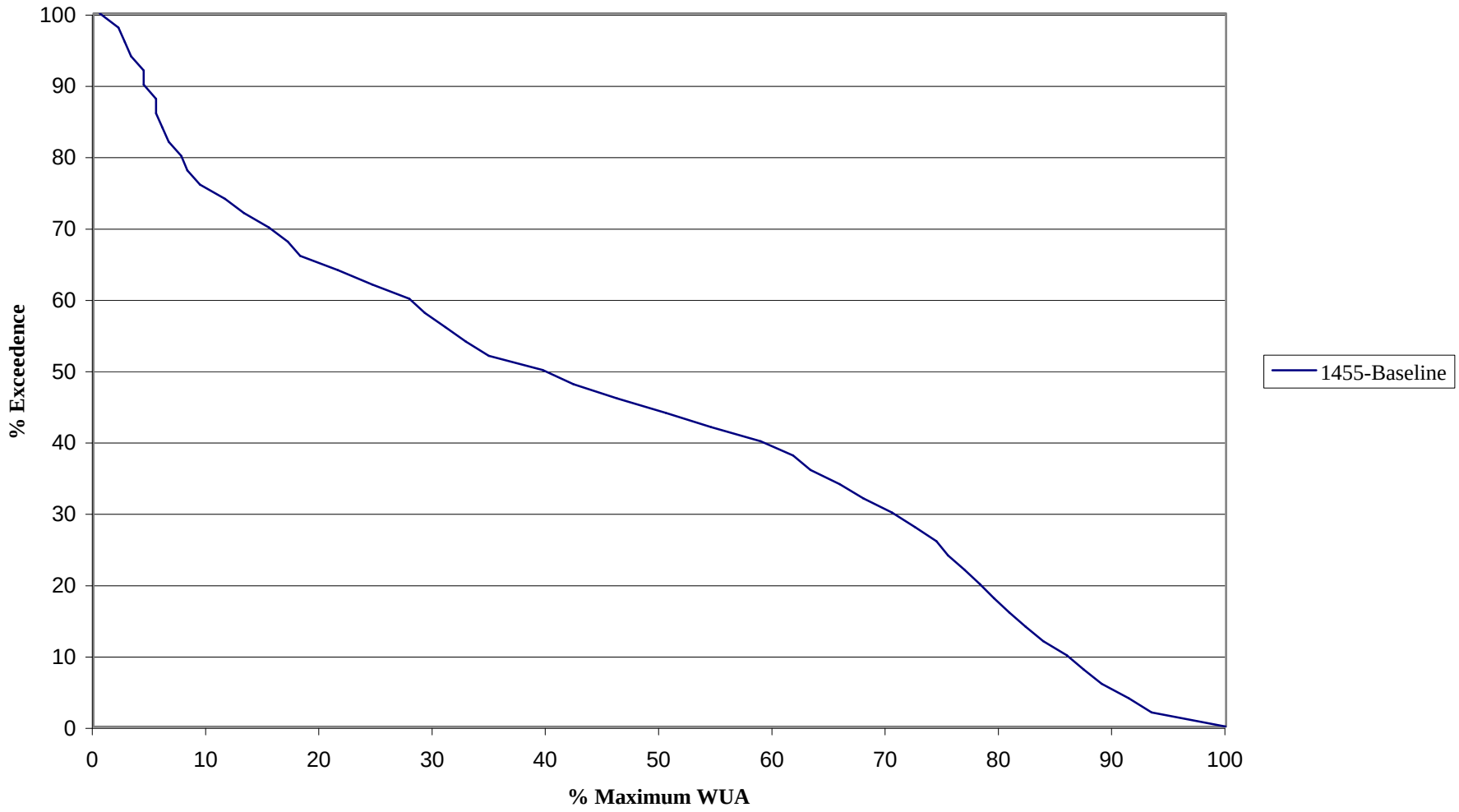

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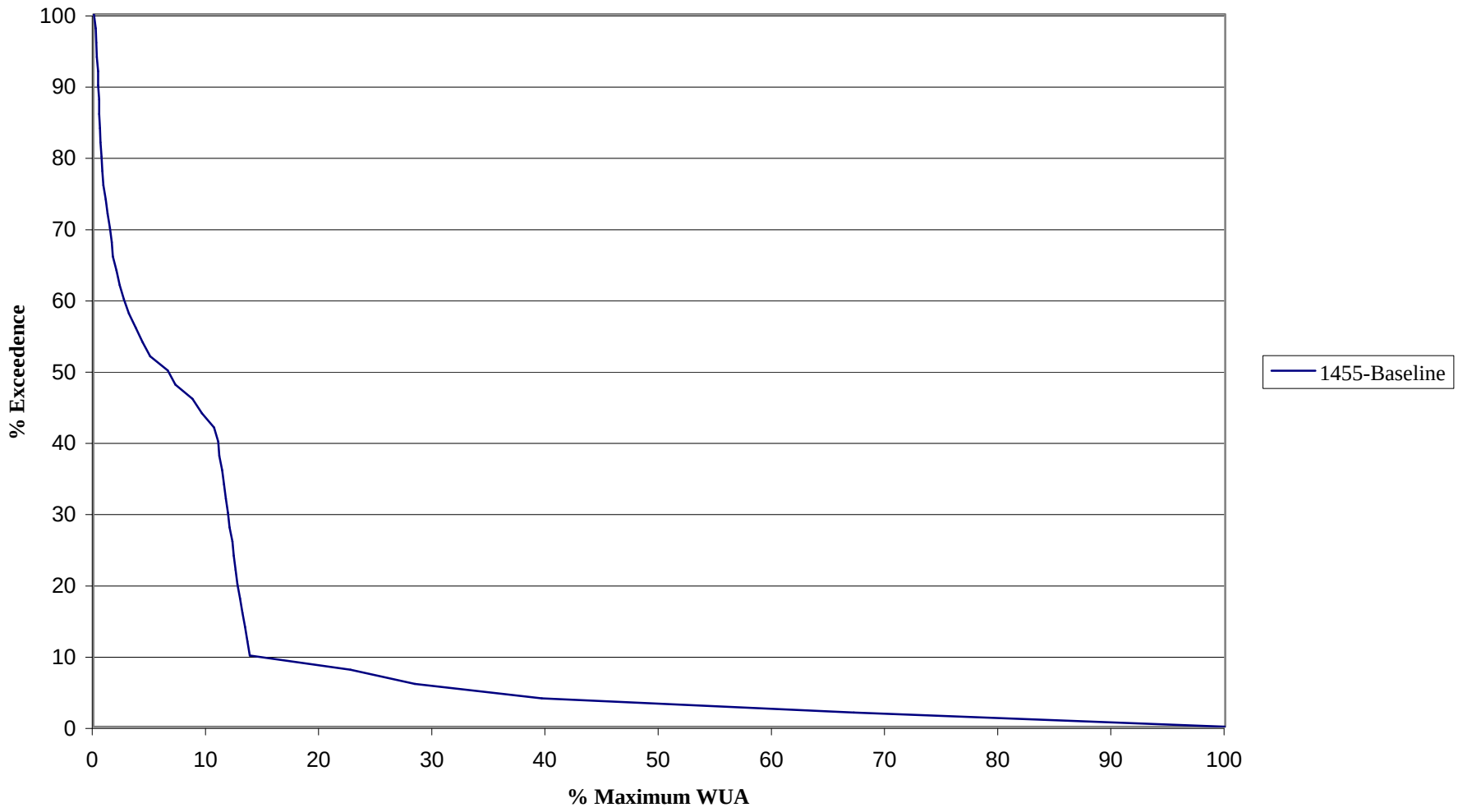

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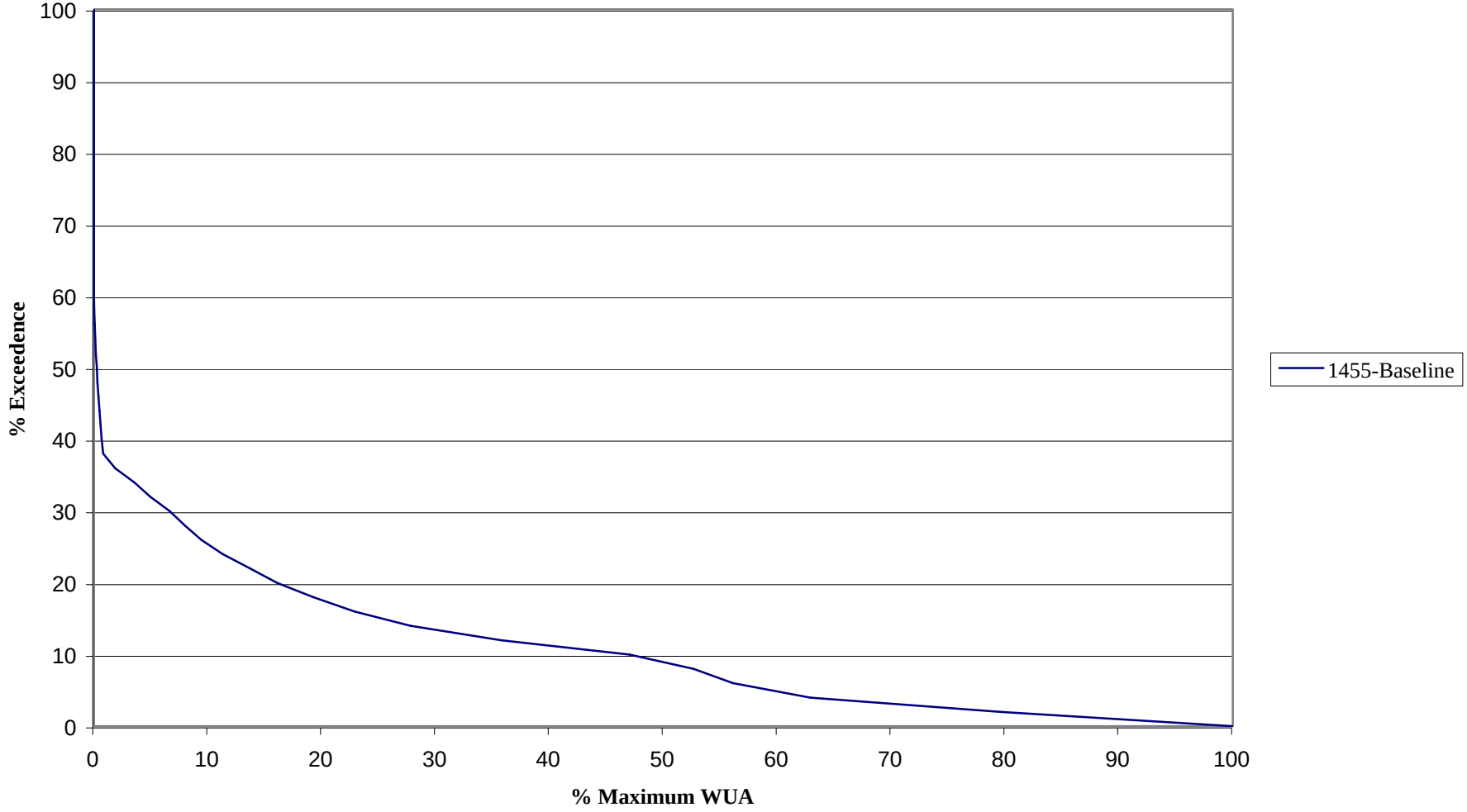

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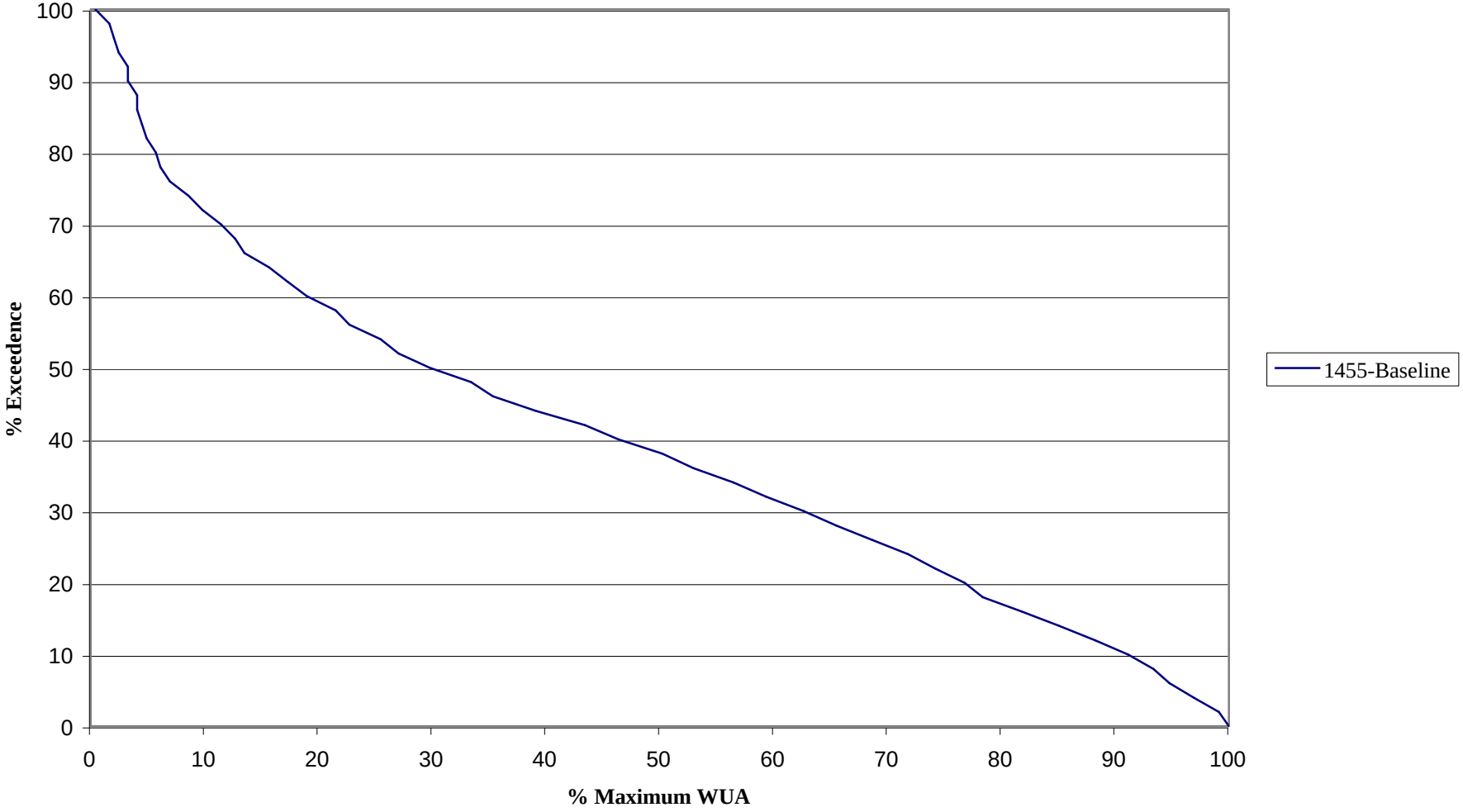

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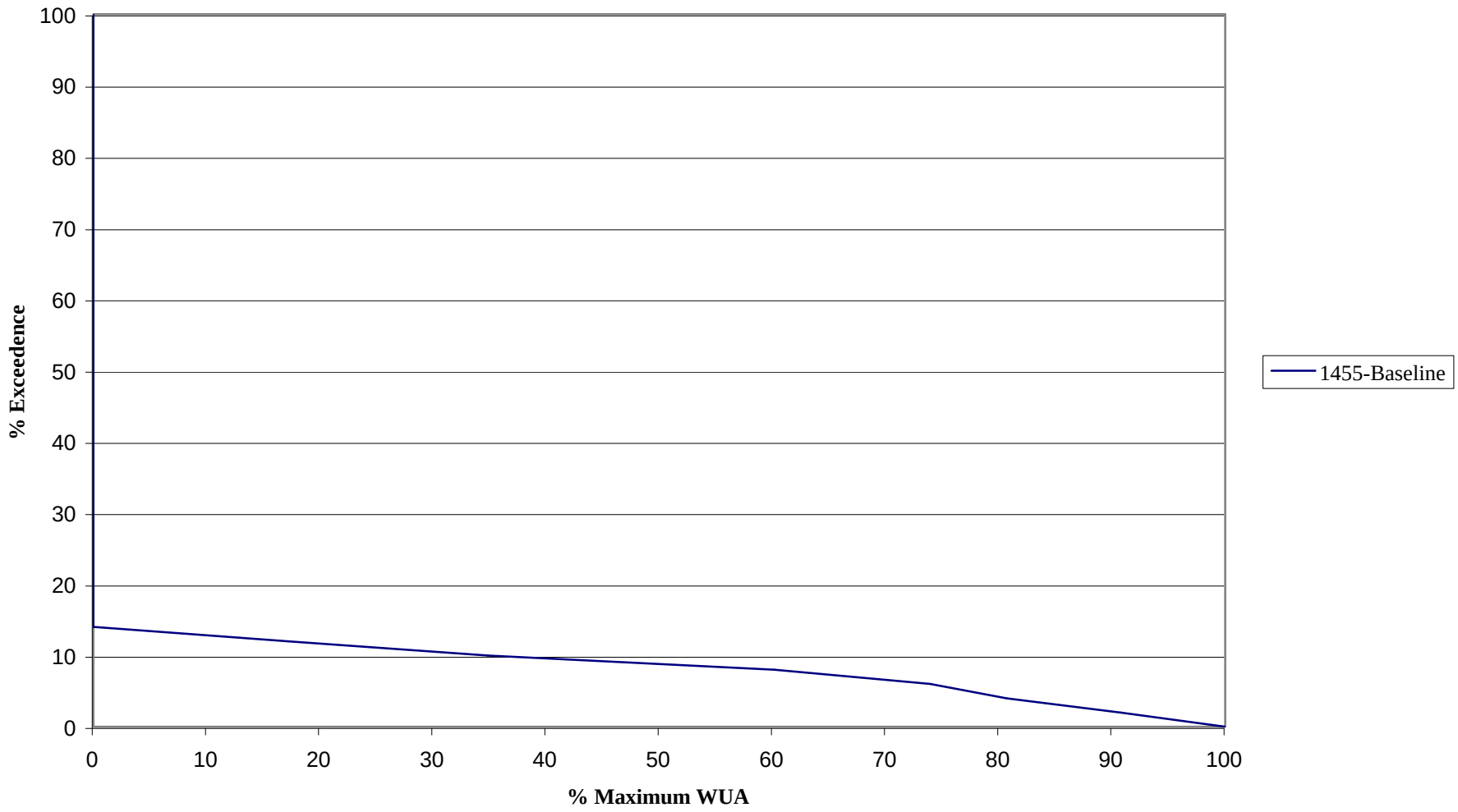

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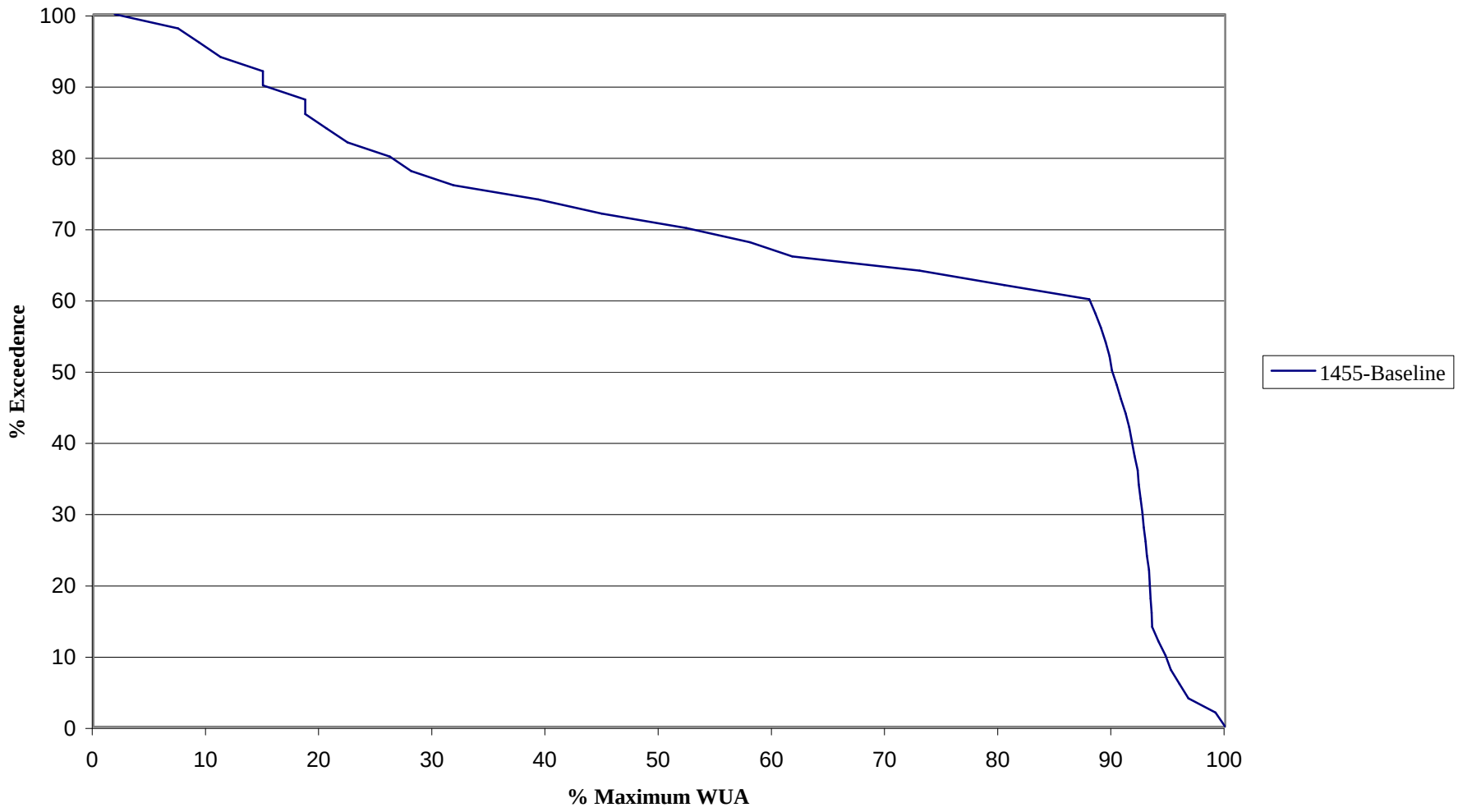

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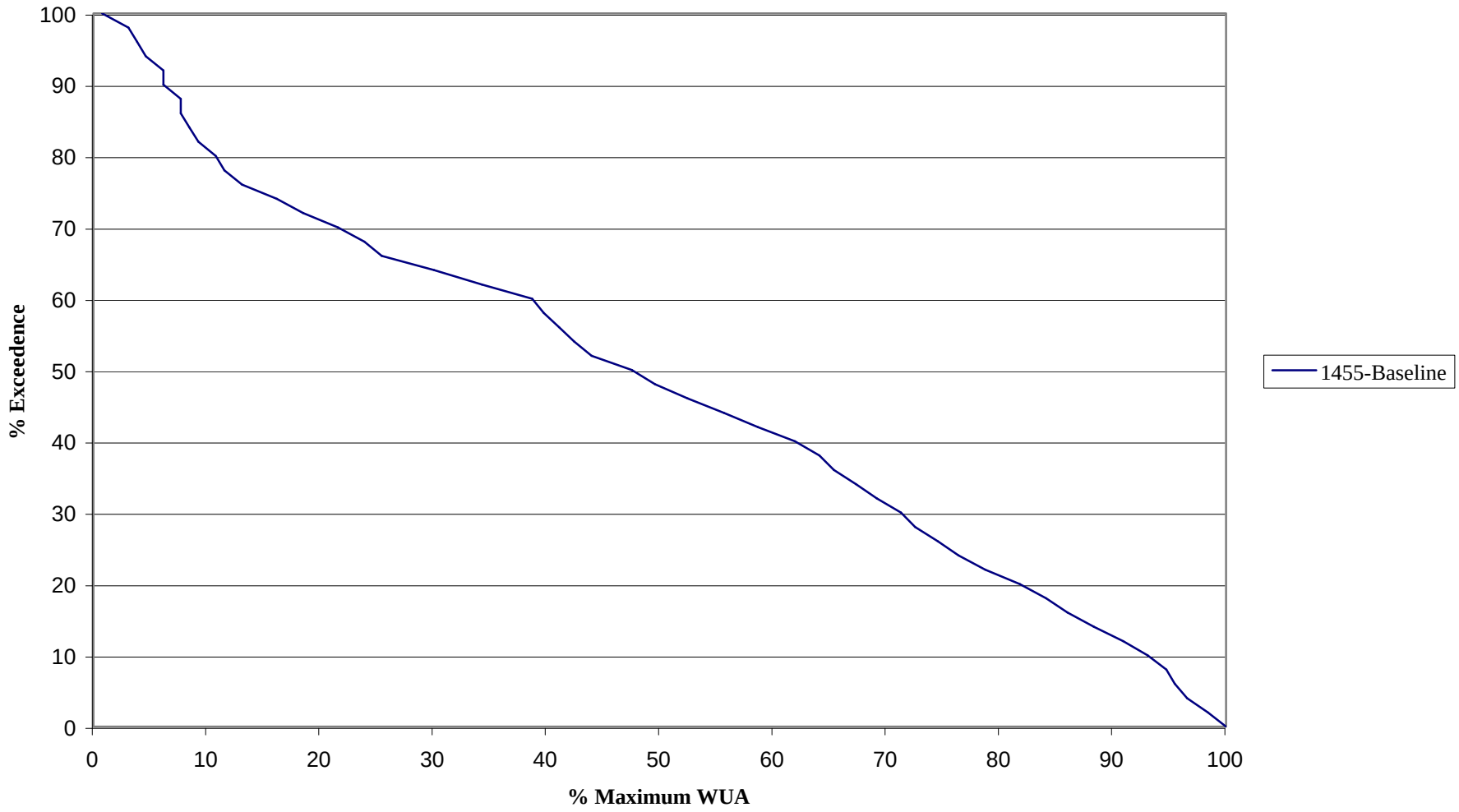

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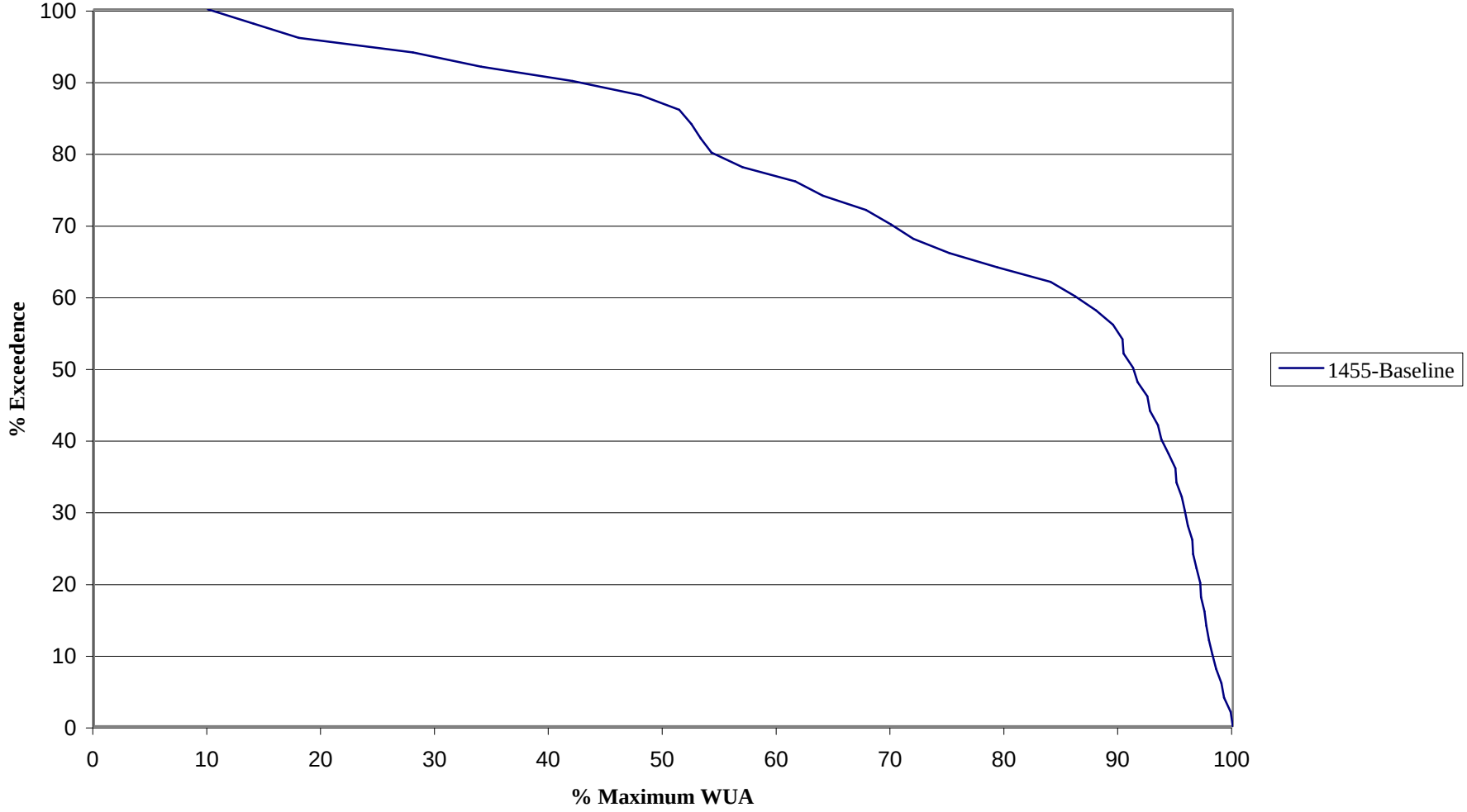

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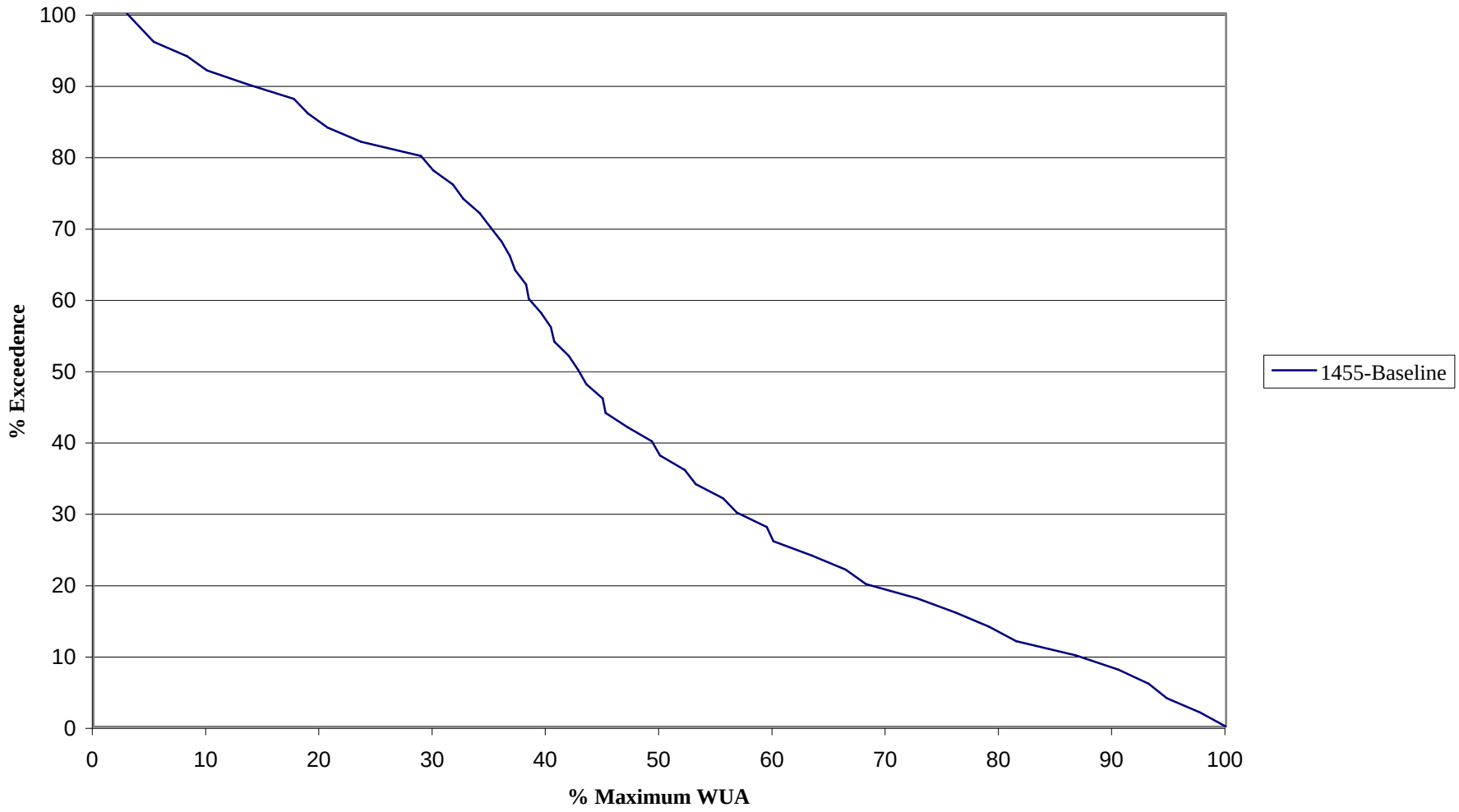

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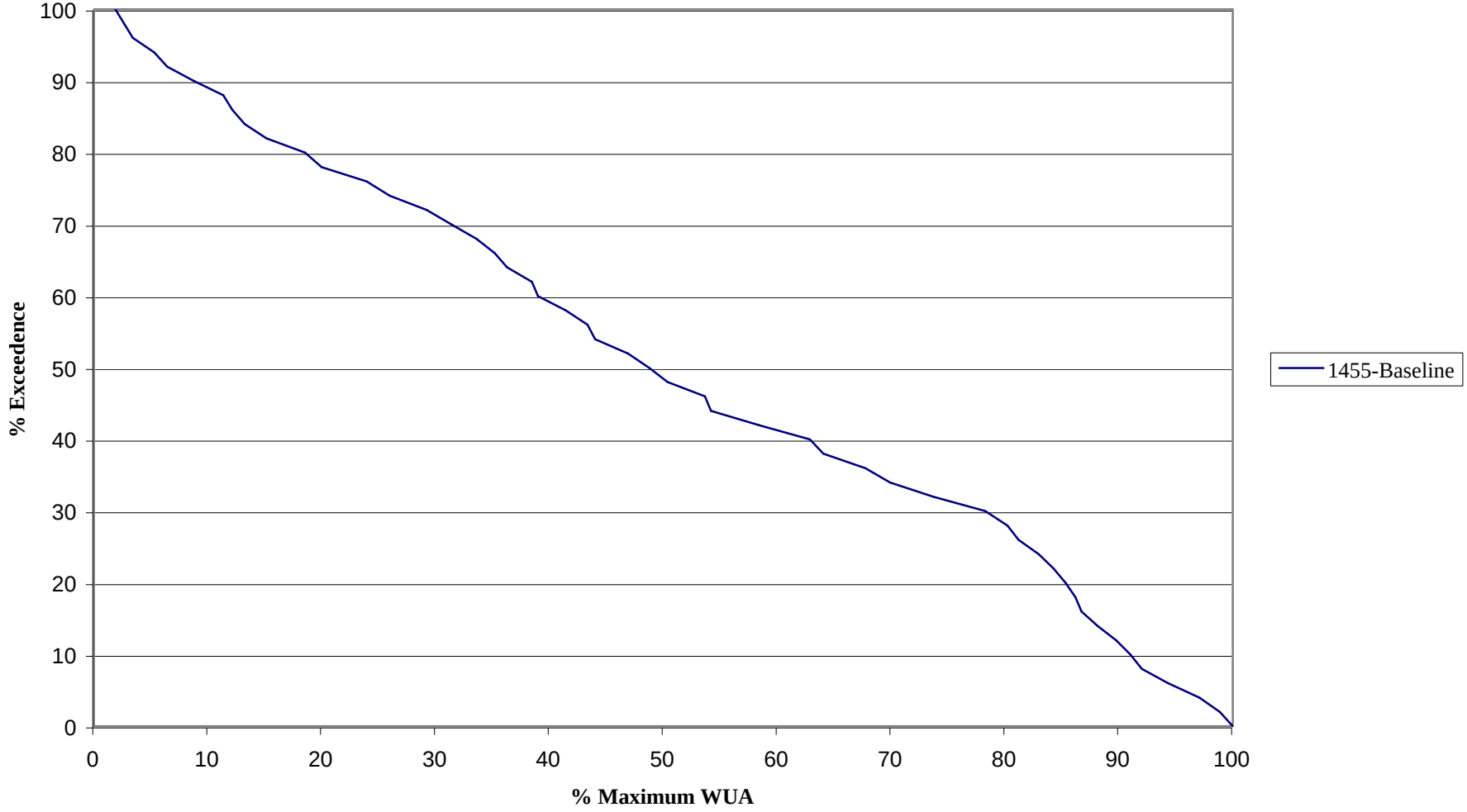

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FALL
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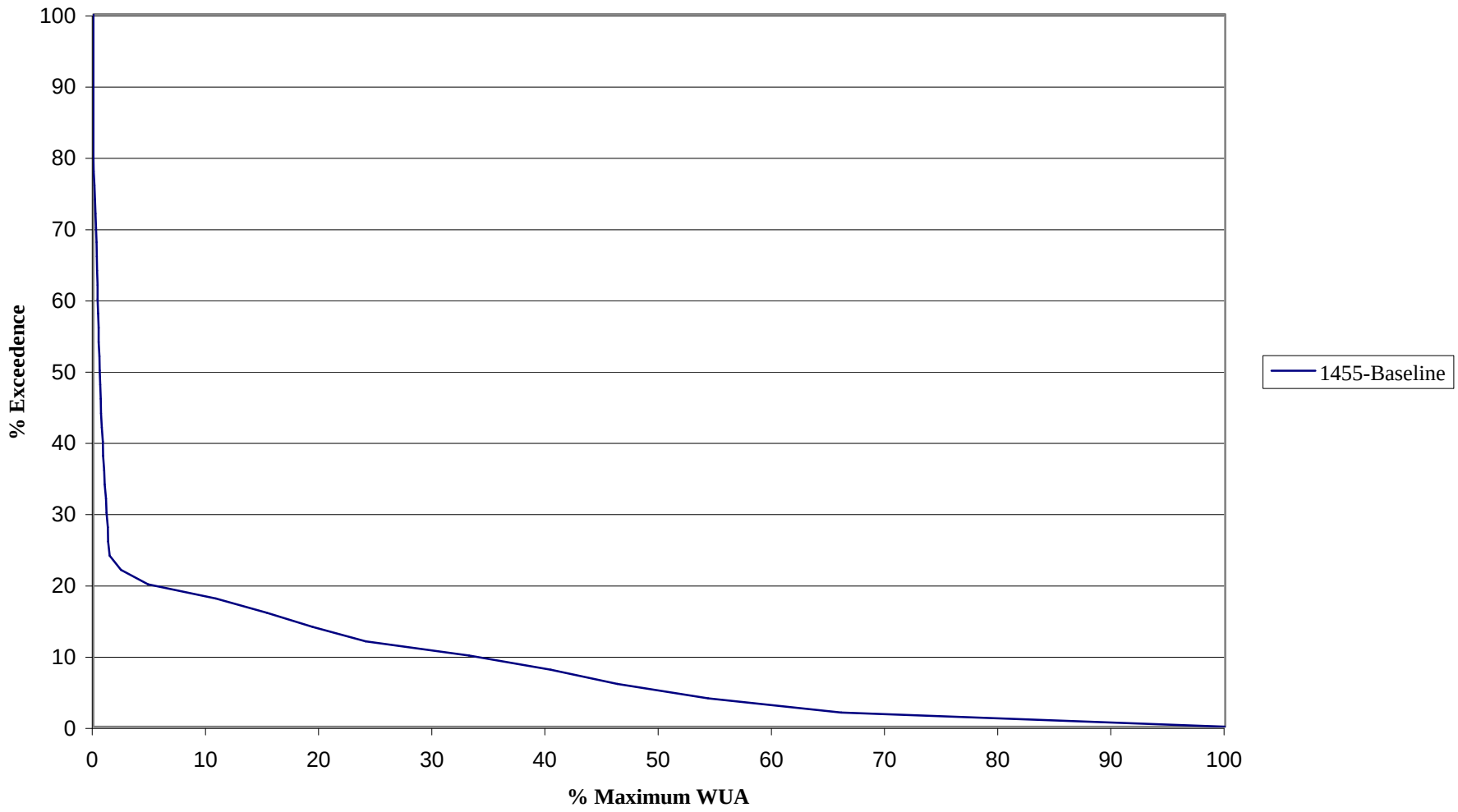

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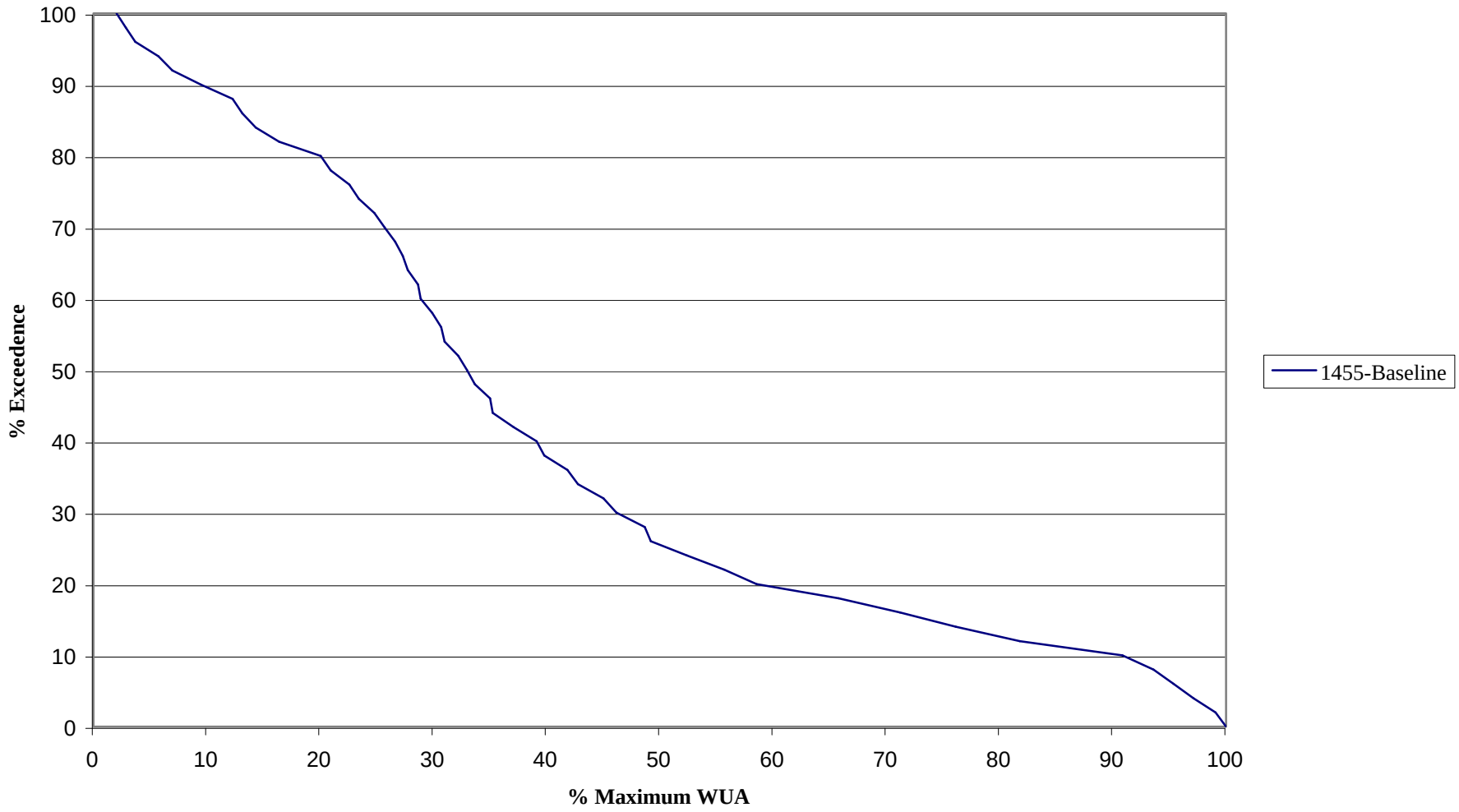

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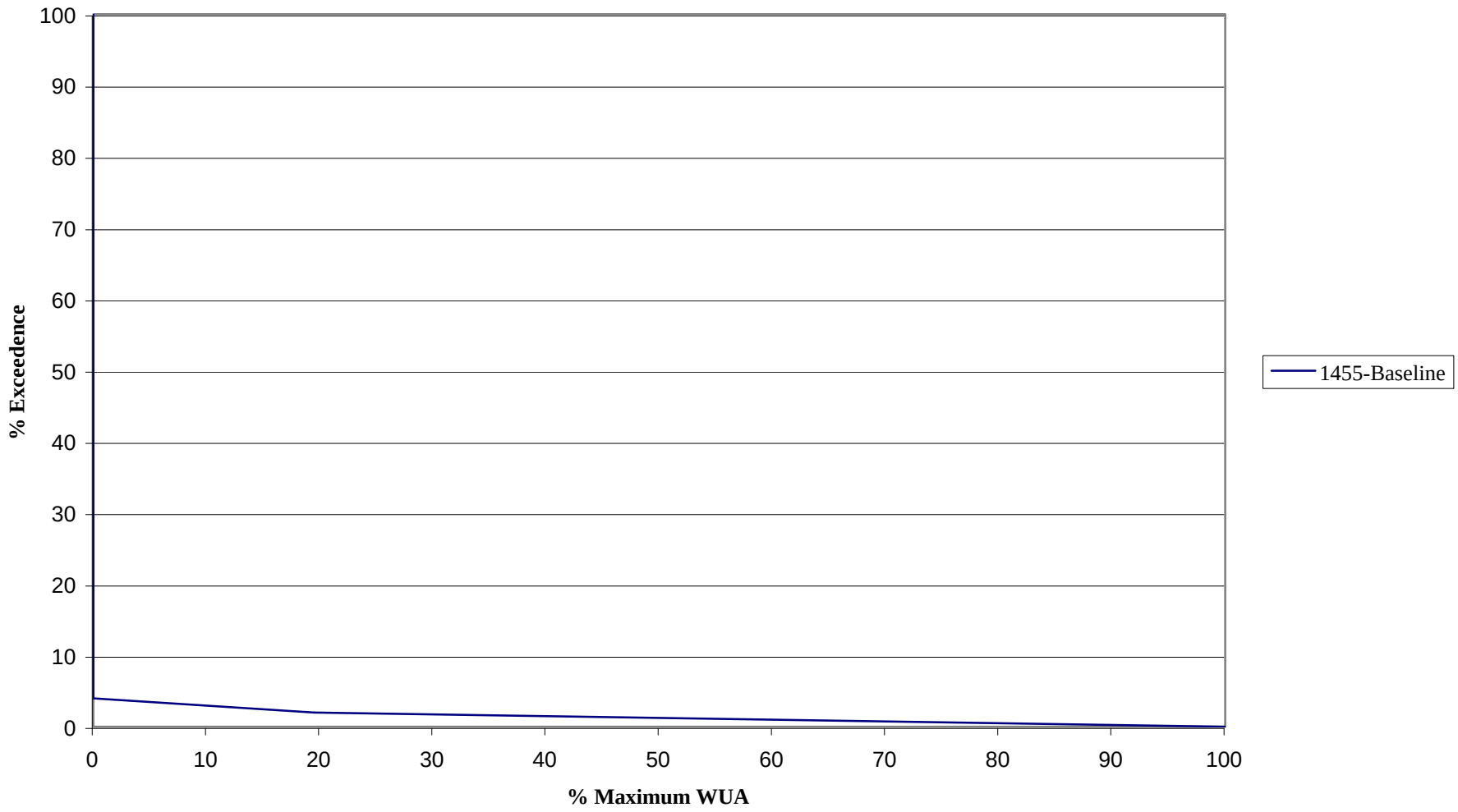

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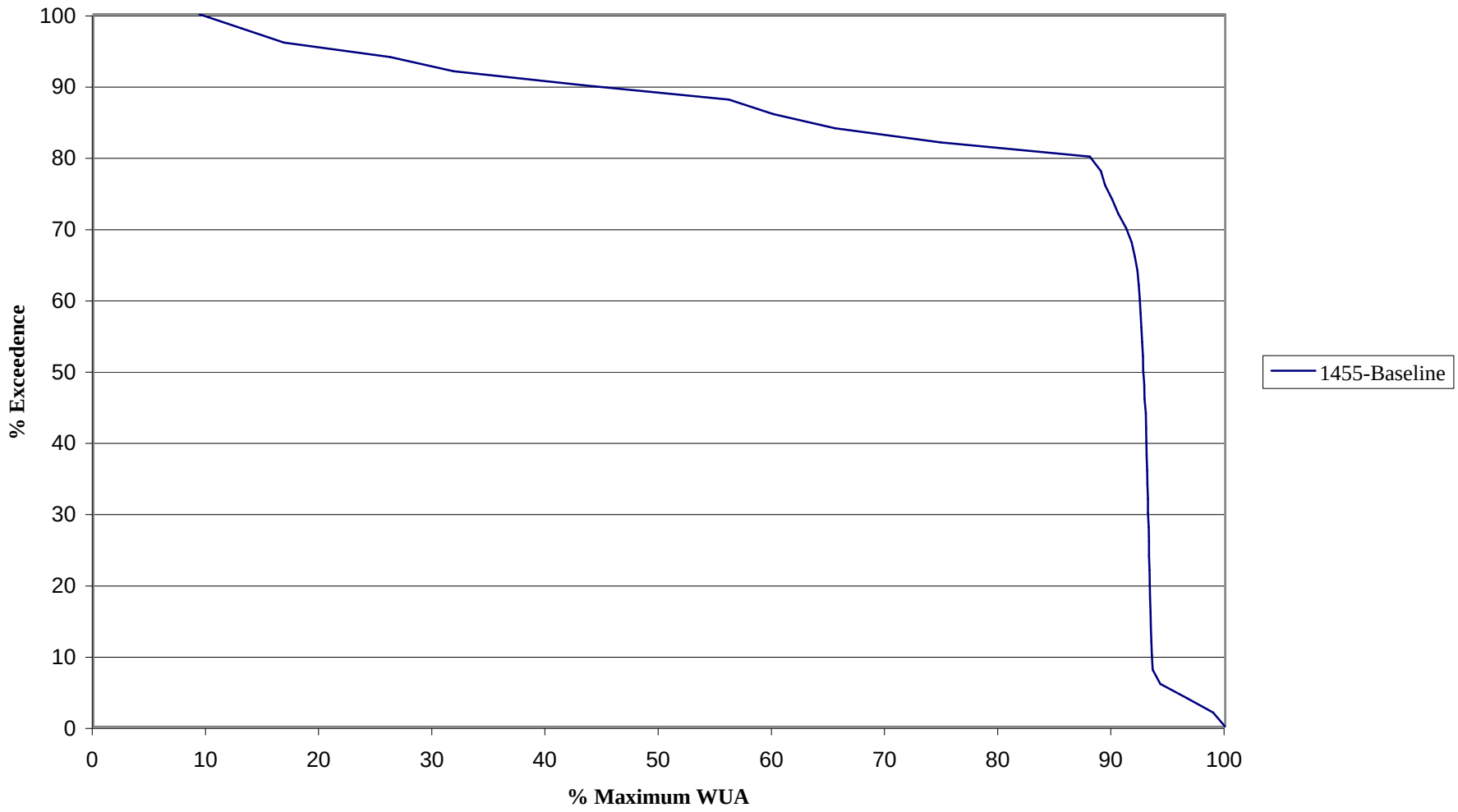

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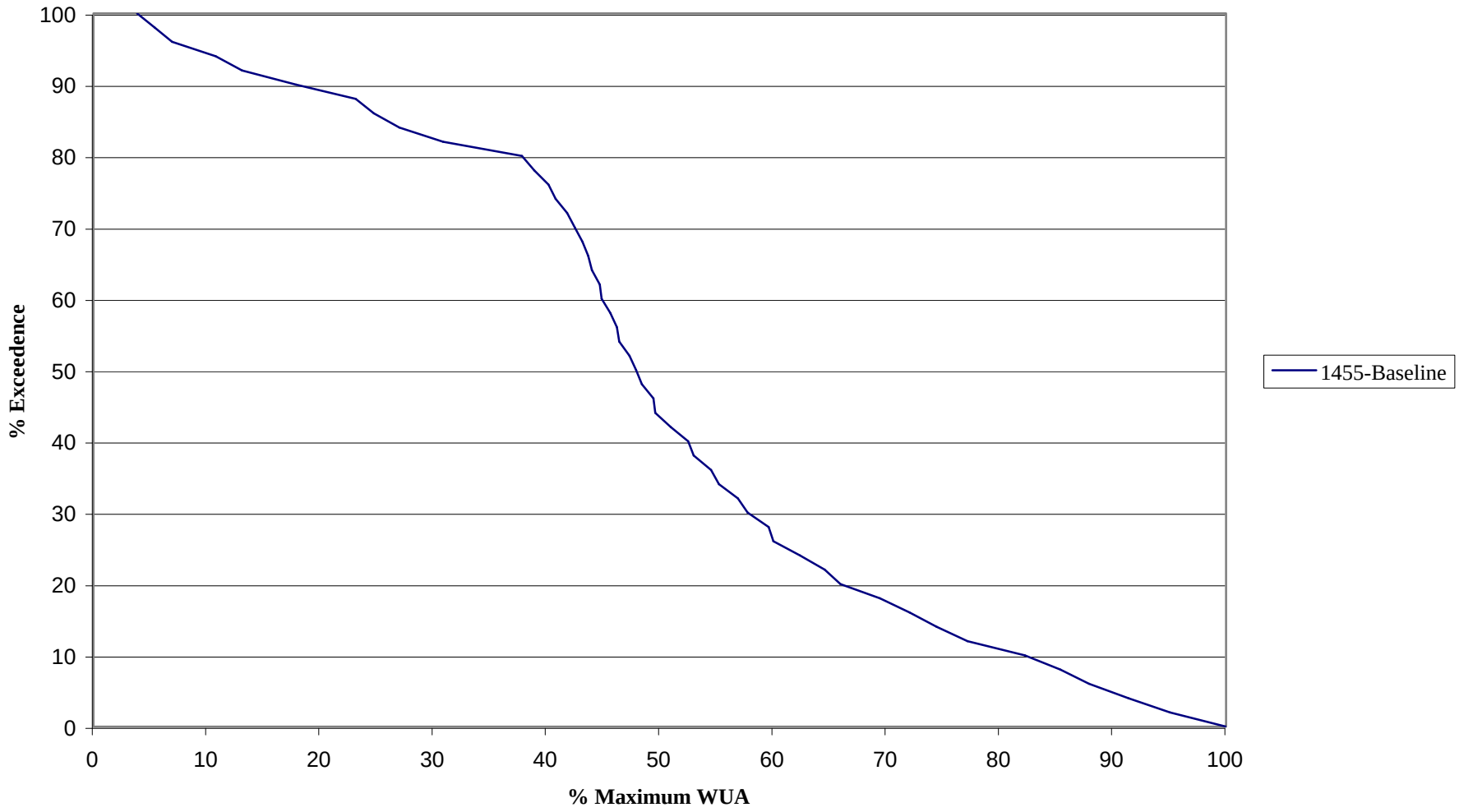

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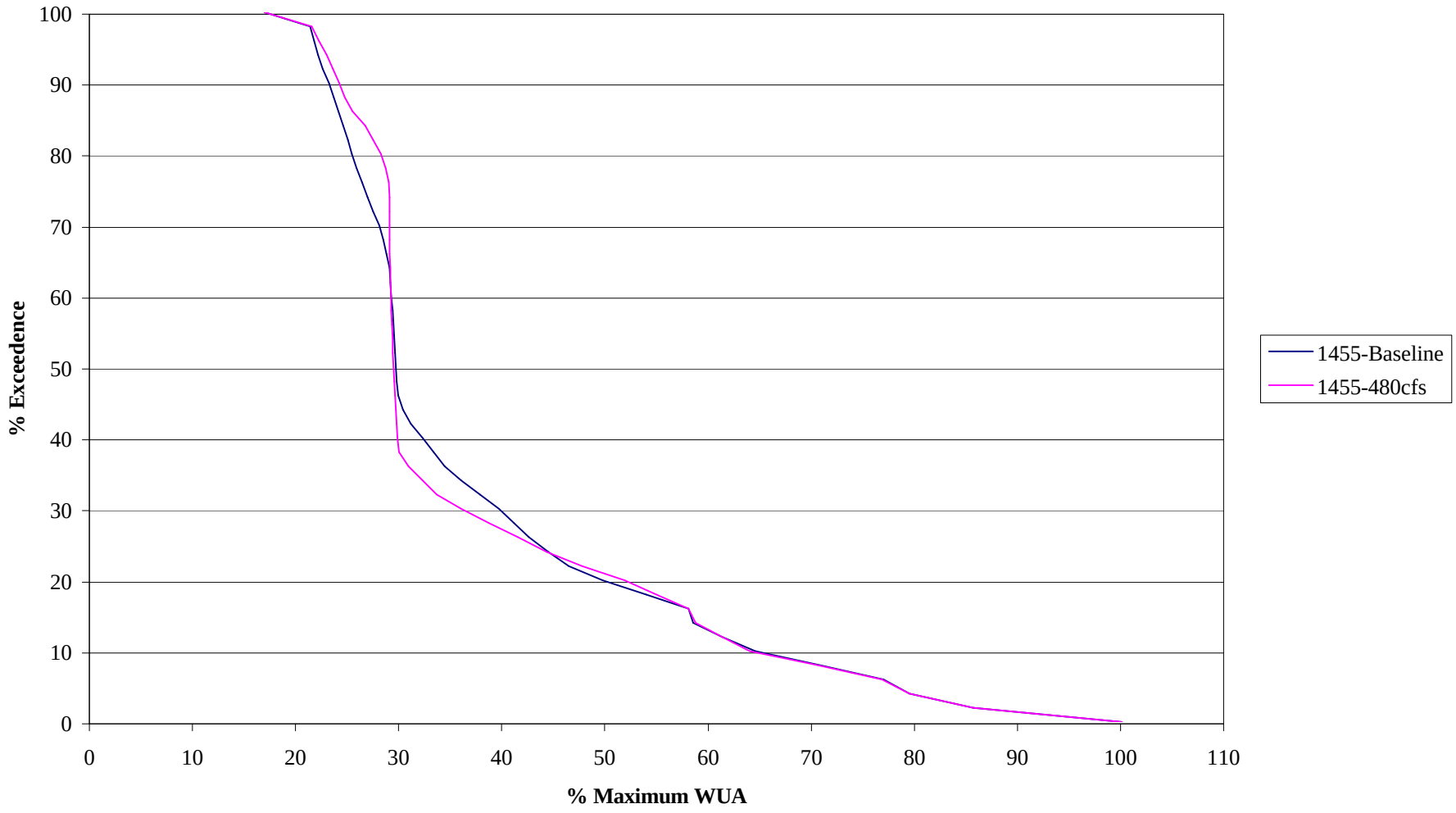

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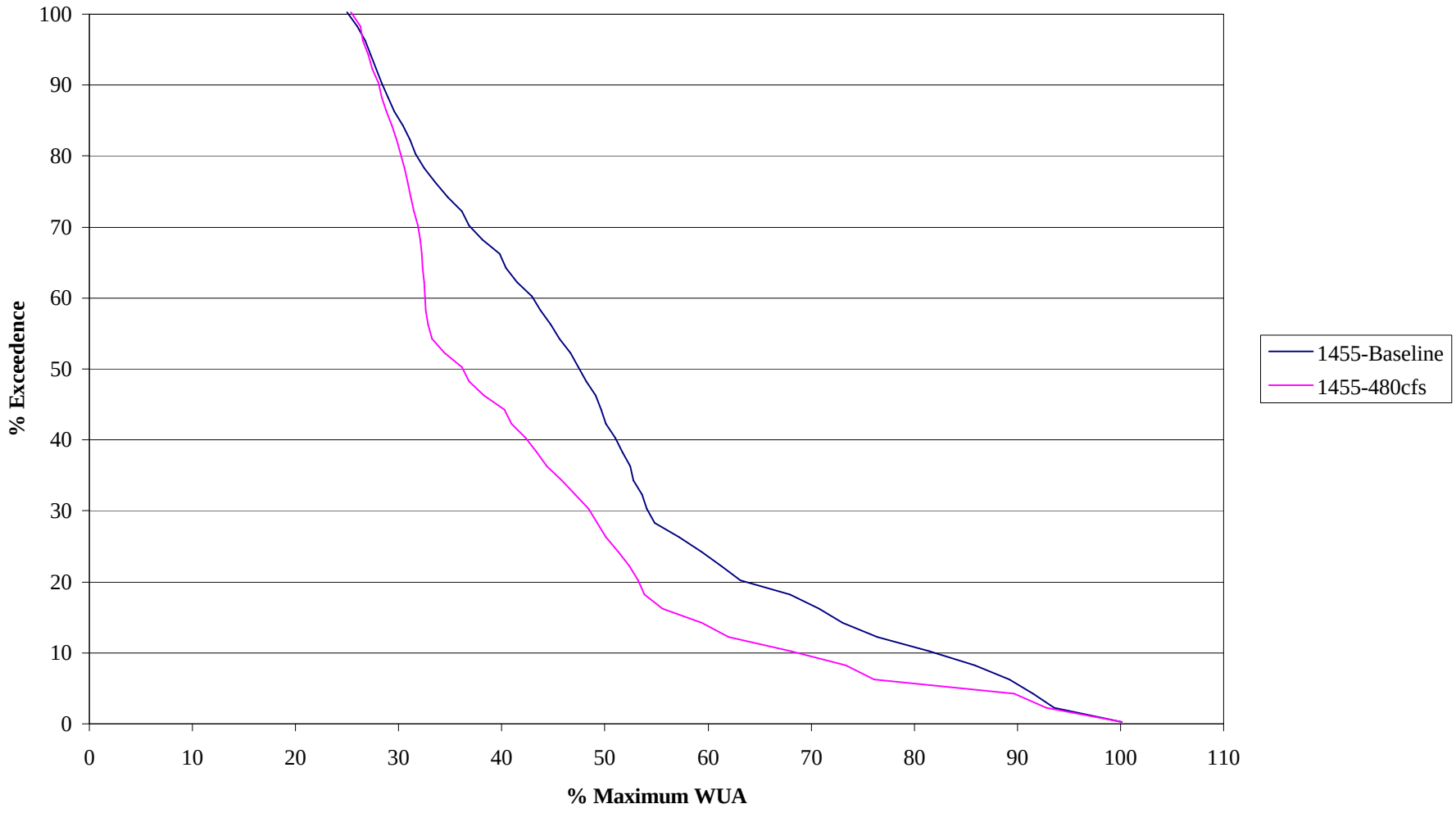

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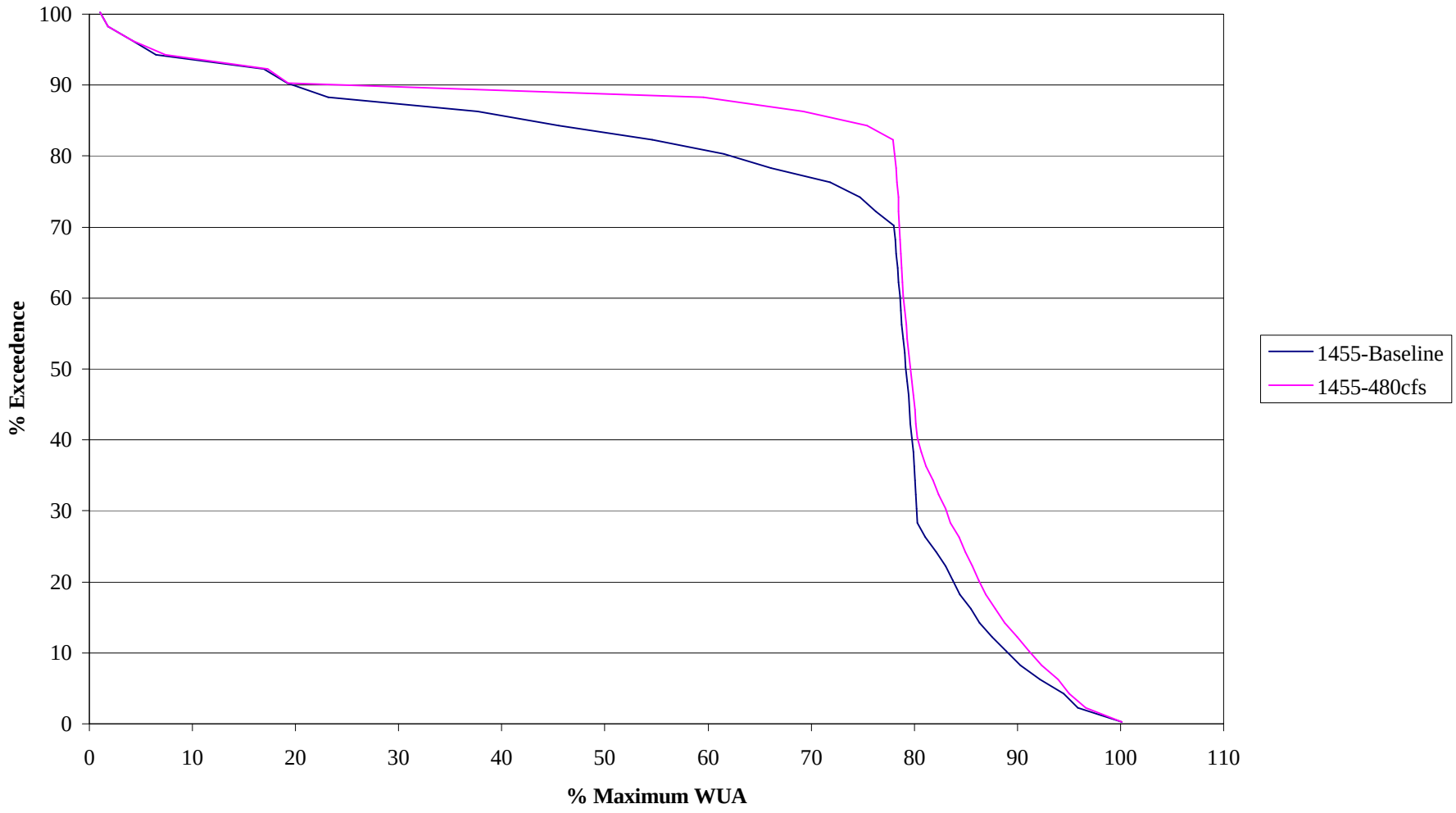

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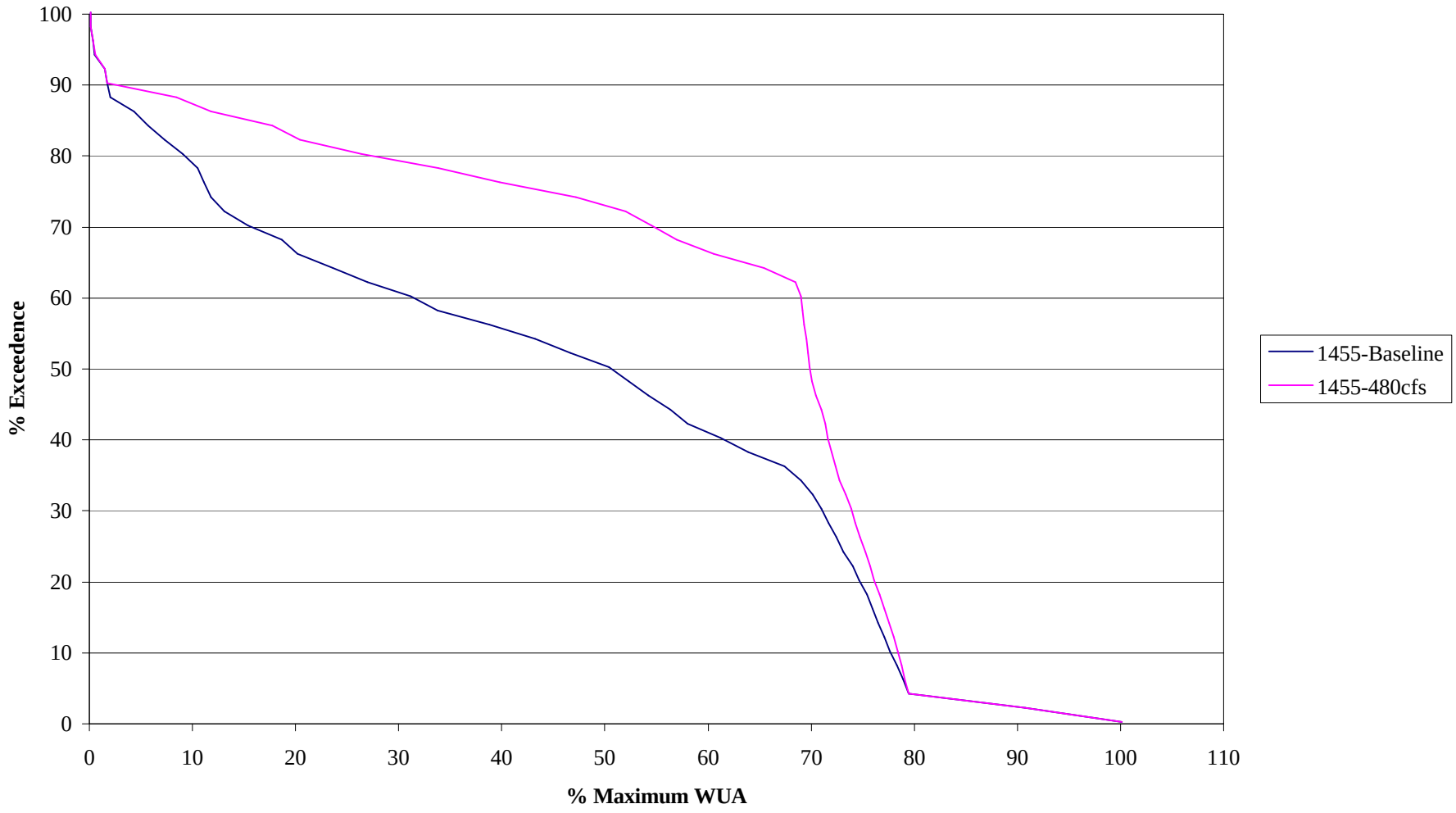

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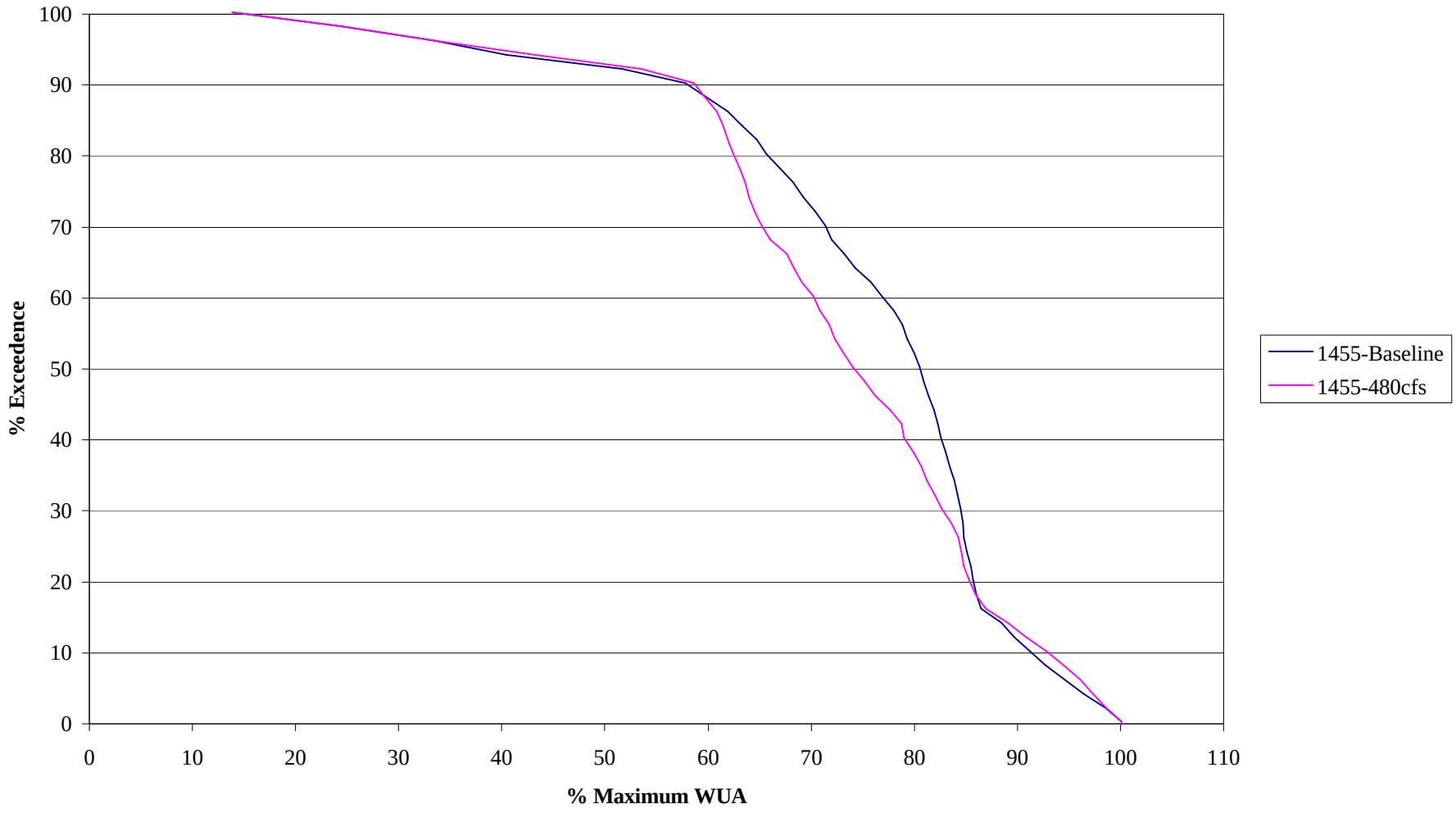

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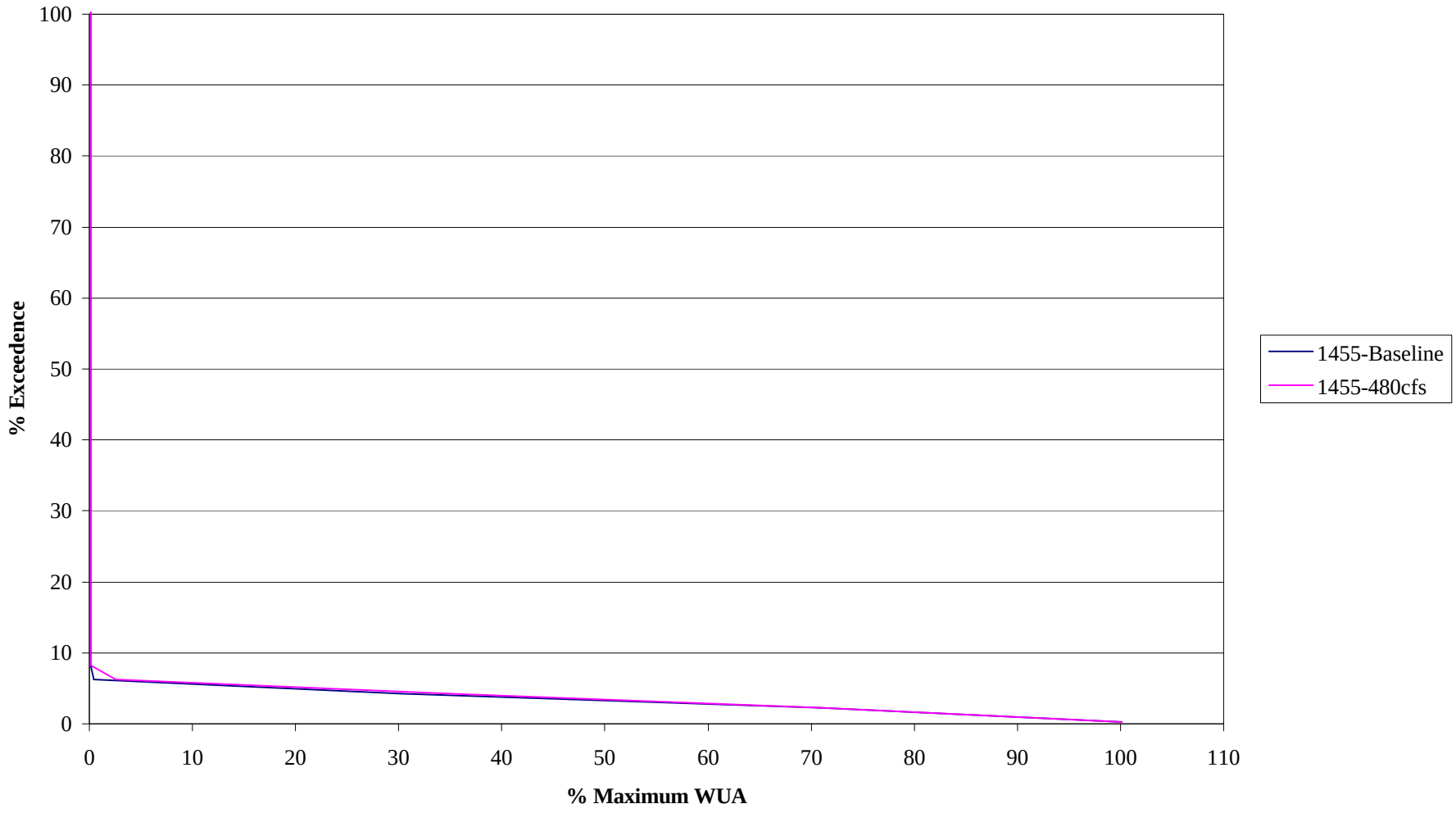

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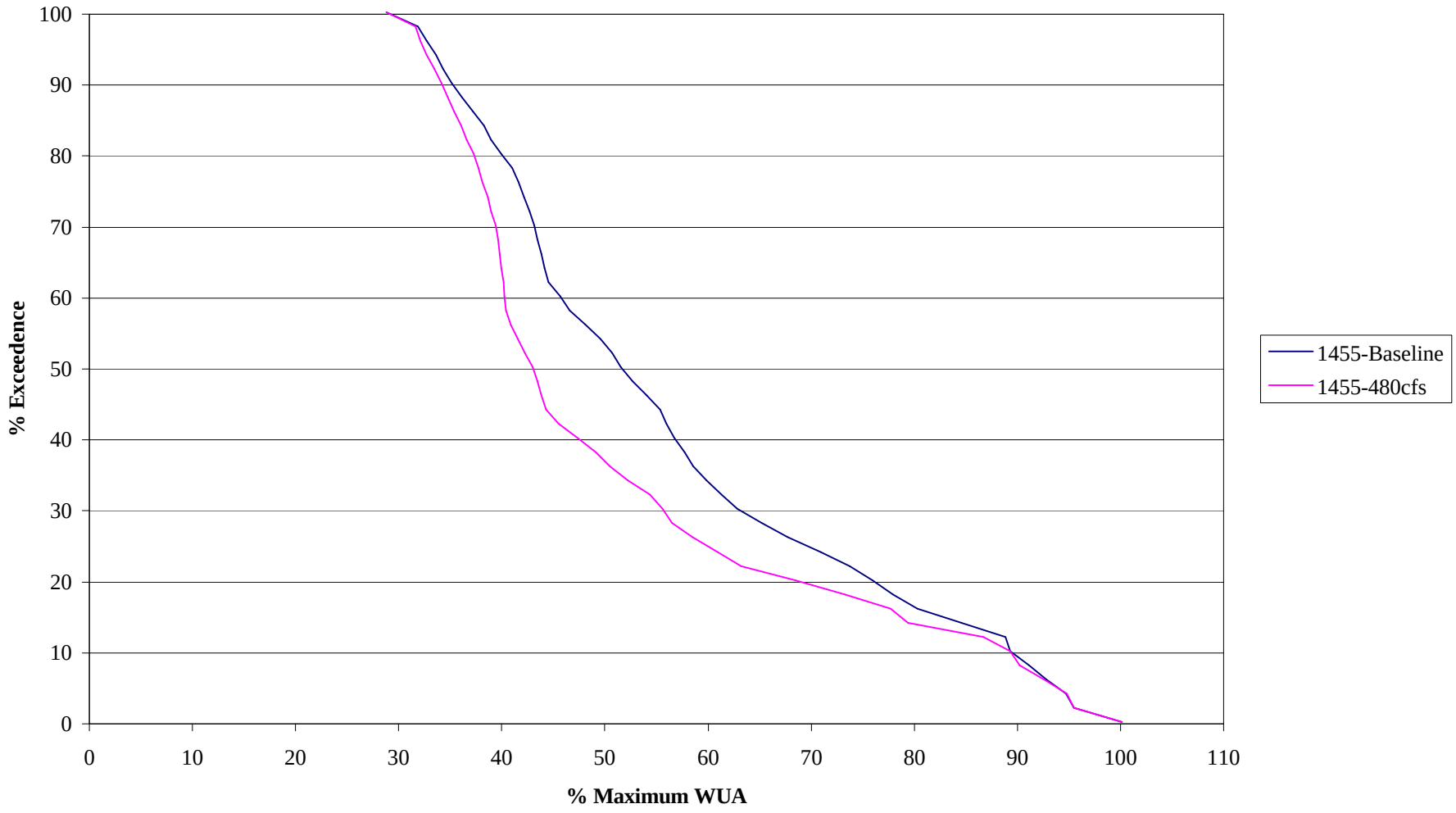

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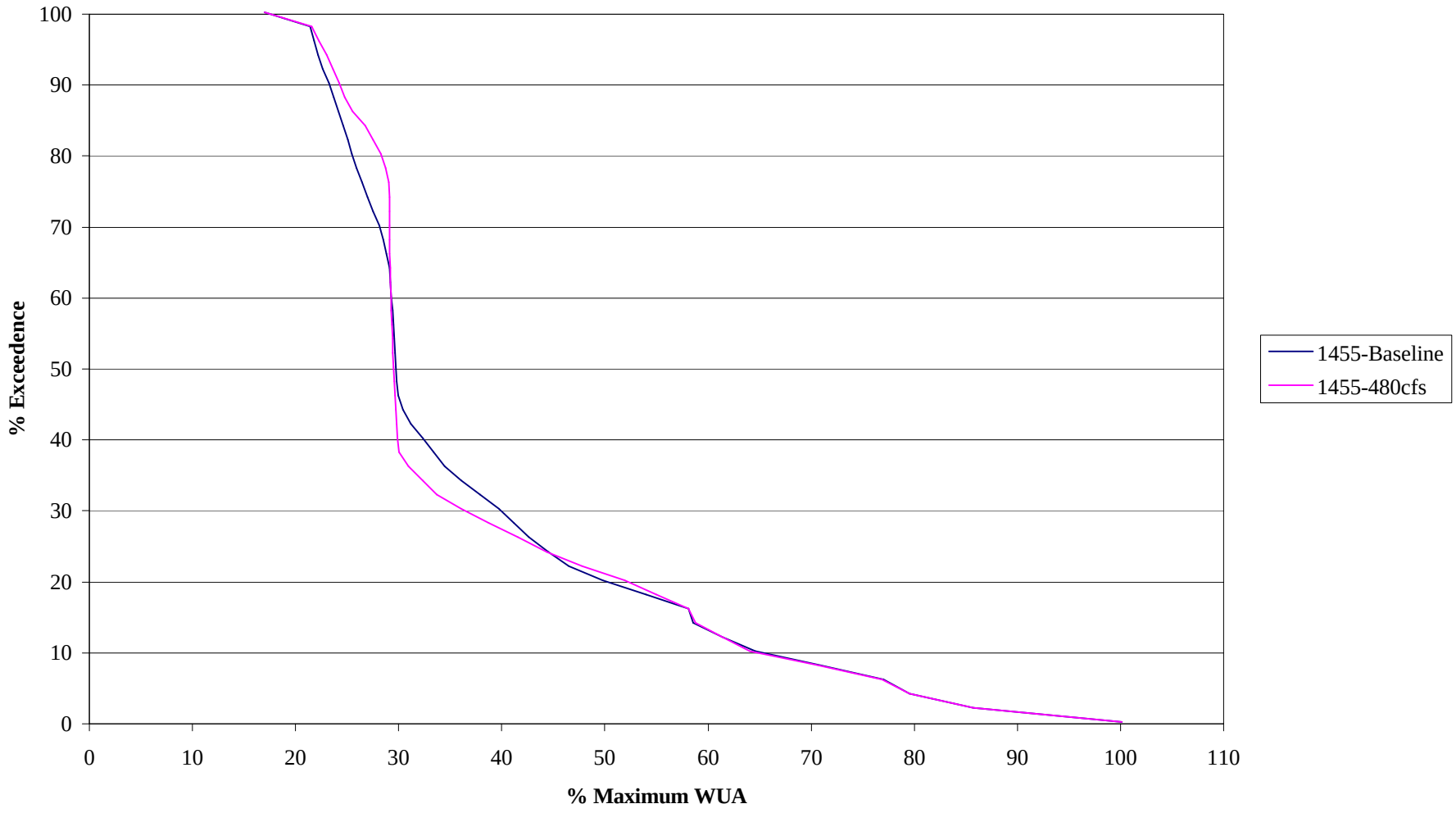

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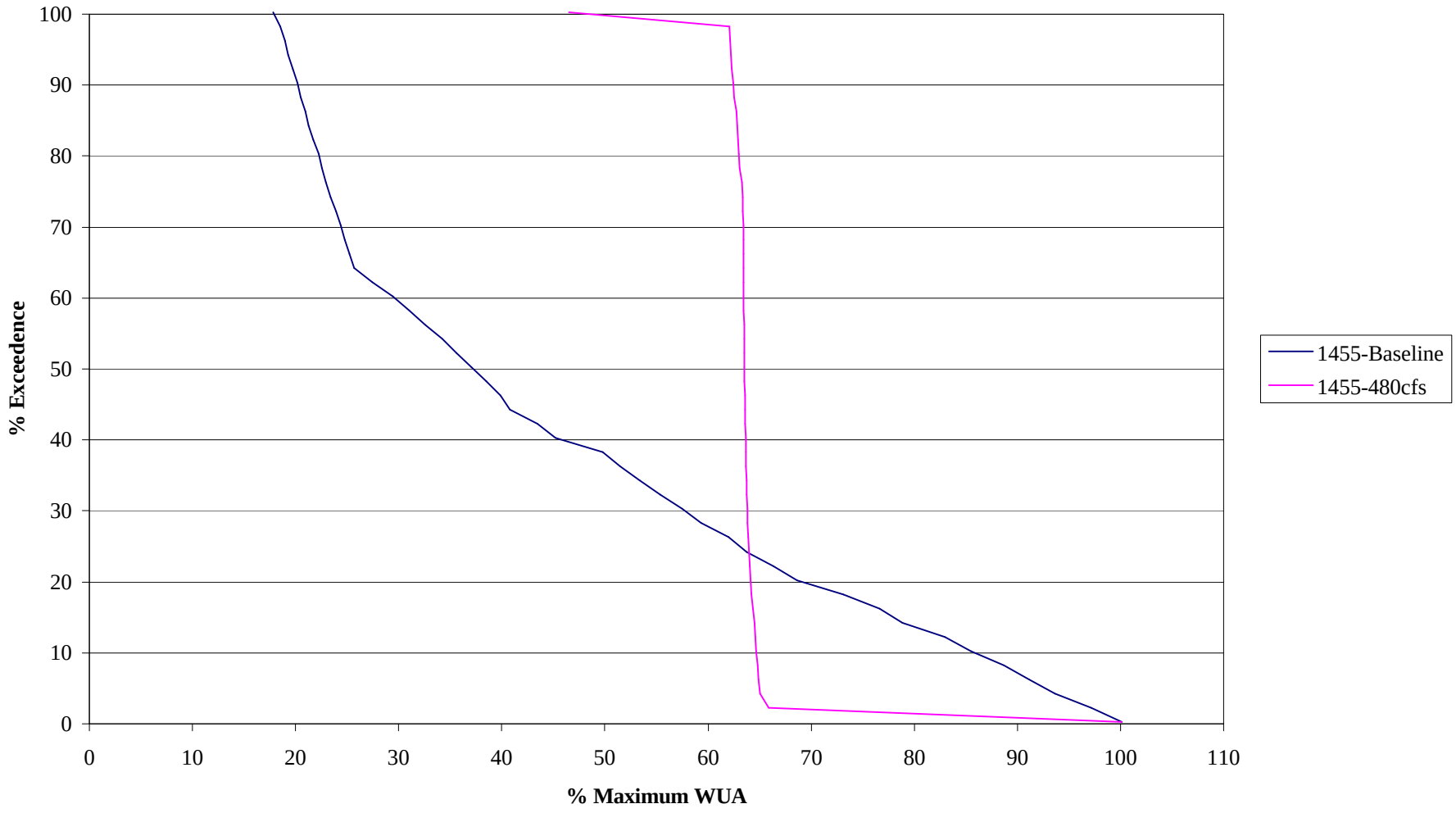

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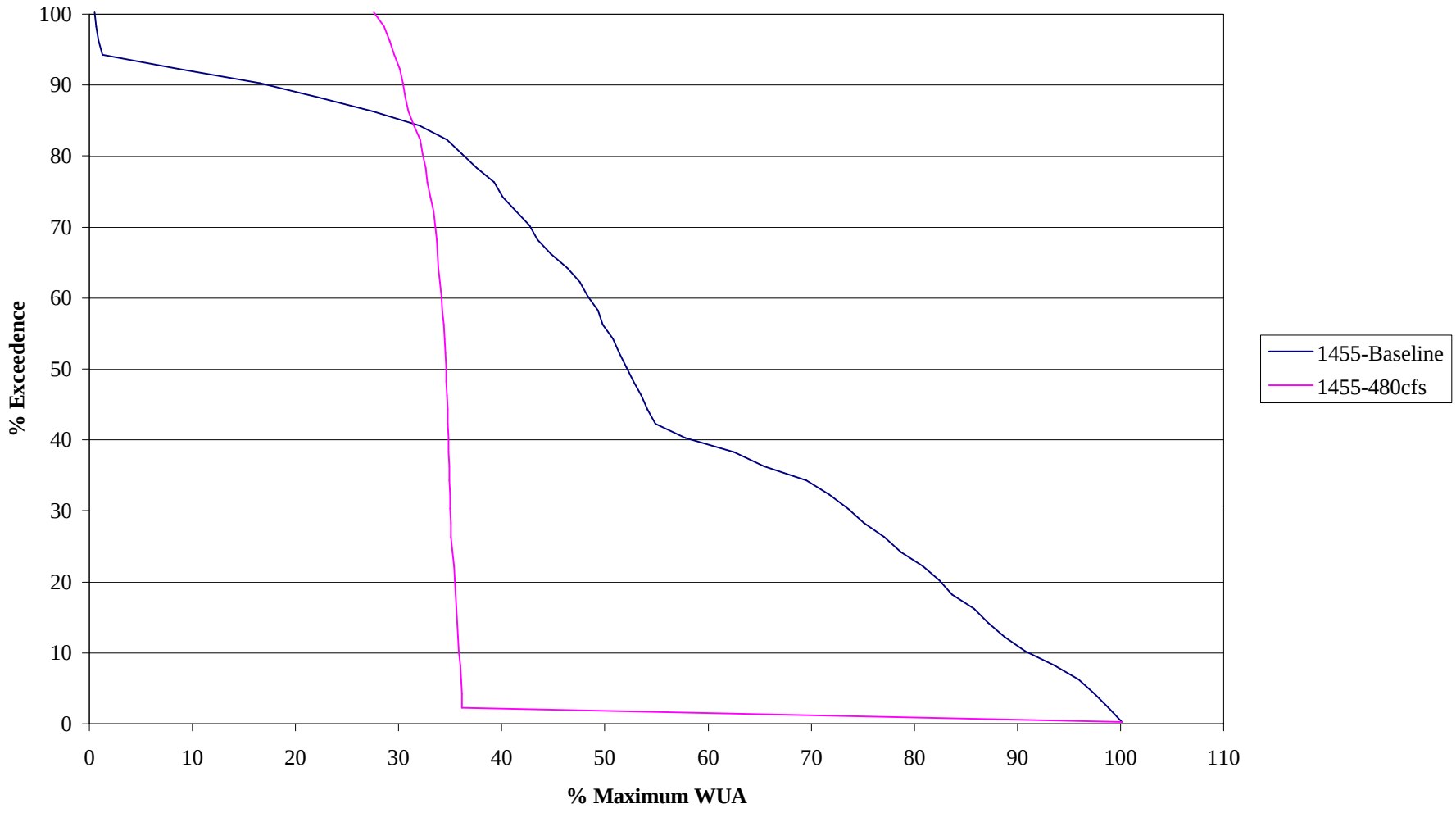

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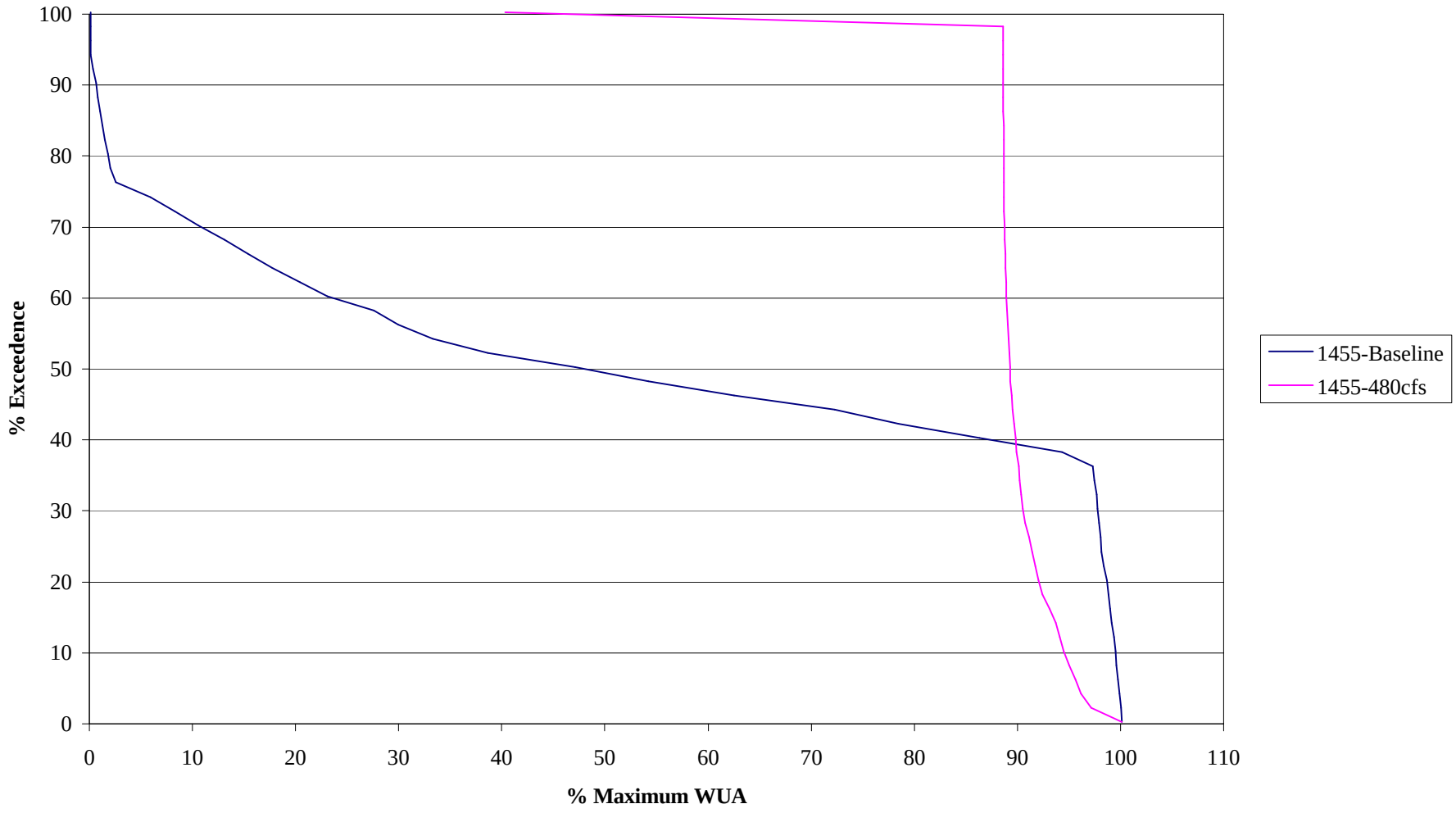

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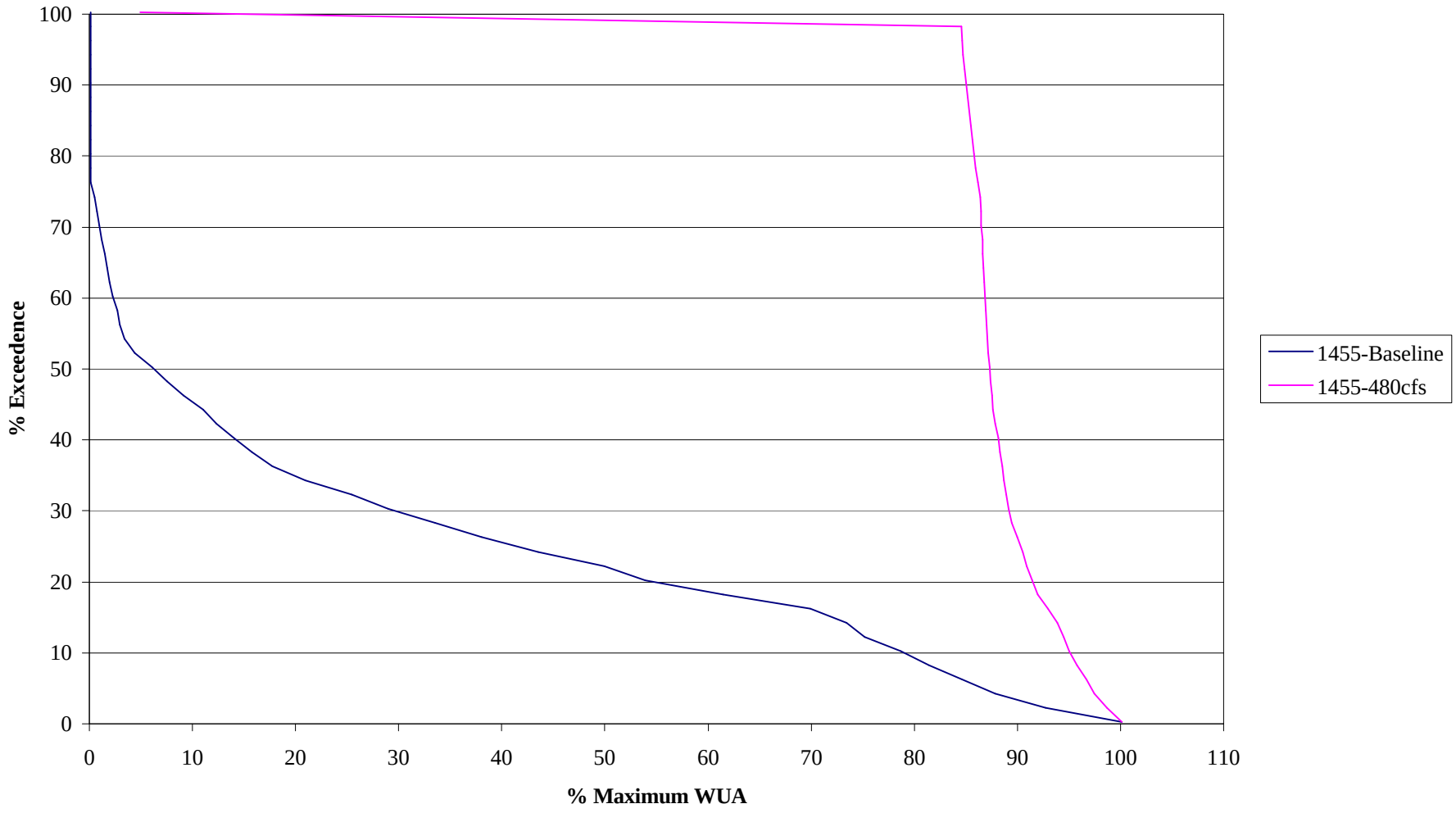

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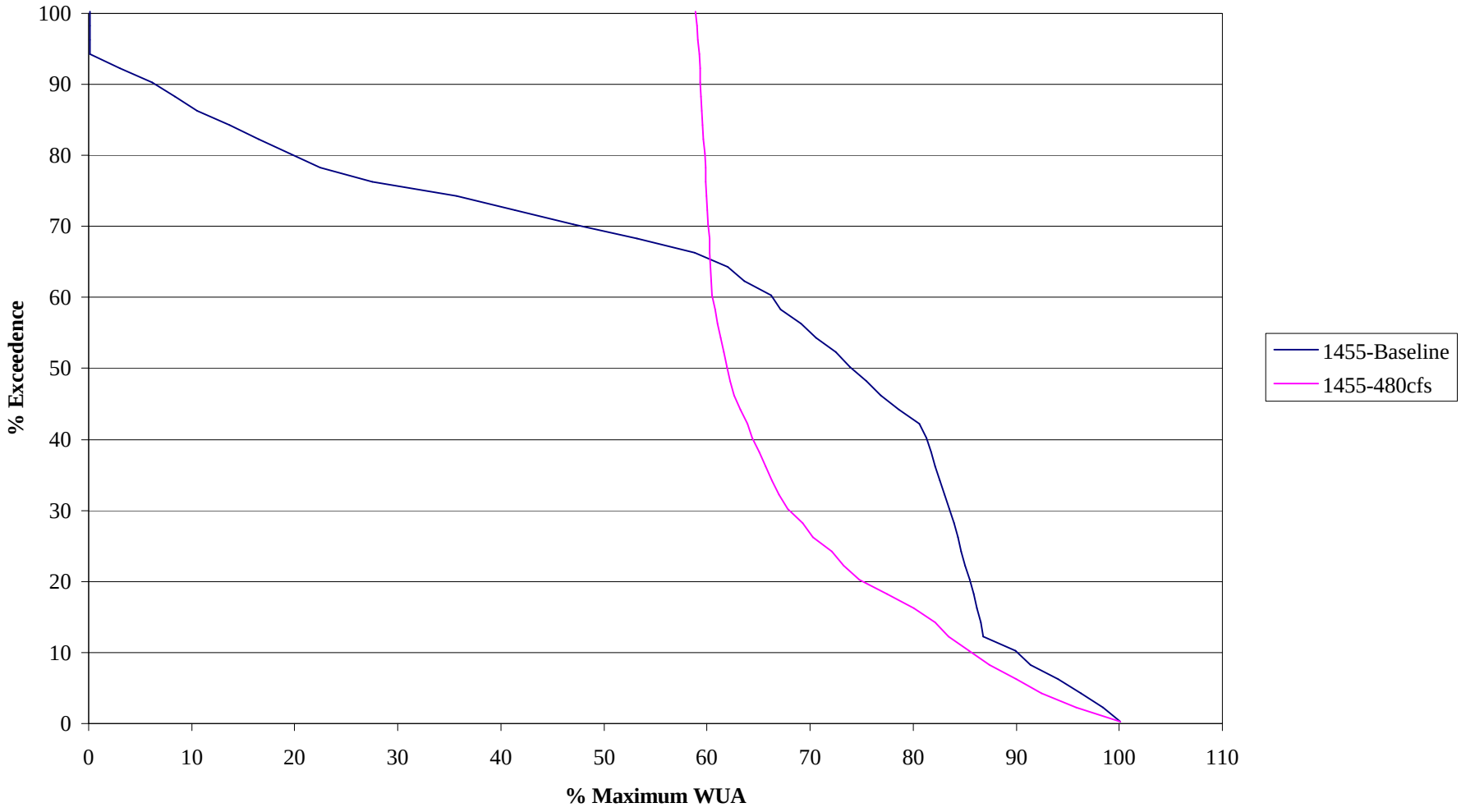

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Final Aquatic Impact Analysis Report

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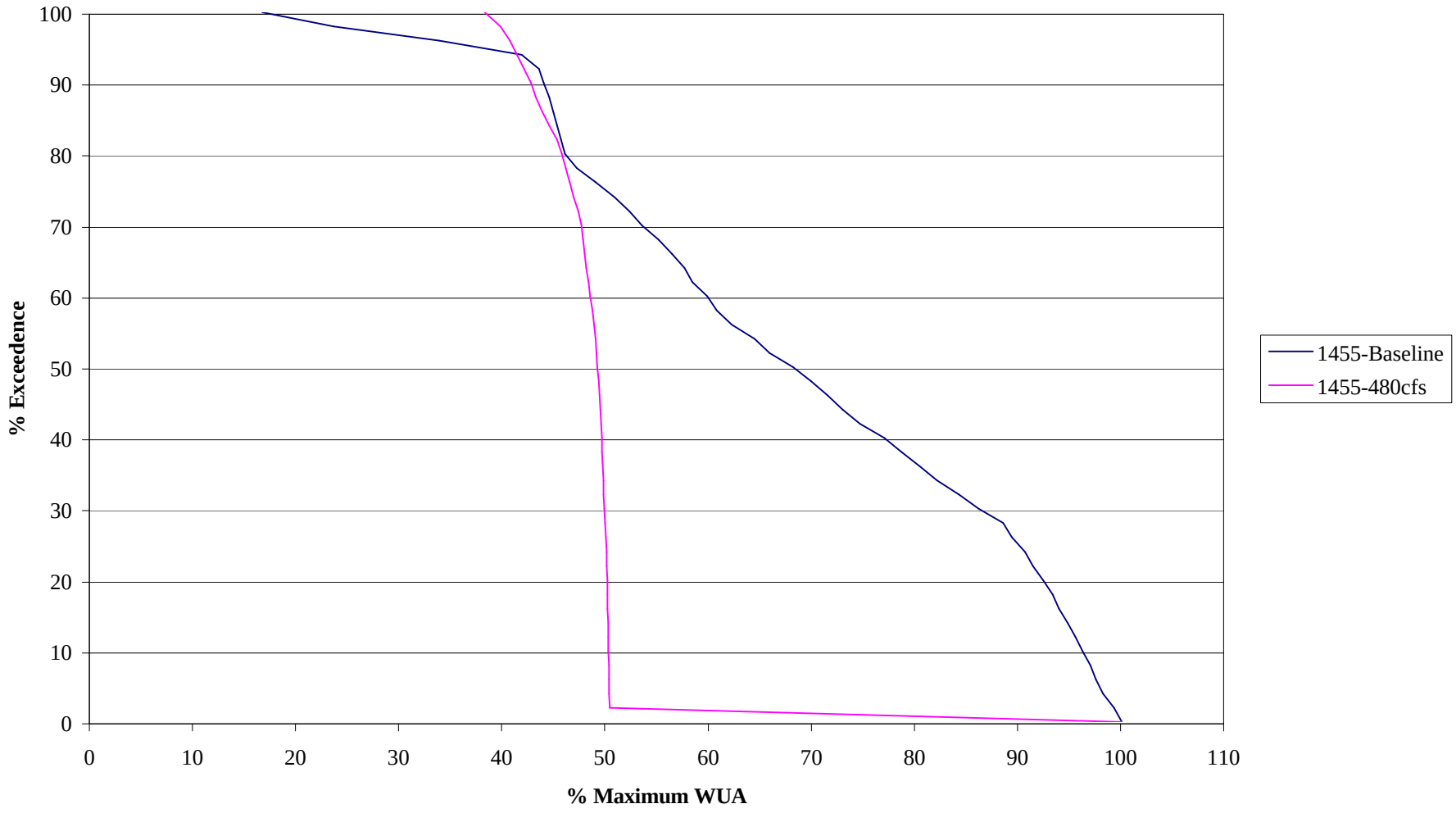
Final Aquatic Impact Analysis Report



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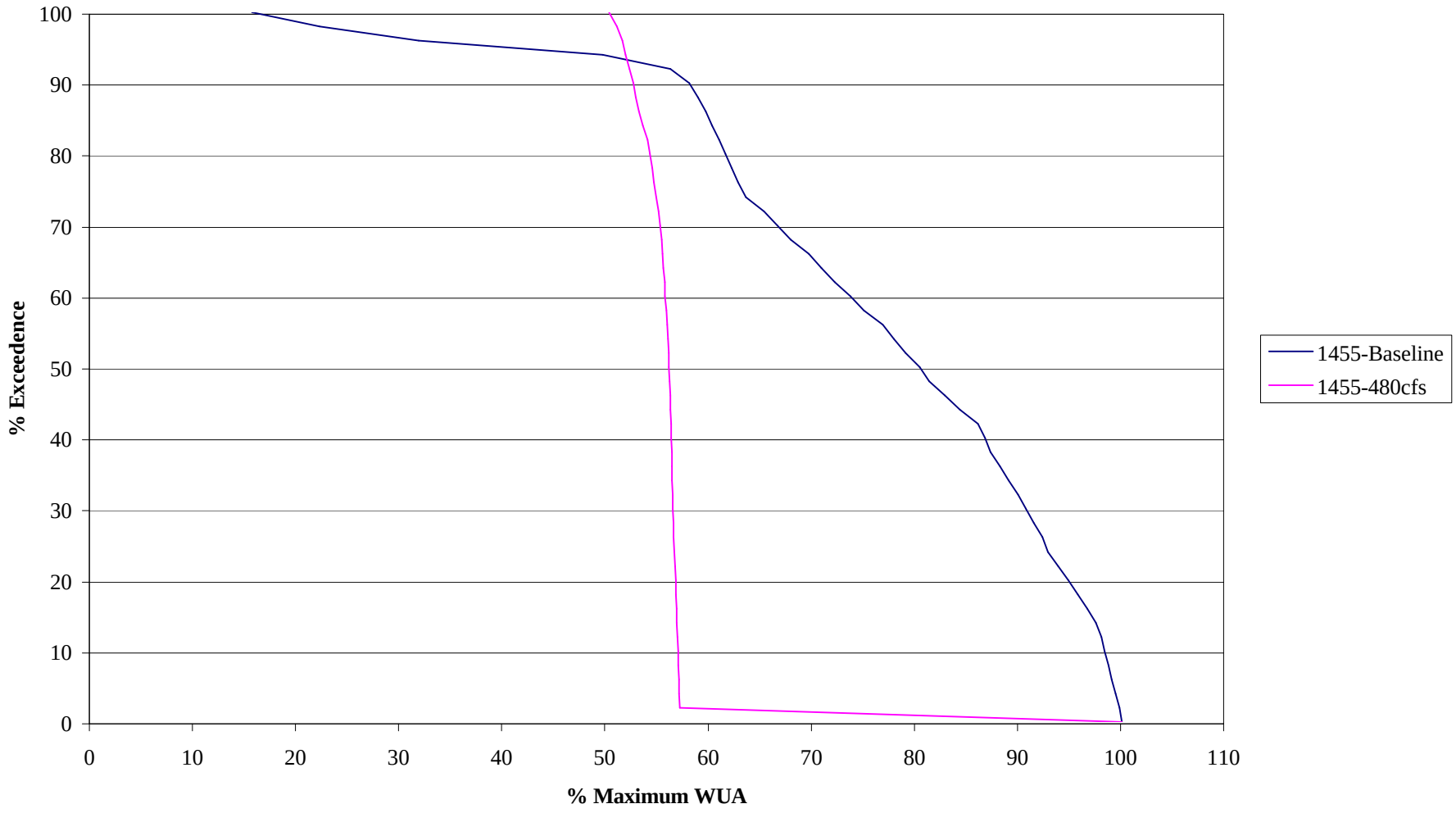

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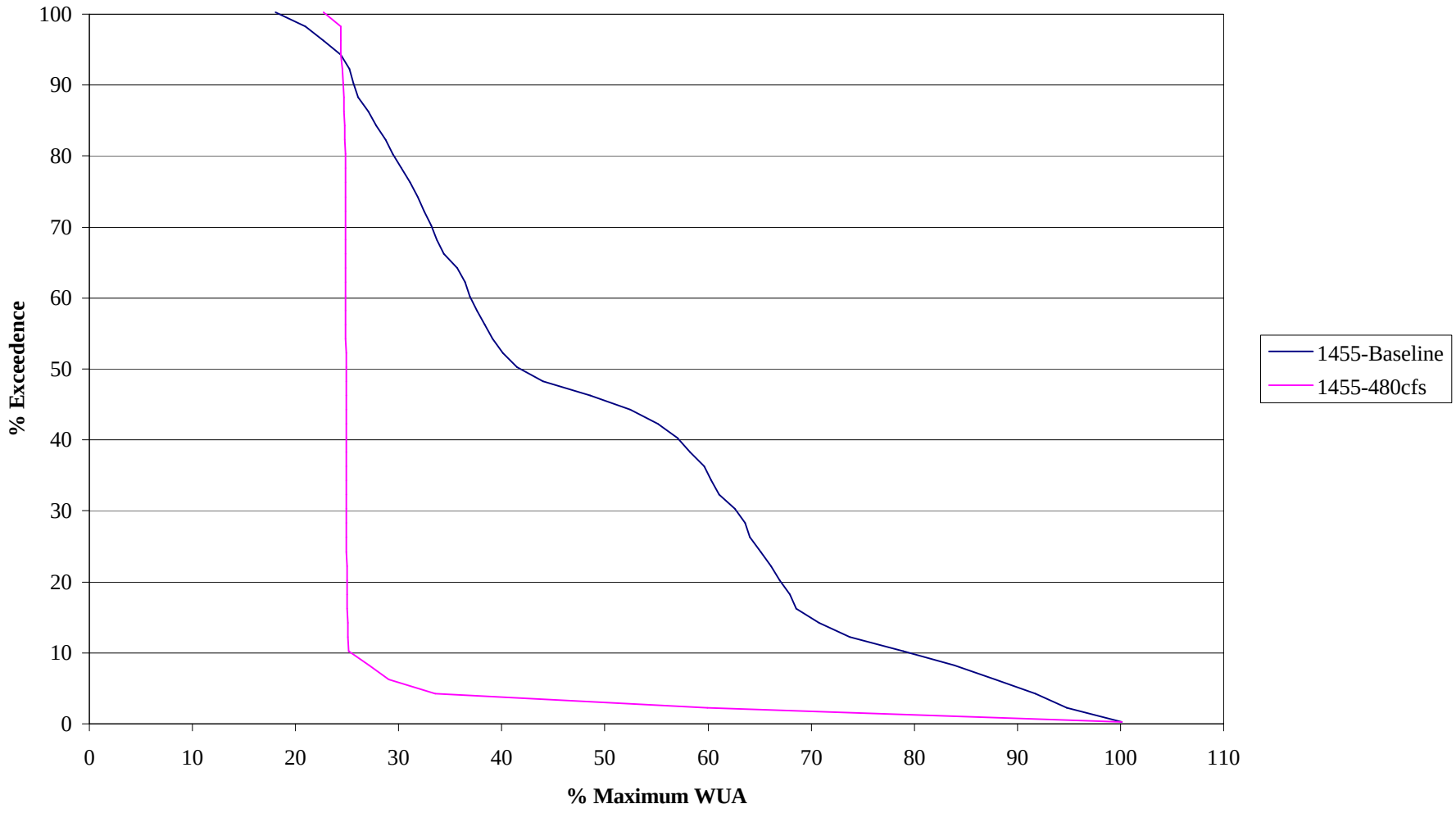

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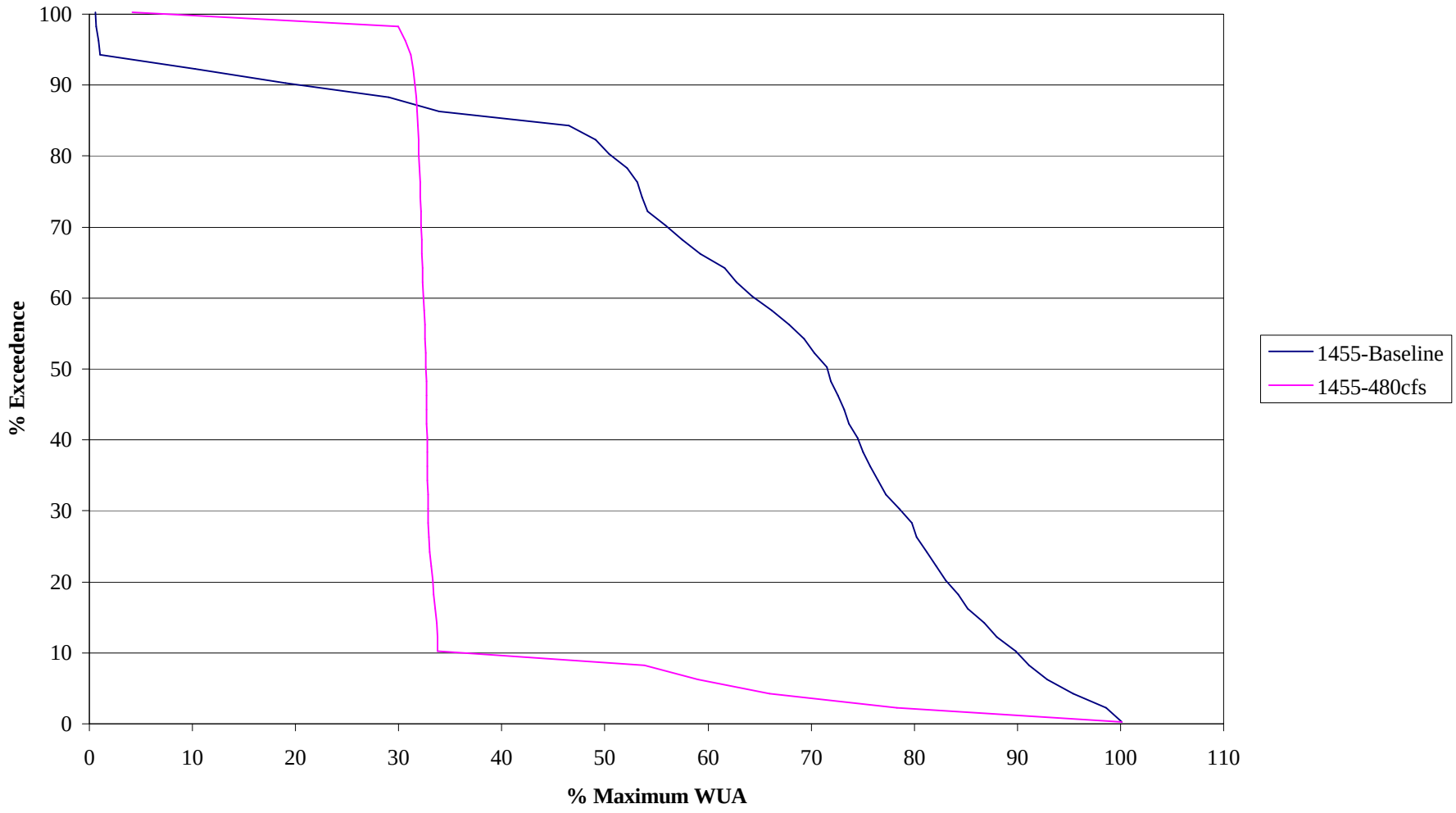

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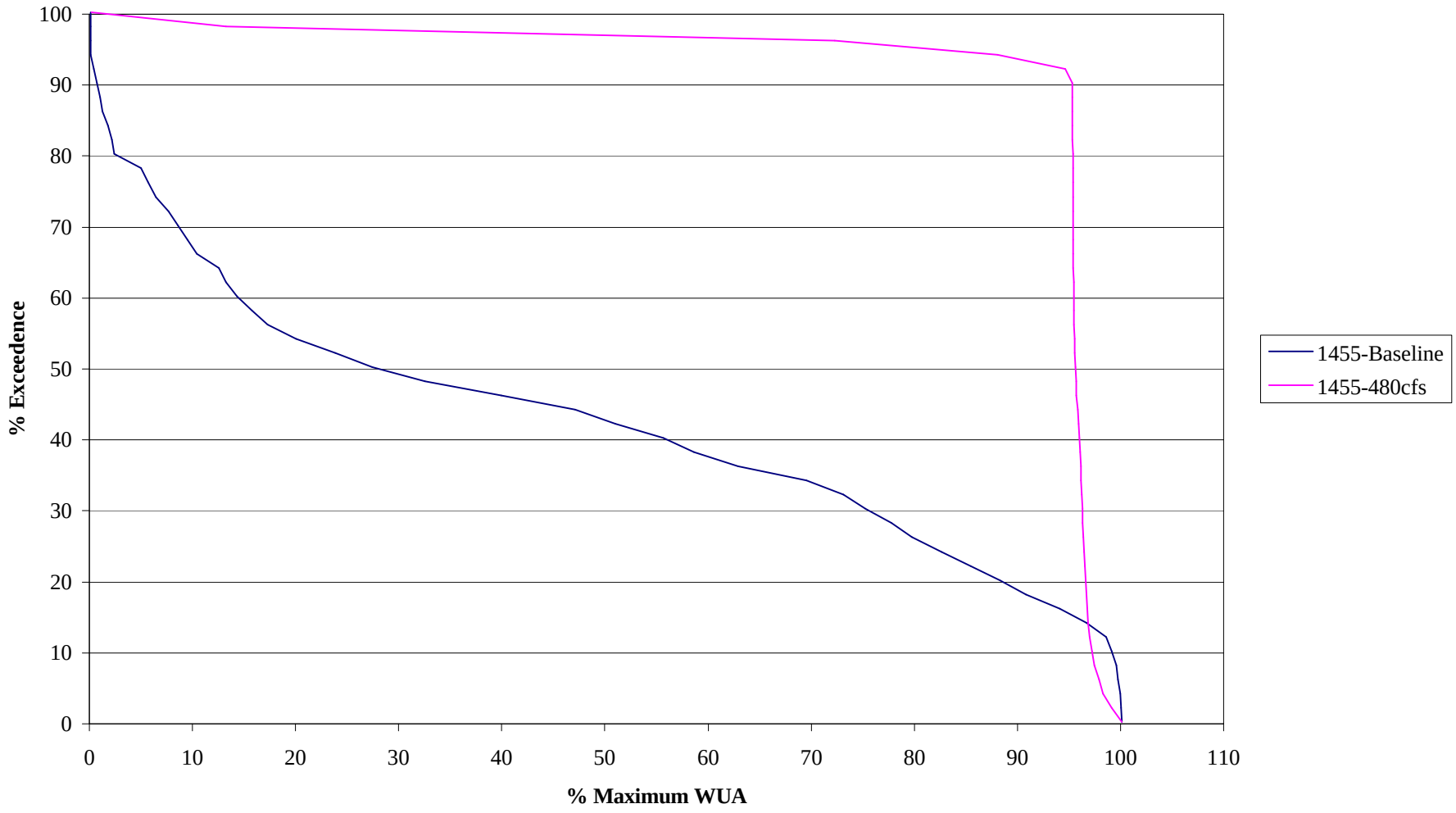

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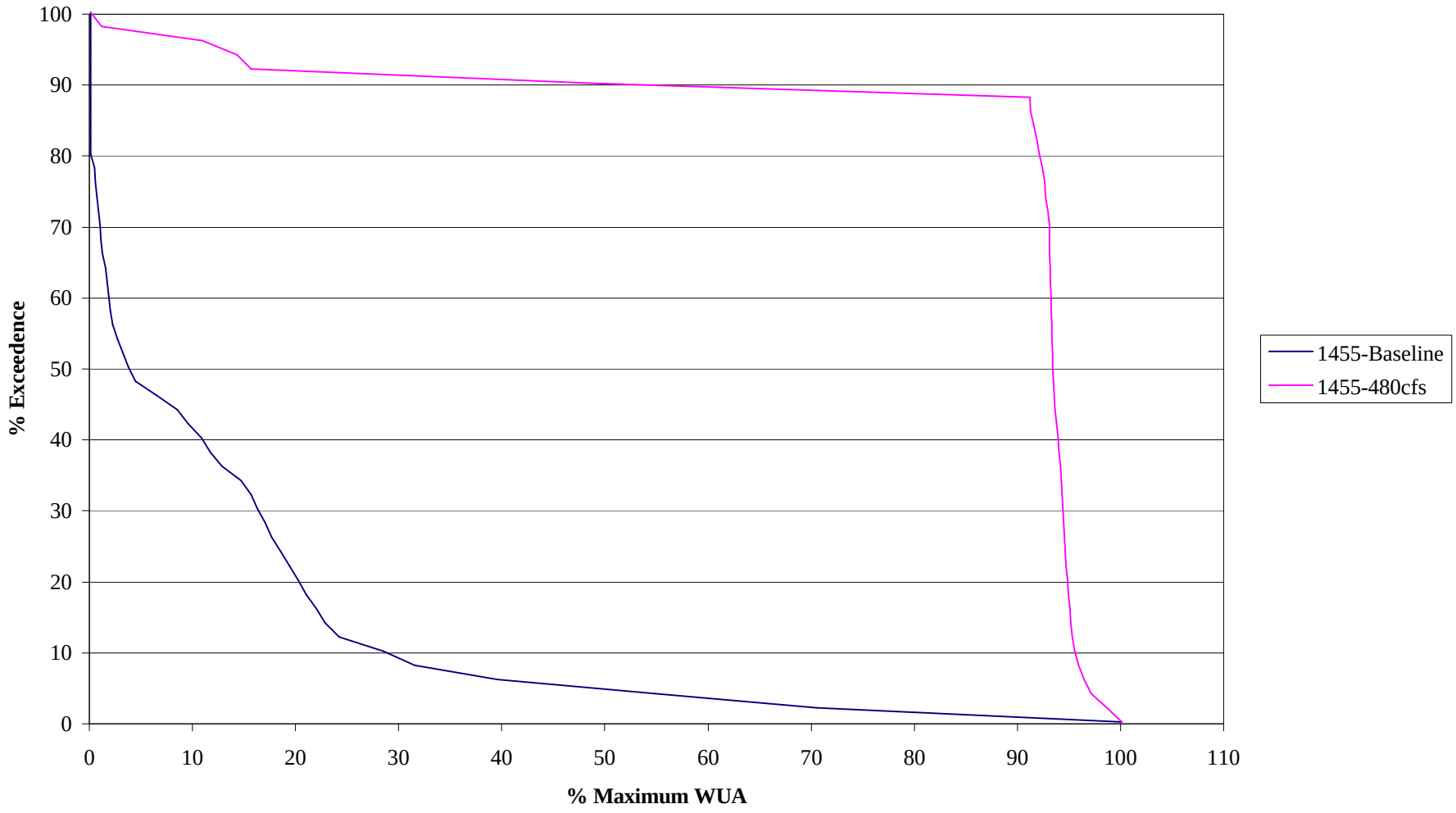

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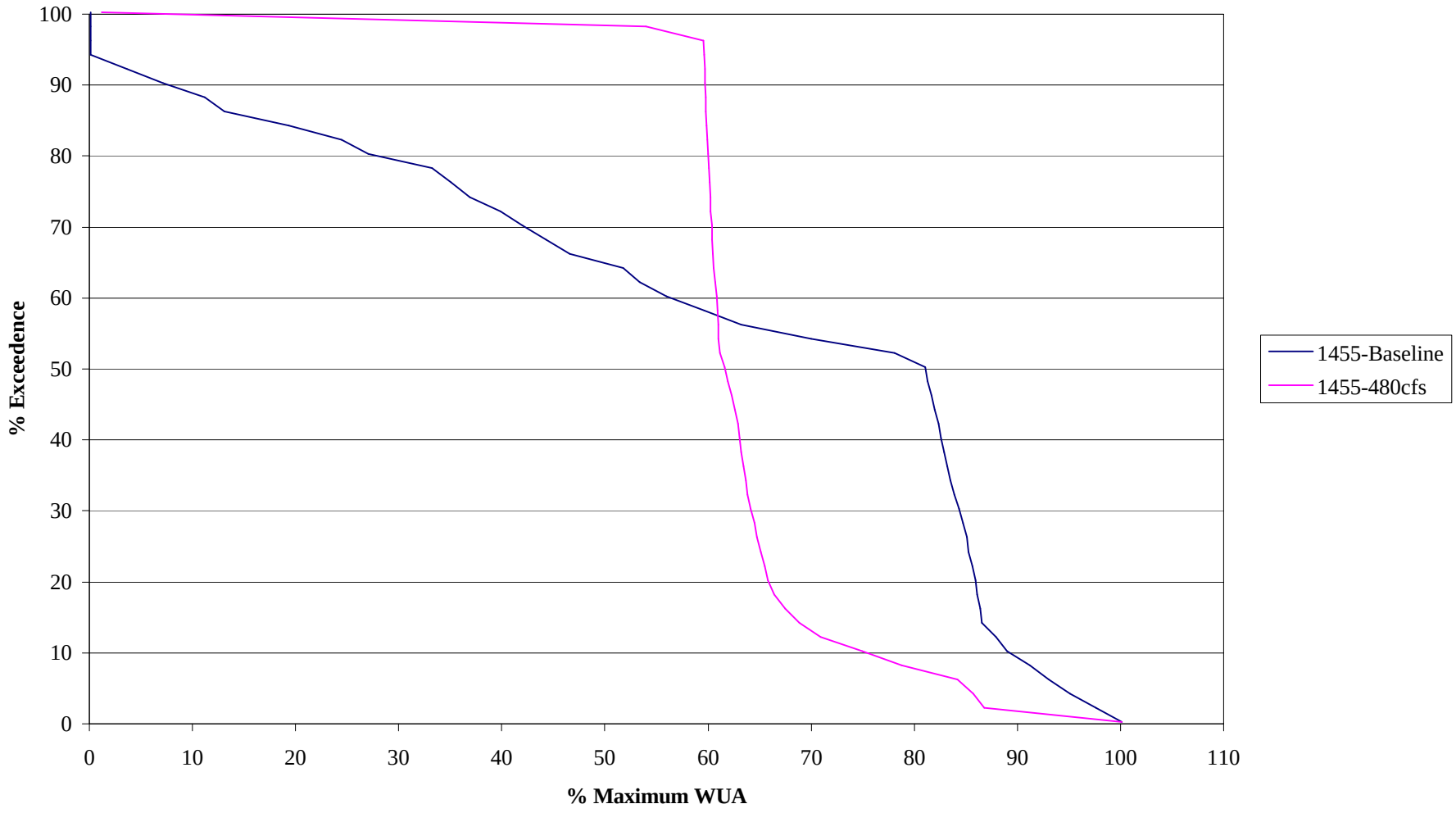

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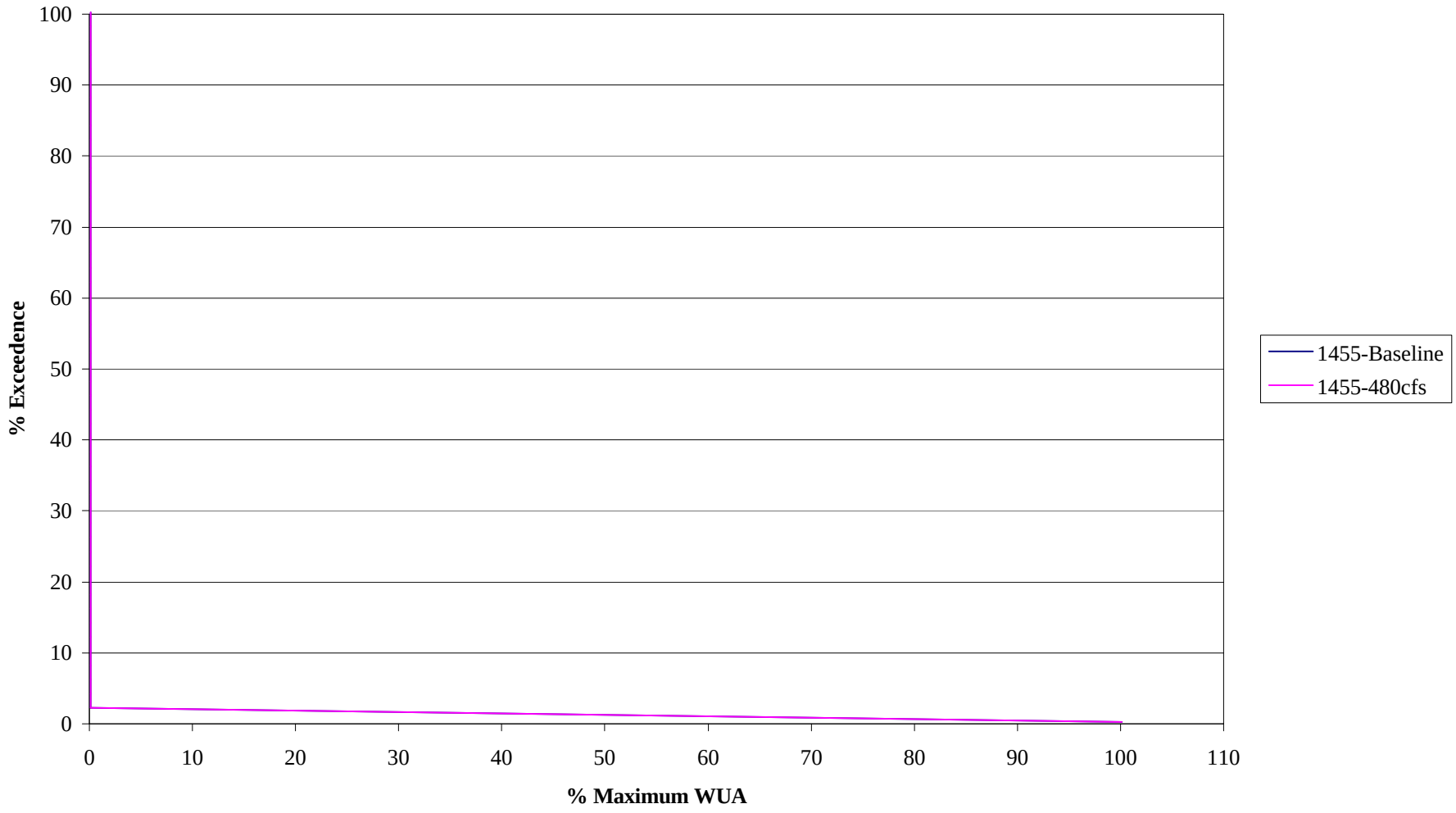

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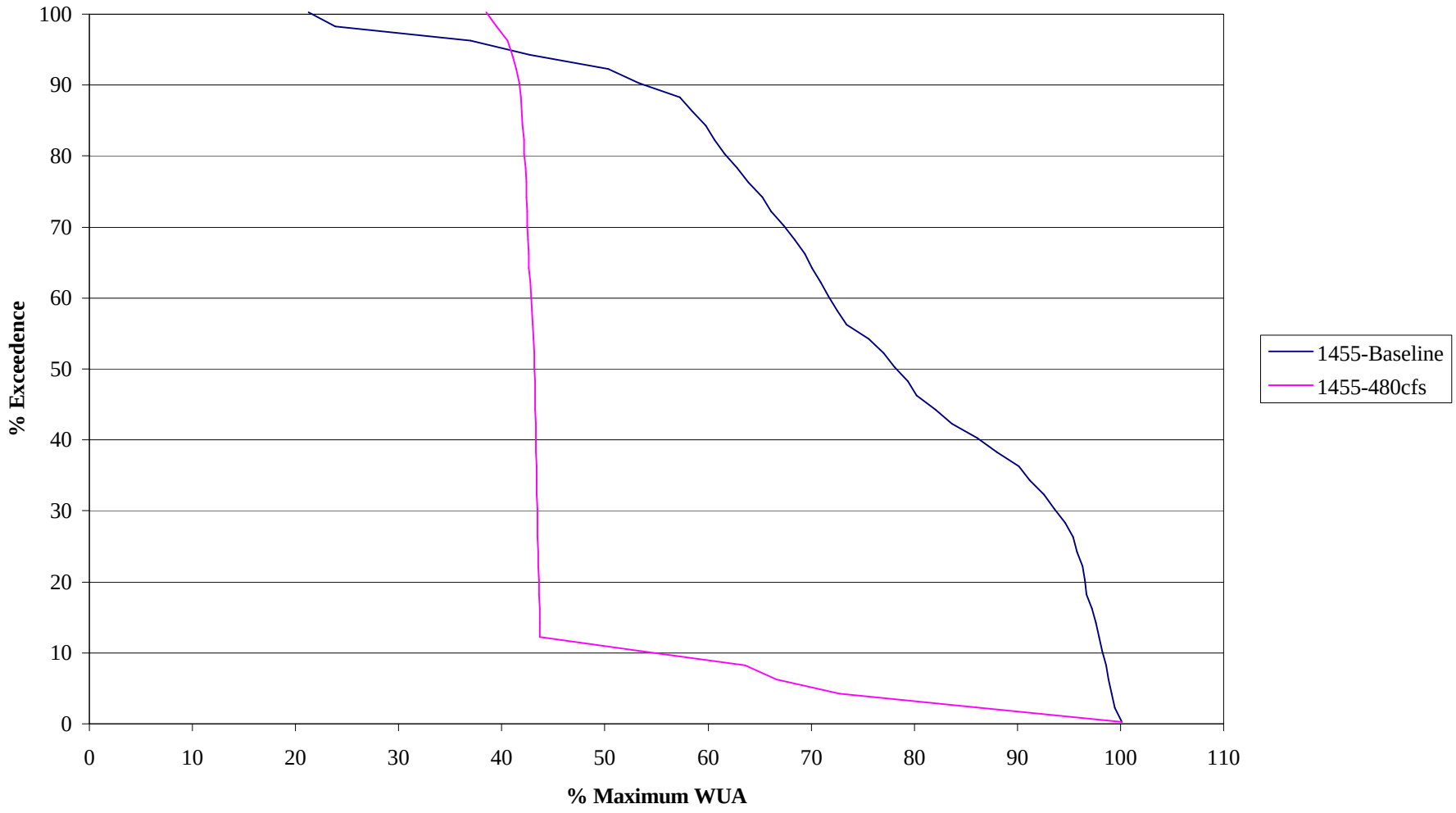

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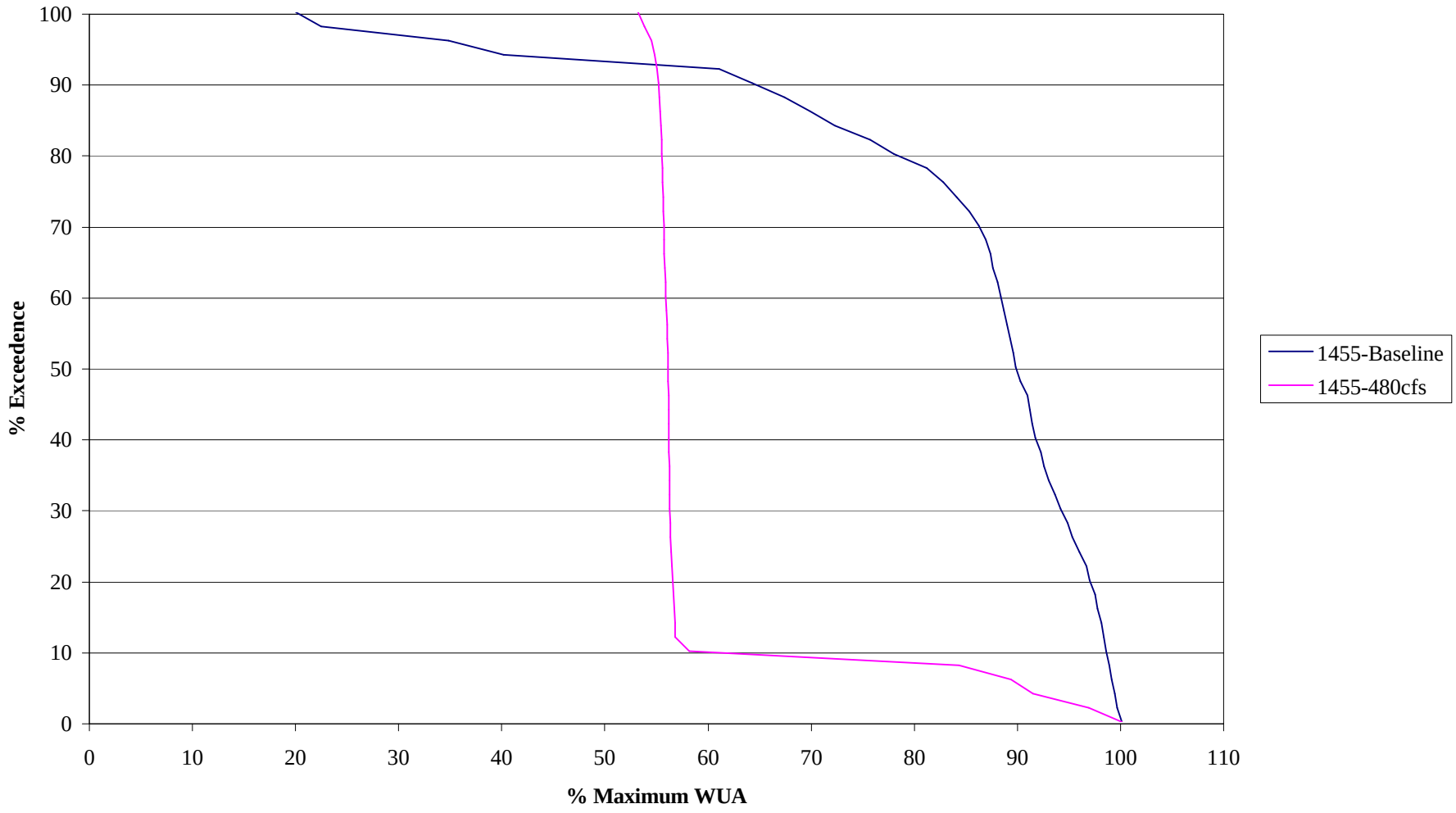

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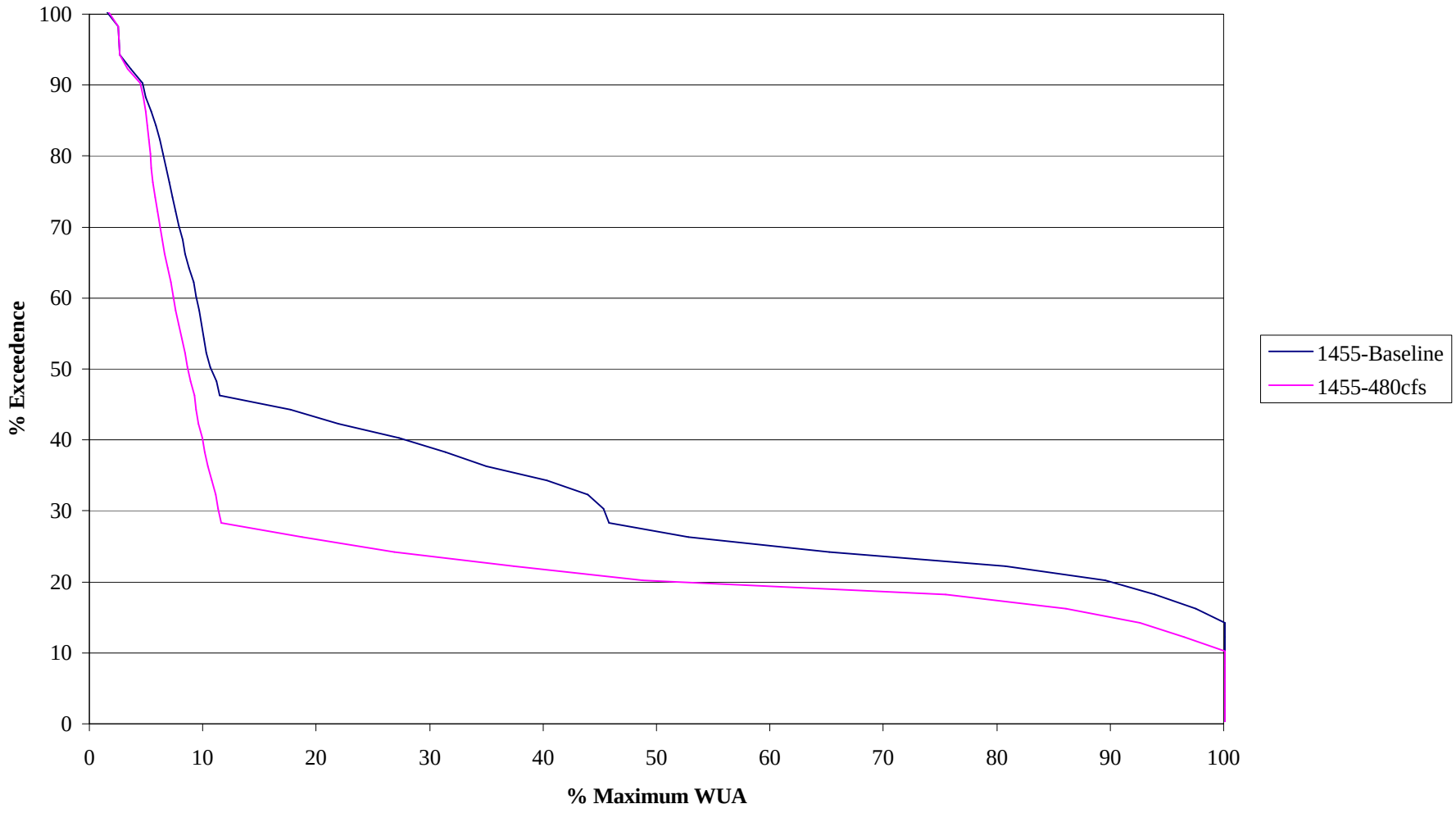

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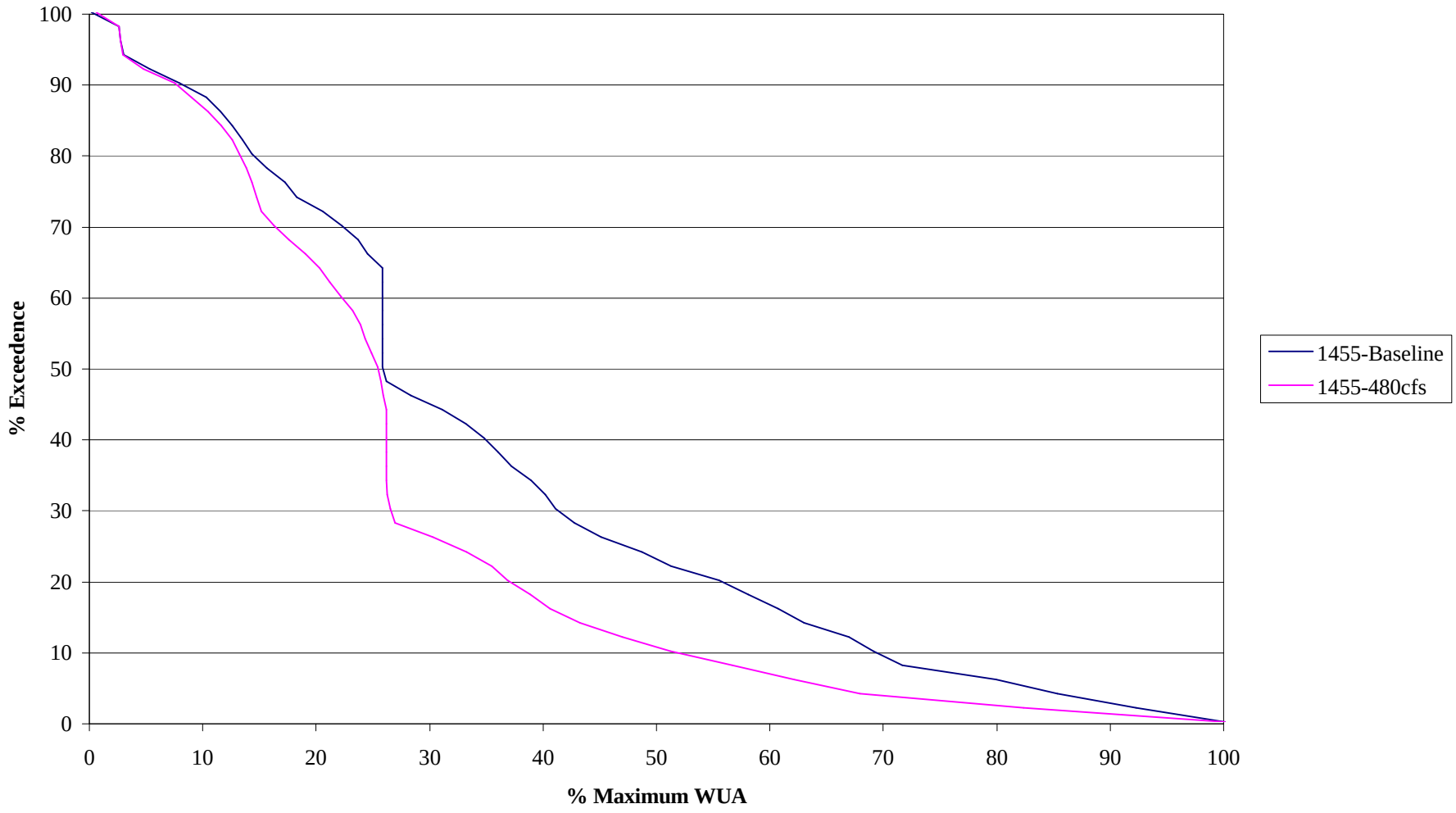

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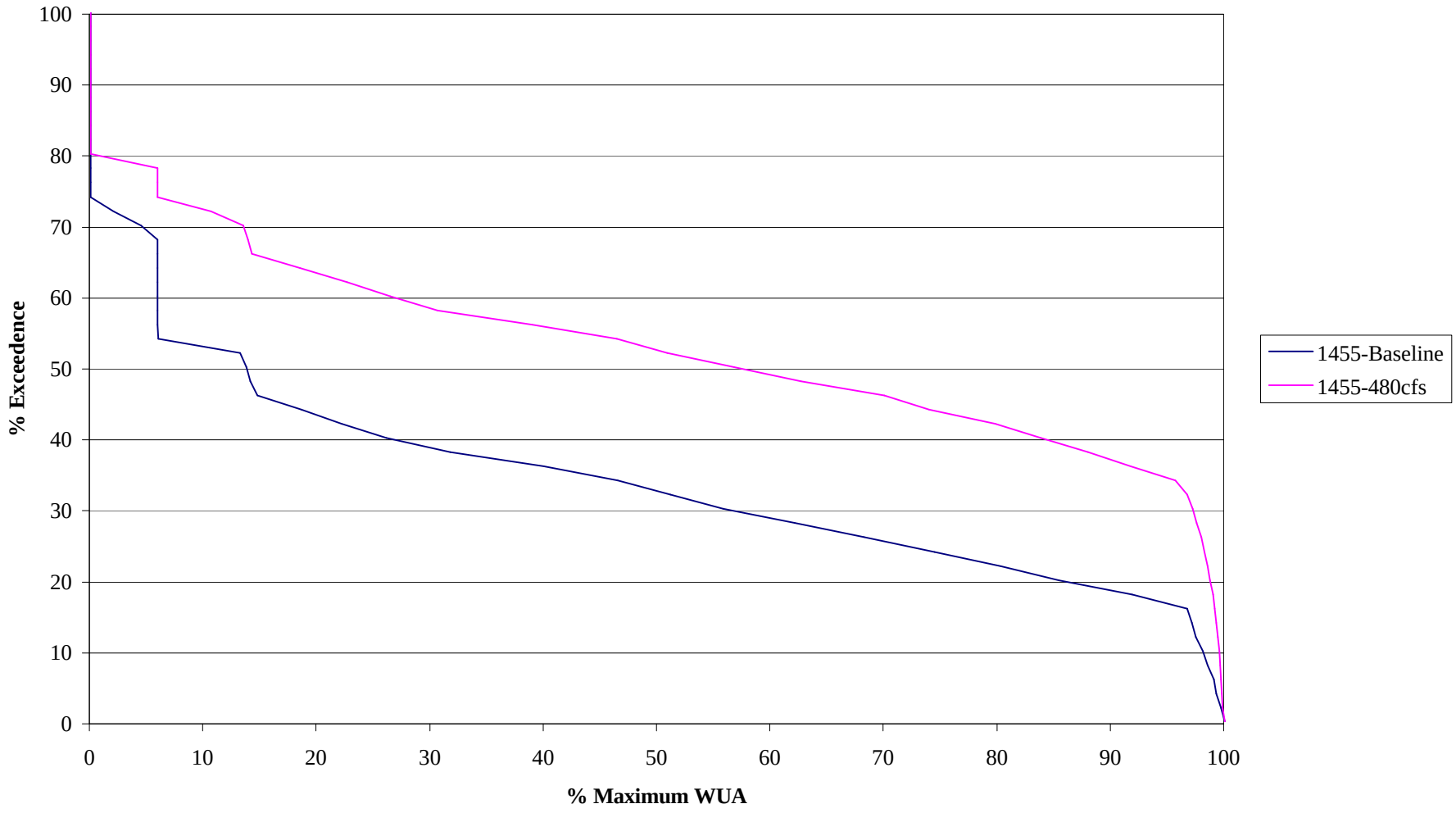

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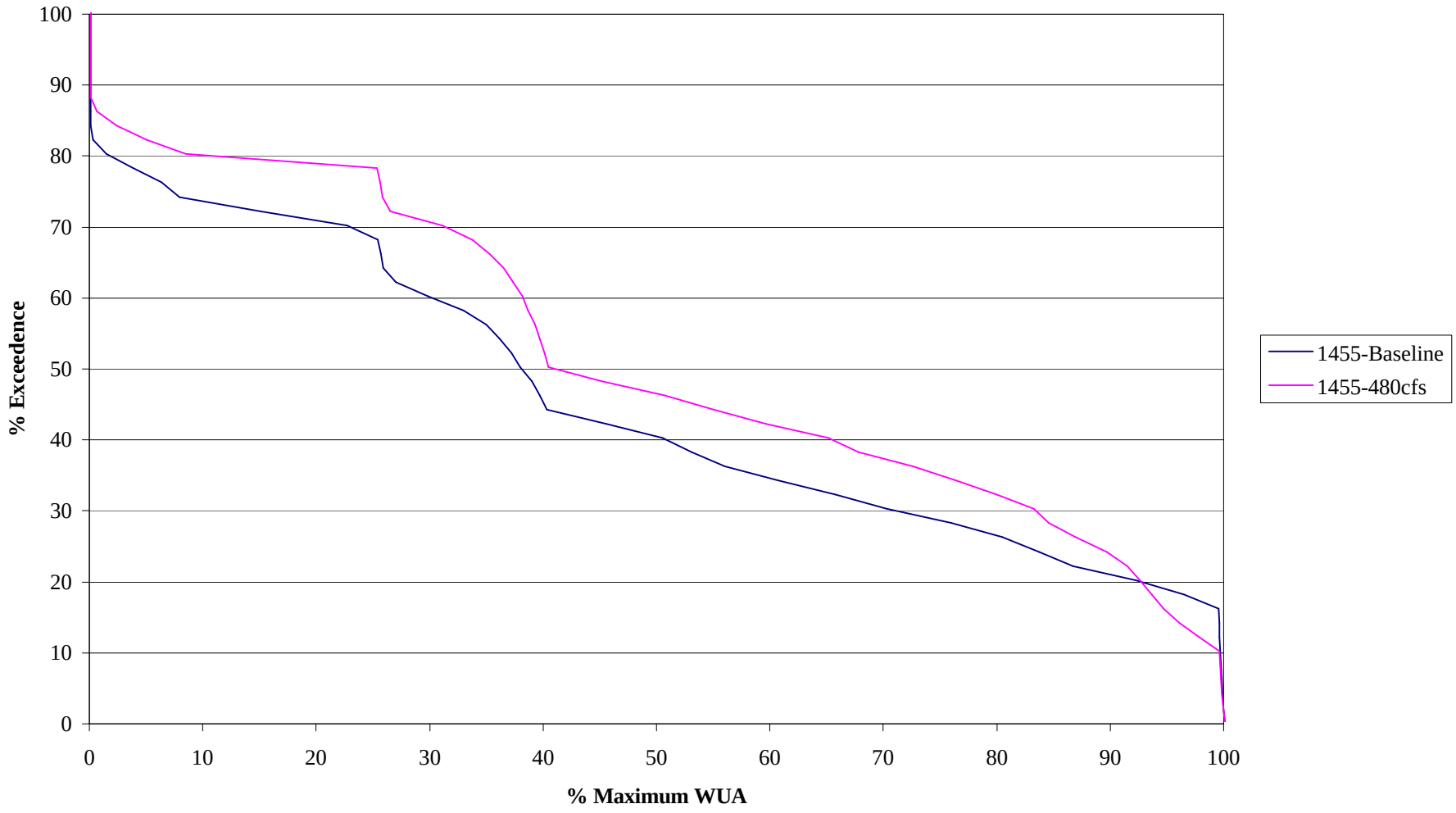

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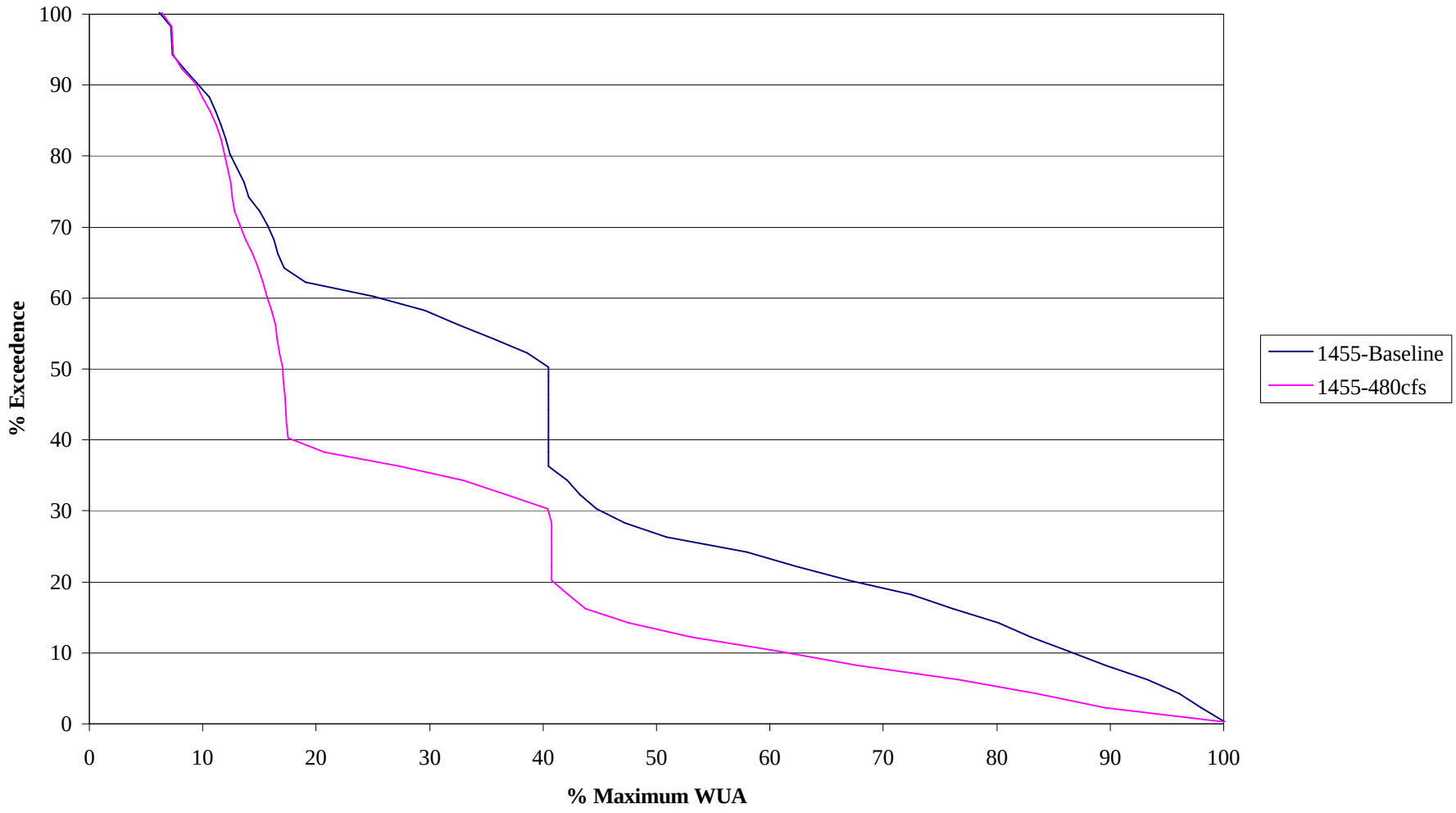

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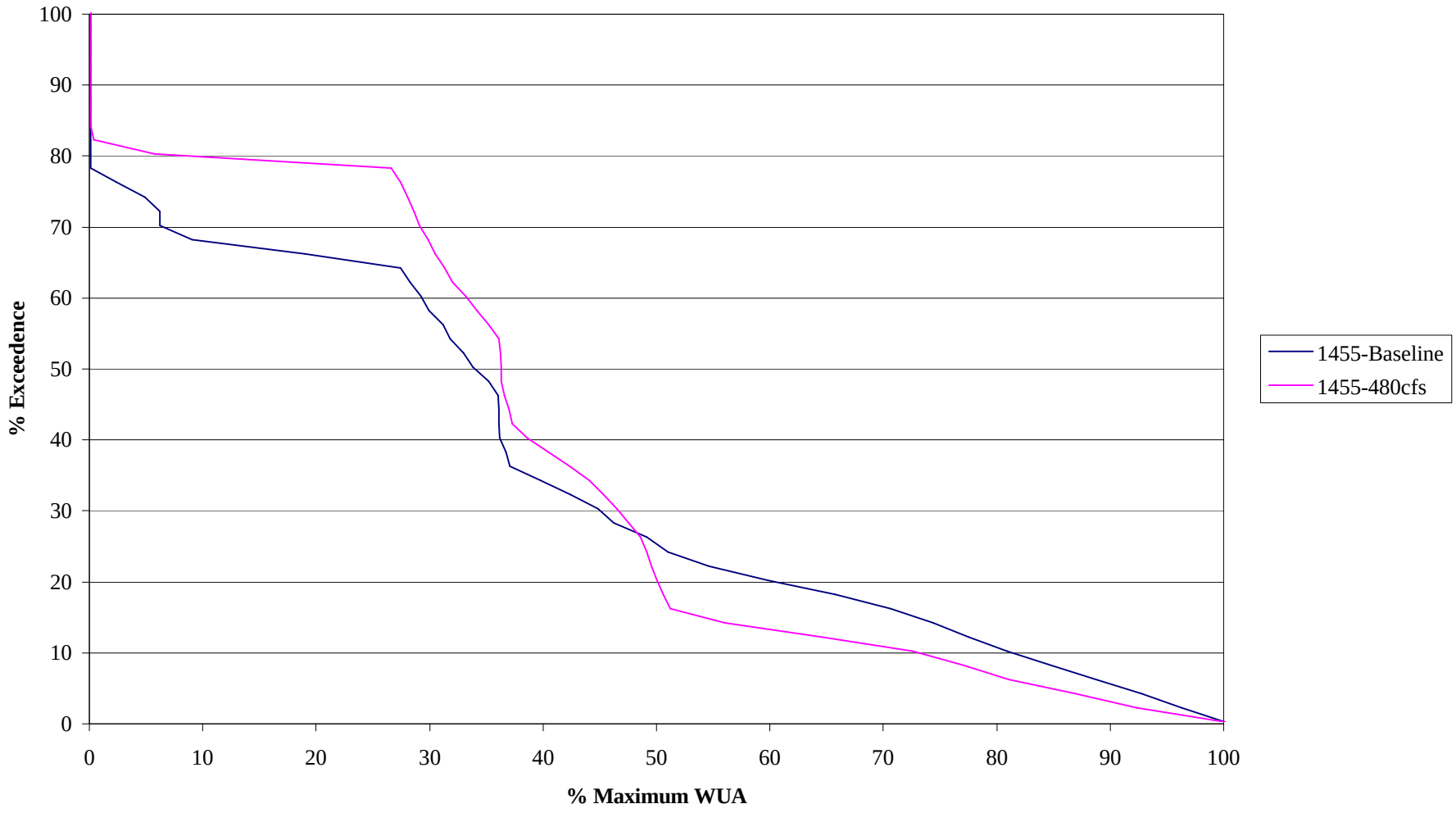
Final Aquatic Impact Analysis Report



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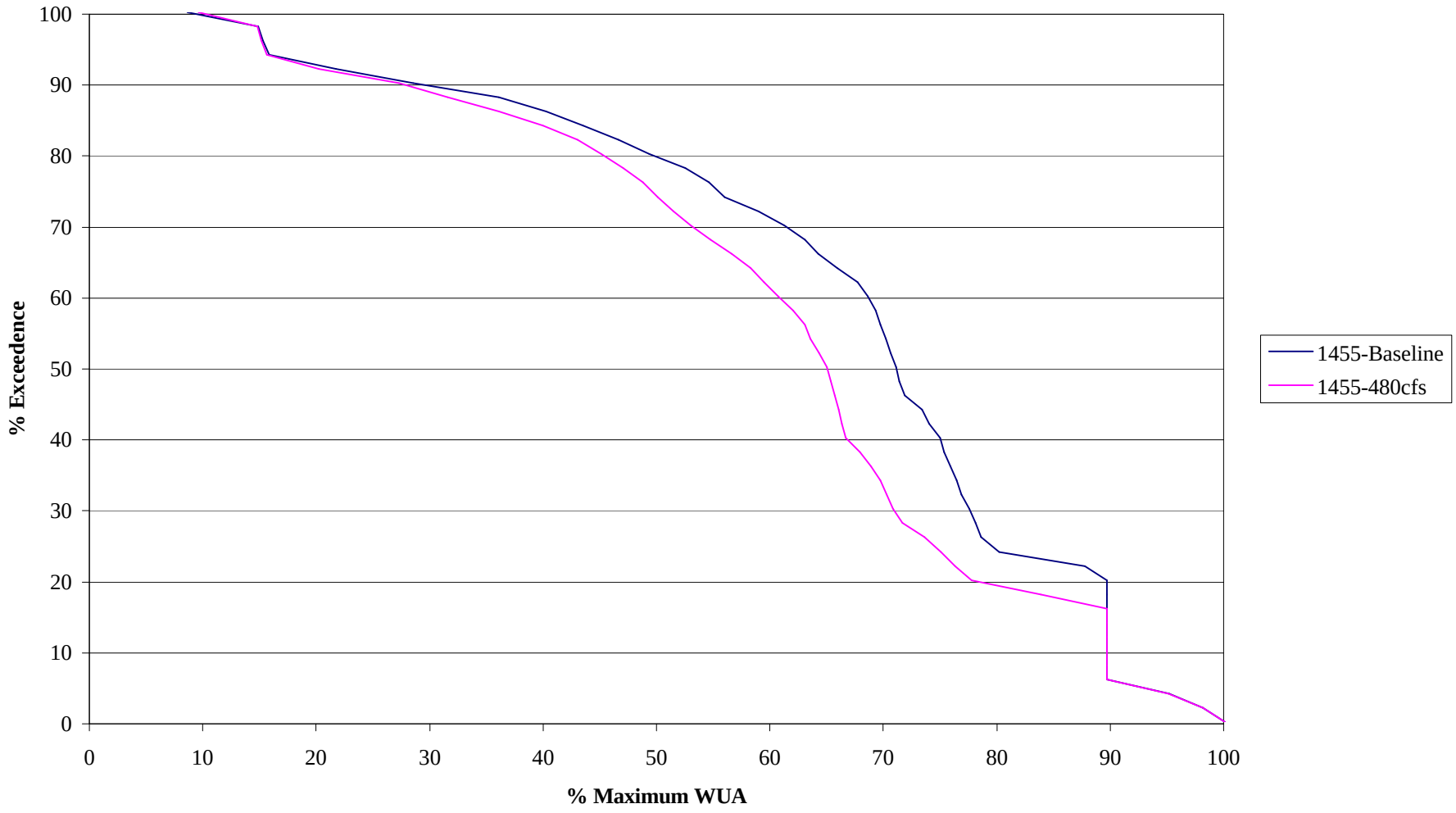

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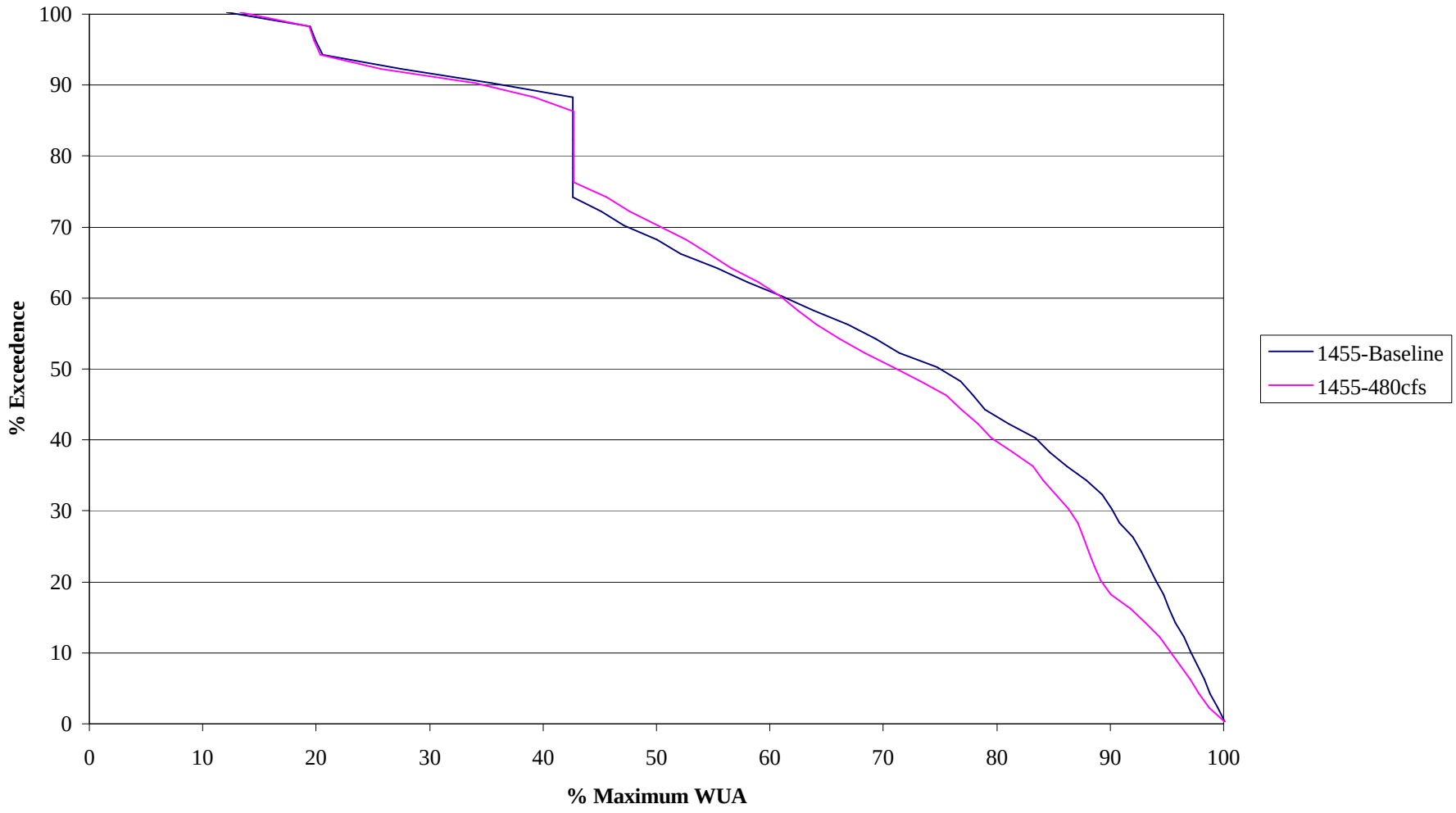

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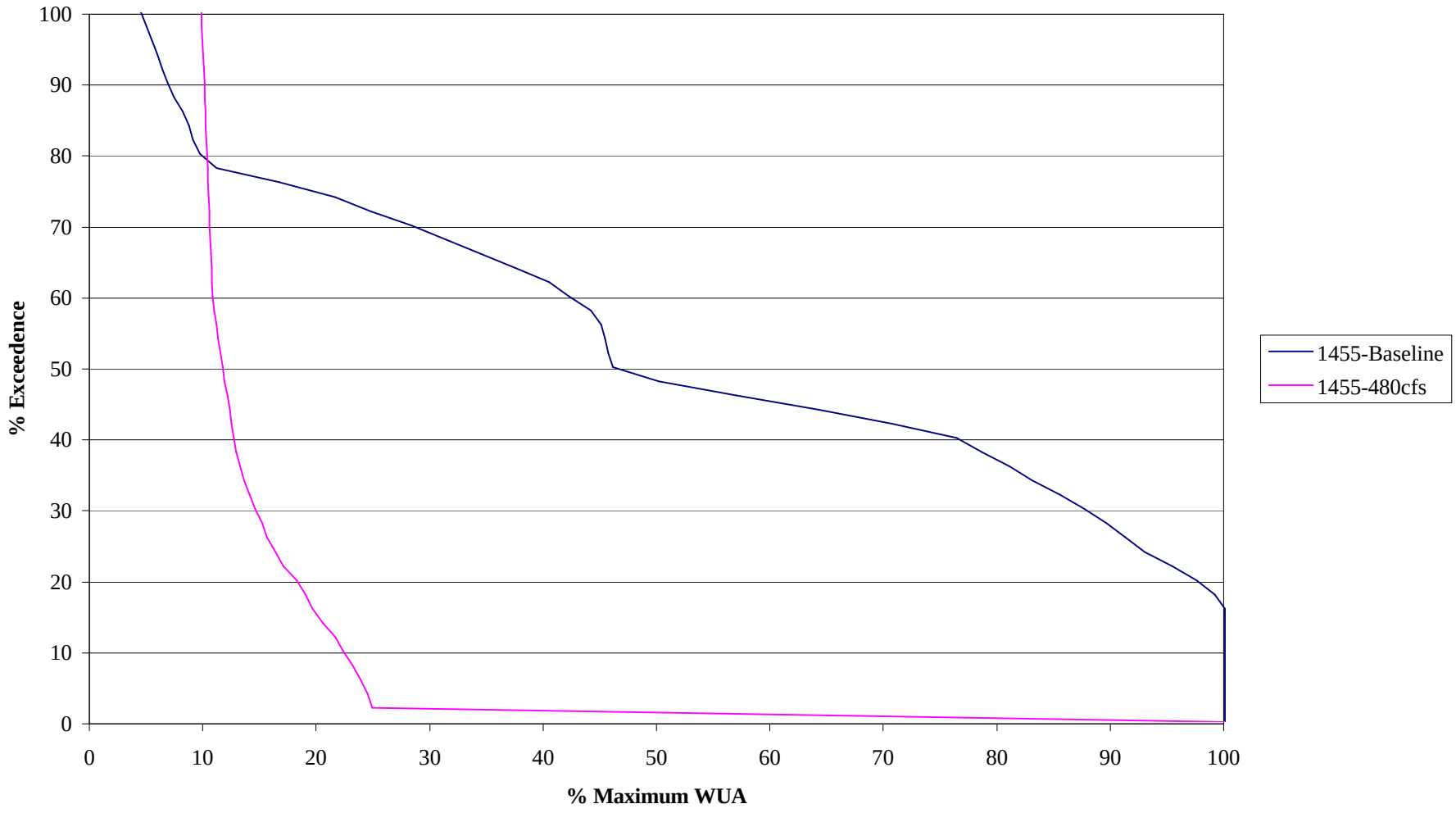

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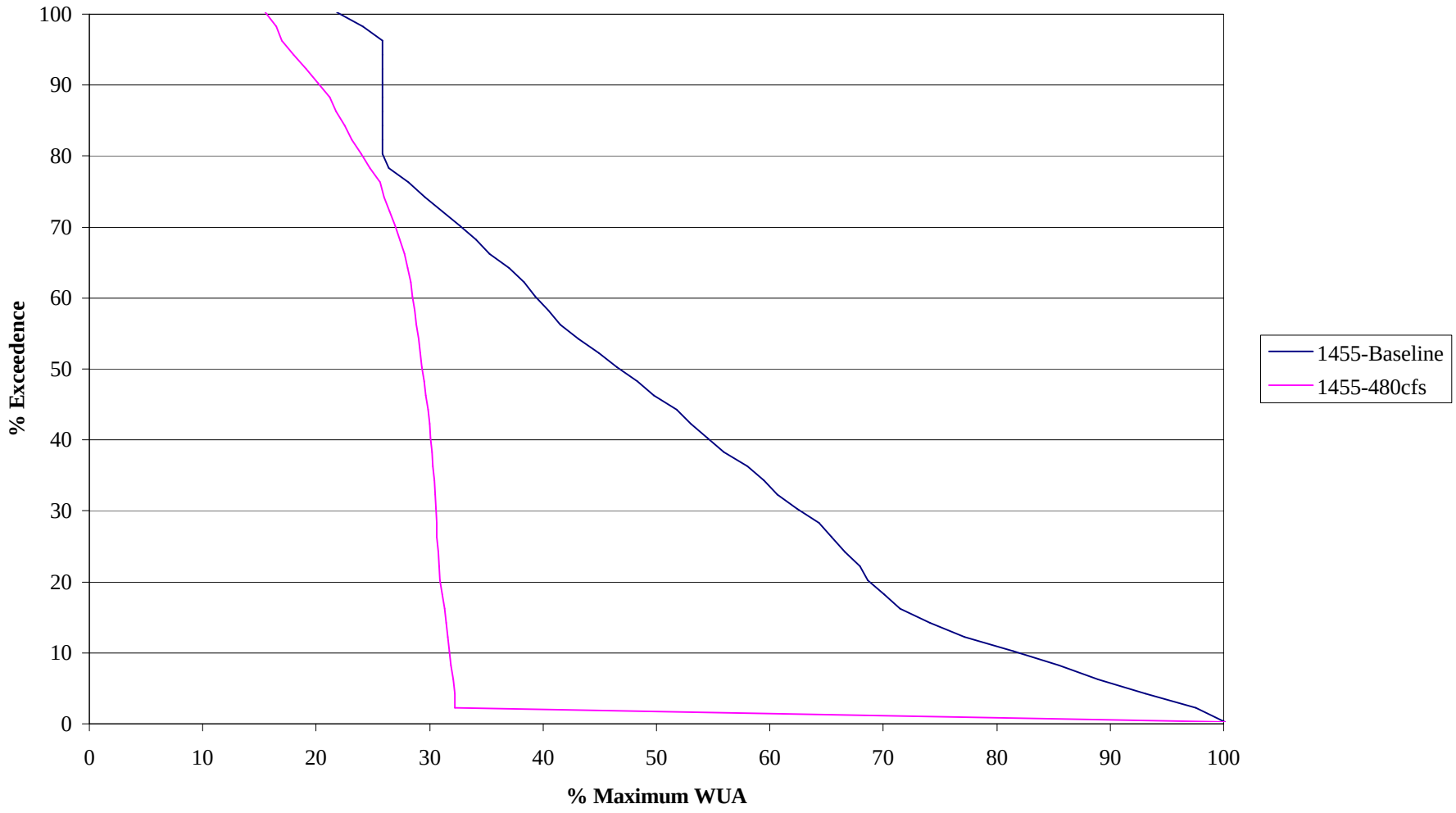

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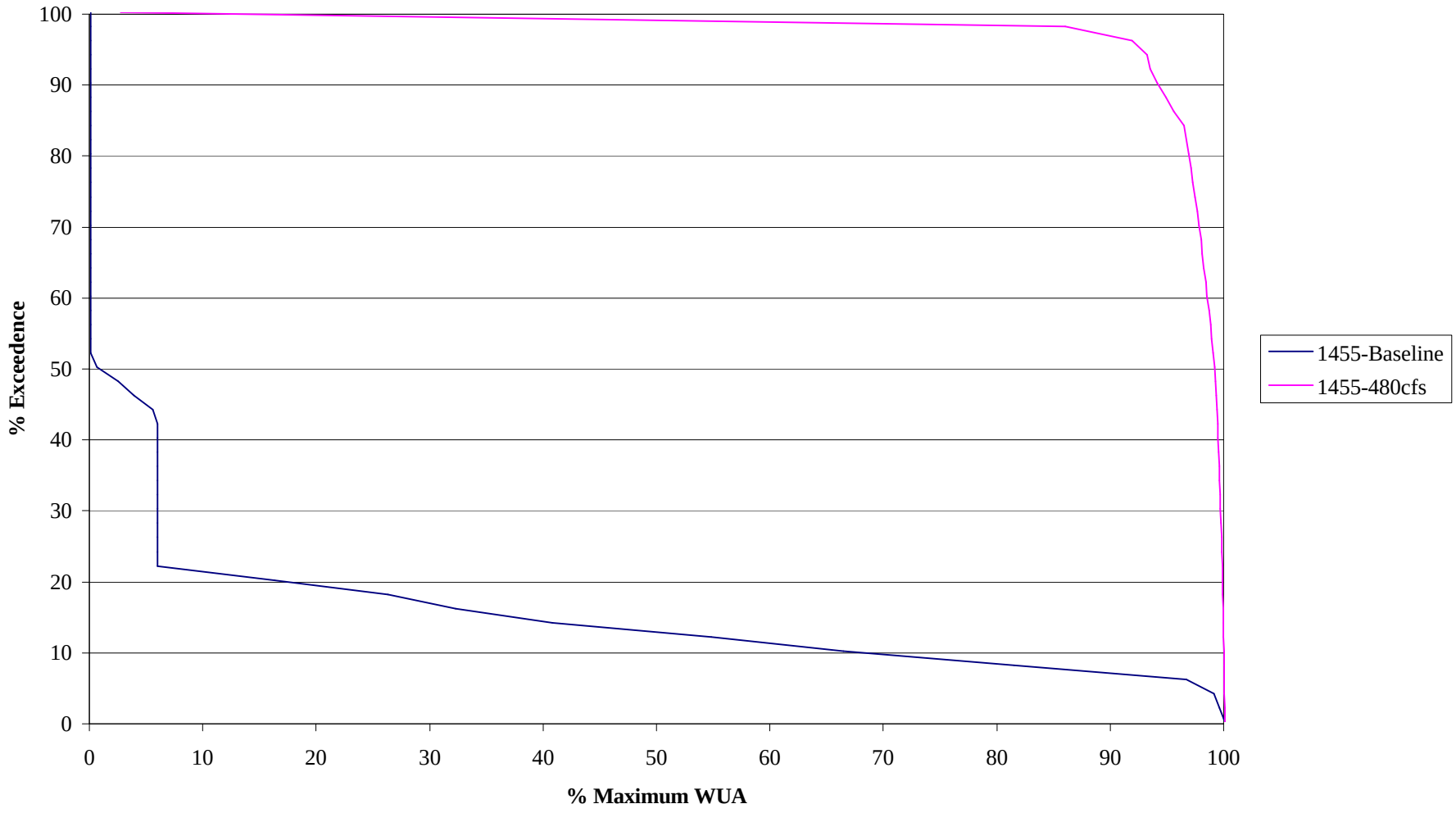

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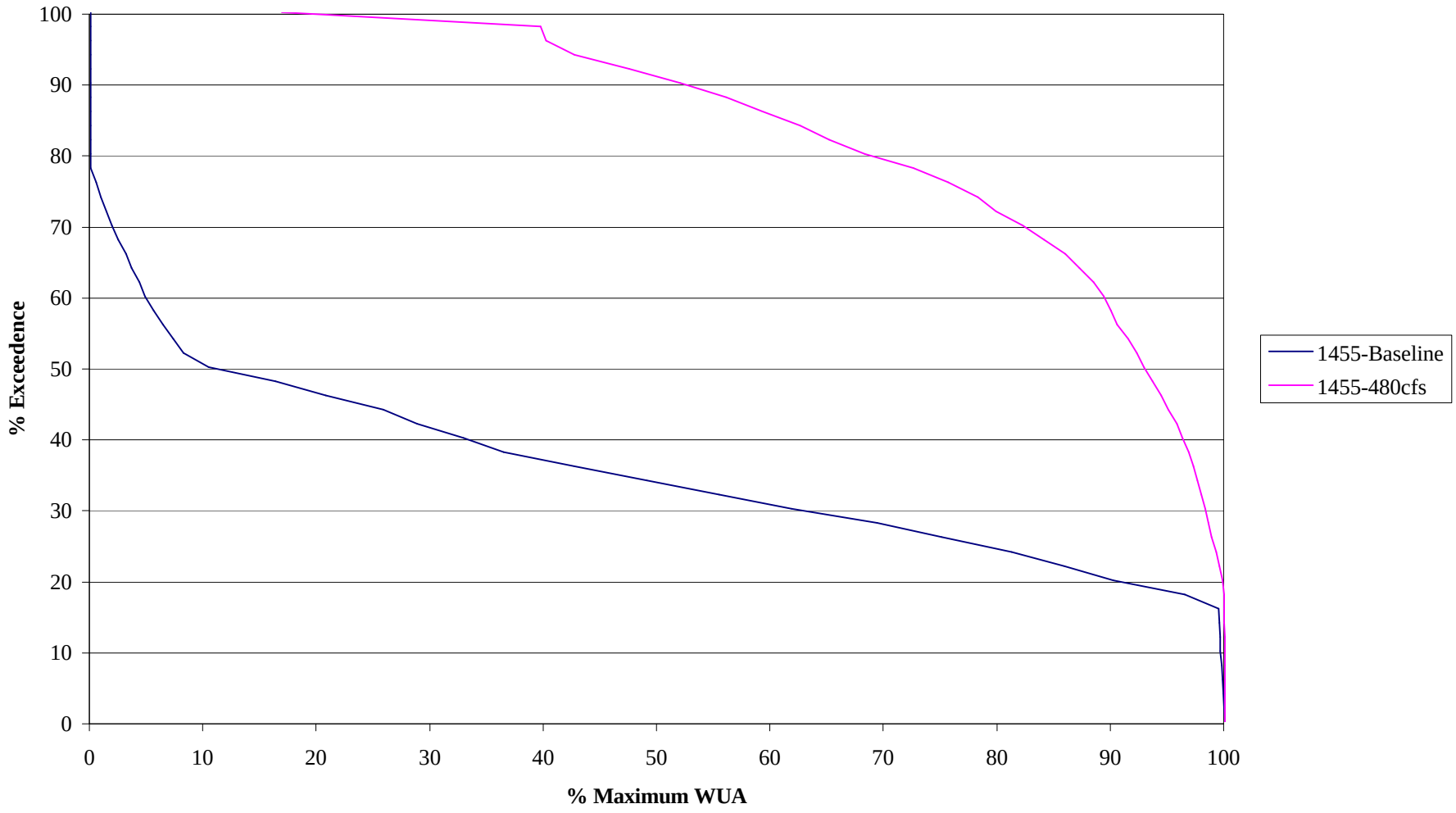

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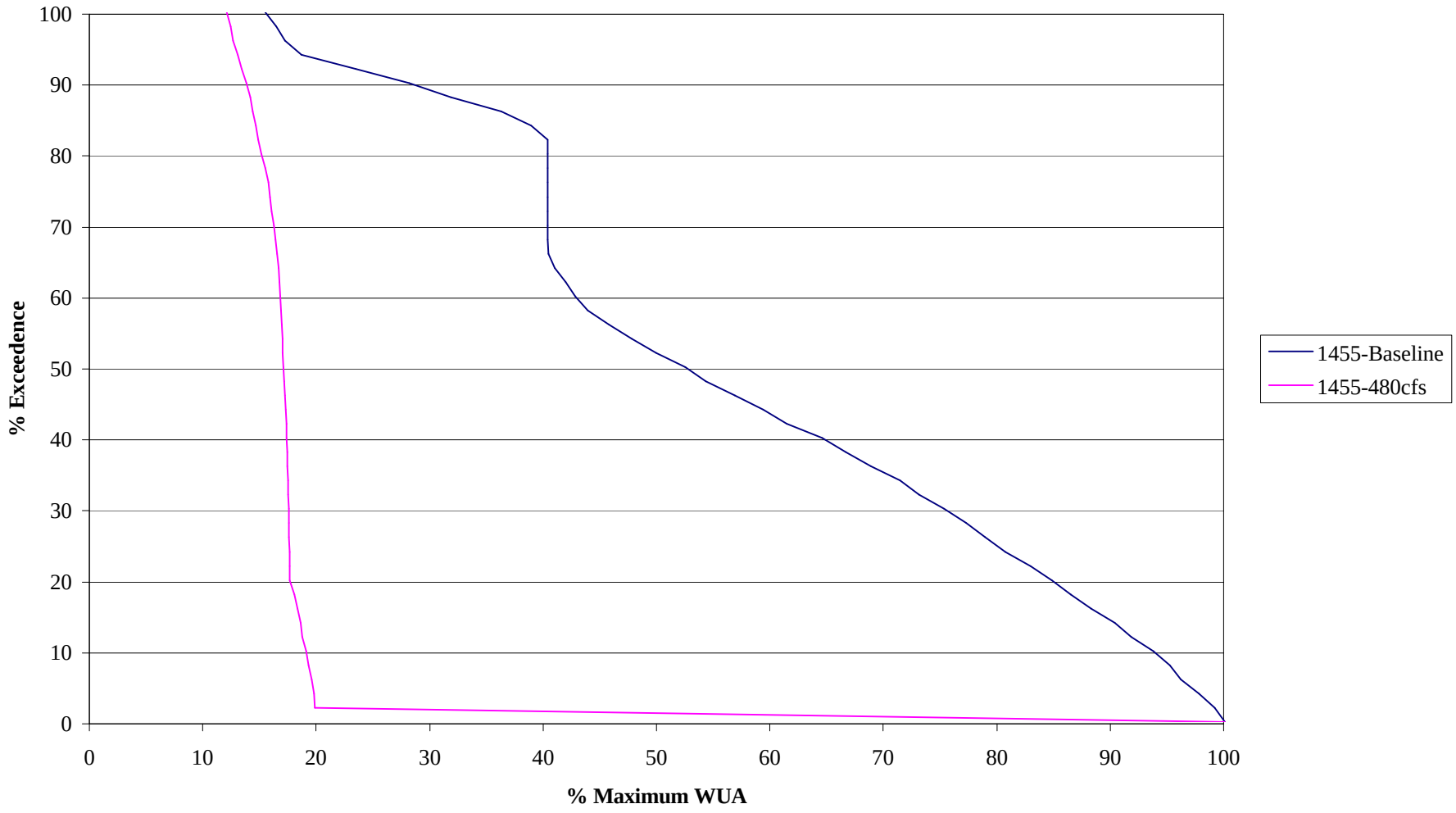

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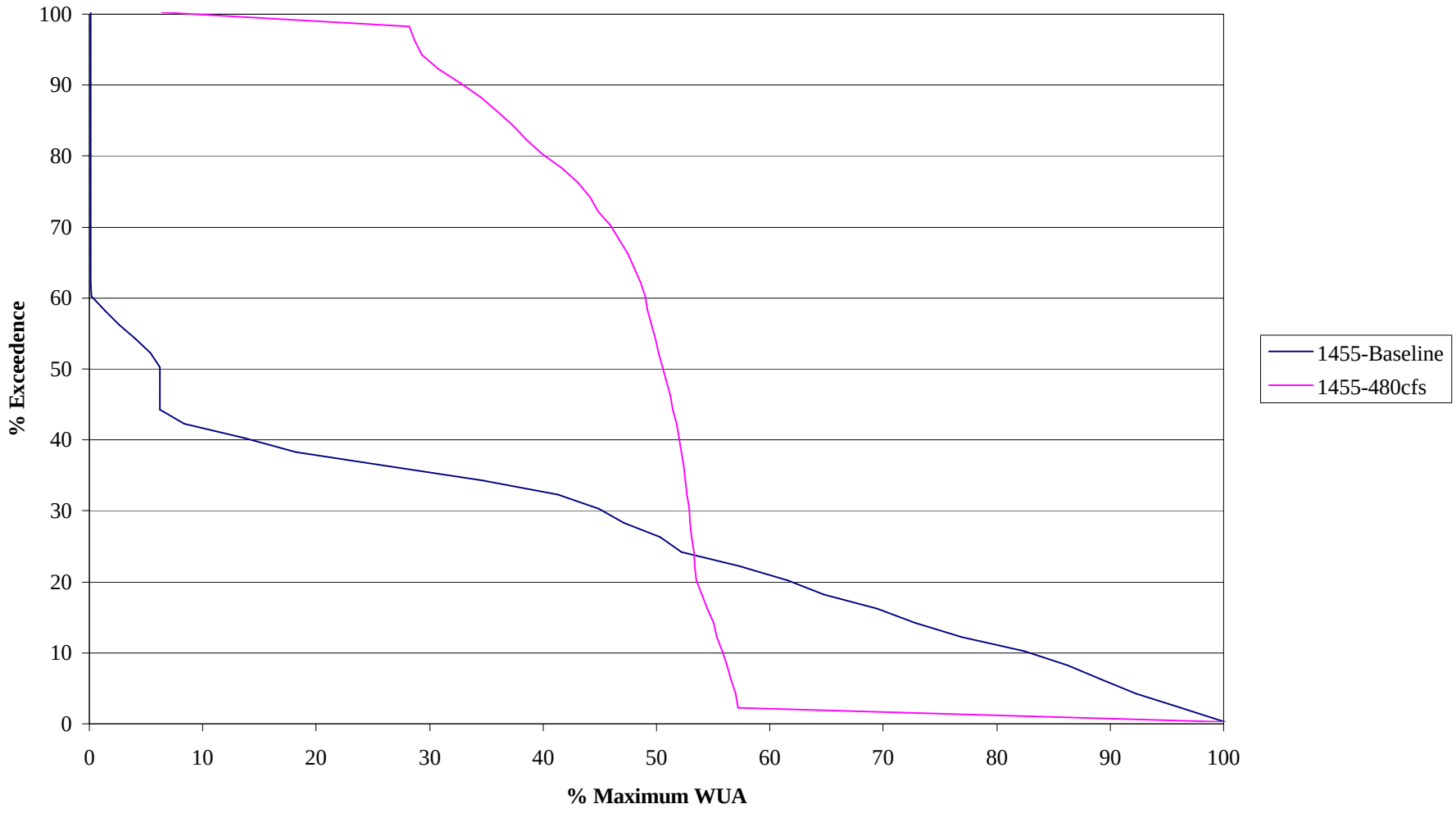

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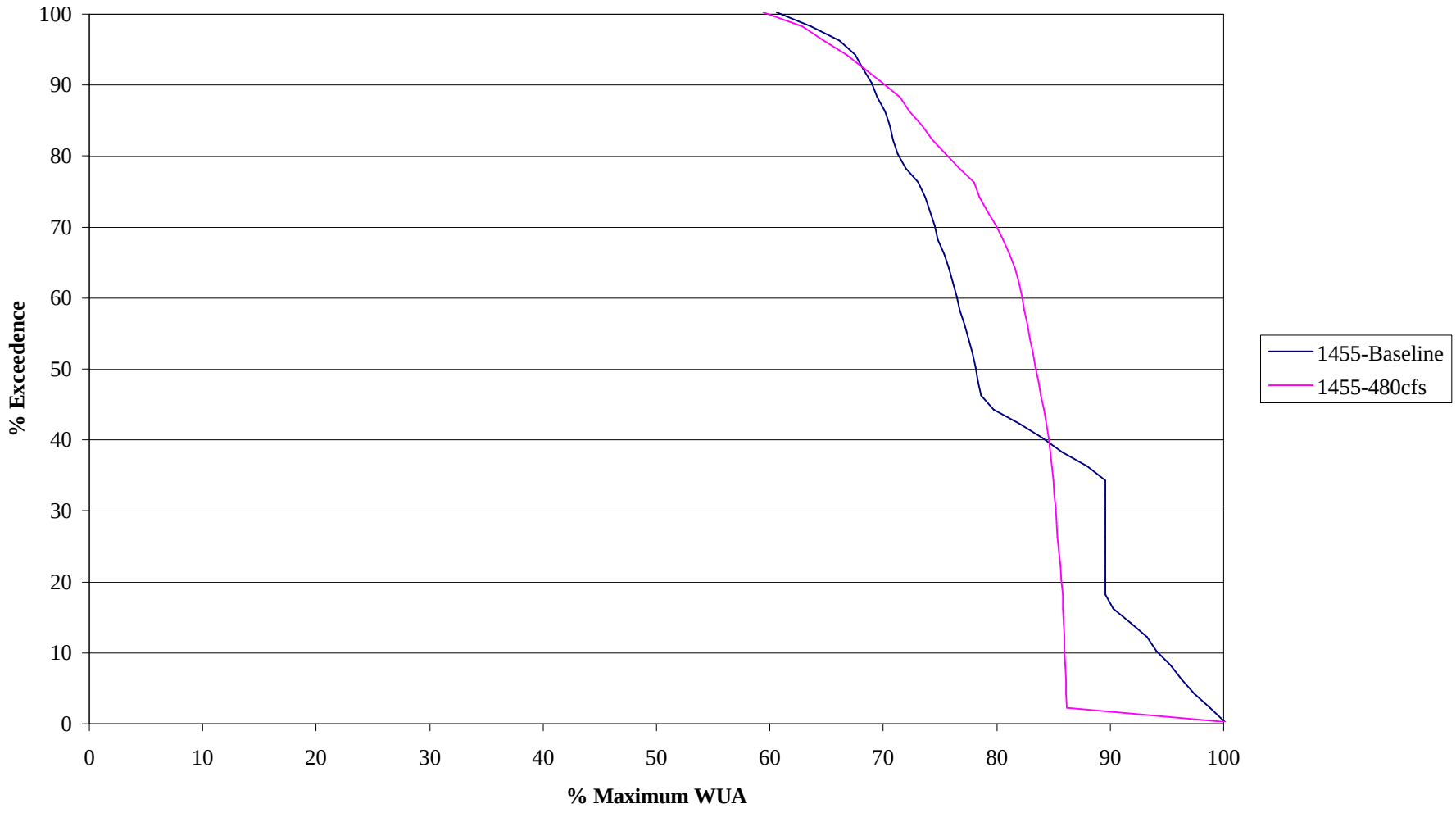

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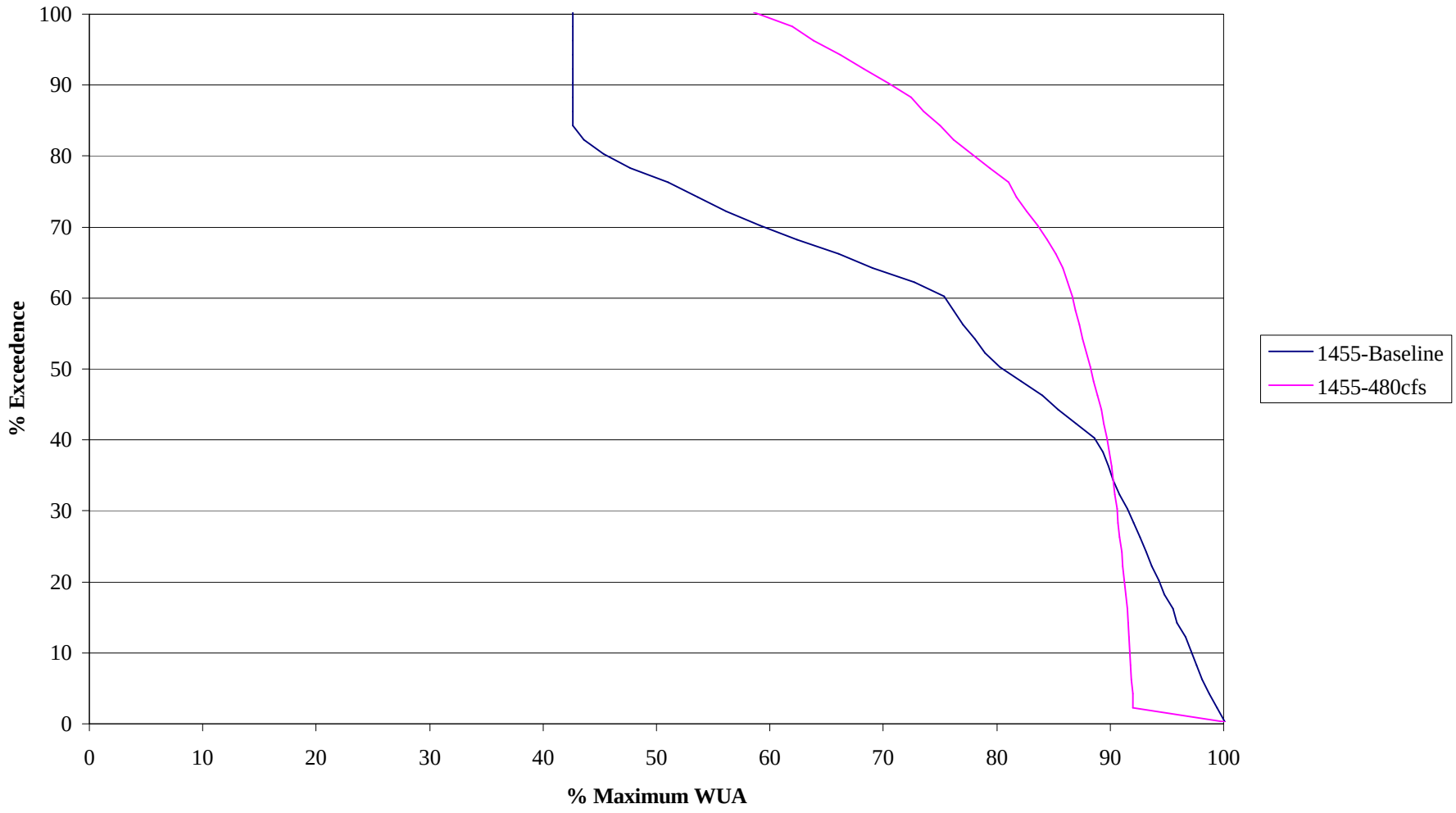

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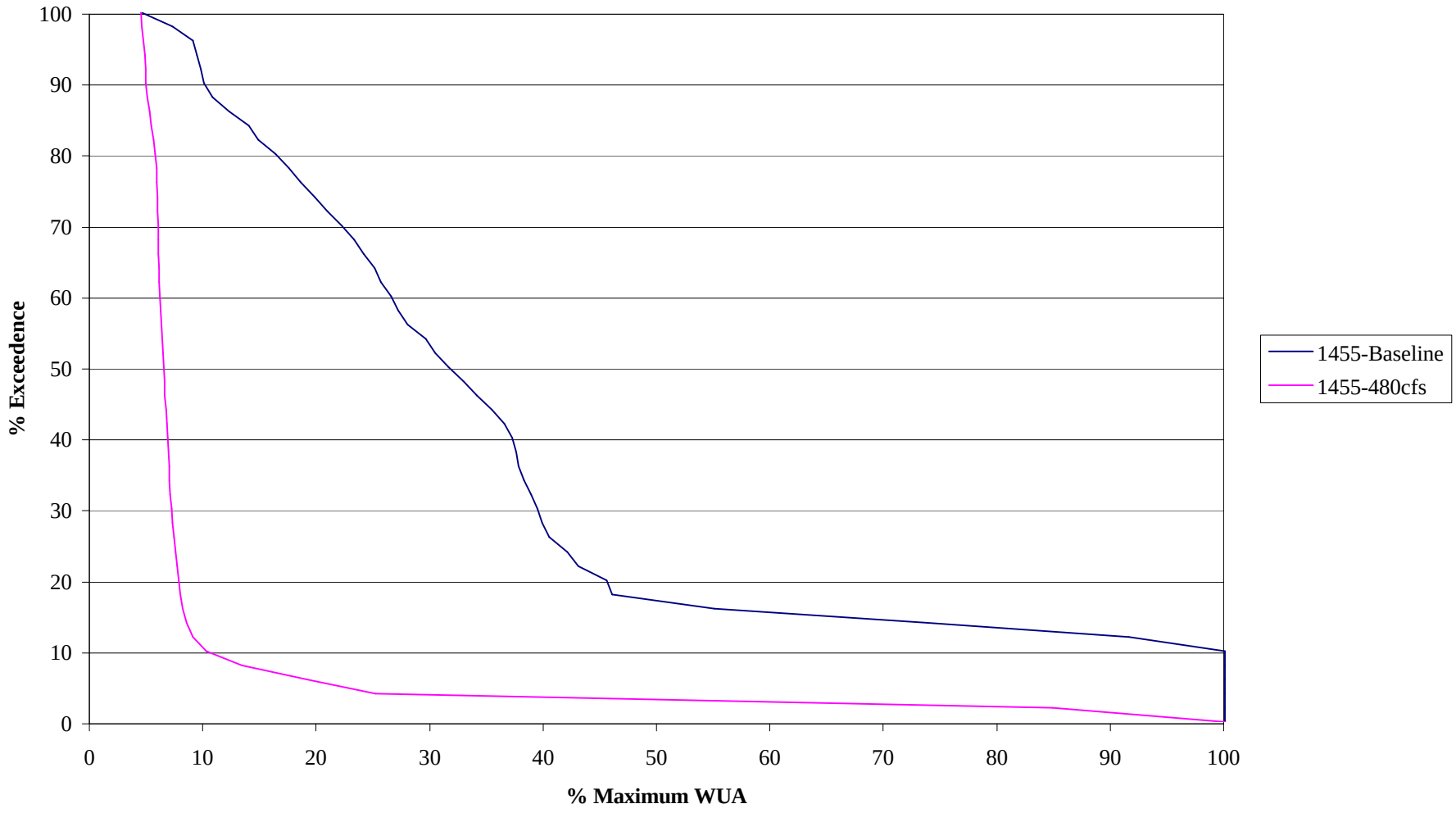

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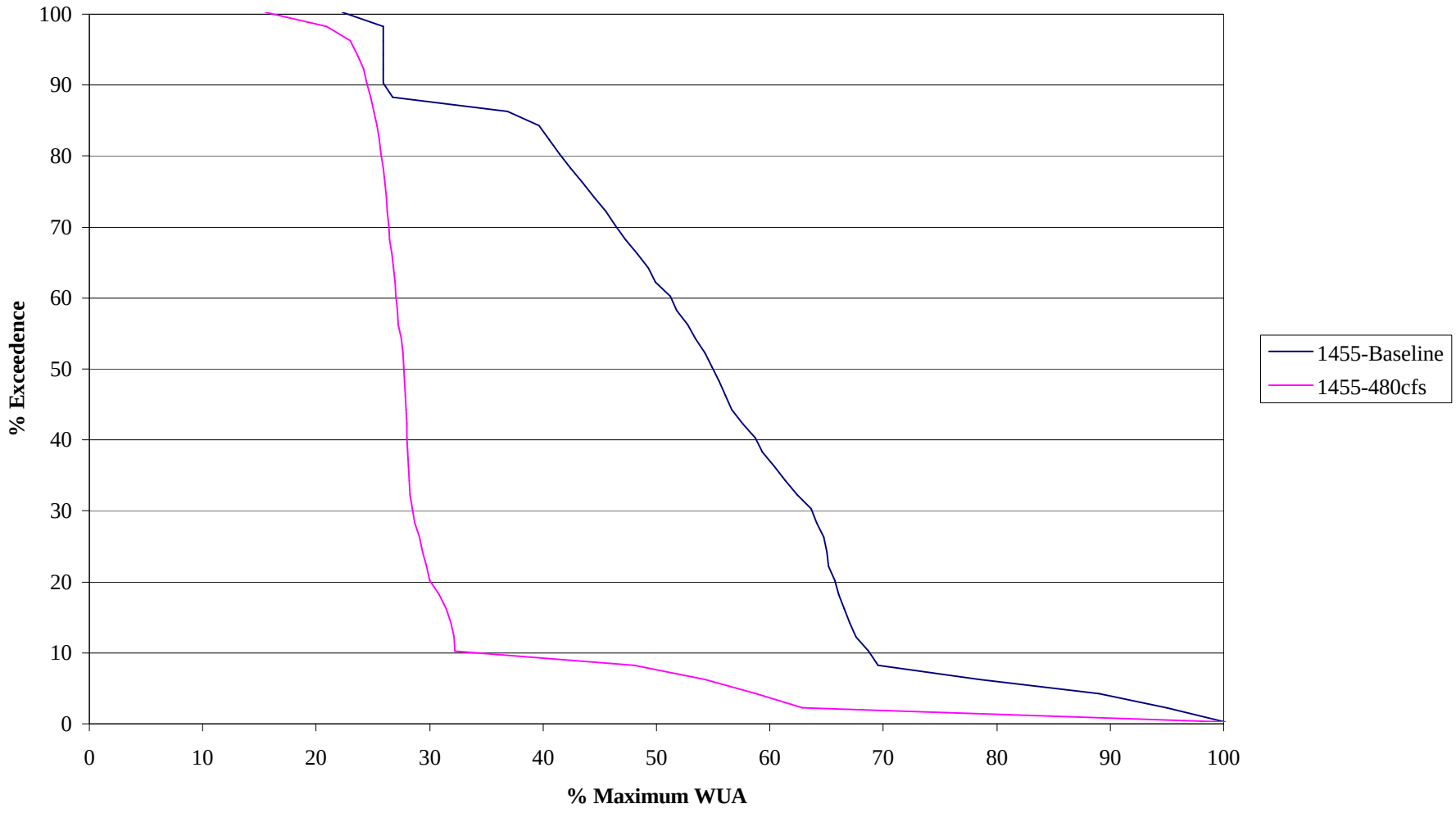

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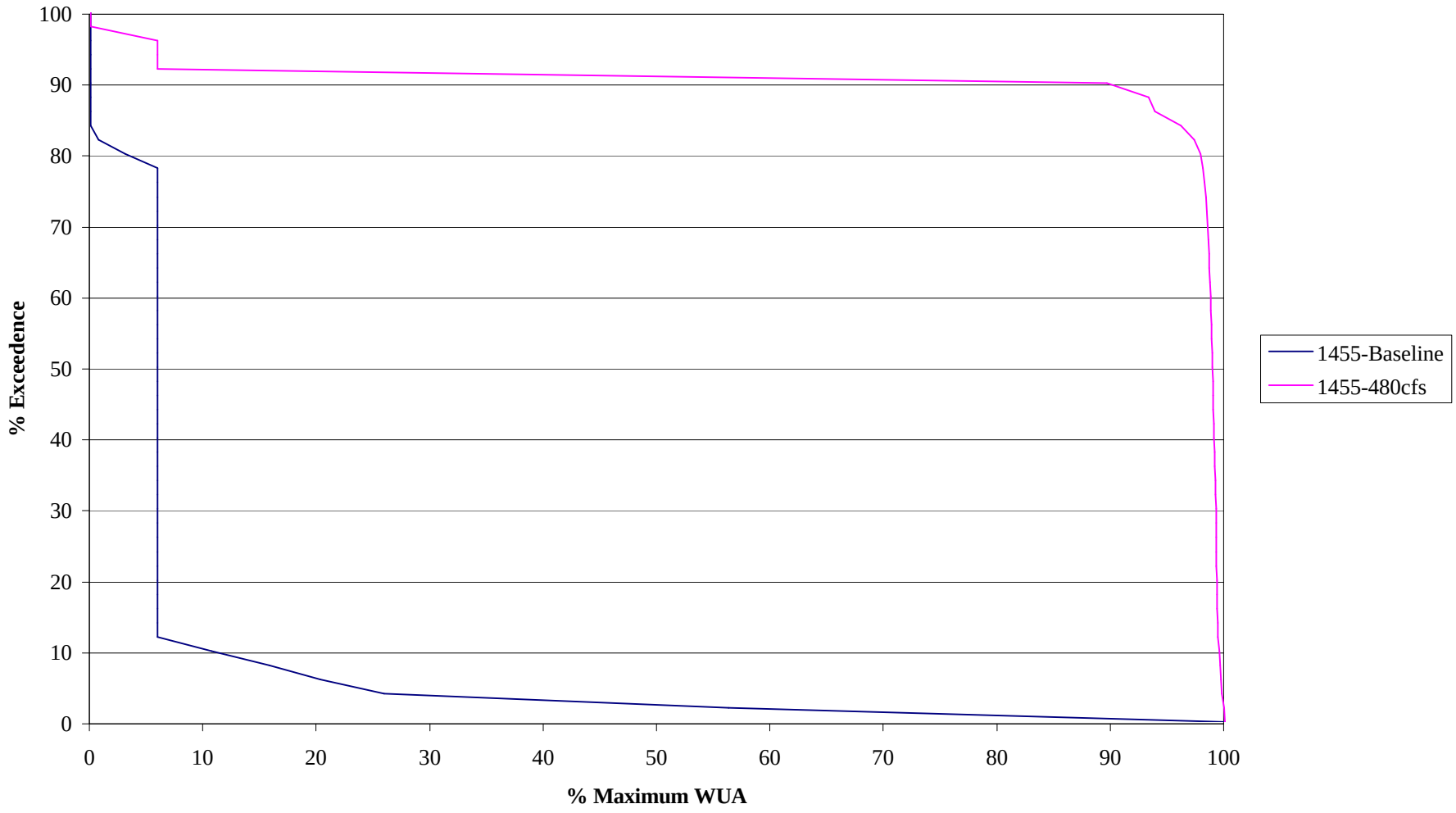

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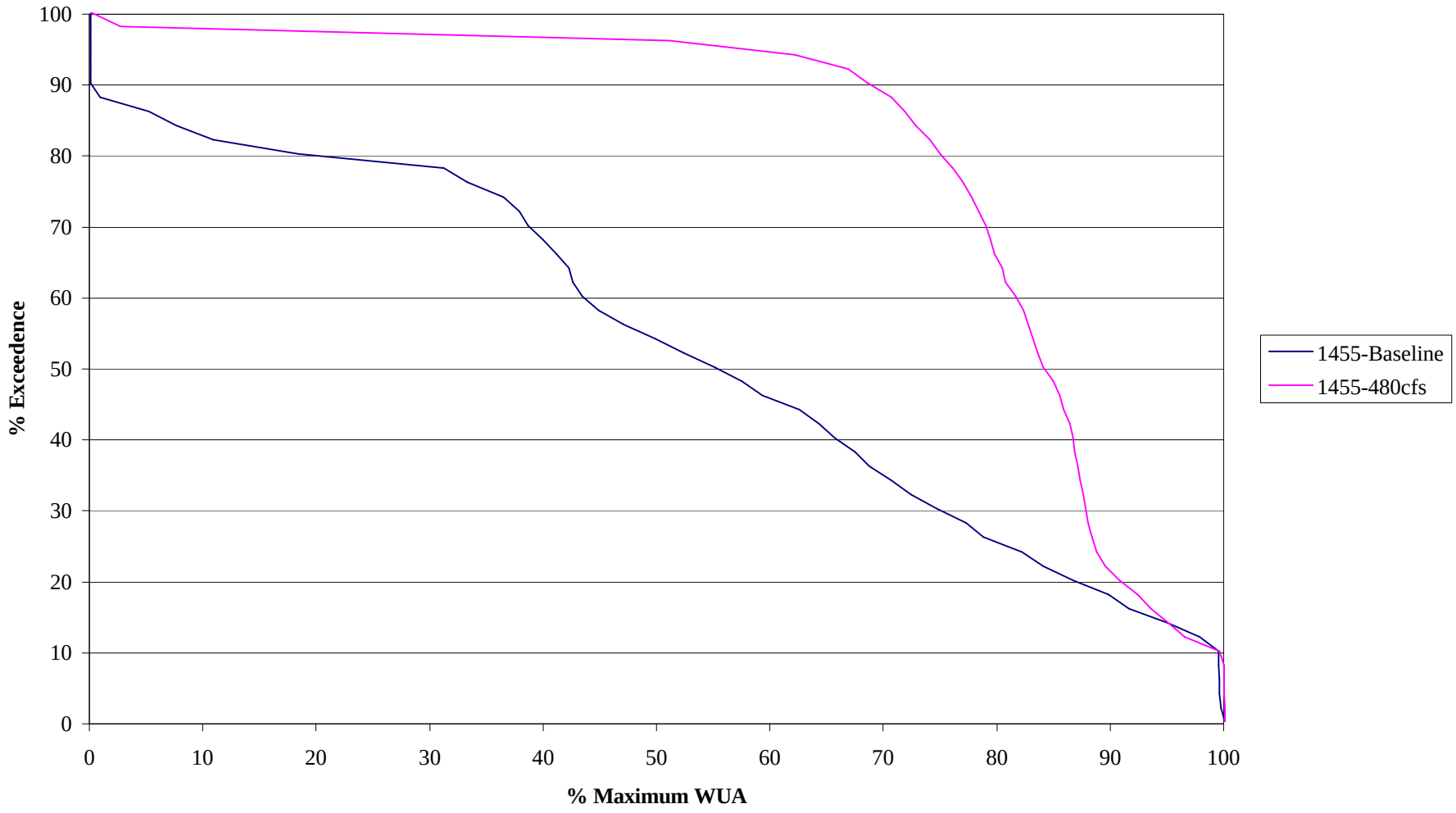

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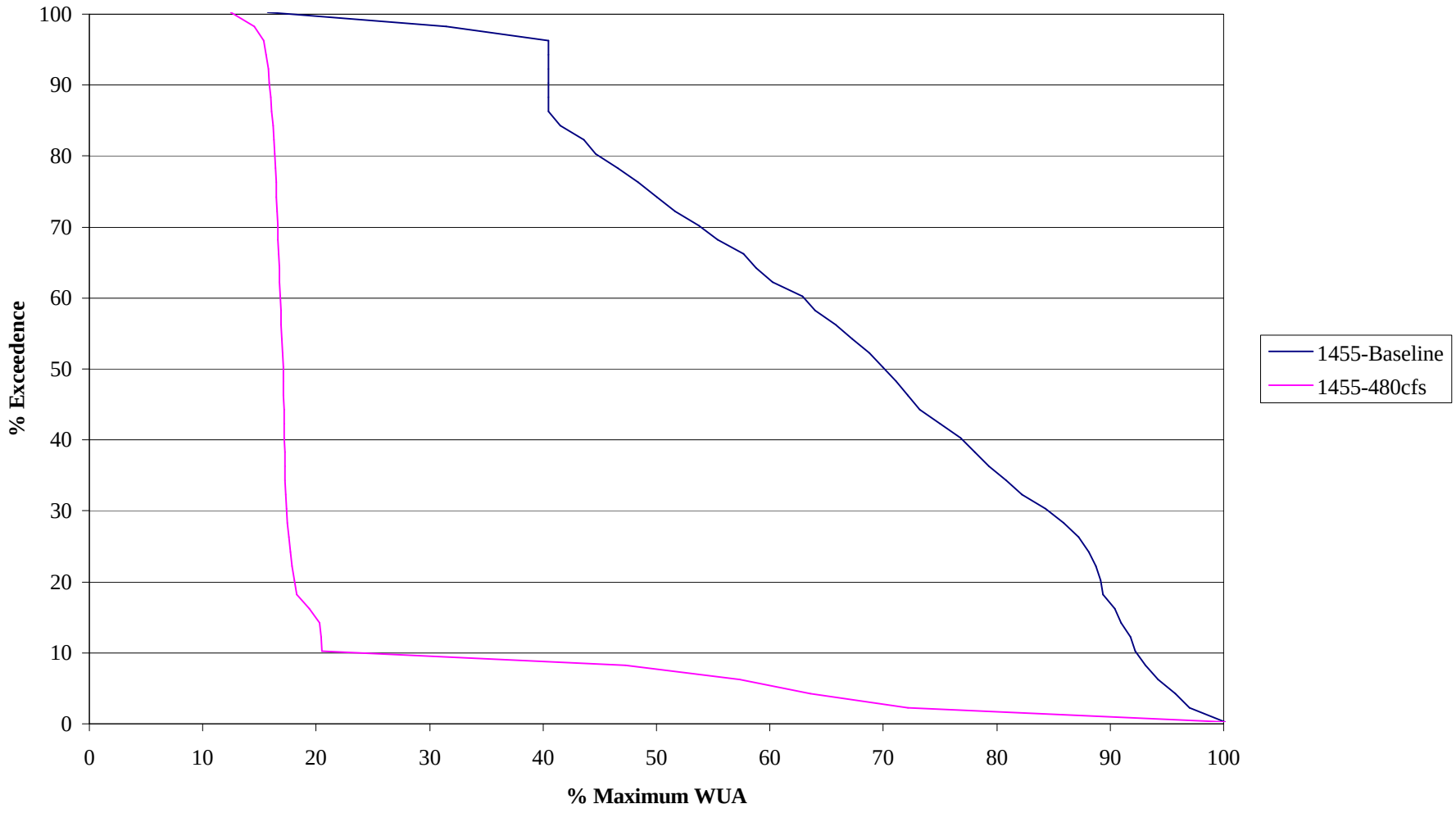

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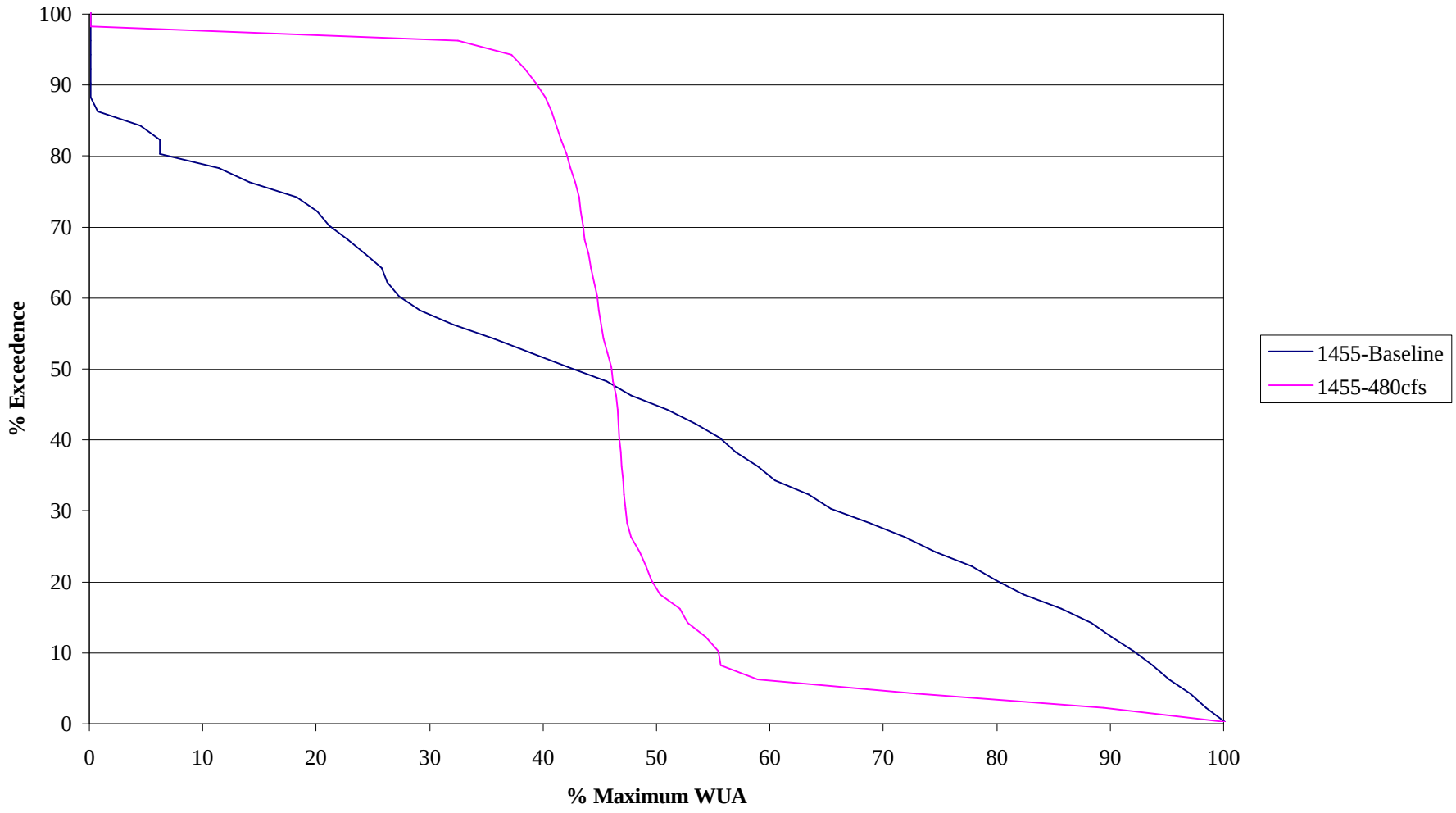

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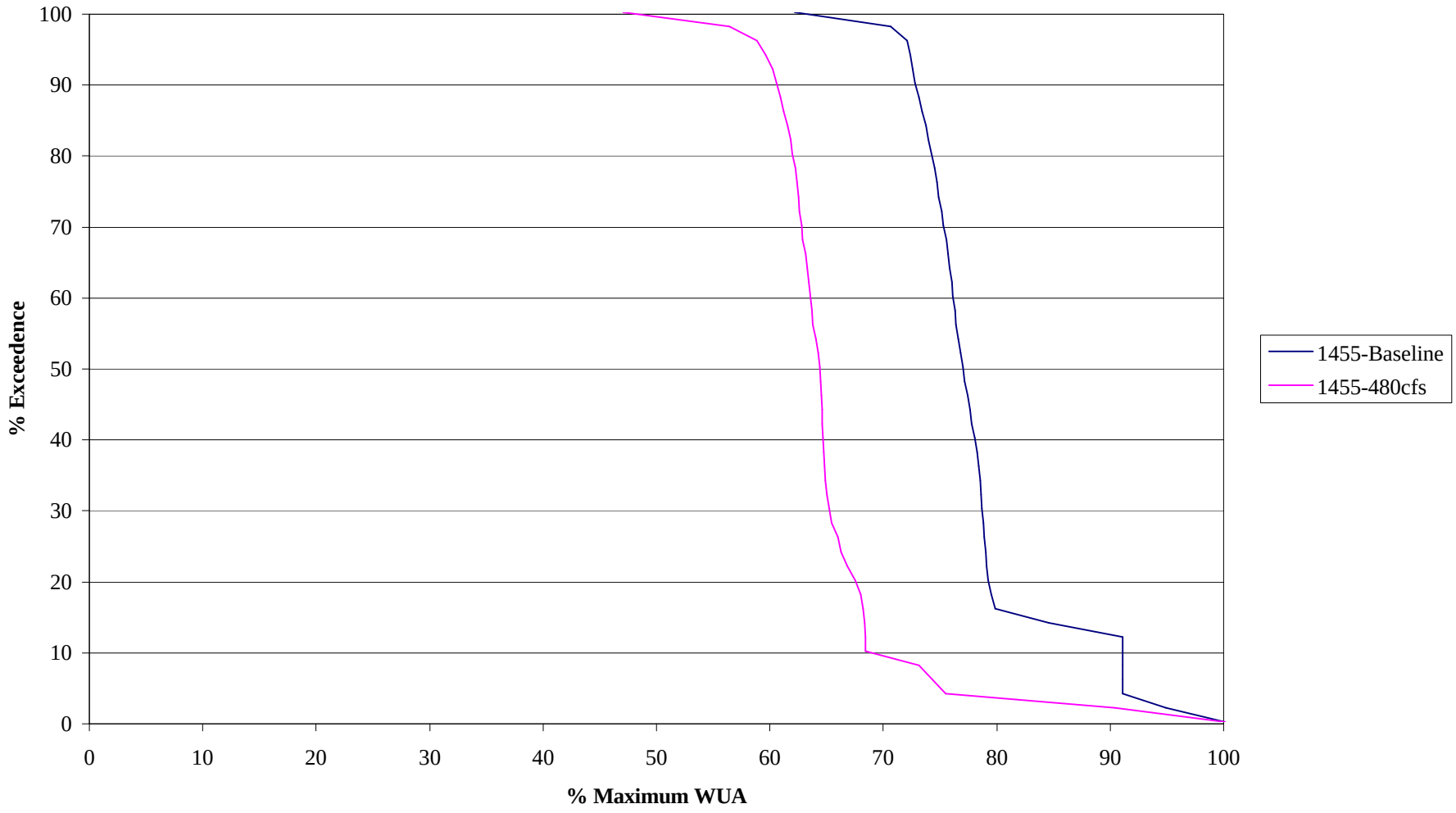

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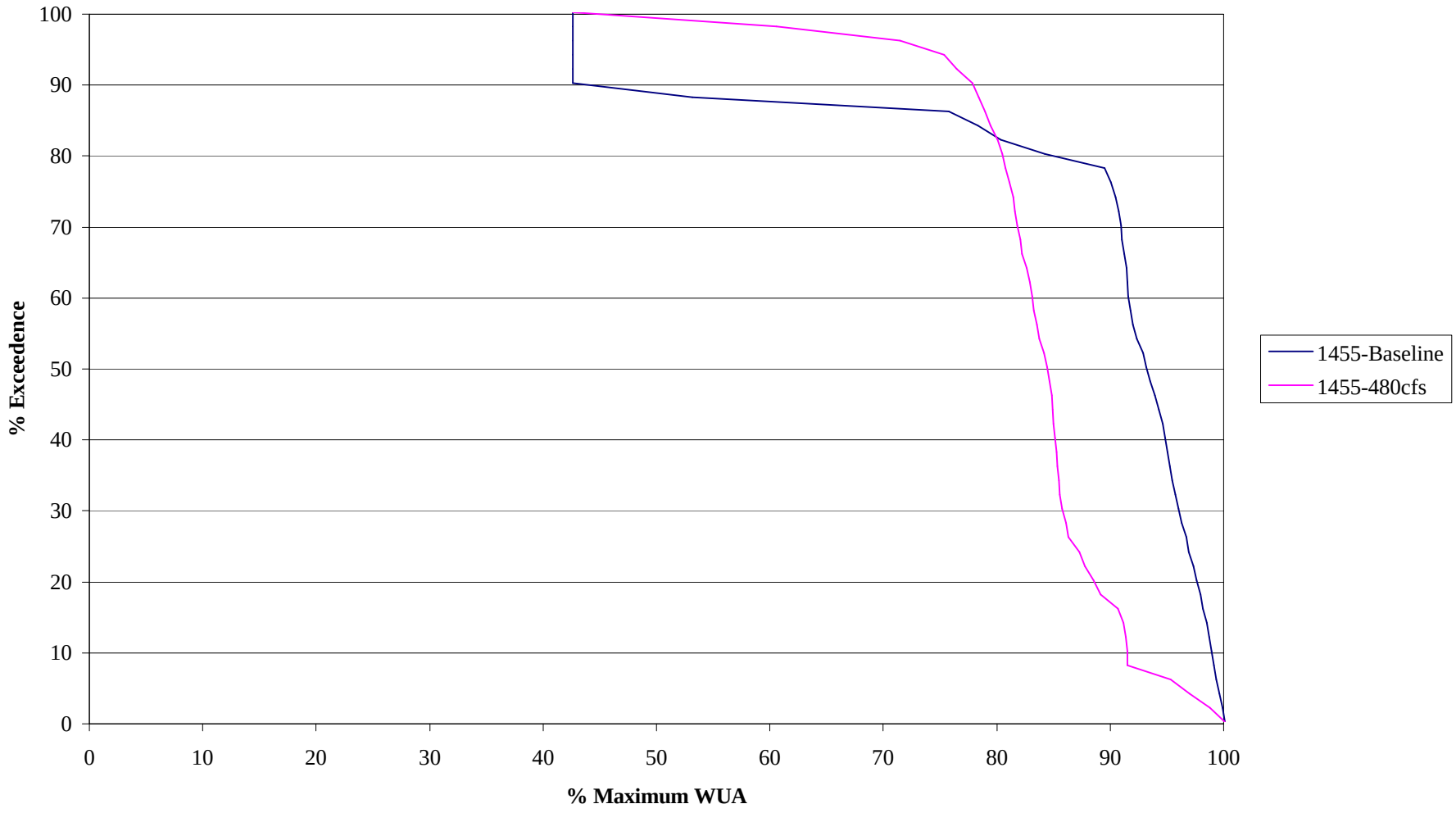

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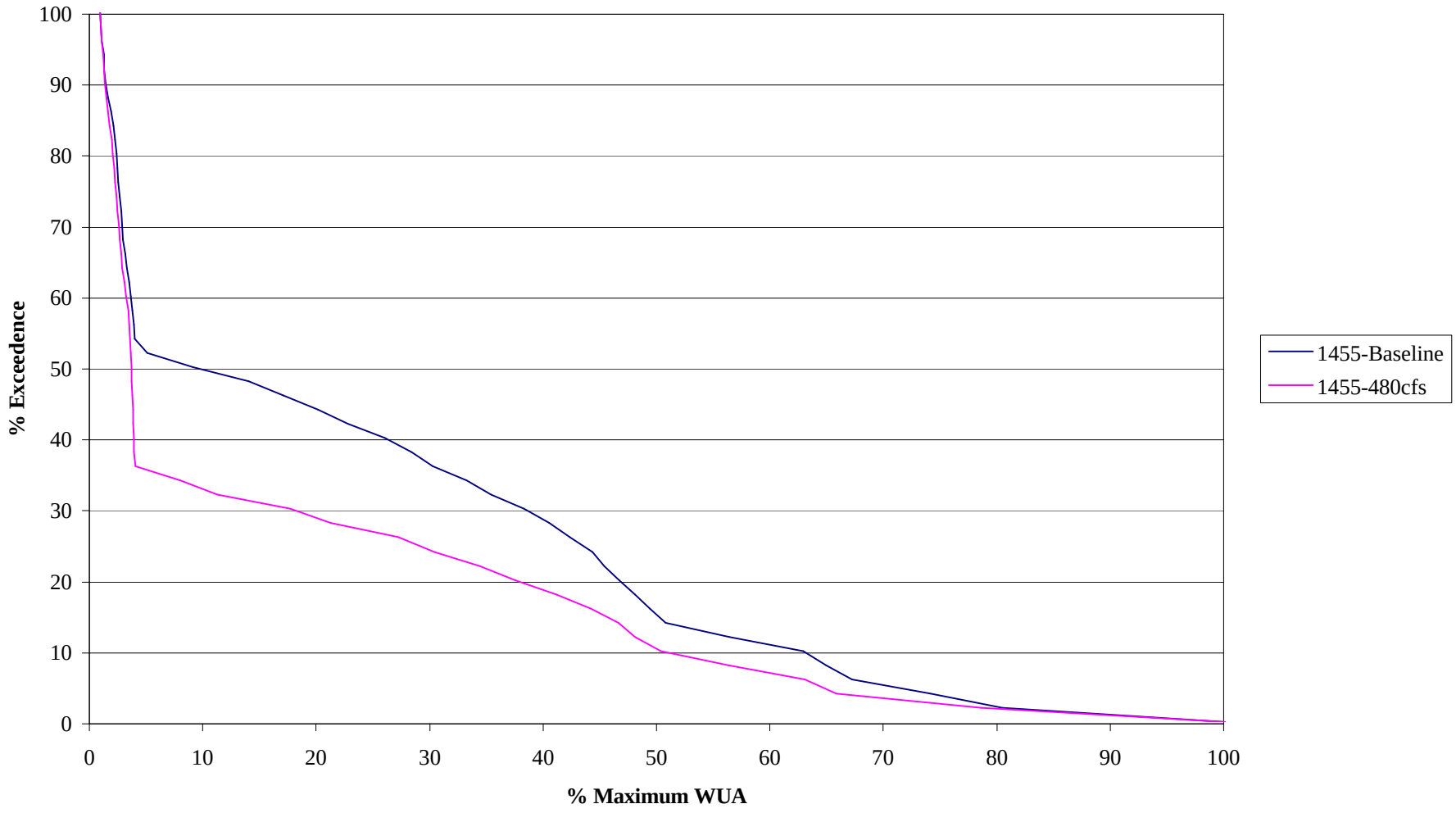

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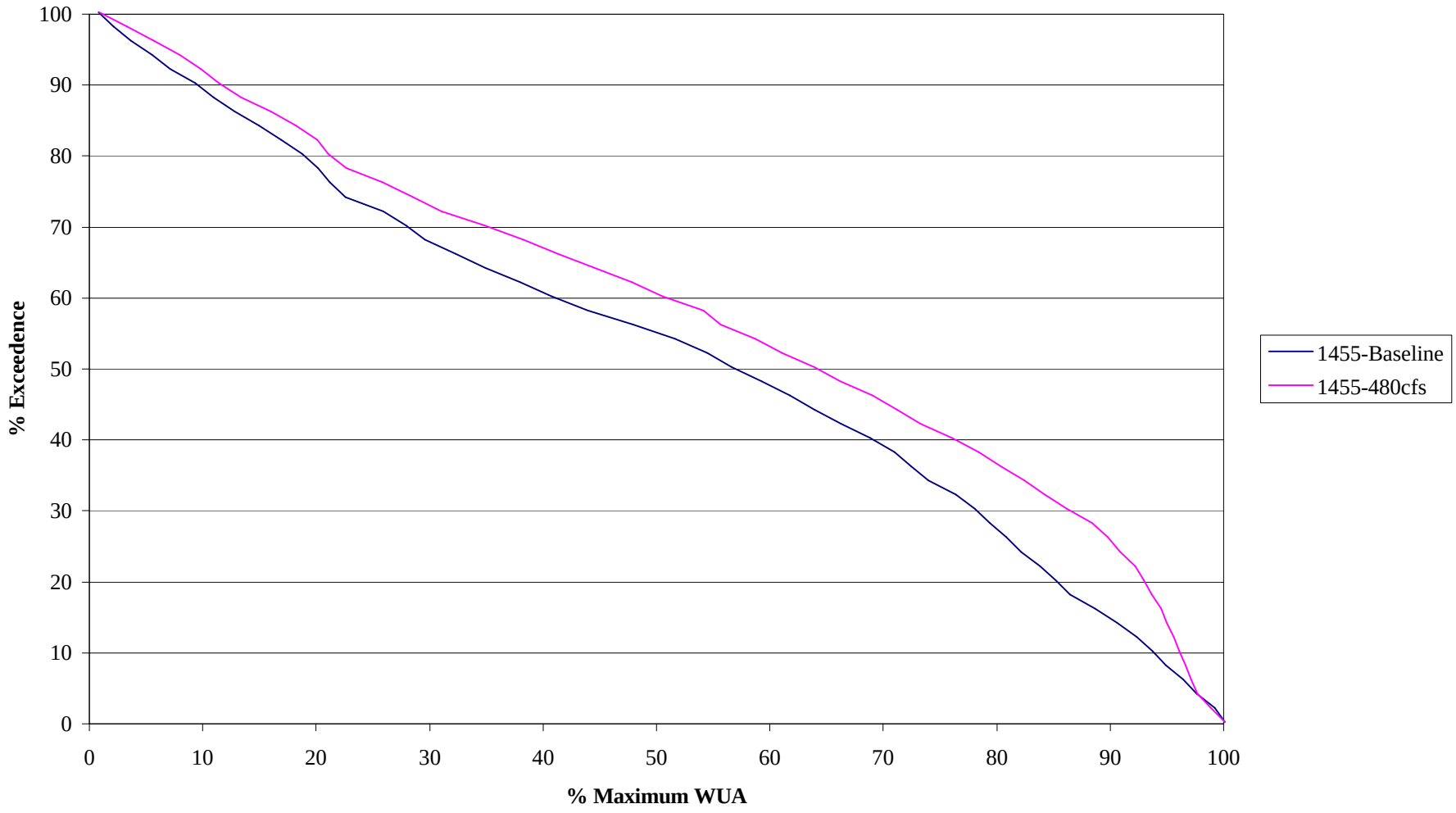

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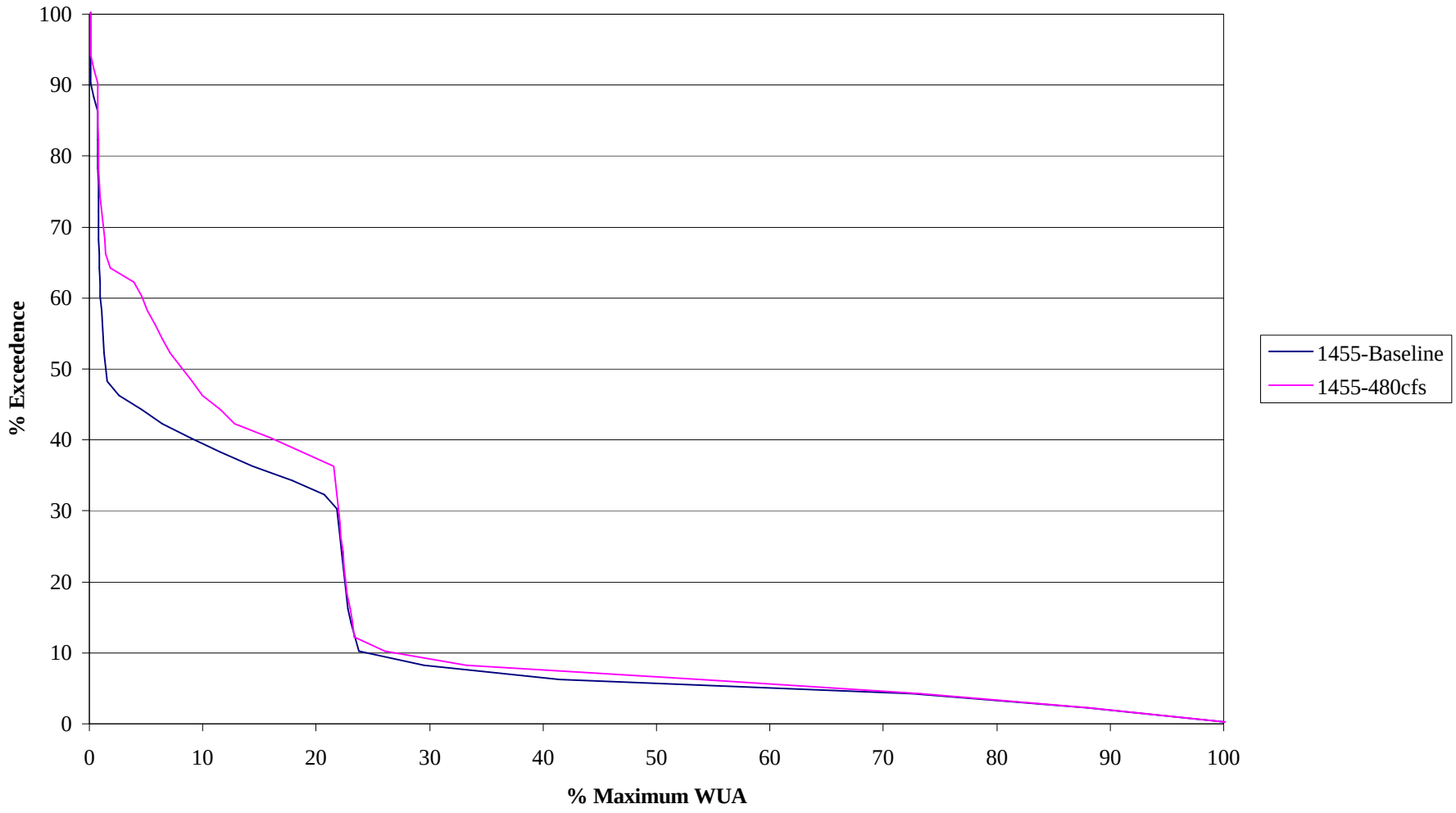

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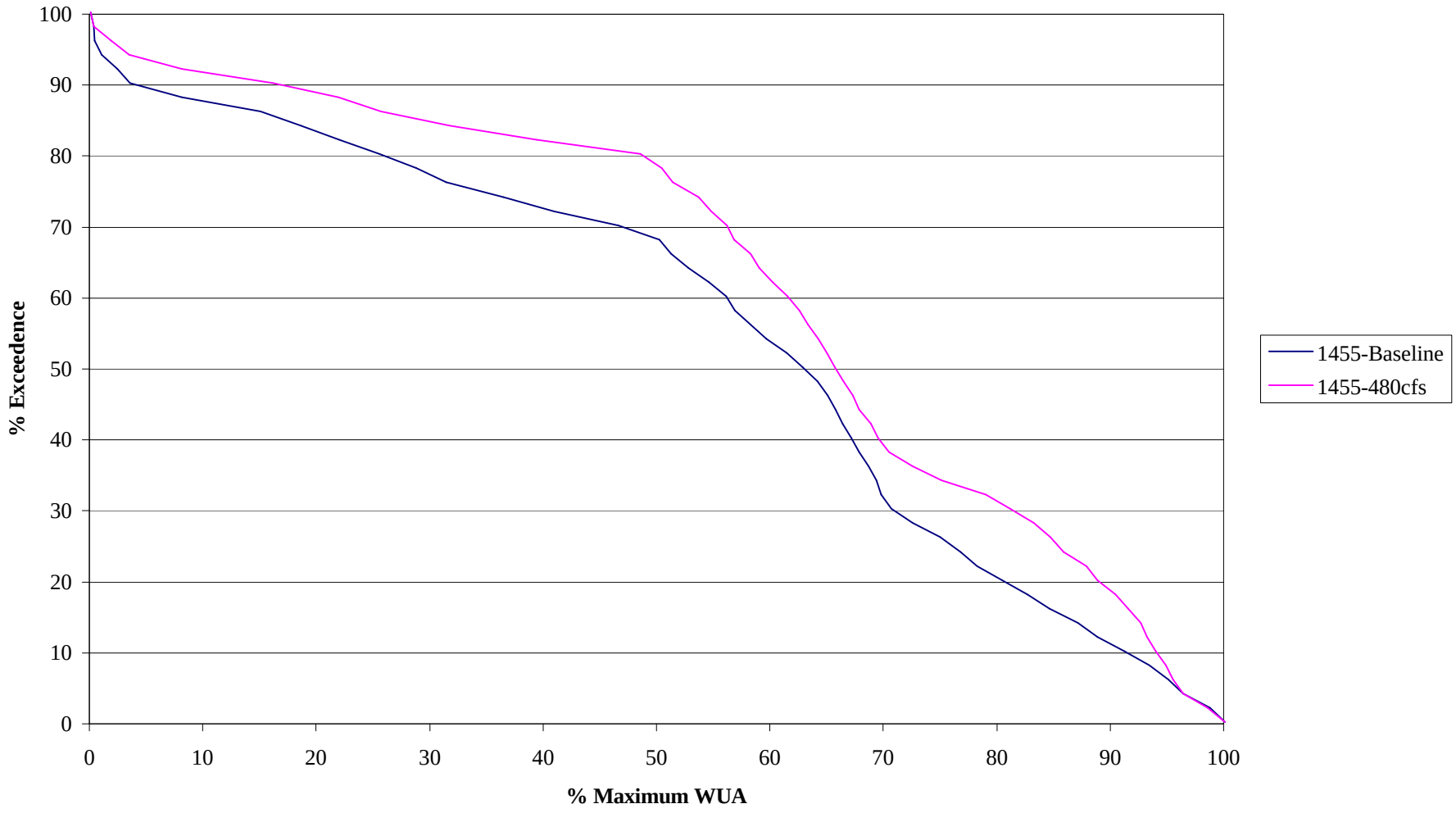

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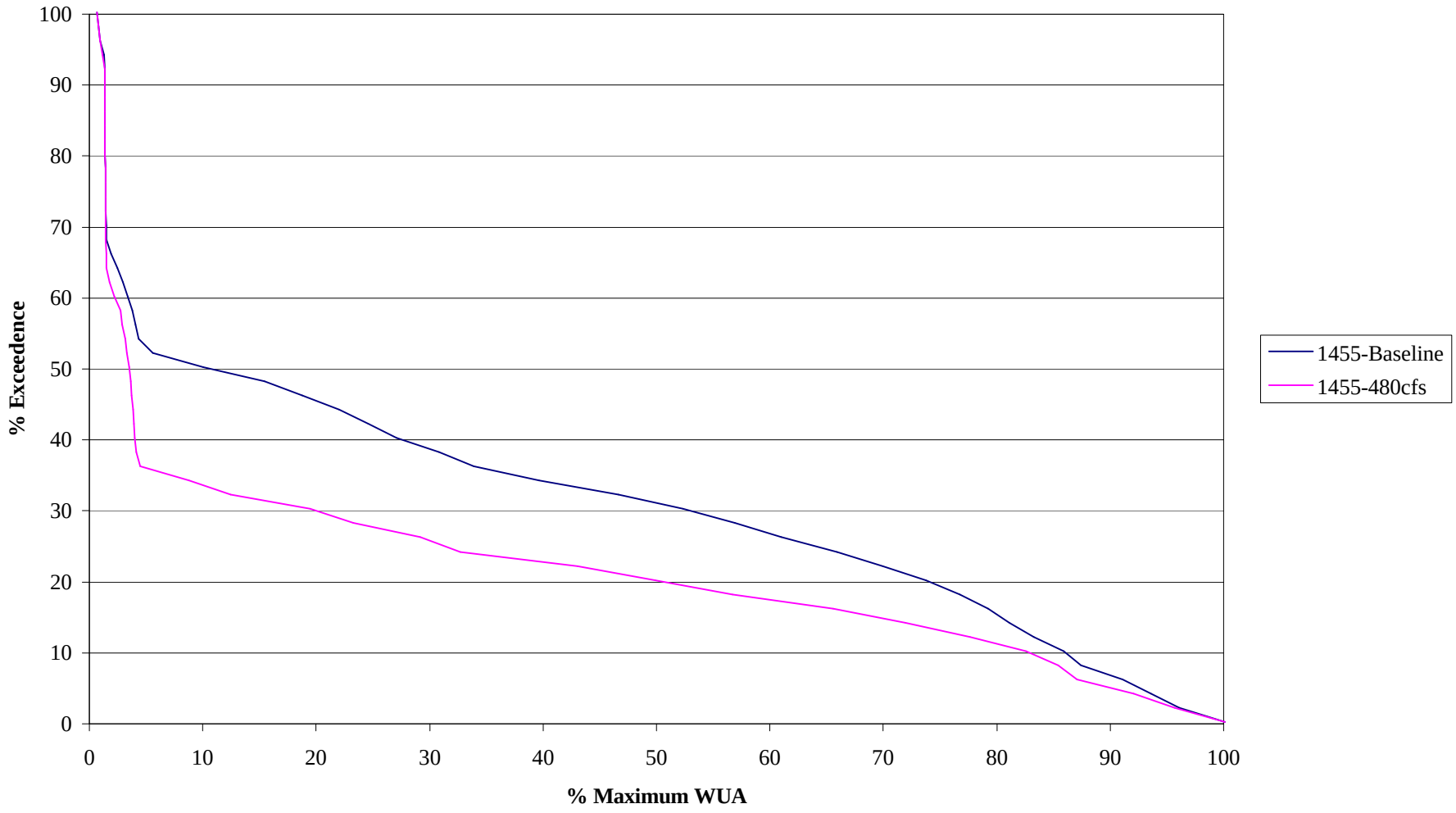

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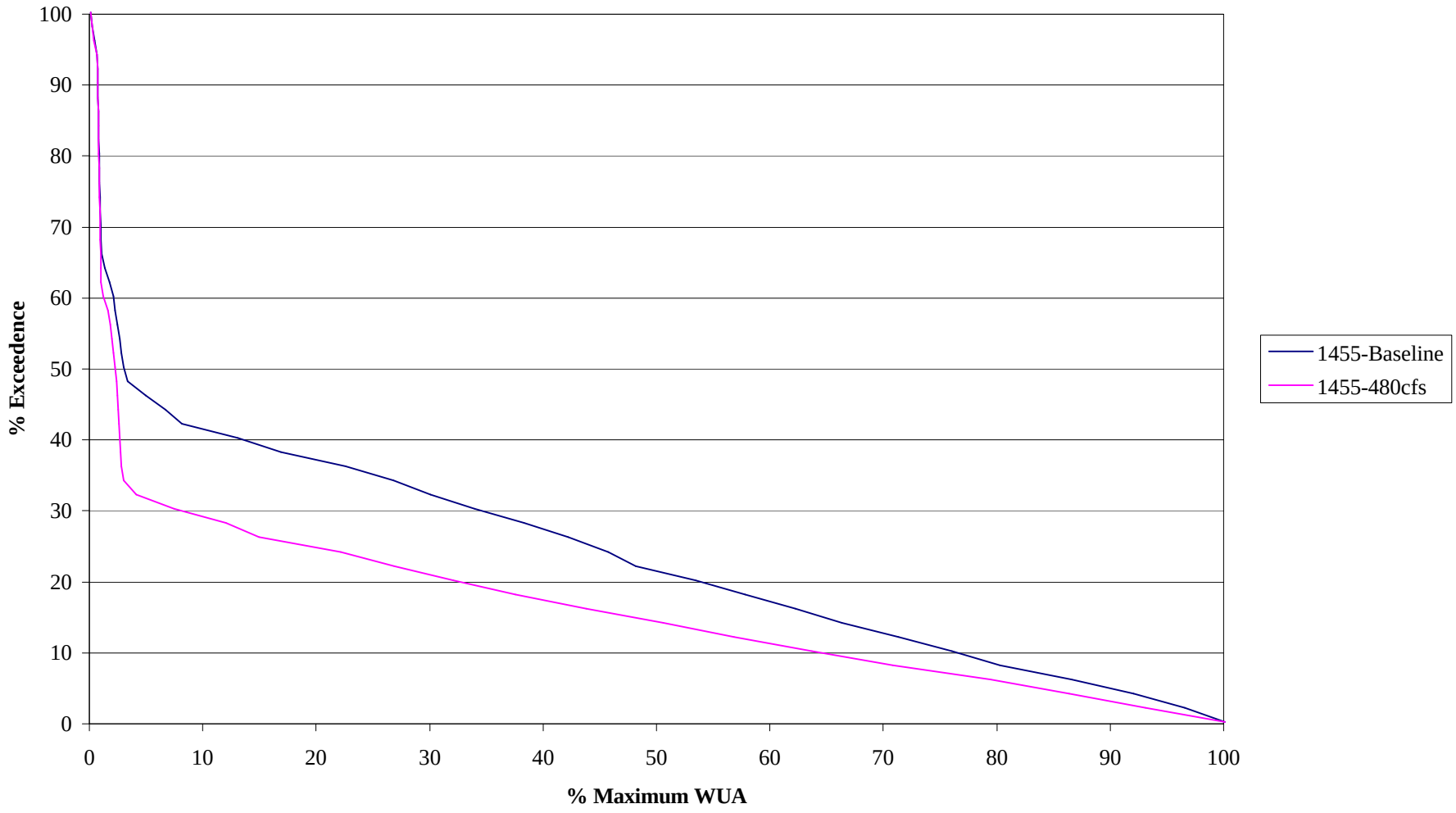

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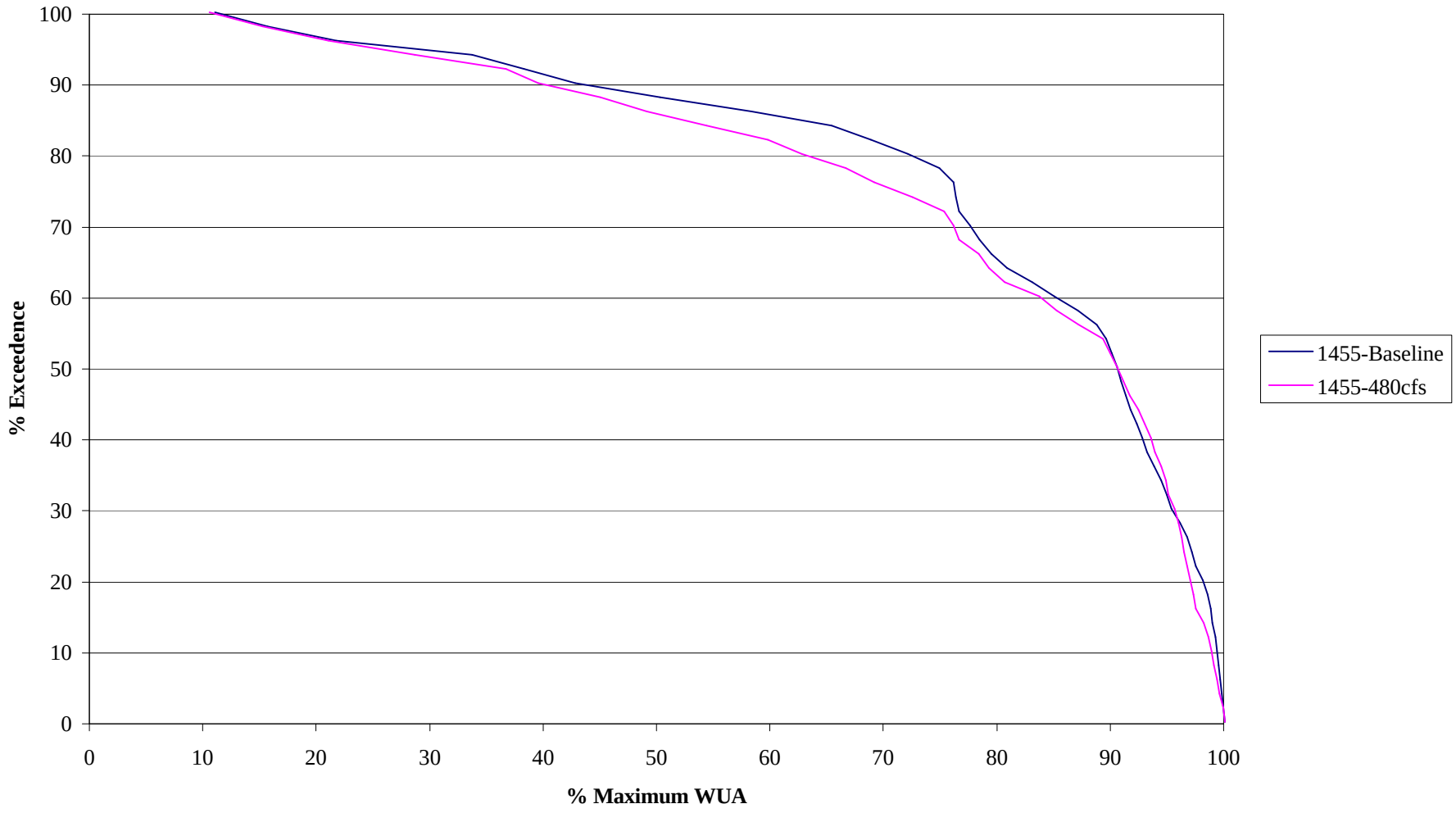

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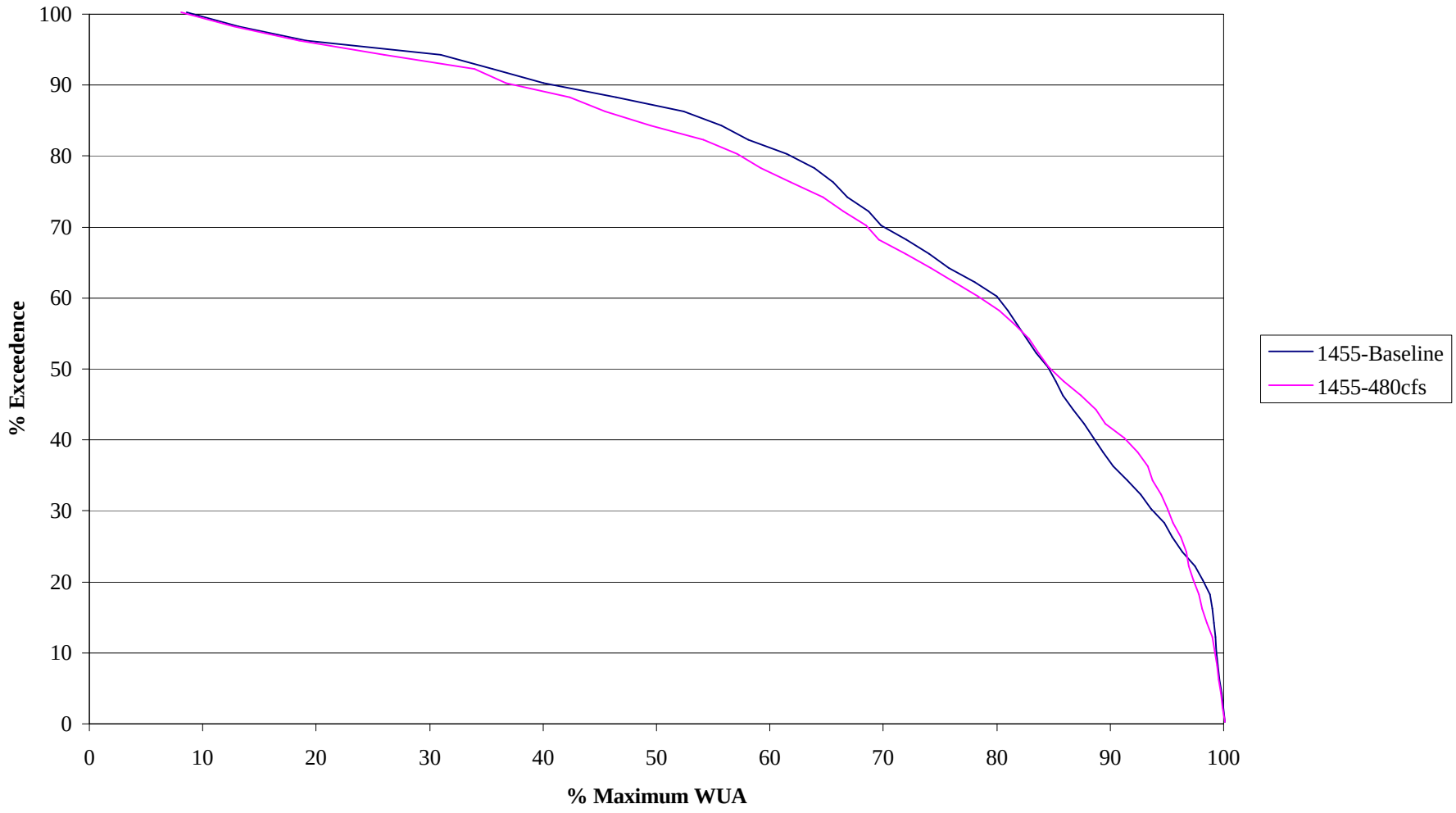

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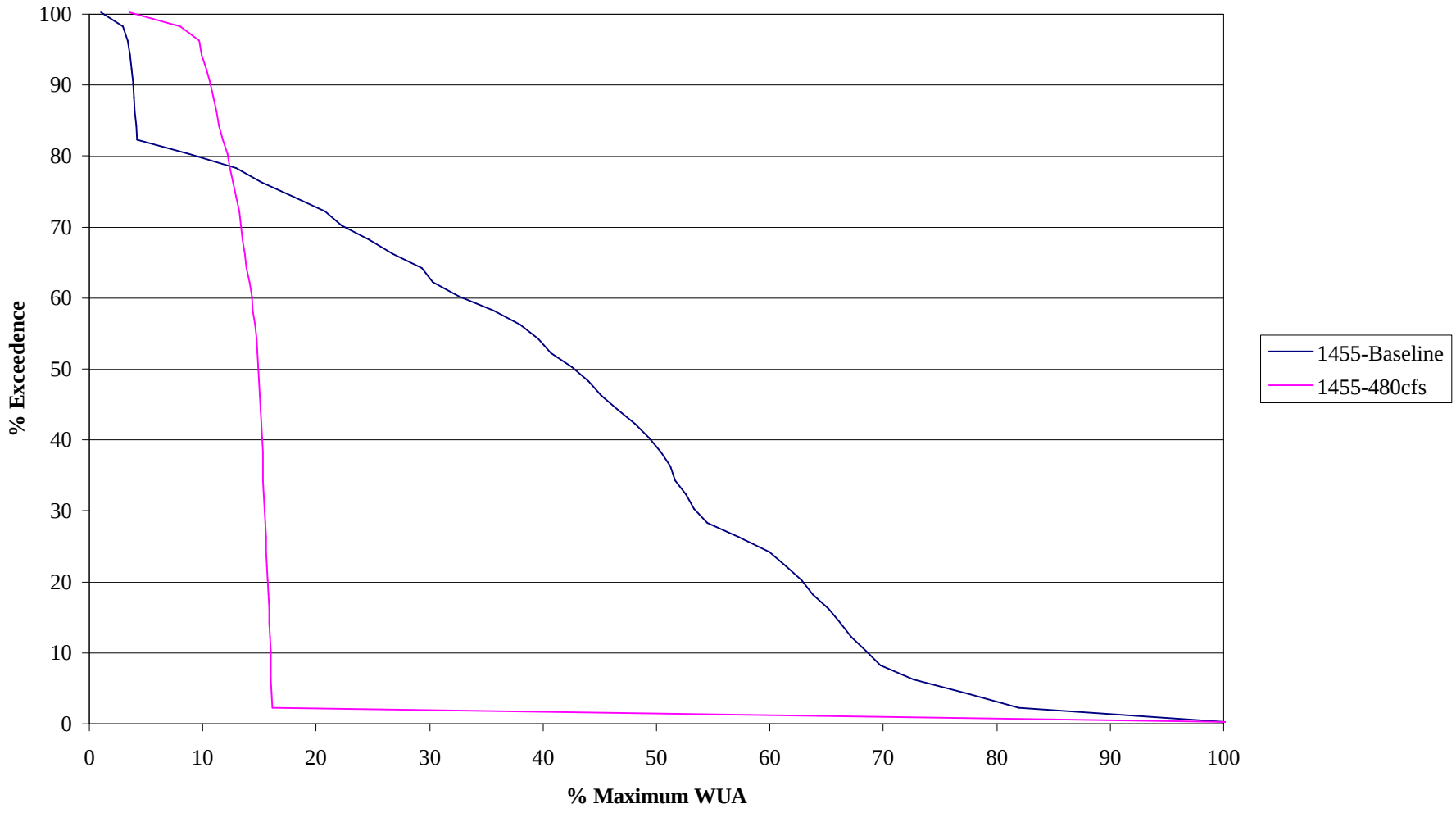

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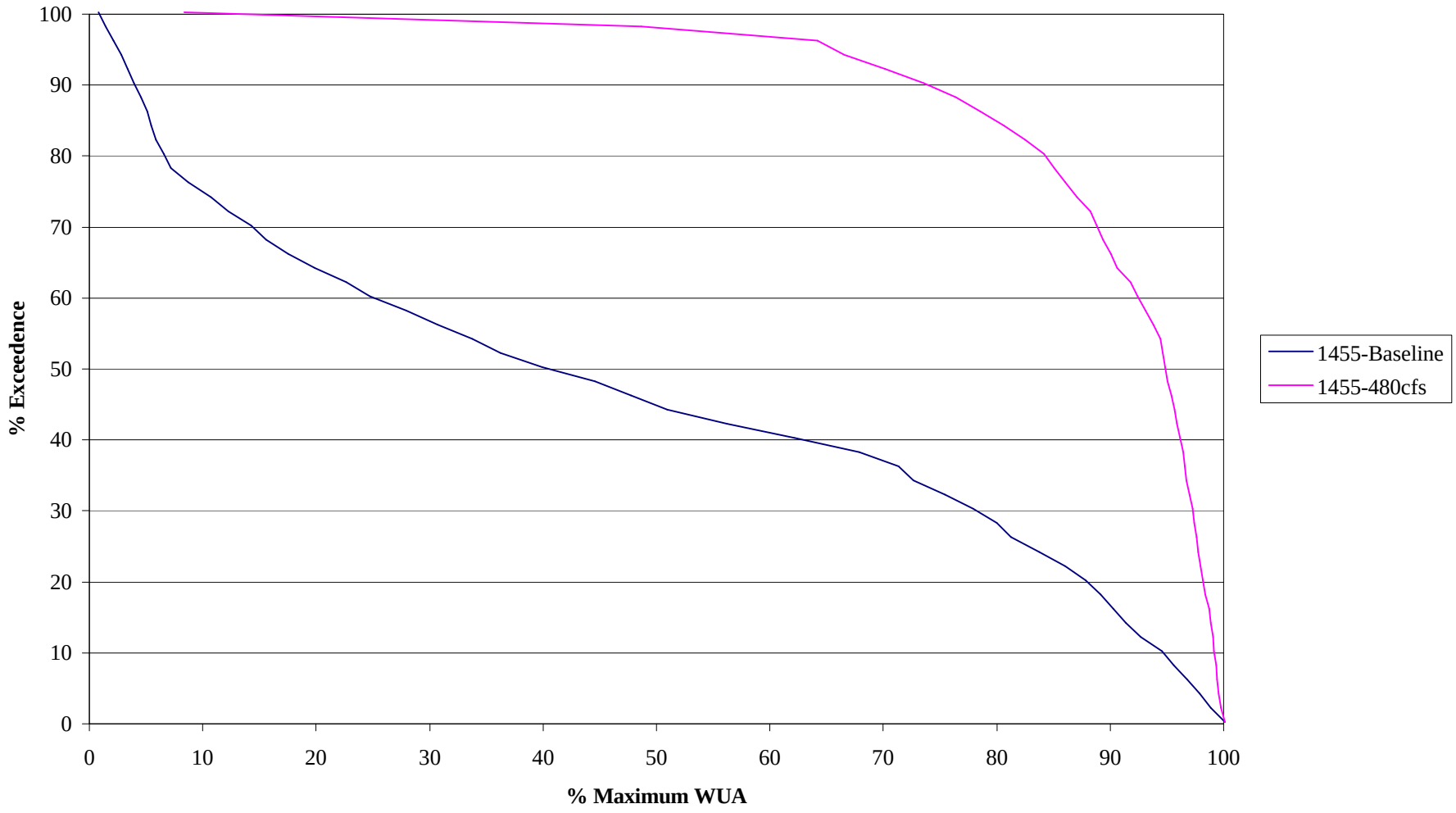

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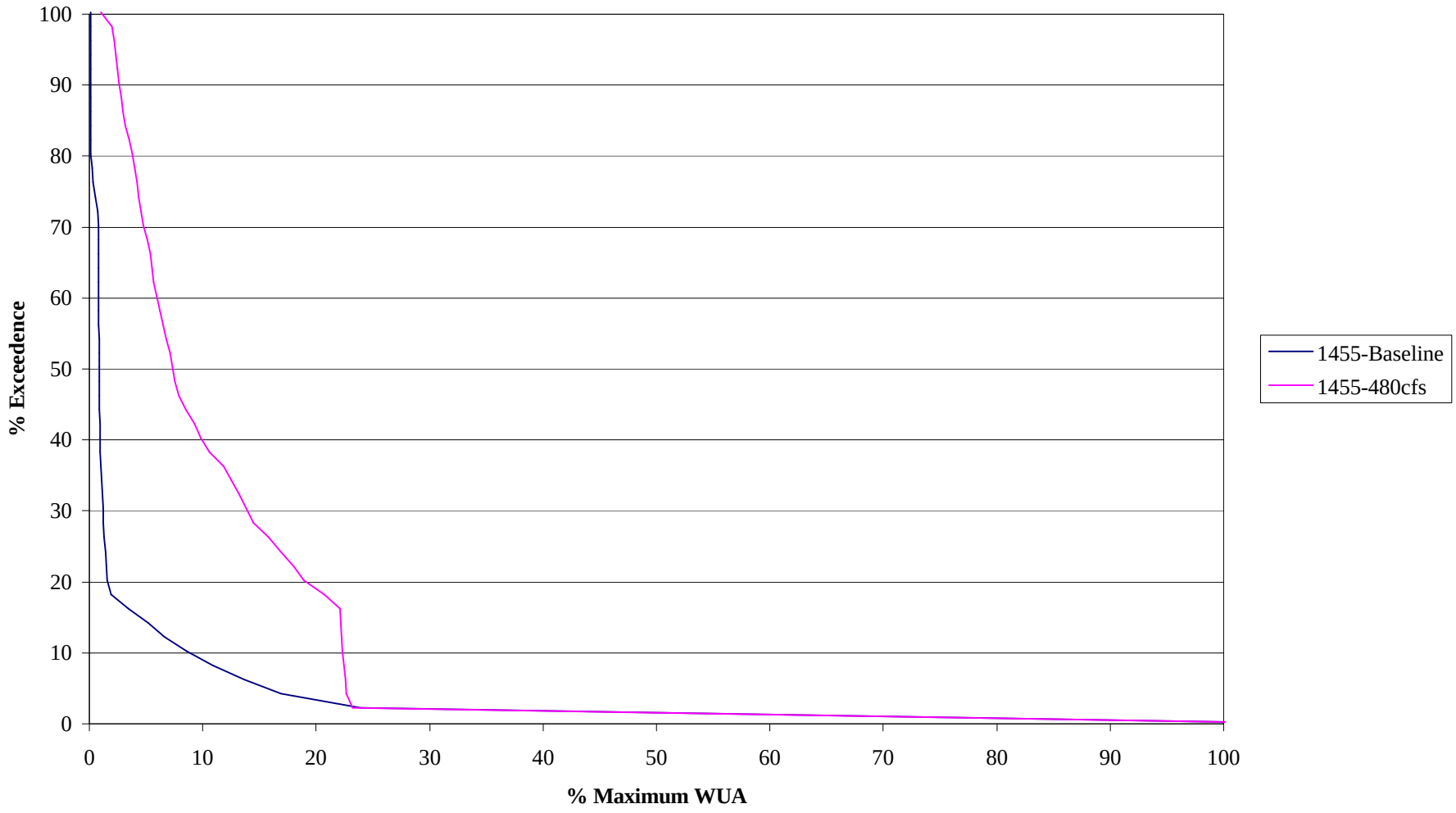

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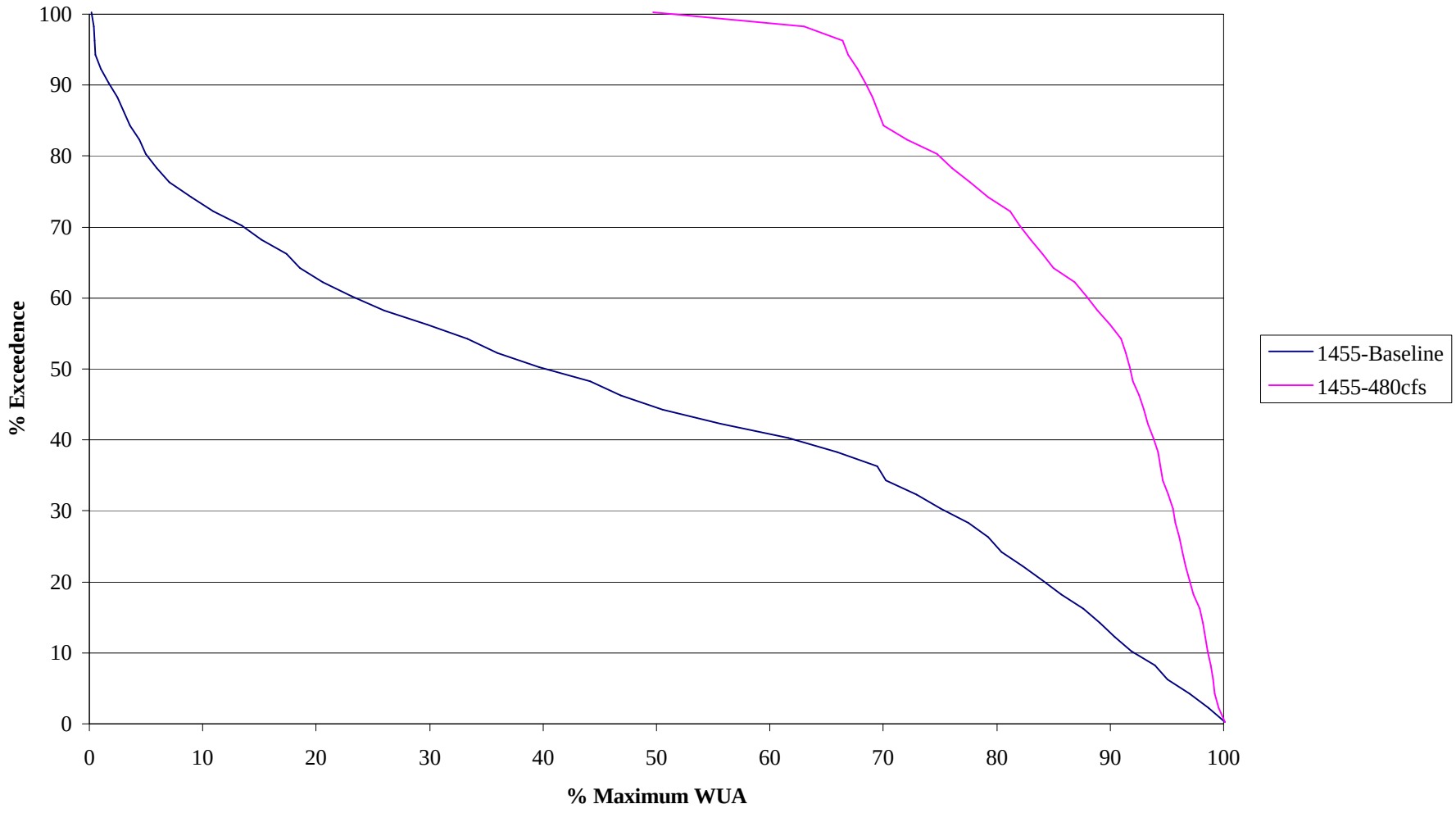

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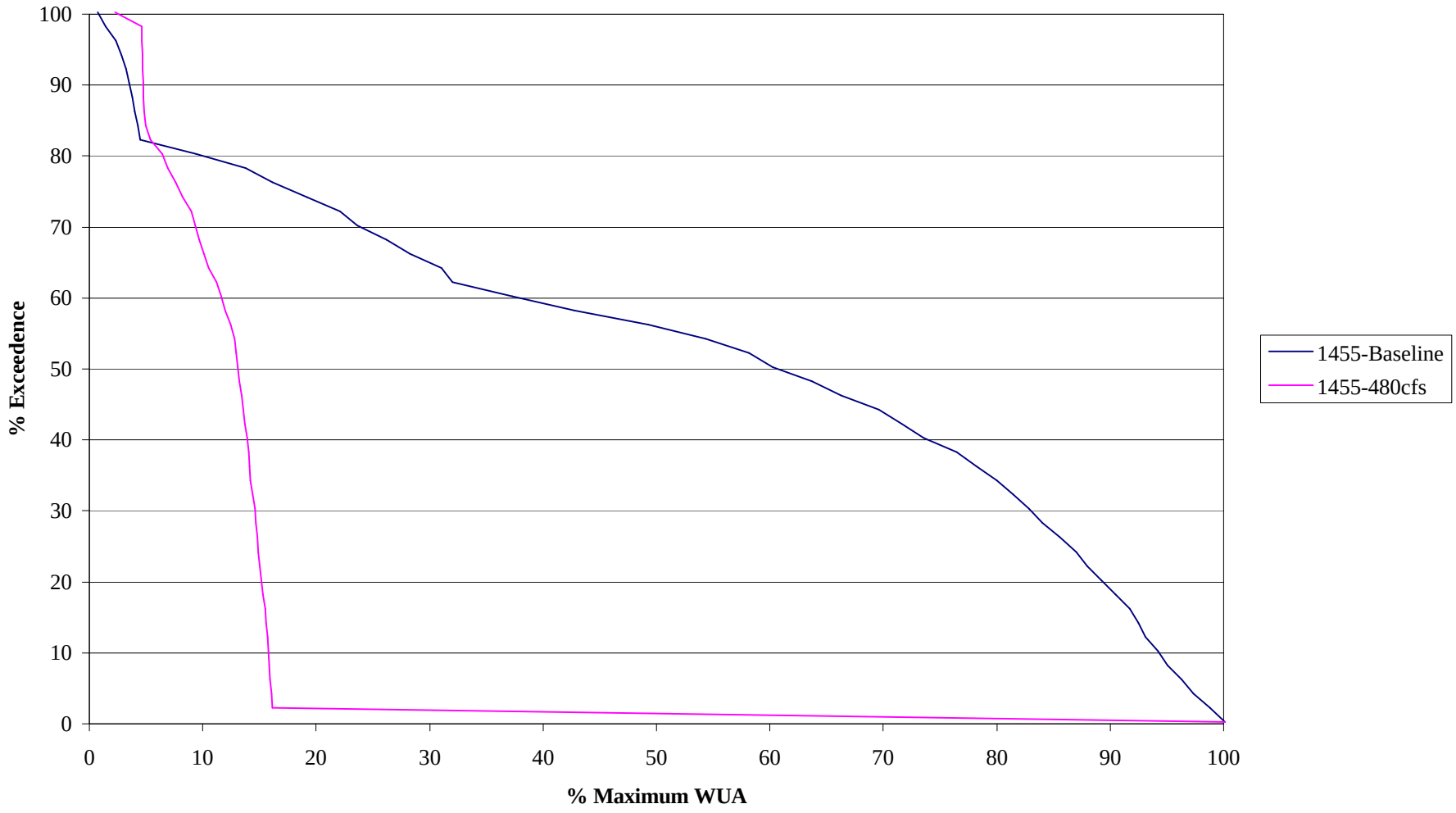

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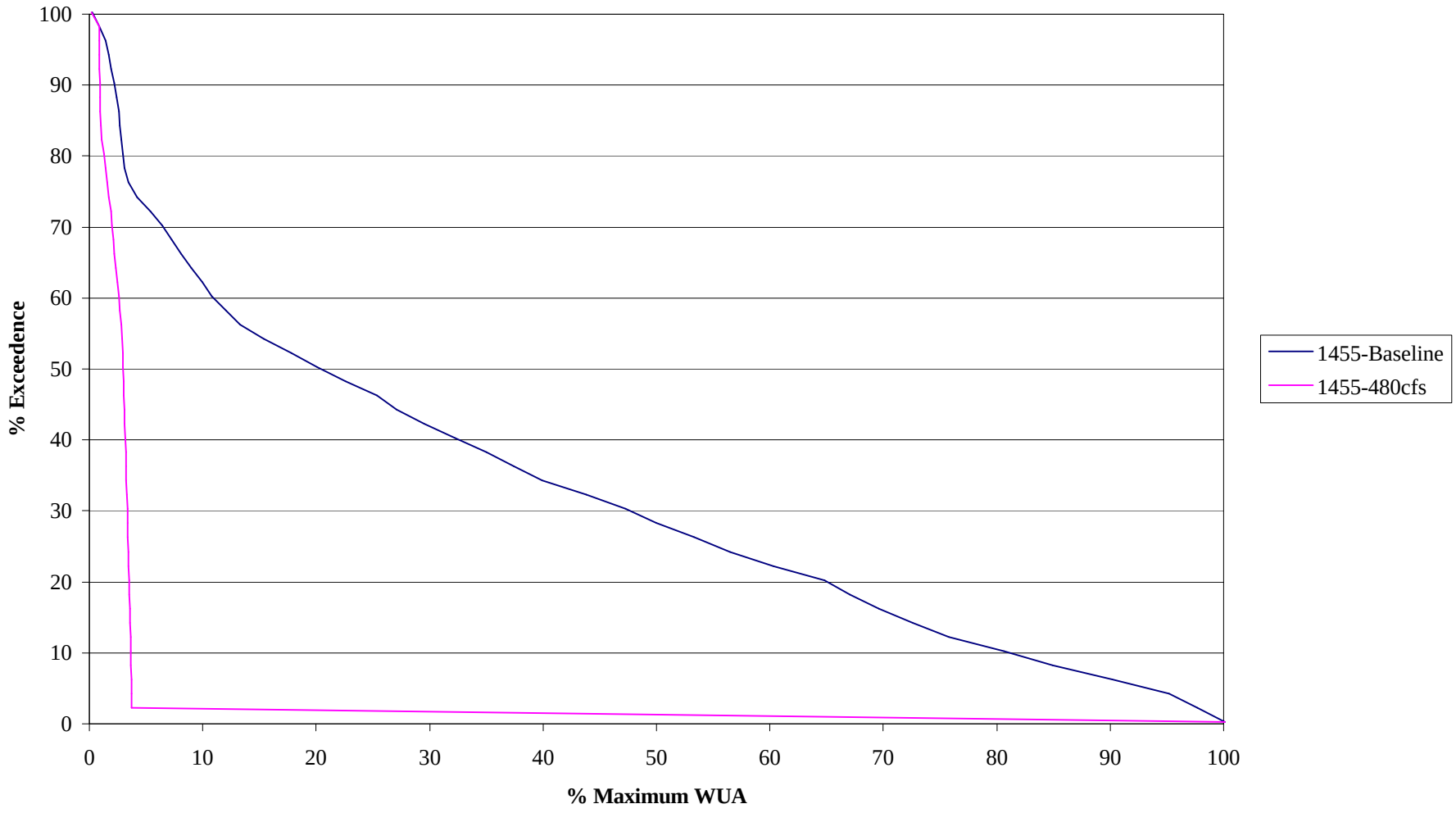

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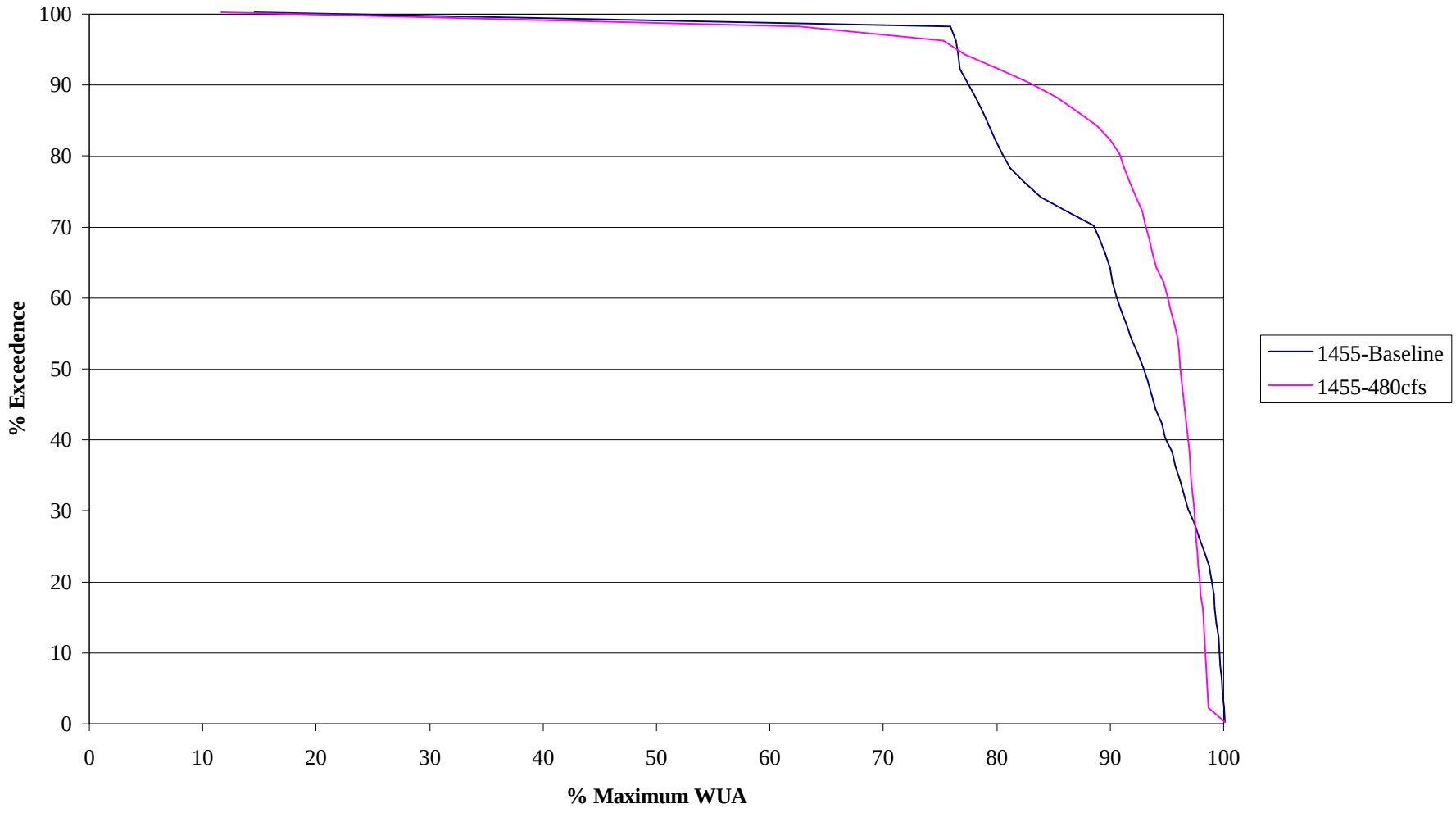

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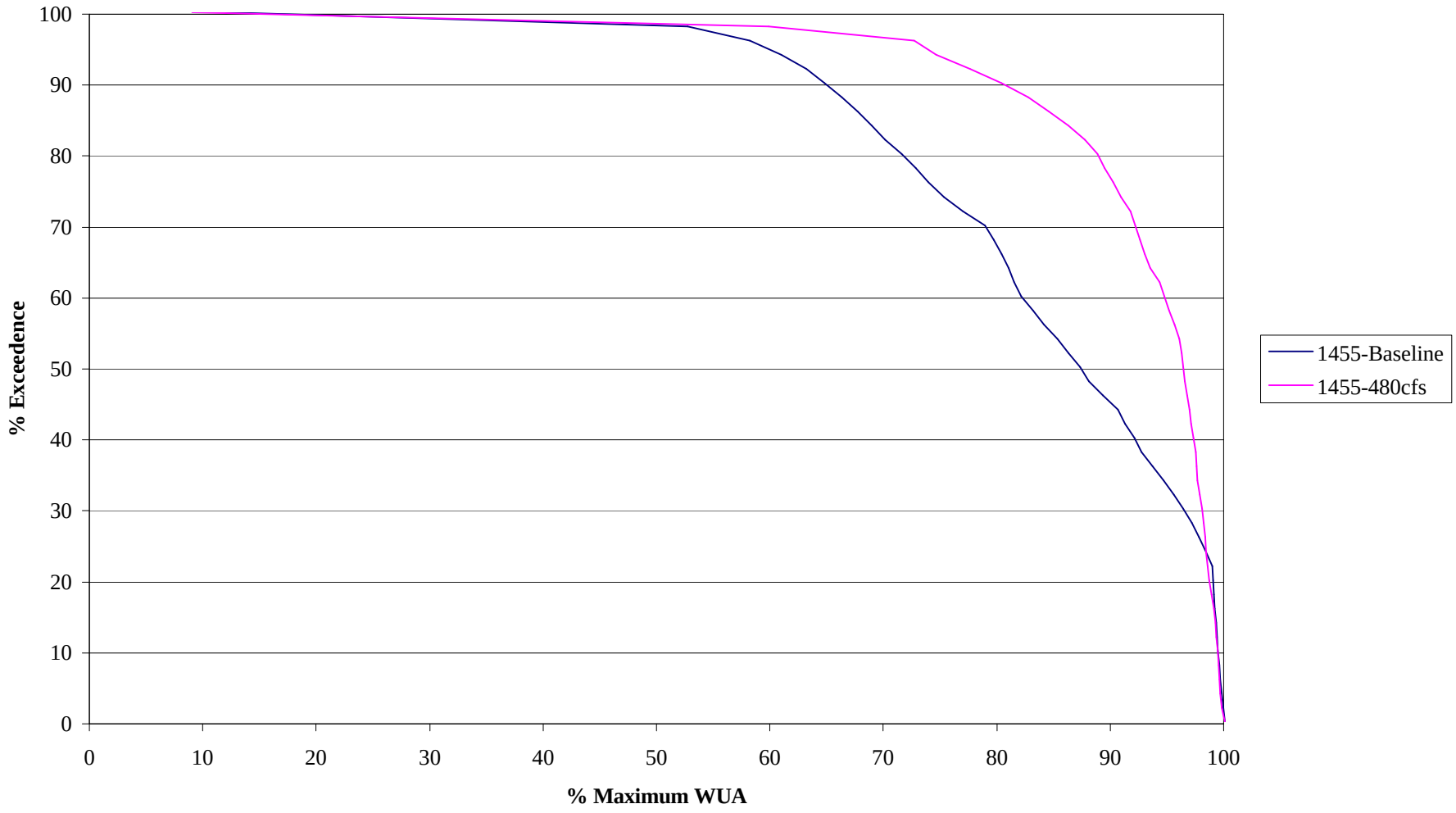

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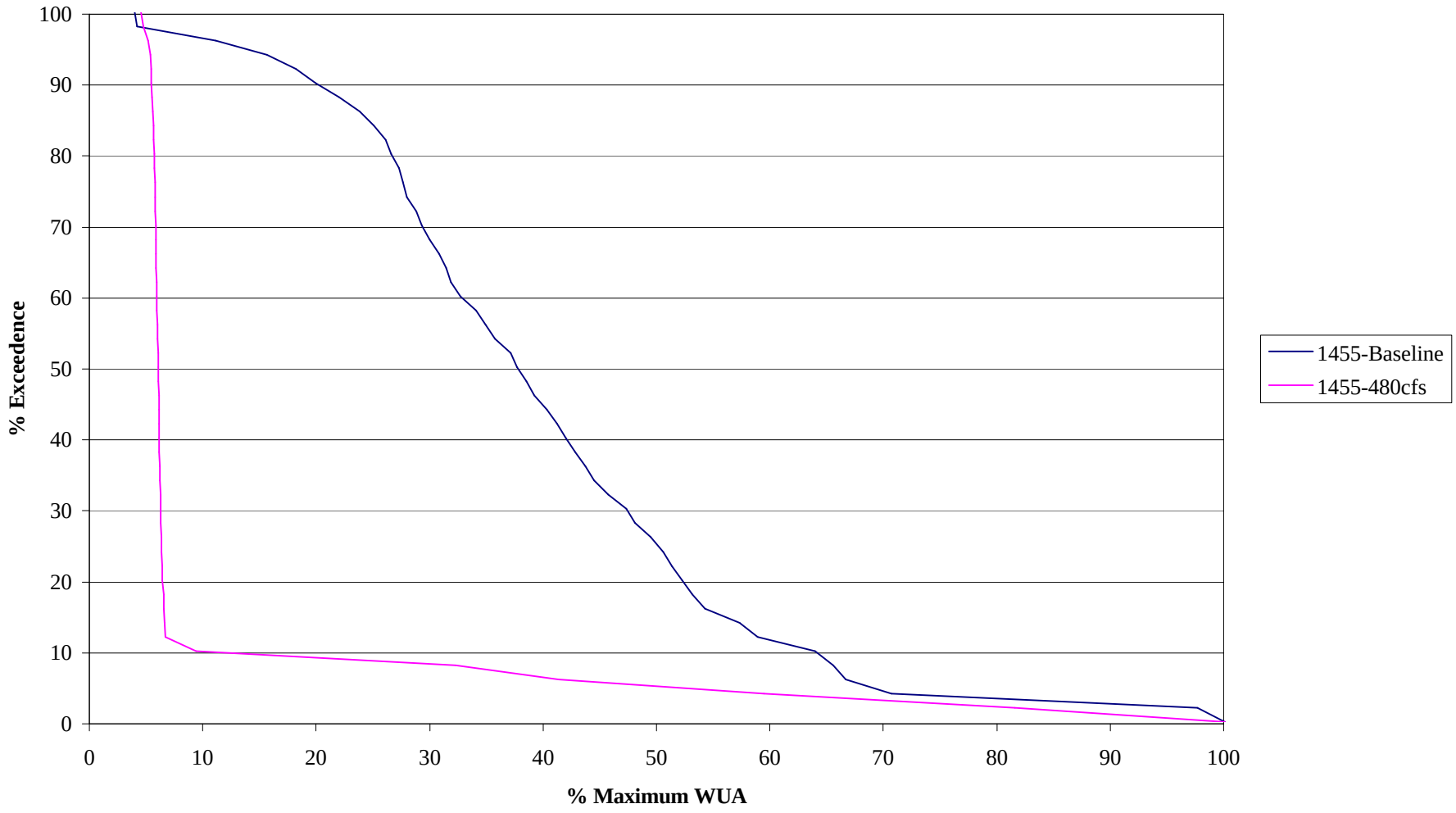

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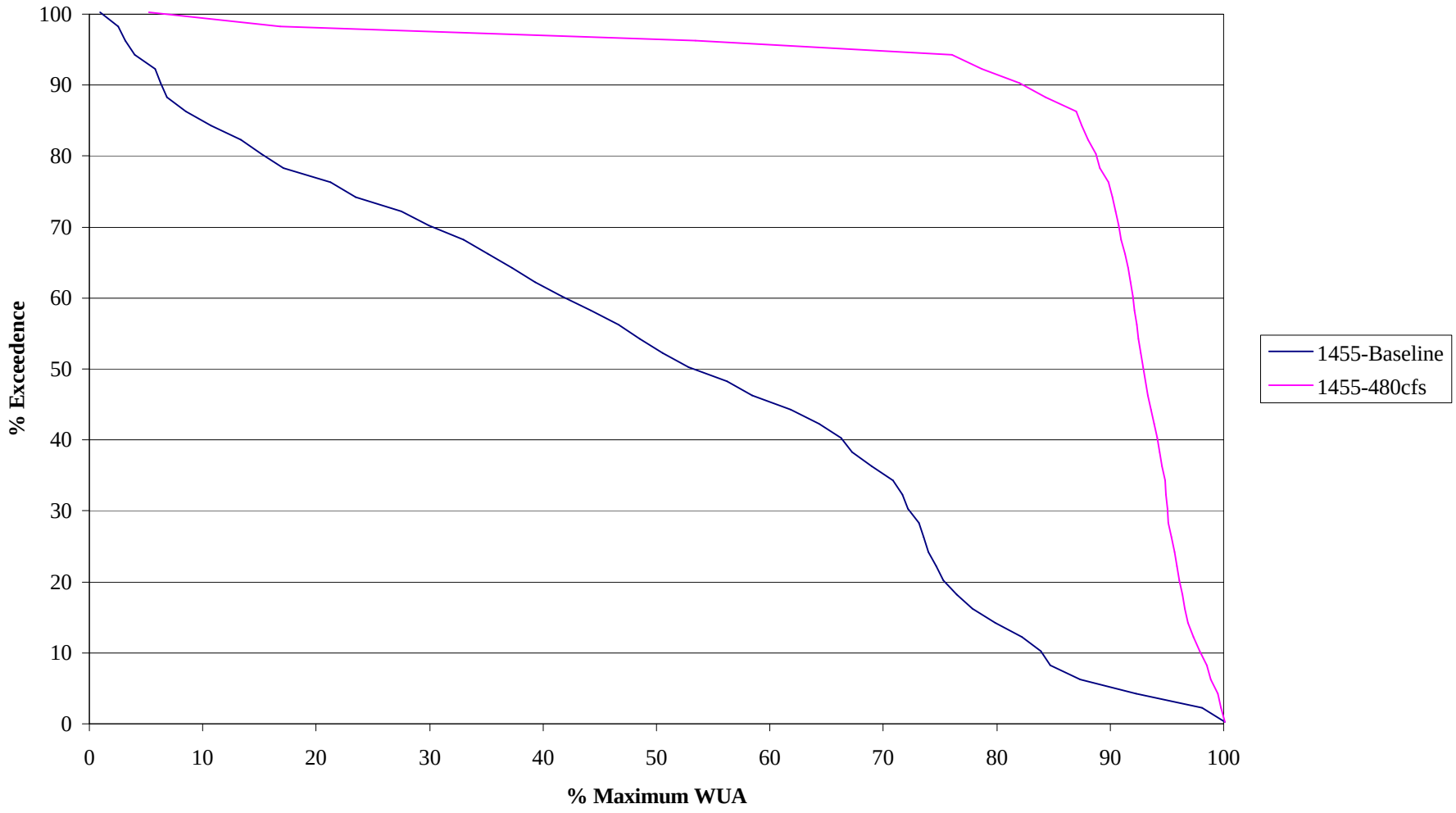

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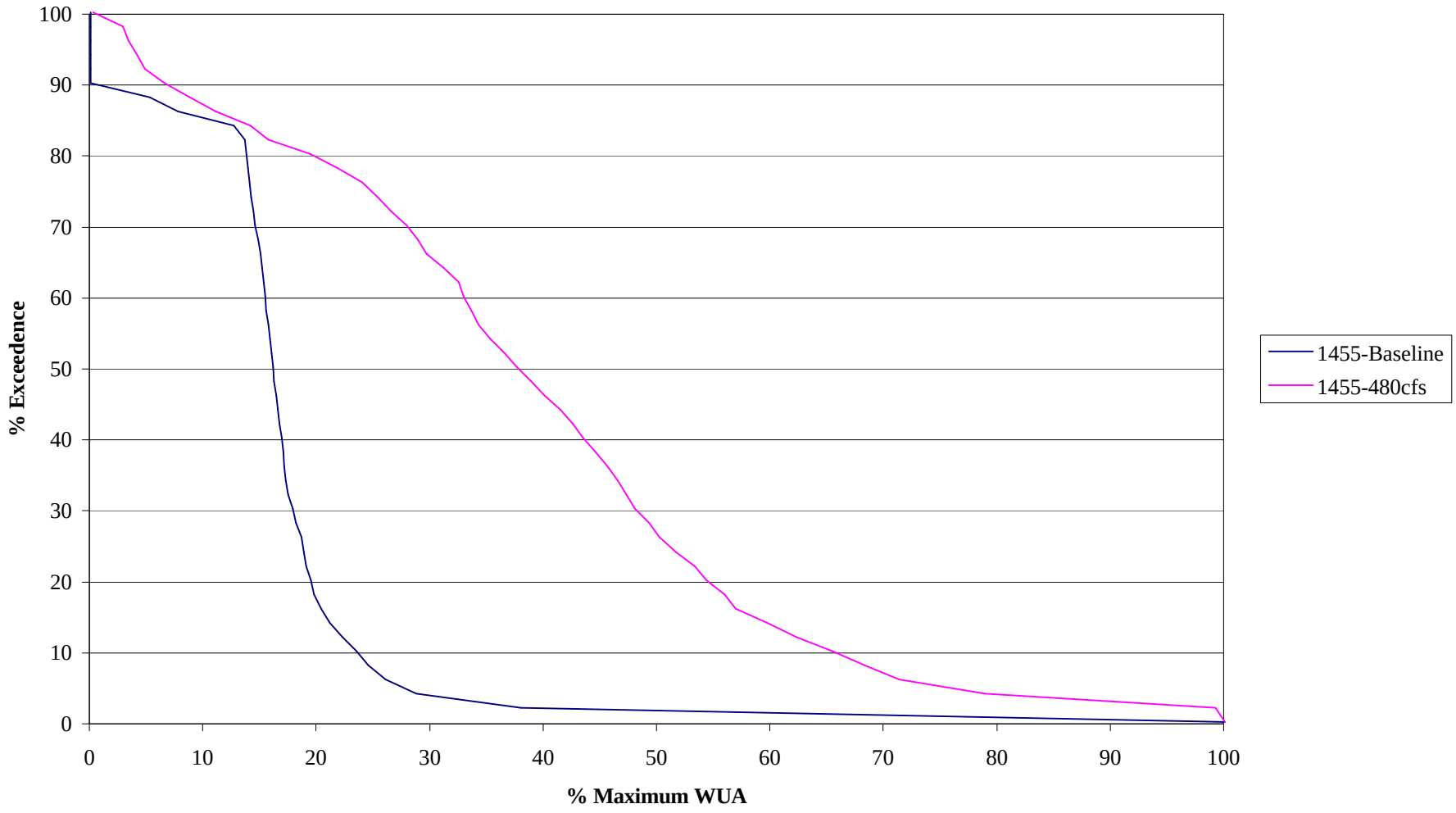

% EXCEEDENCE OF % MAXIMUM WUA FOR HABITAT REACH B RACEWAY
FALL
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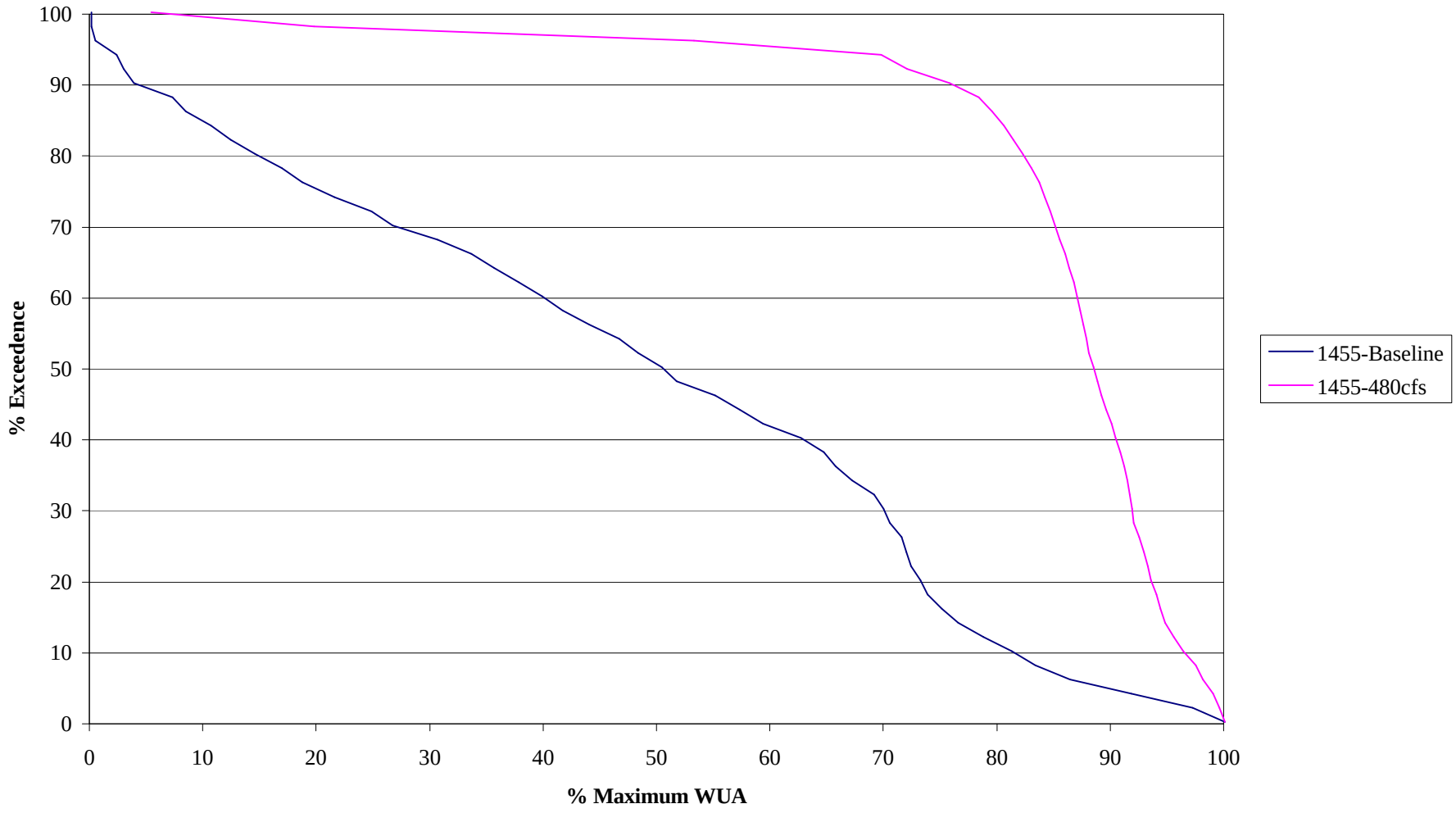

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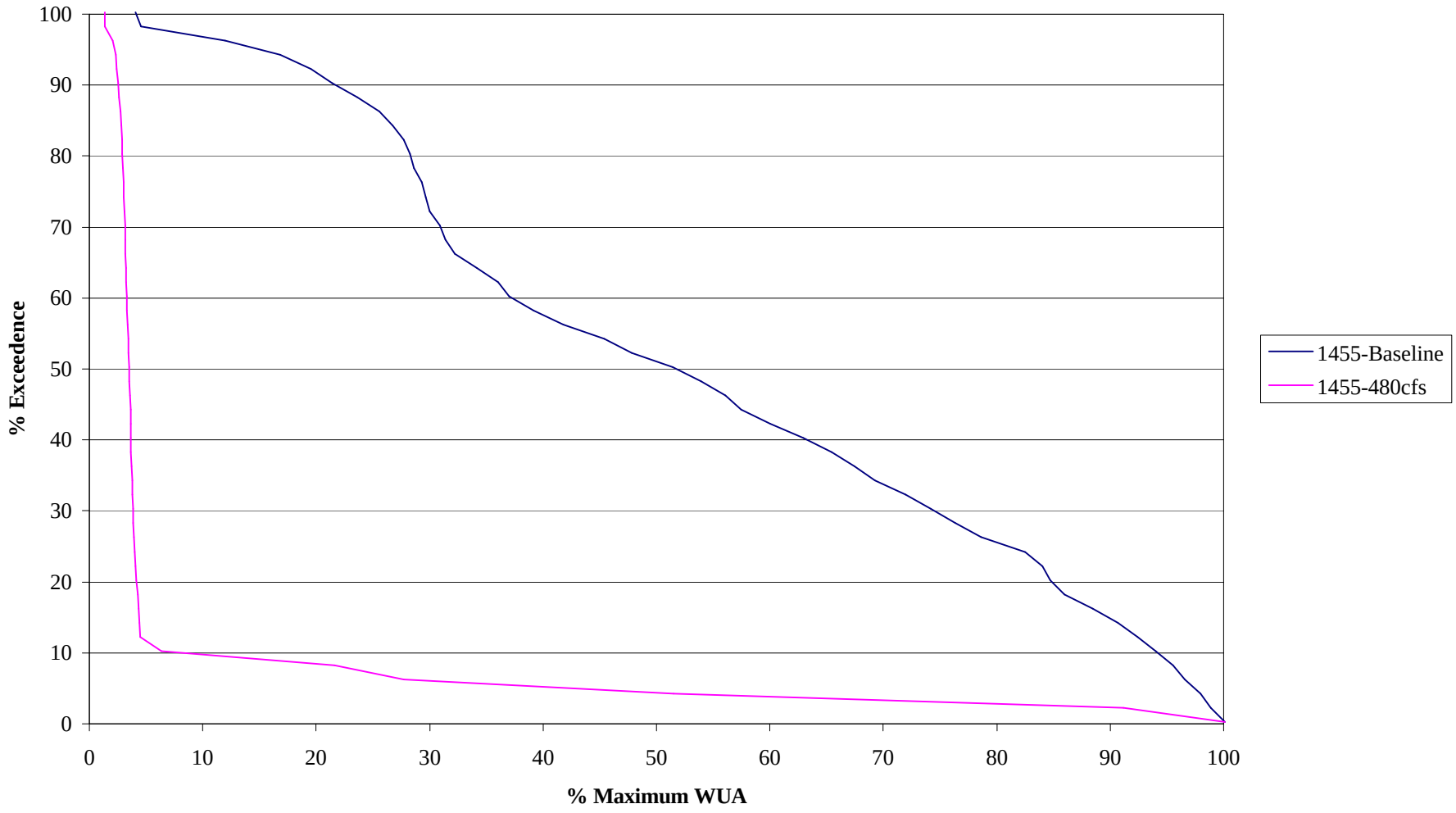

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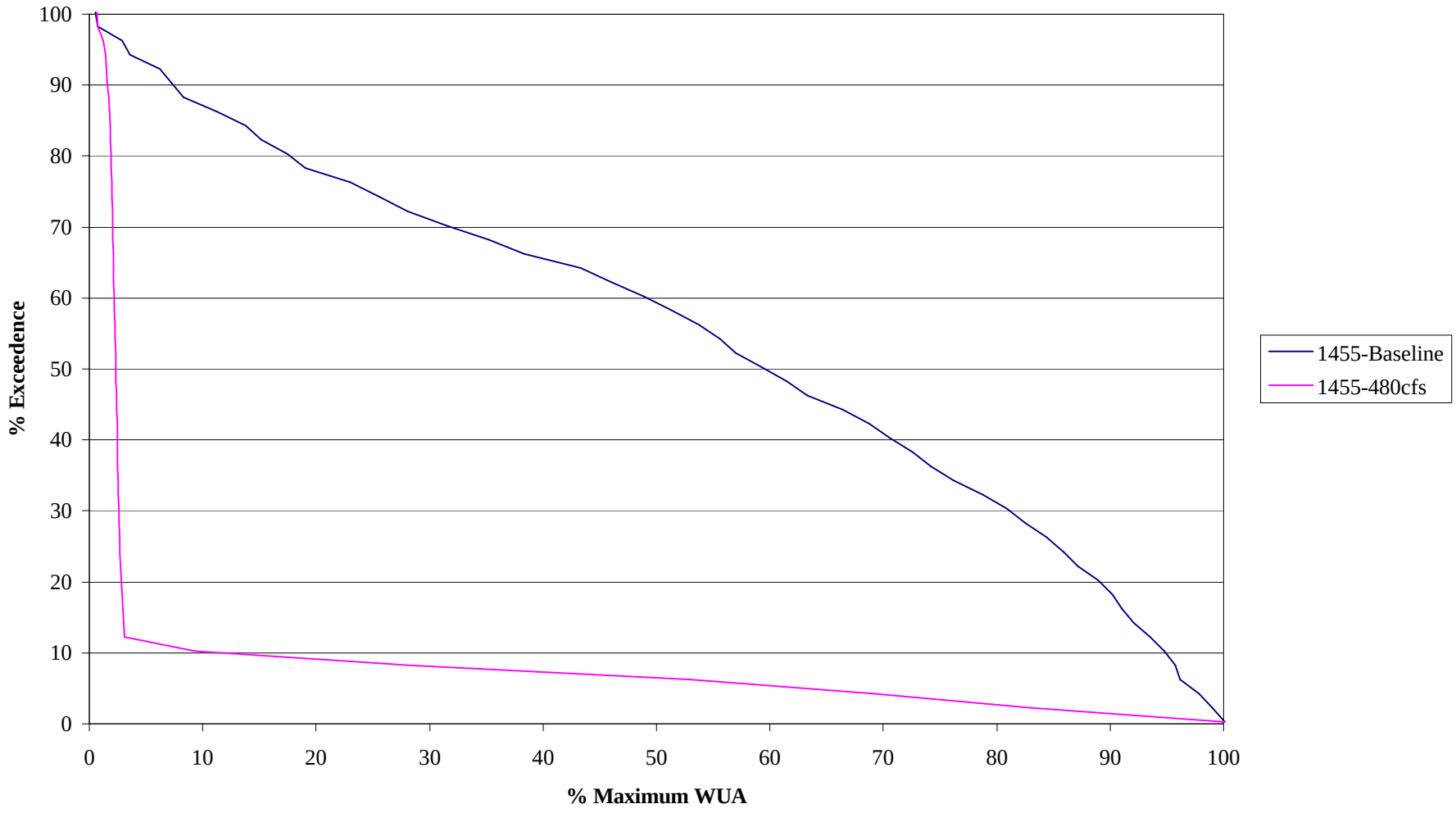

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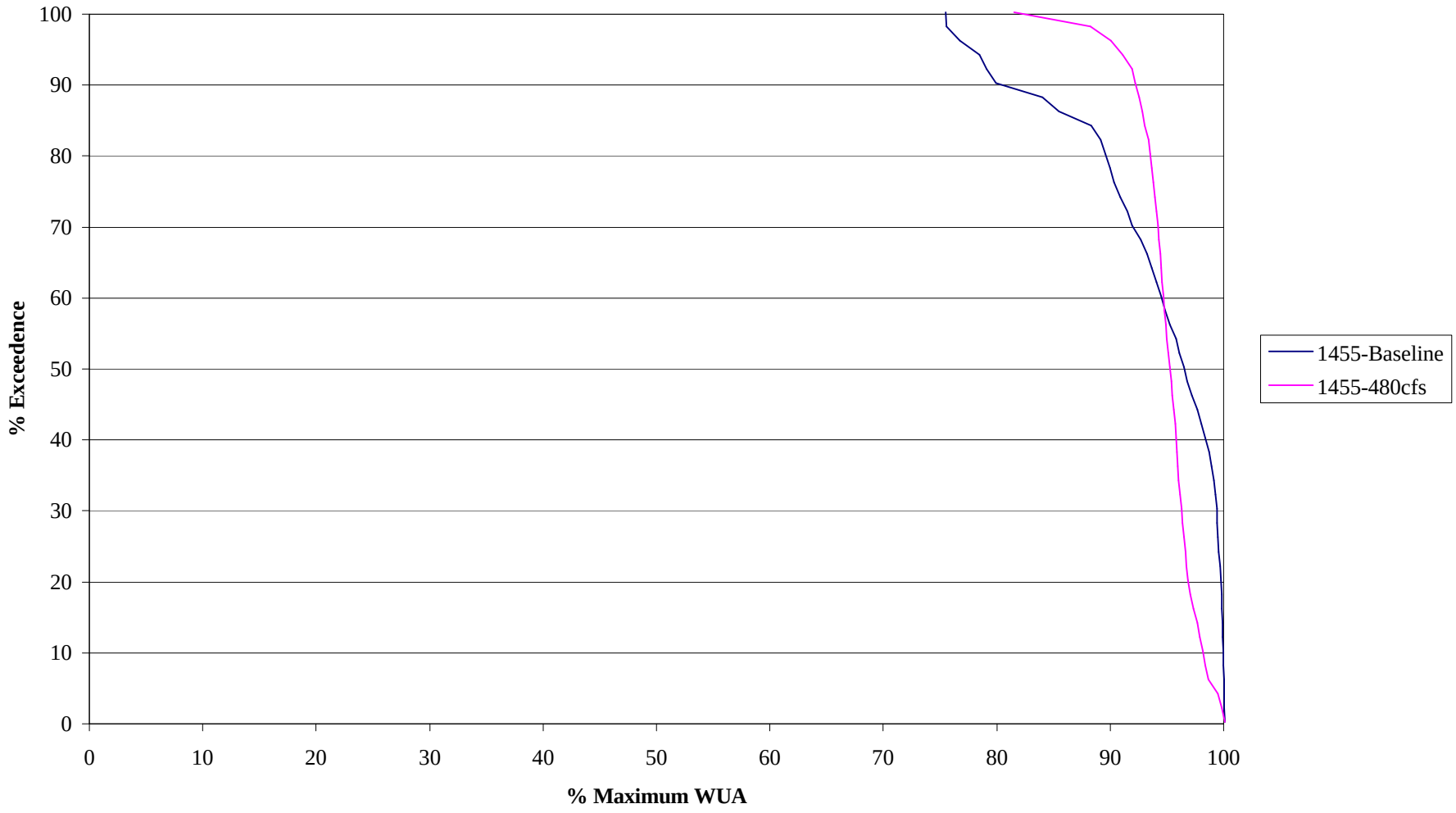

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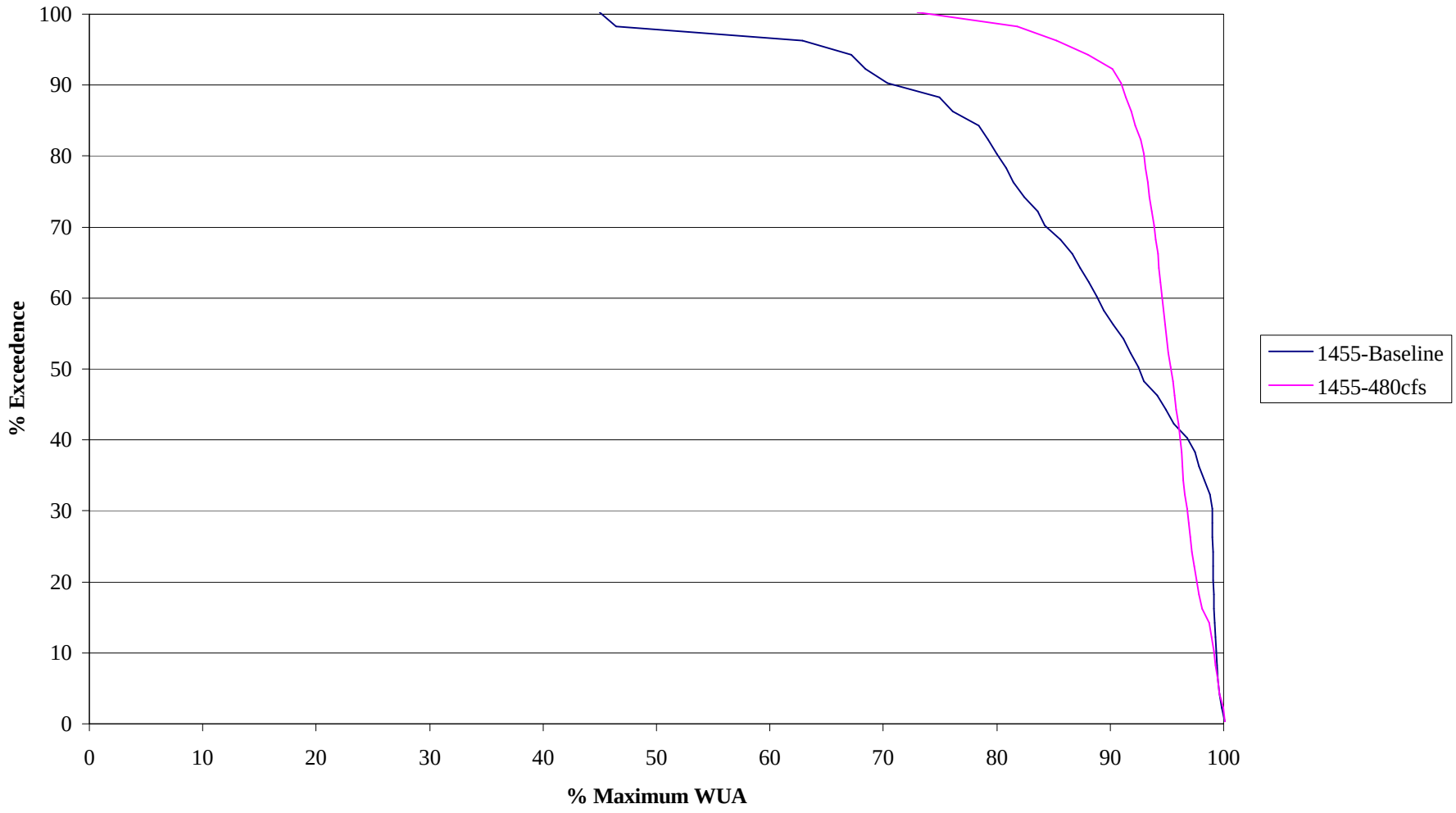
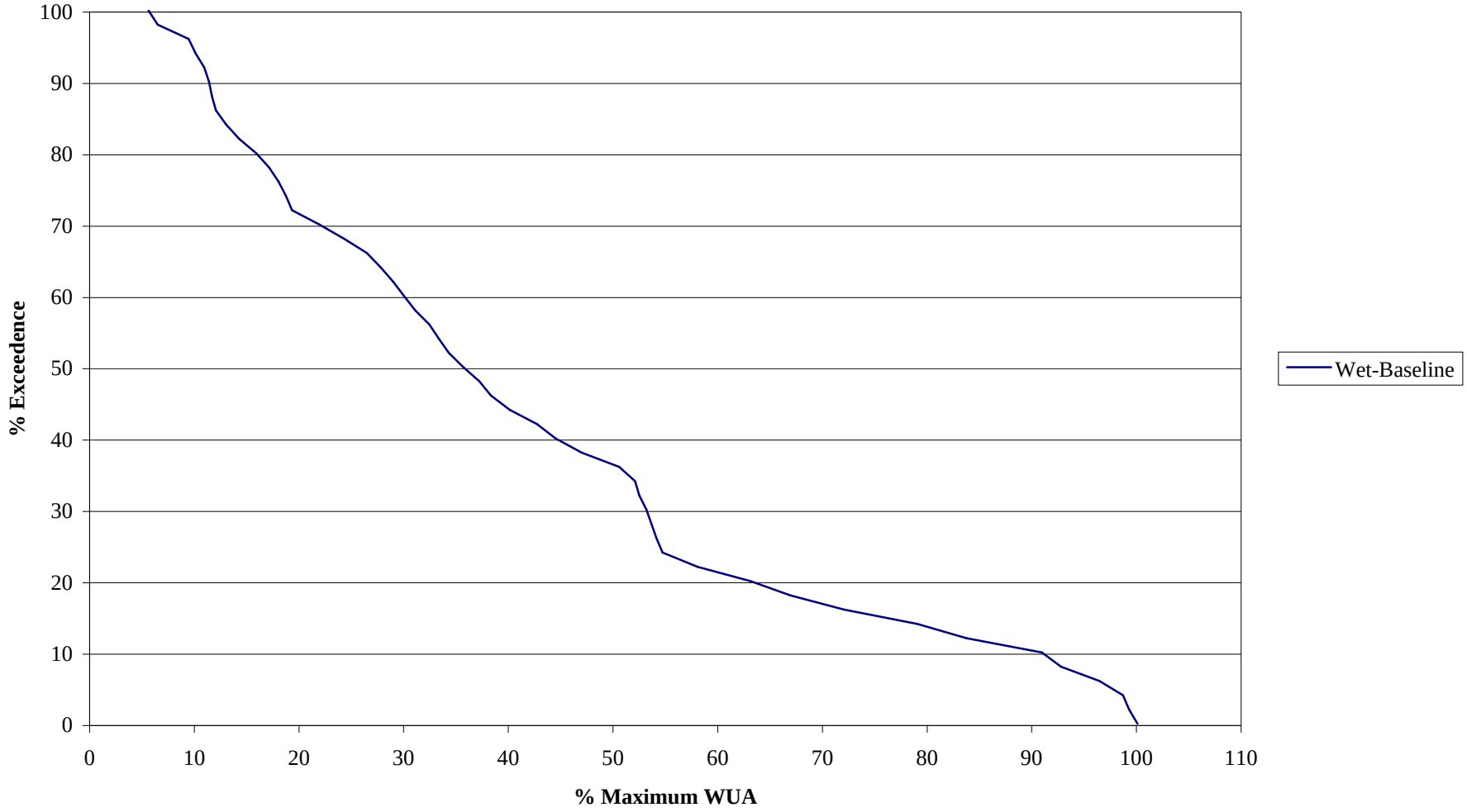


% EXCEEDENCE OF % MAXIMUM WUA FOR HABITAT REACH L SHALLOW POOL SPRING

Final Aquatic Impact Analysis Report



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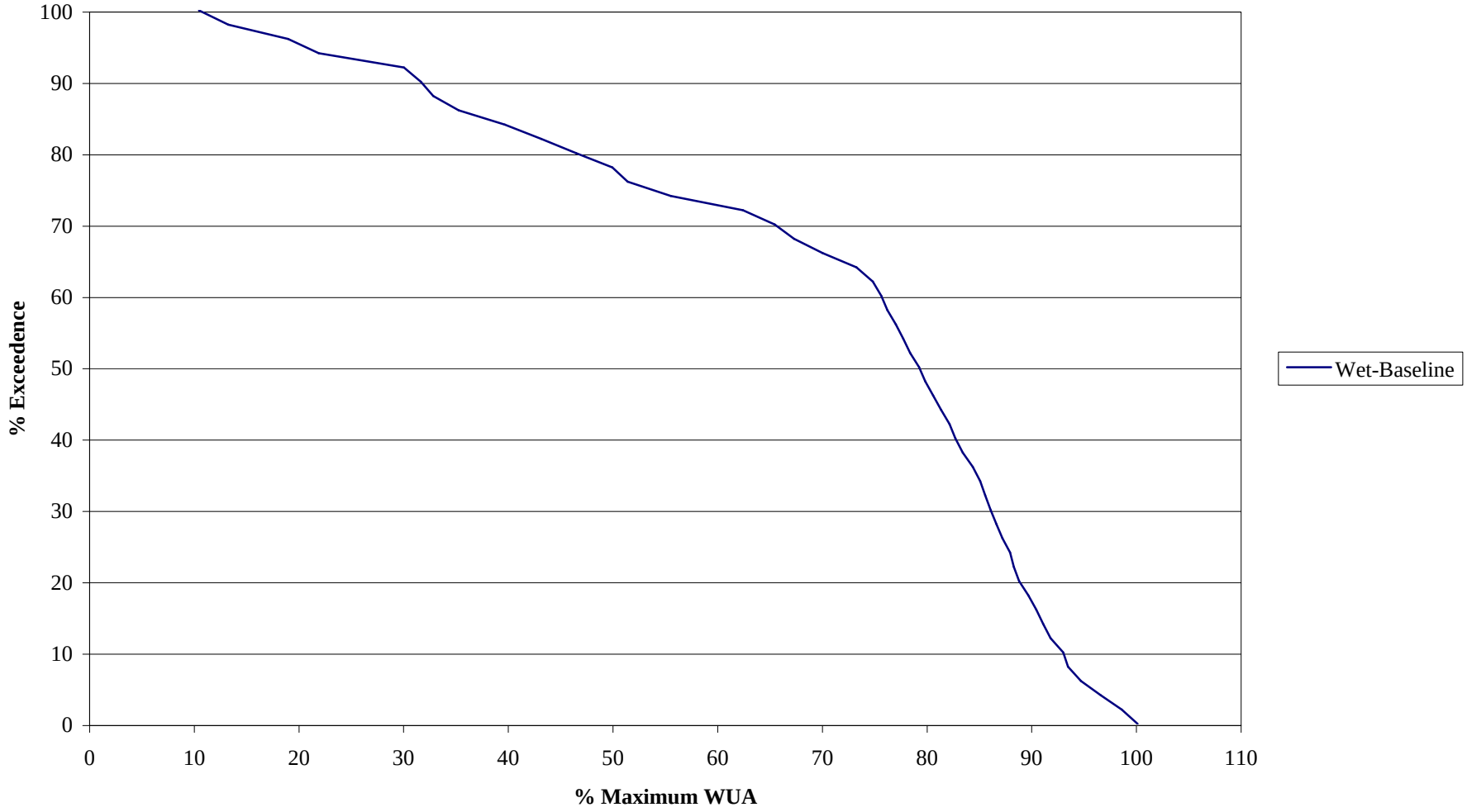

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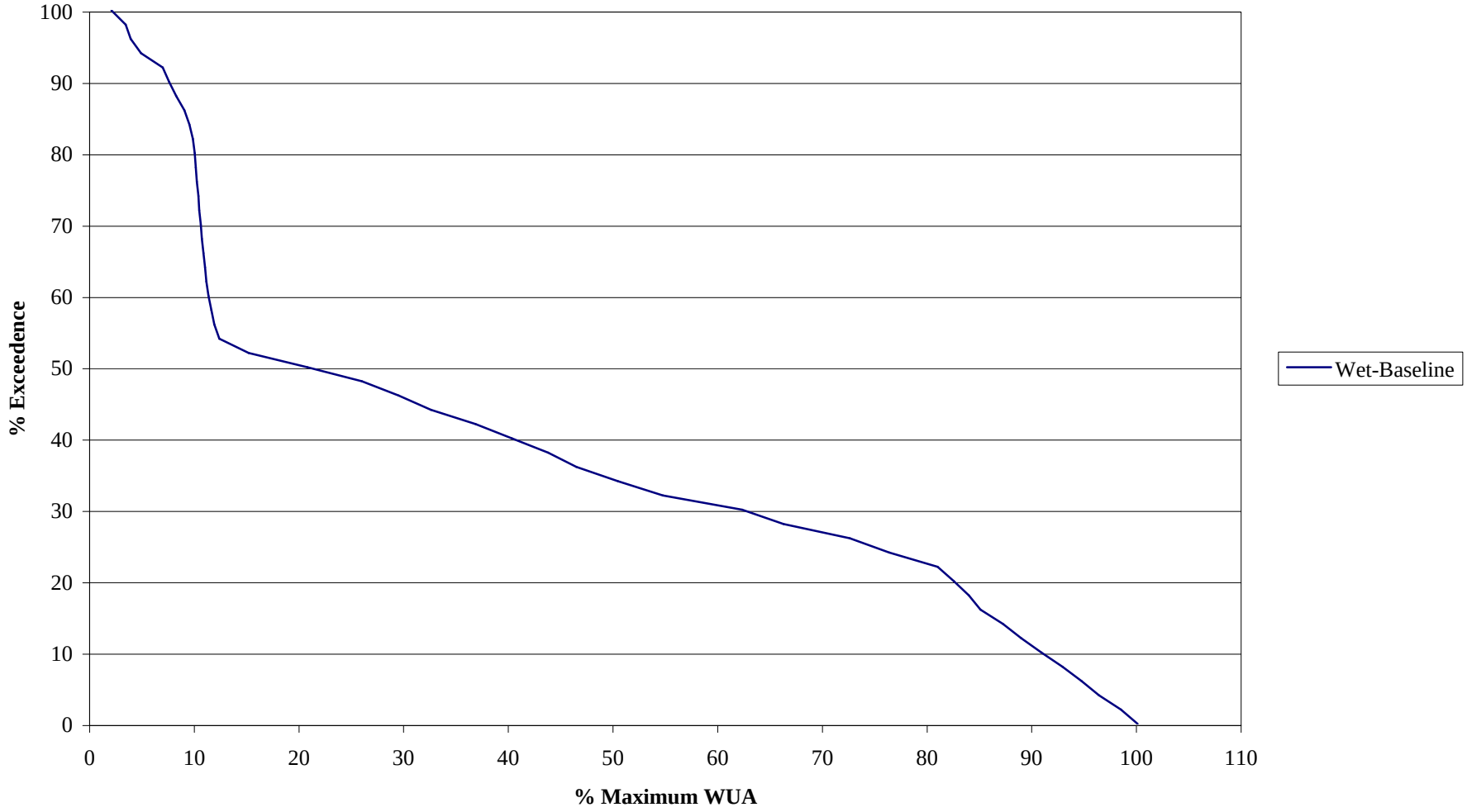

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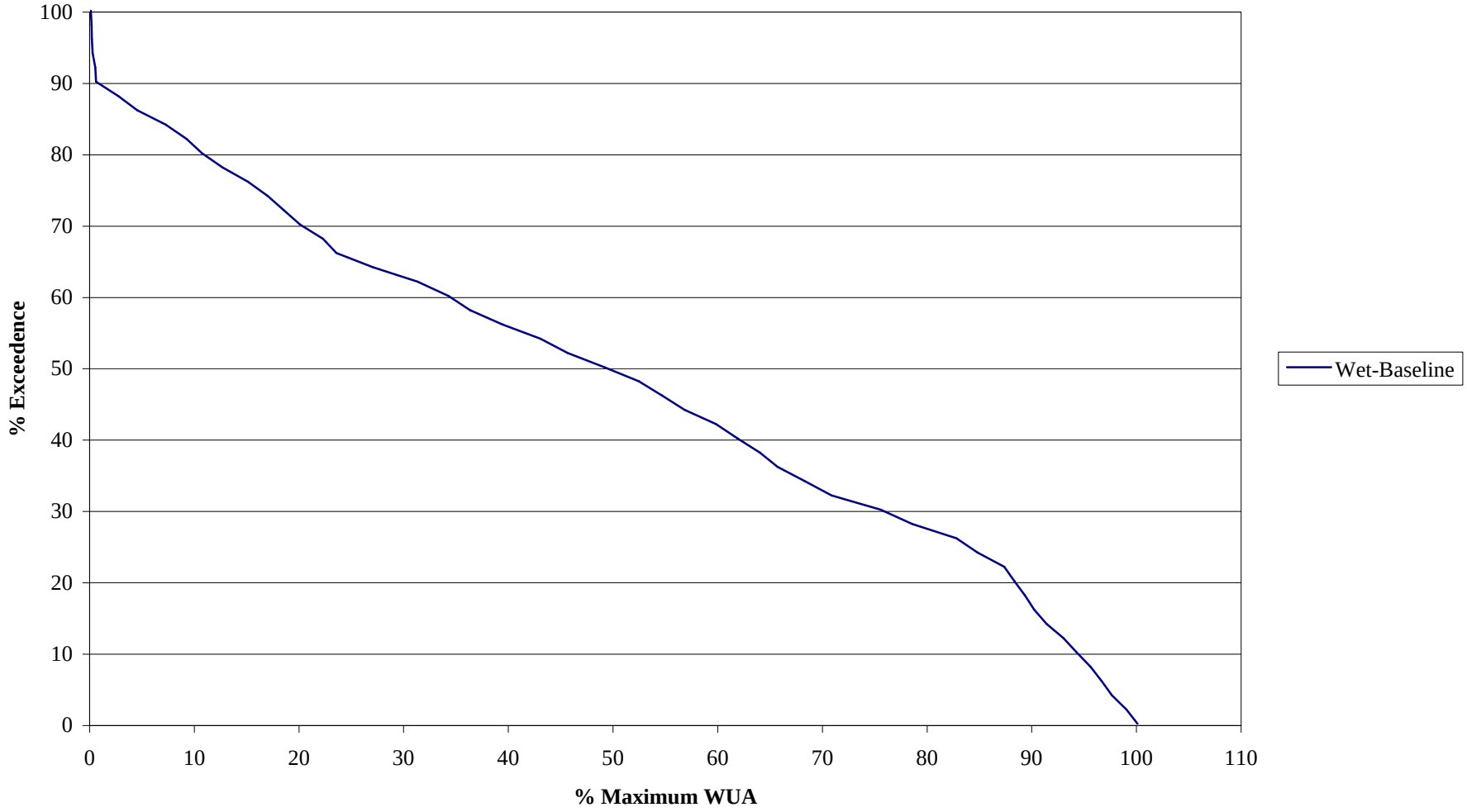

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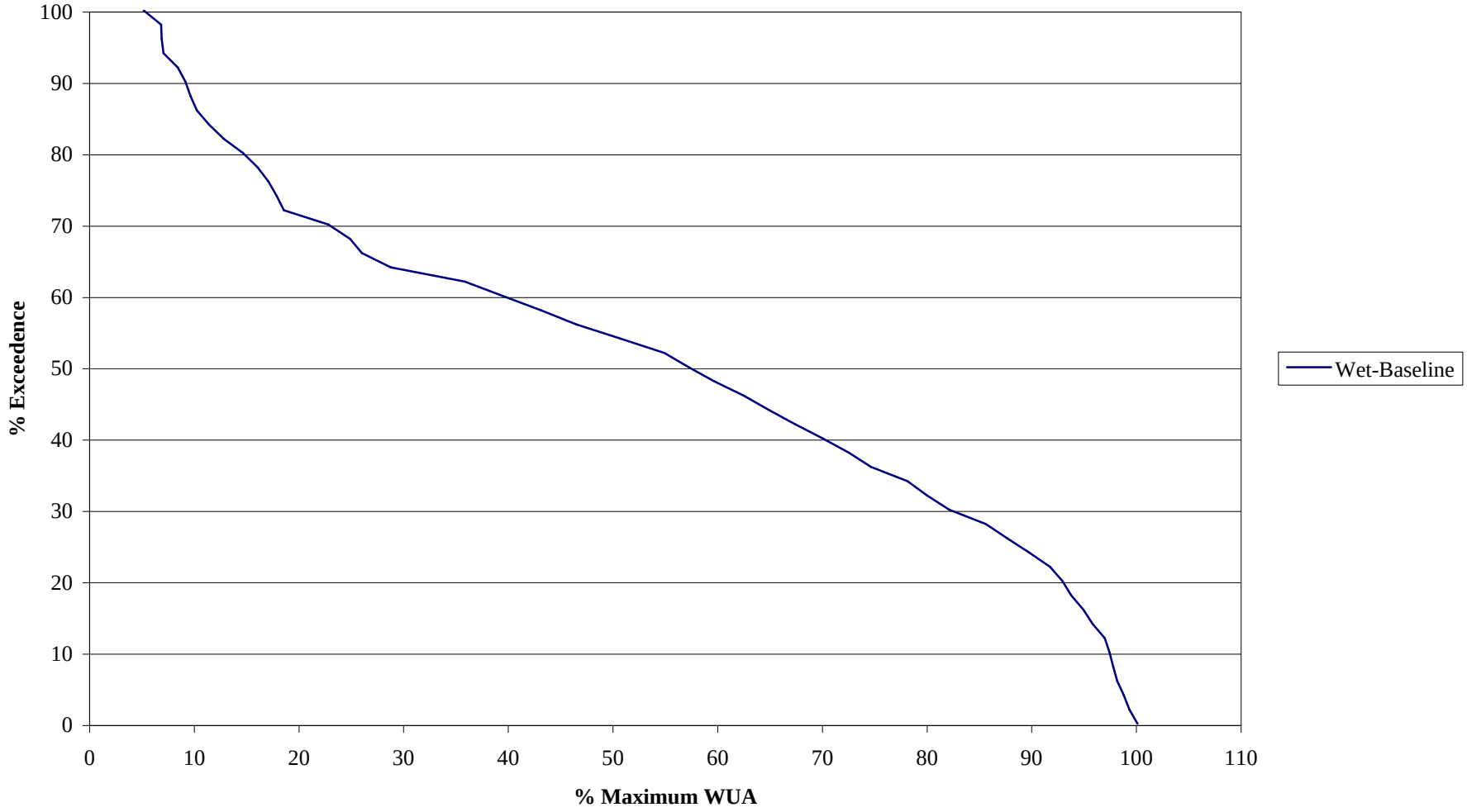

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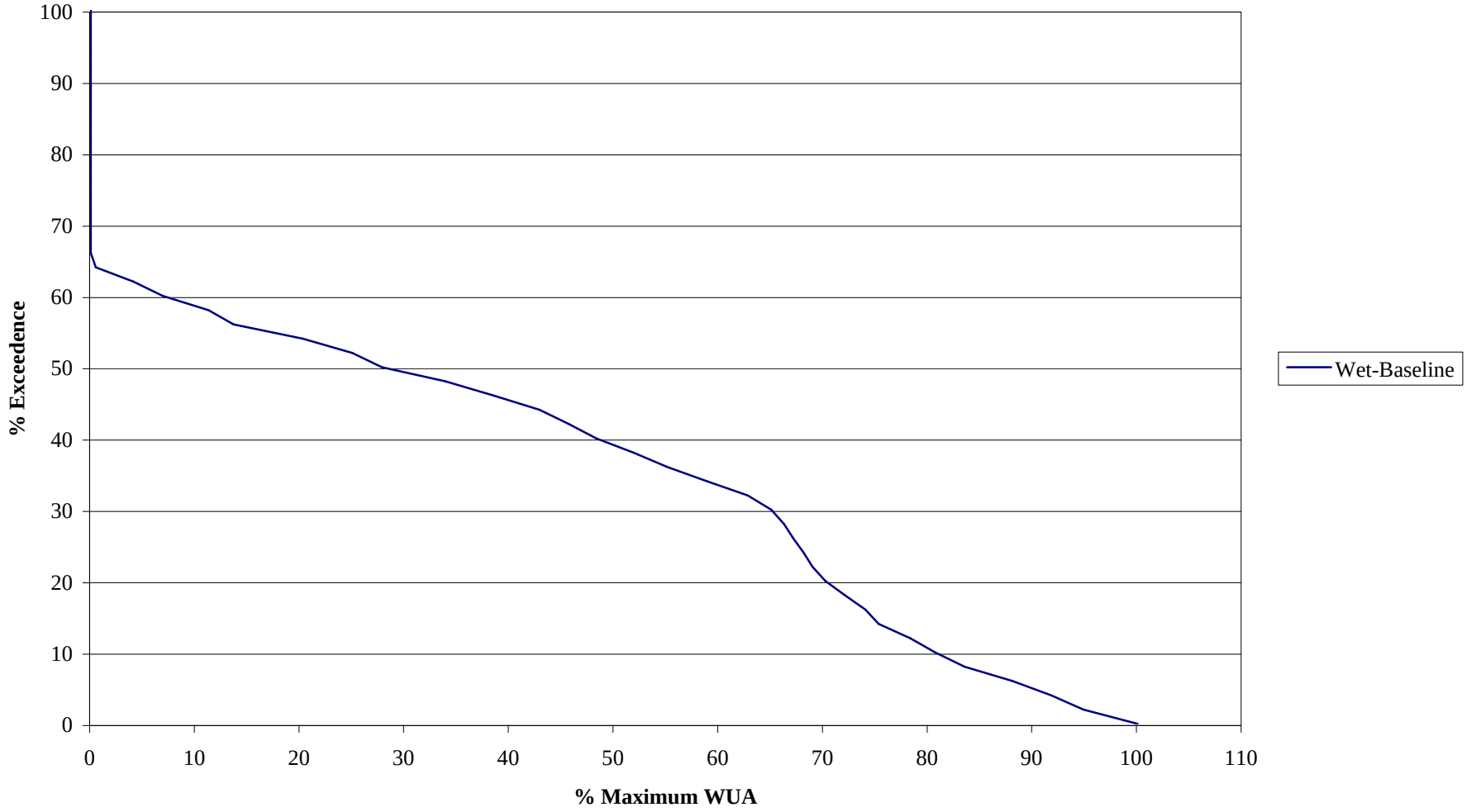
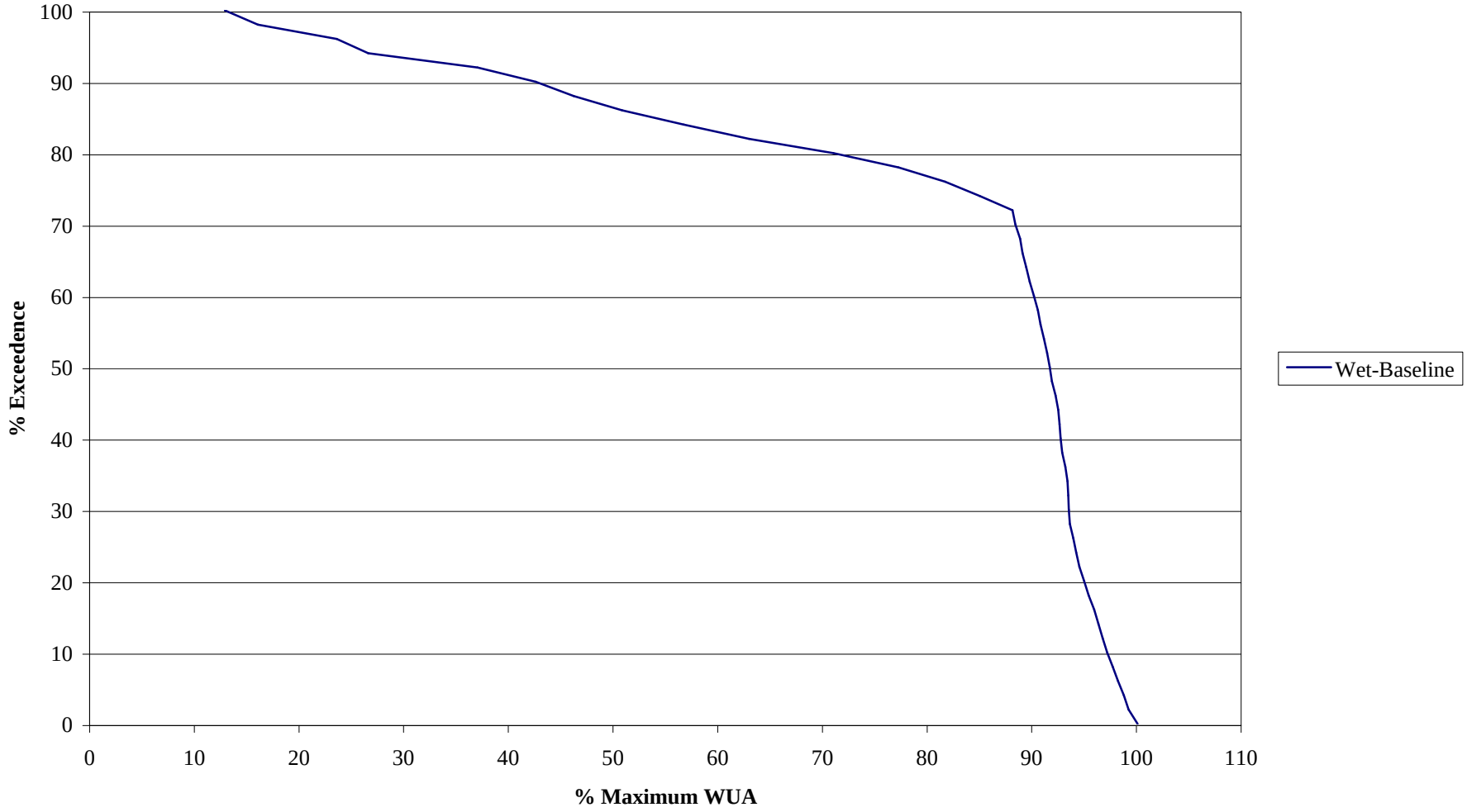


% EXCEEDENCE OF % MAXIMUM WUA FOR HABITAT REACH L LOW GRADIENT SPRING

Final Aquatic Impact Analysis Report



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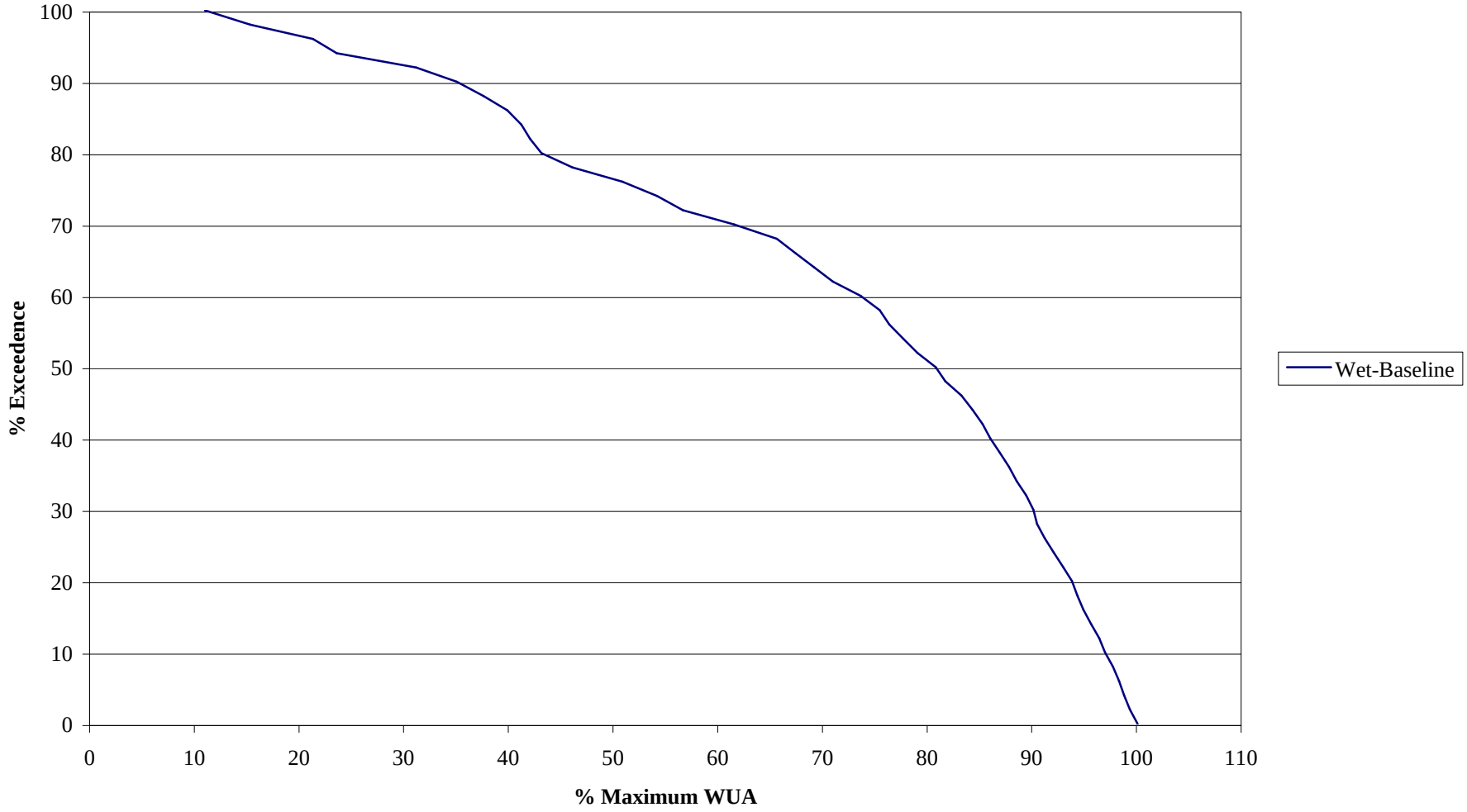

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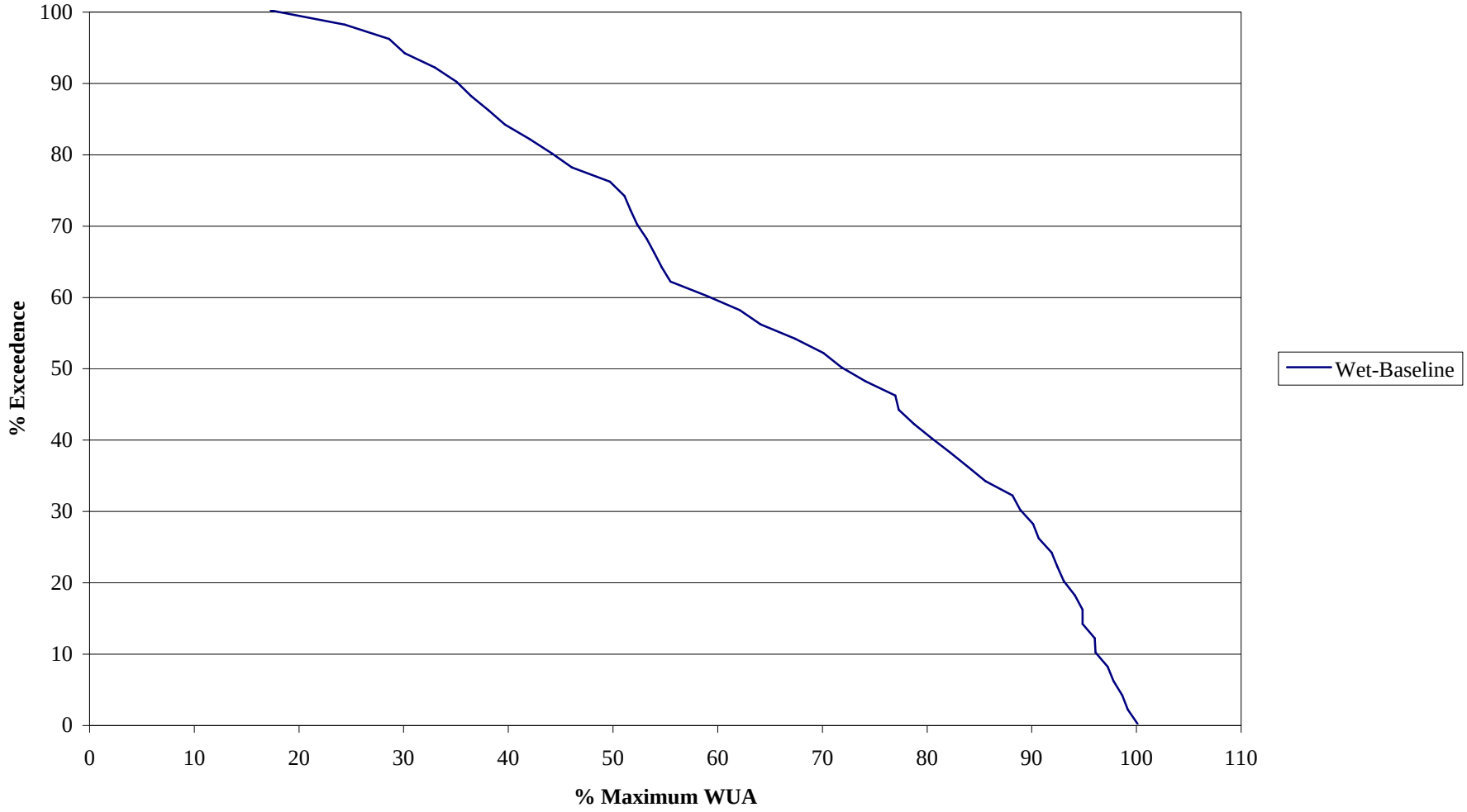

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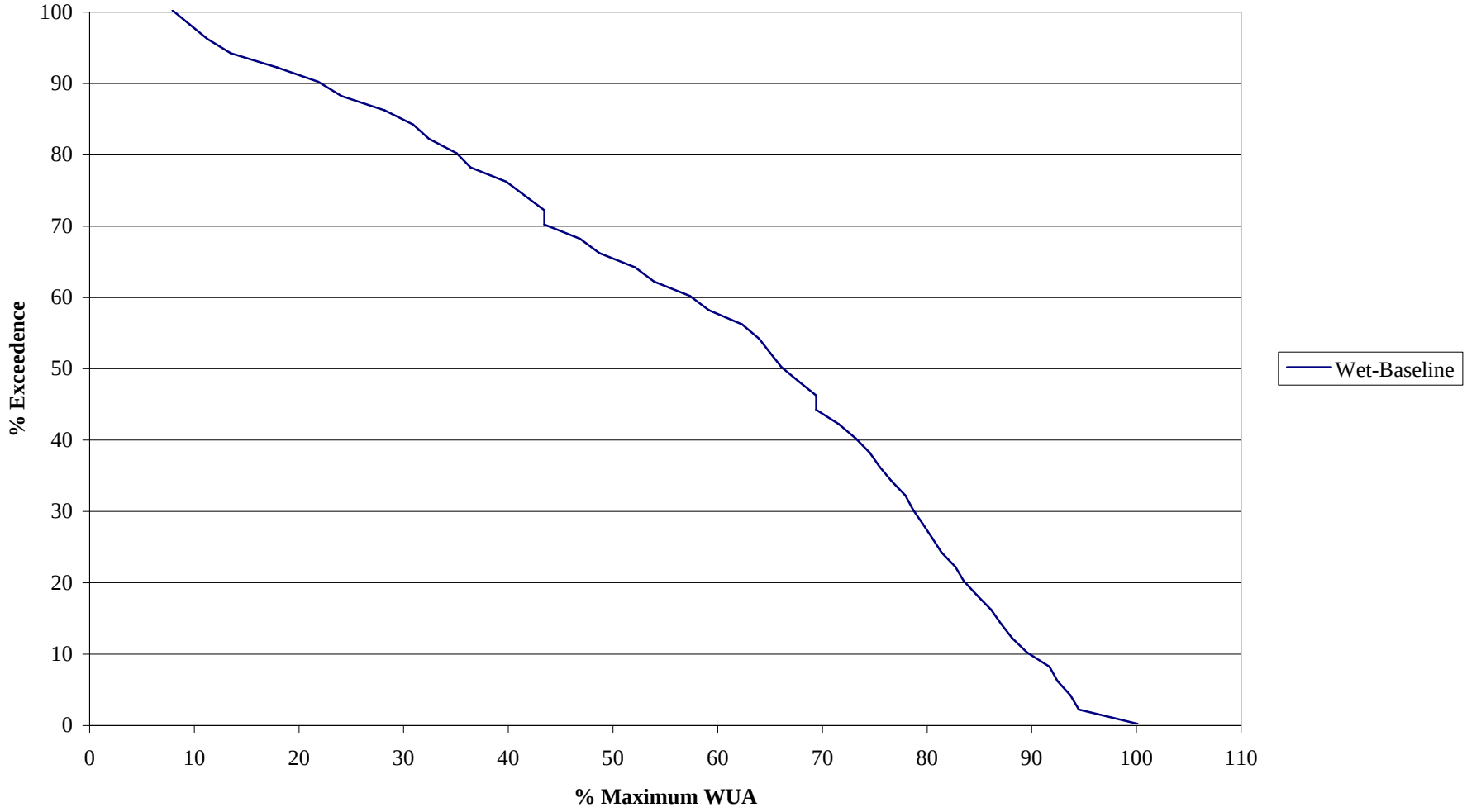

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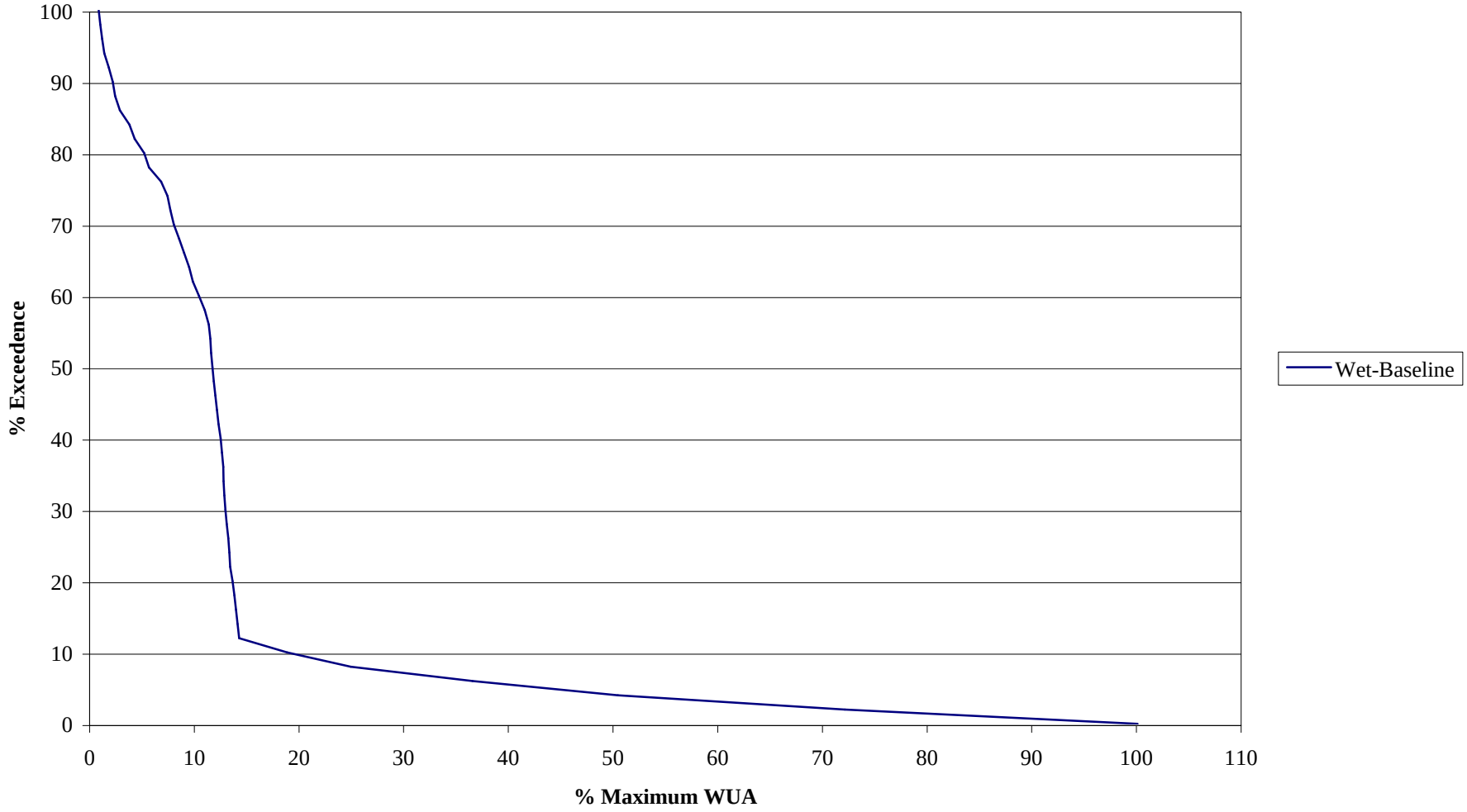

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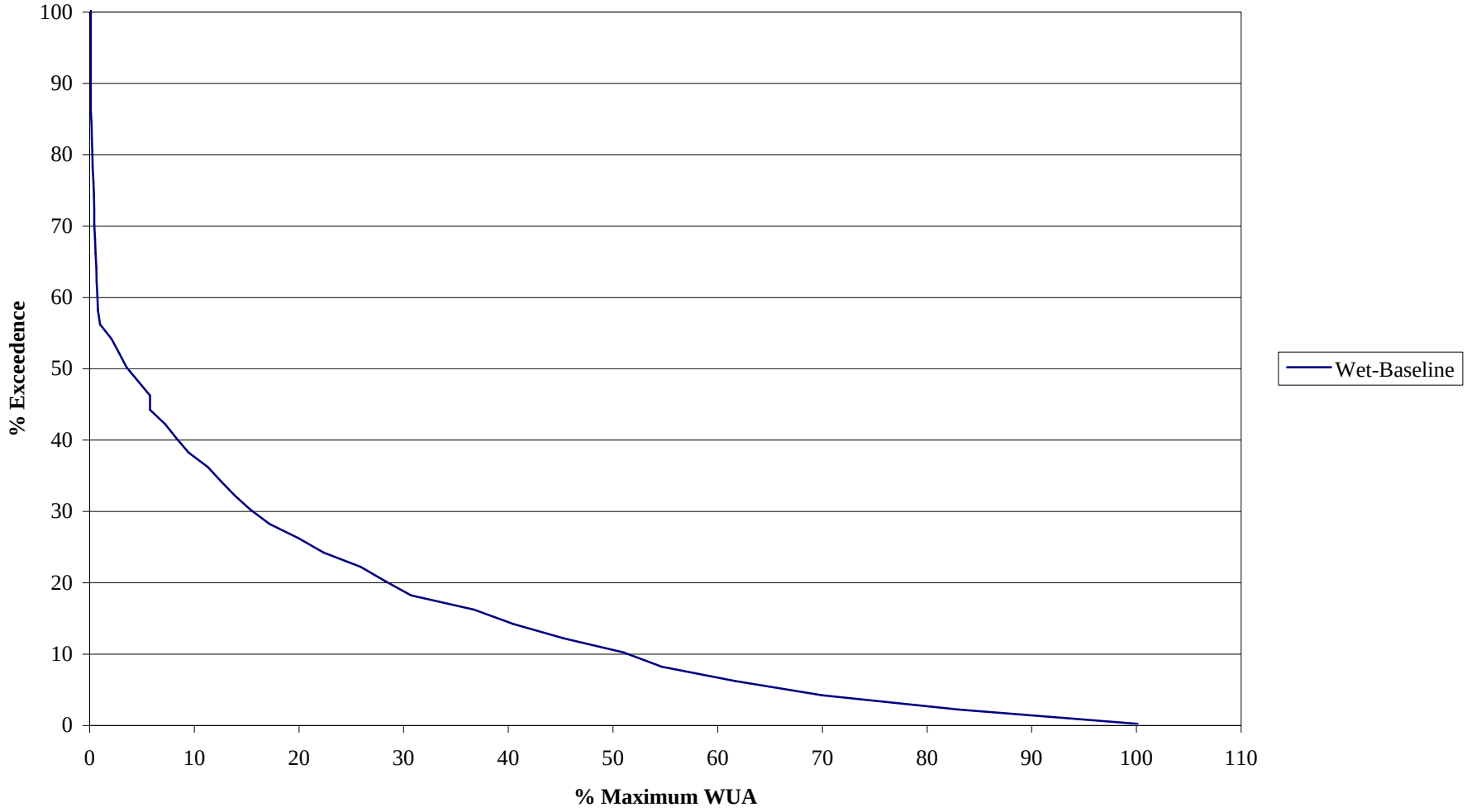

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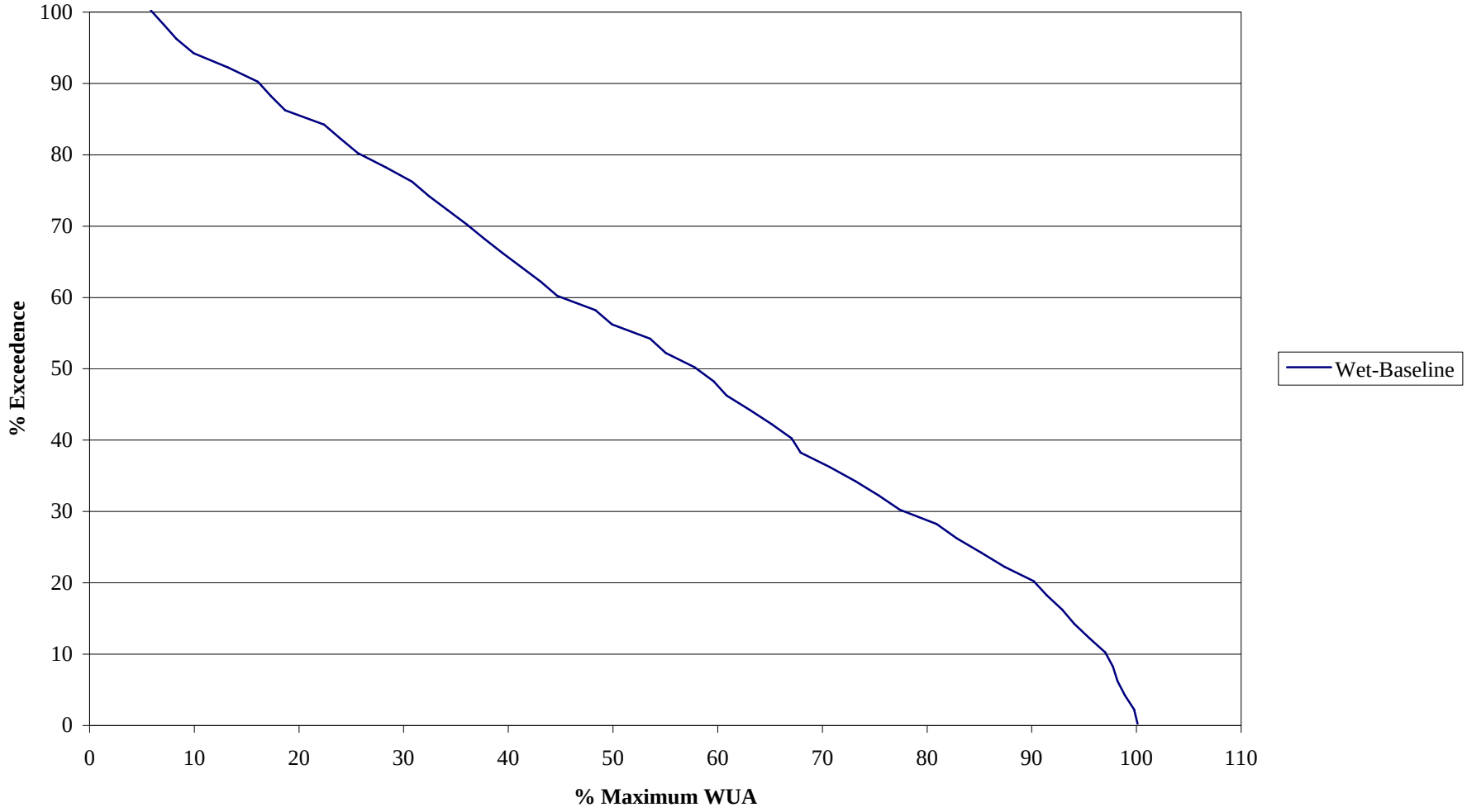

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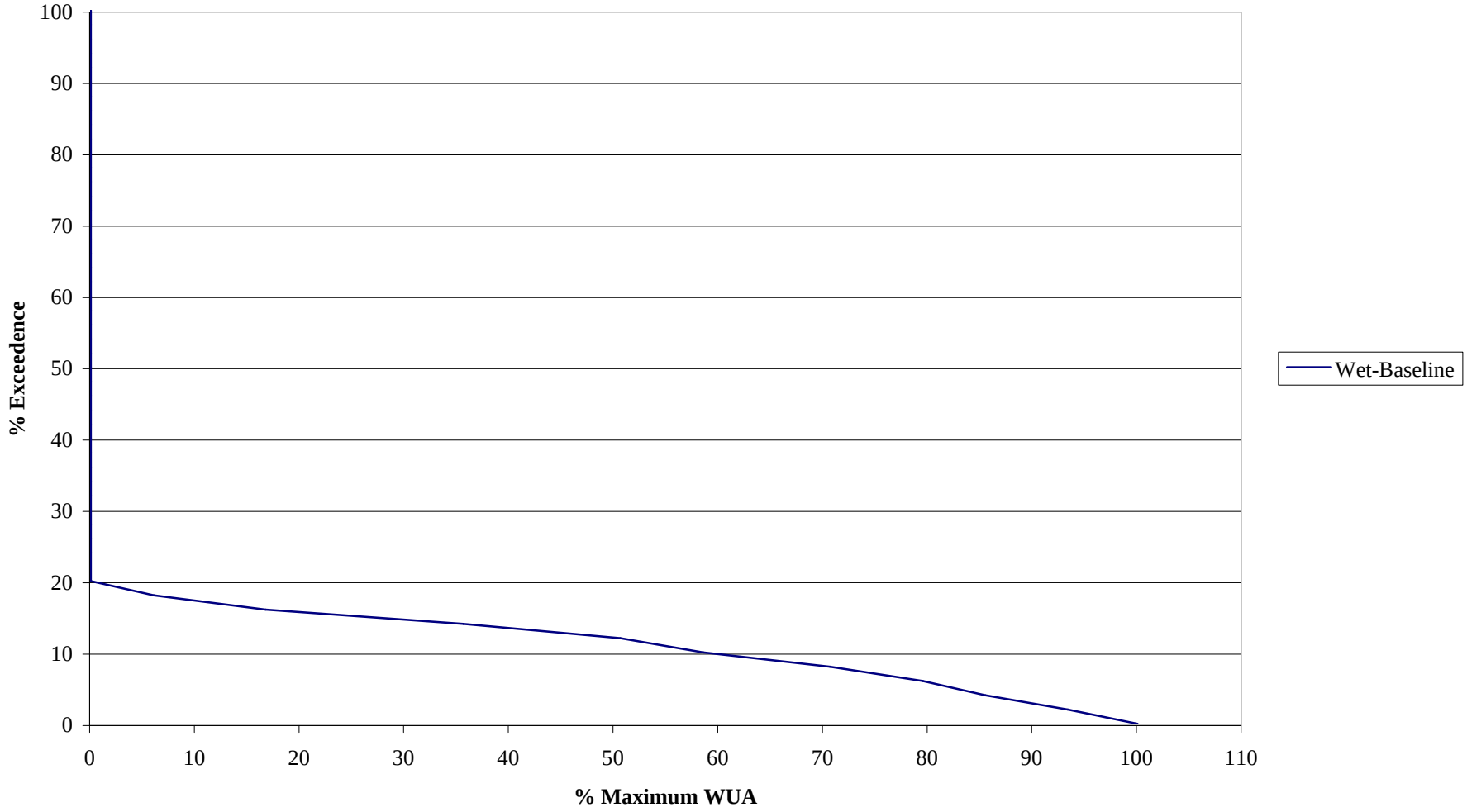

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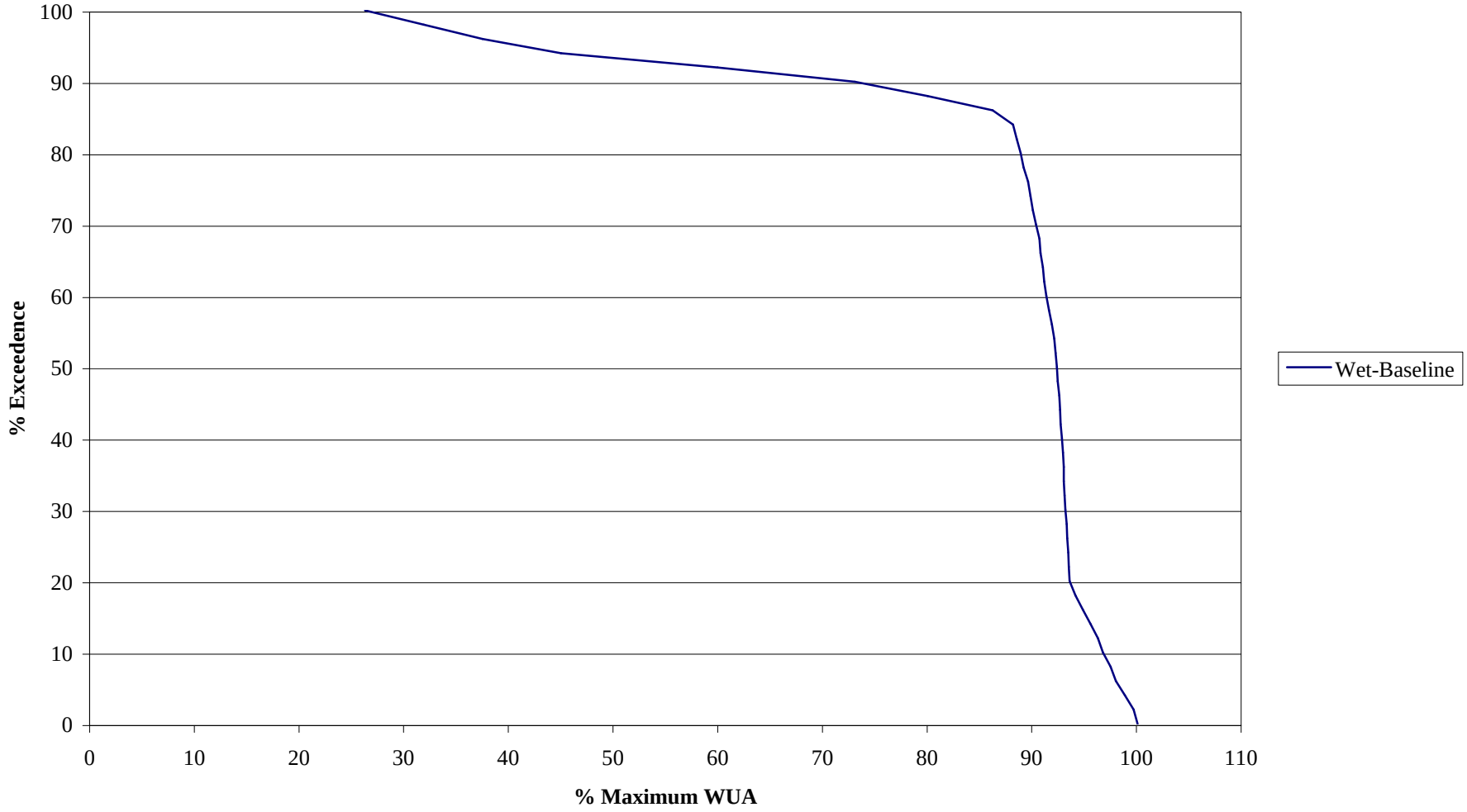

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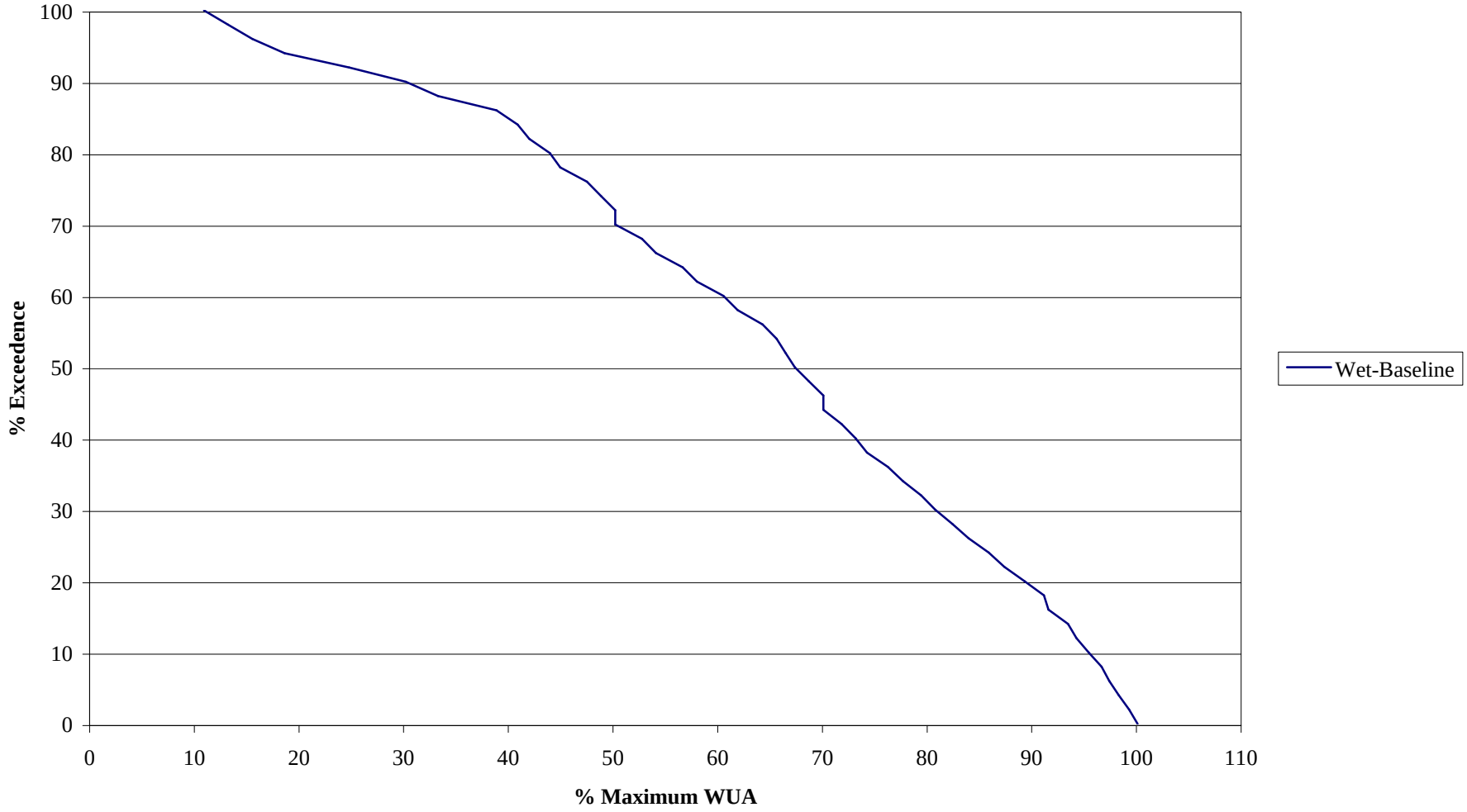

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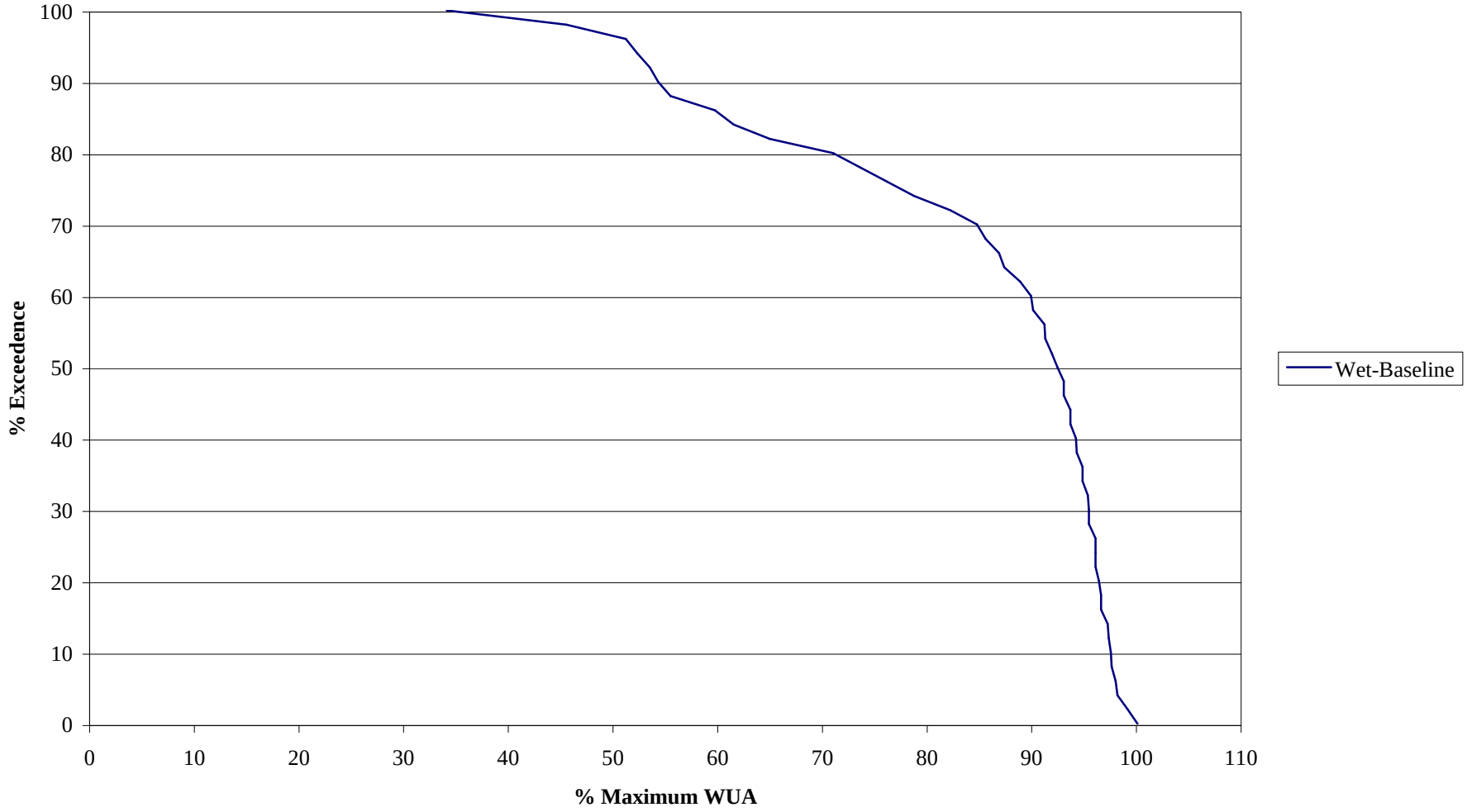

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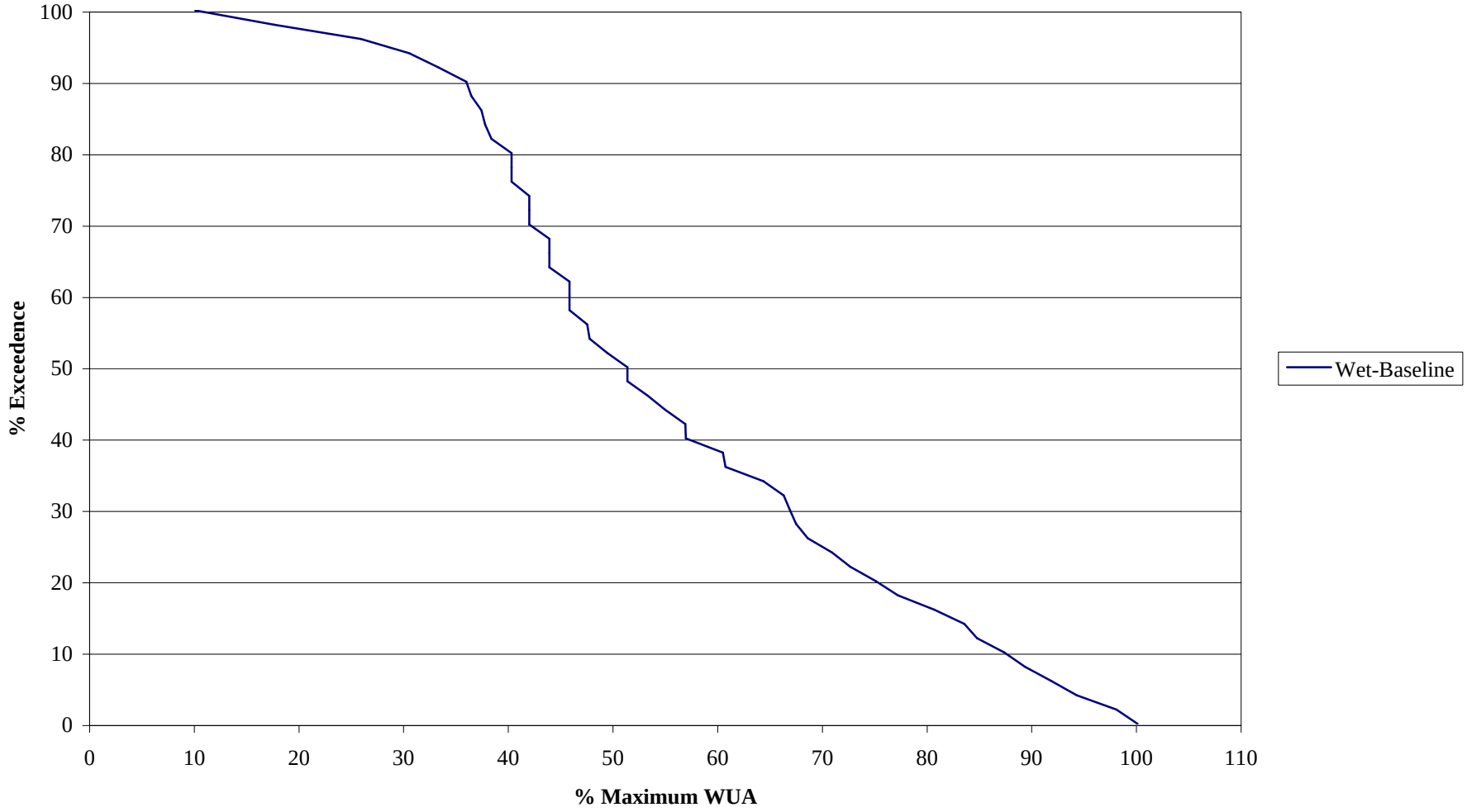

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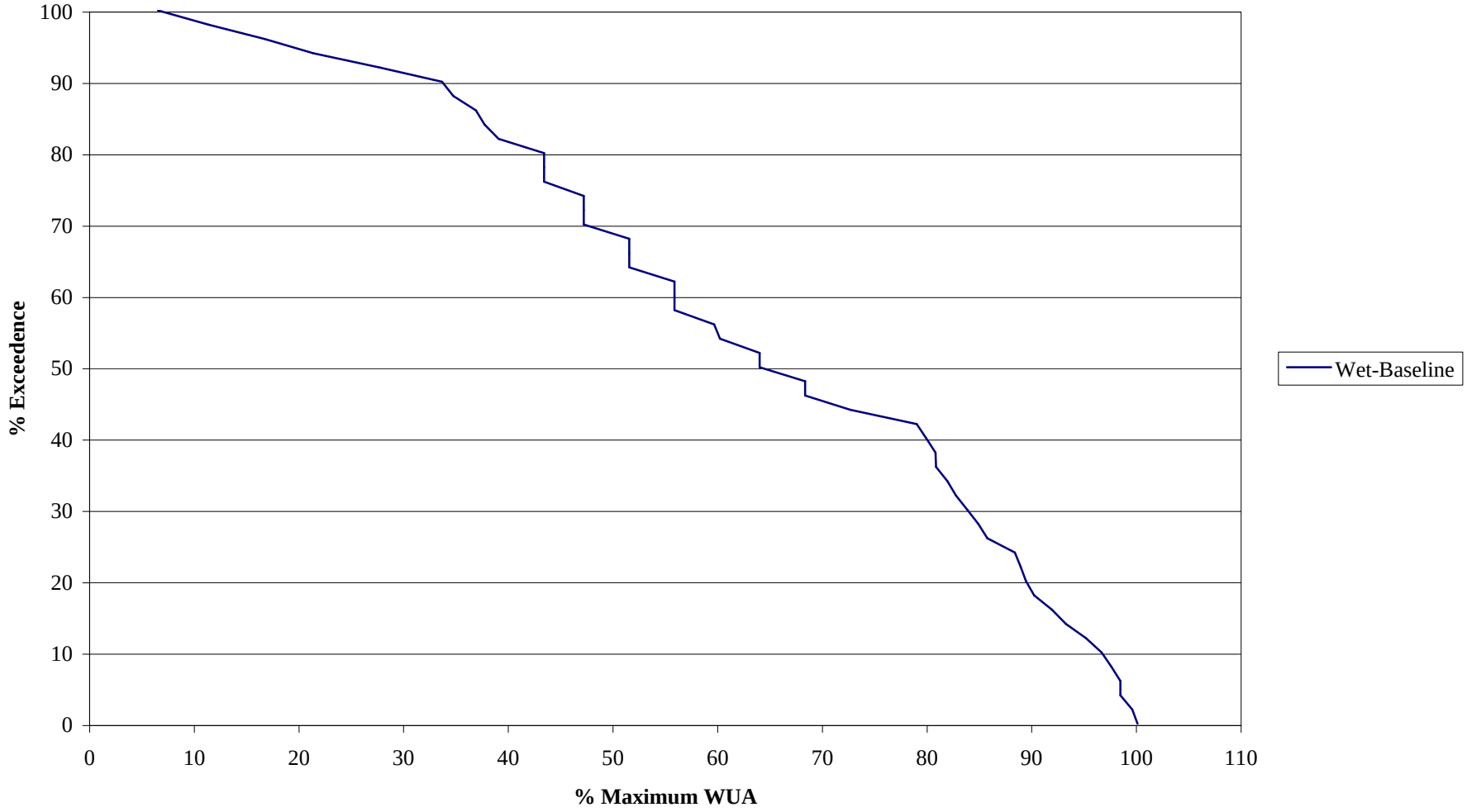

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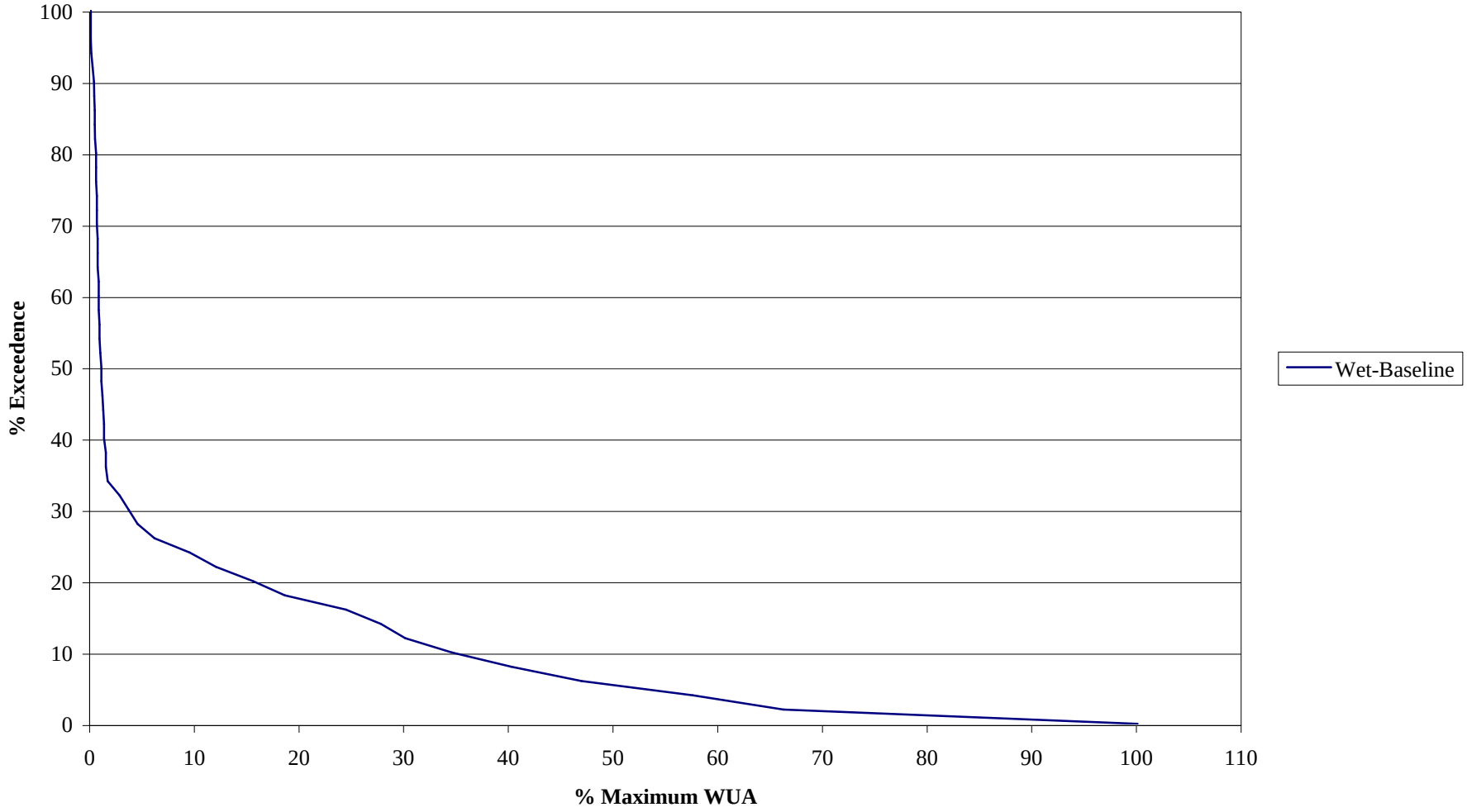

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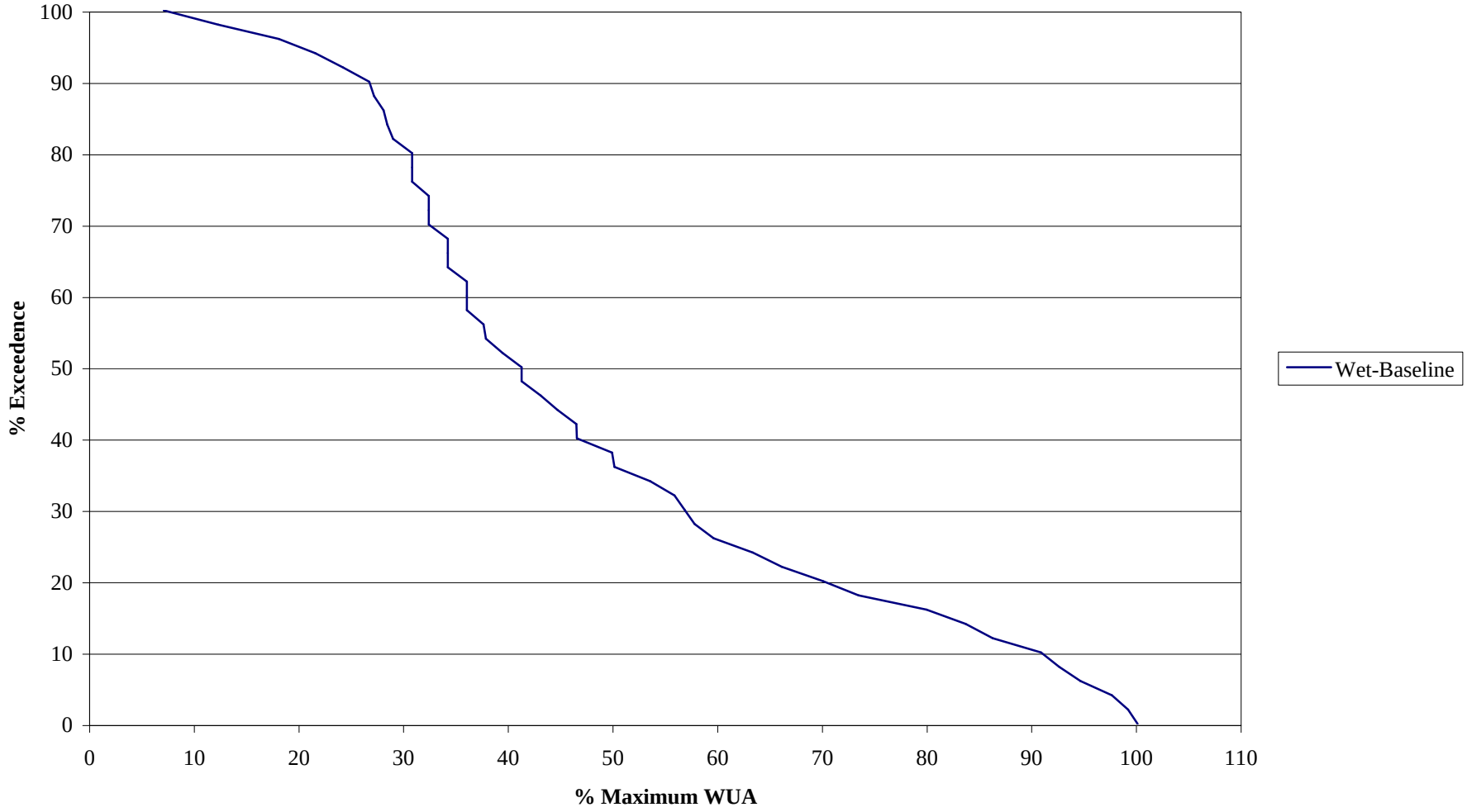

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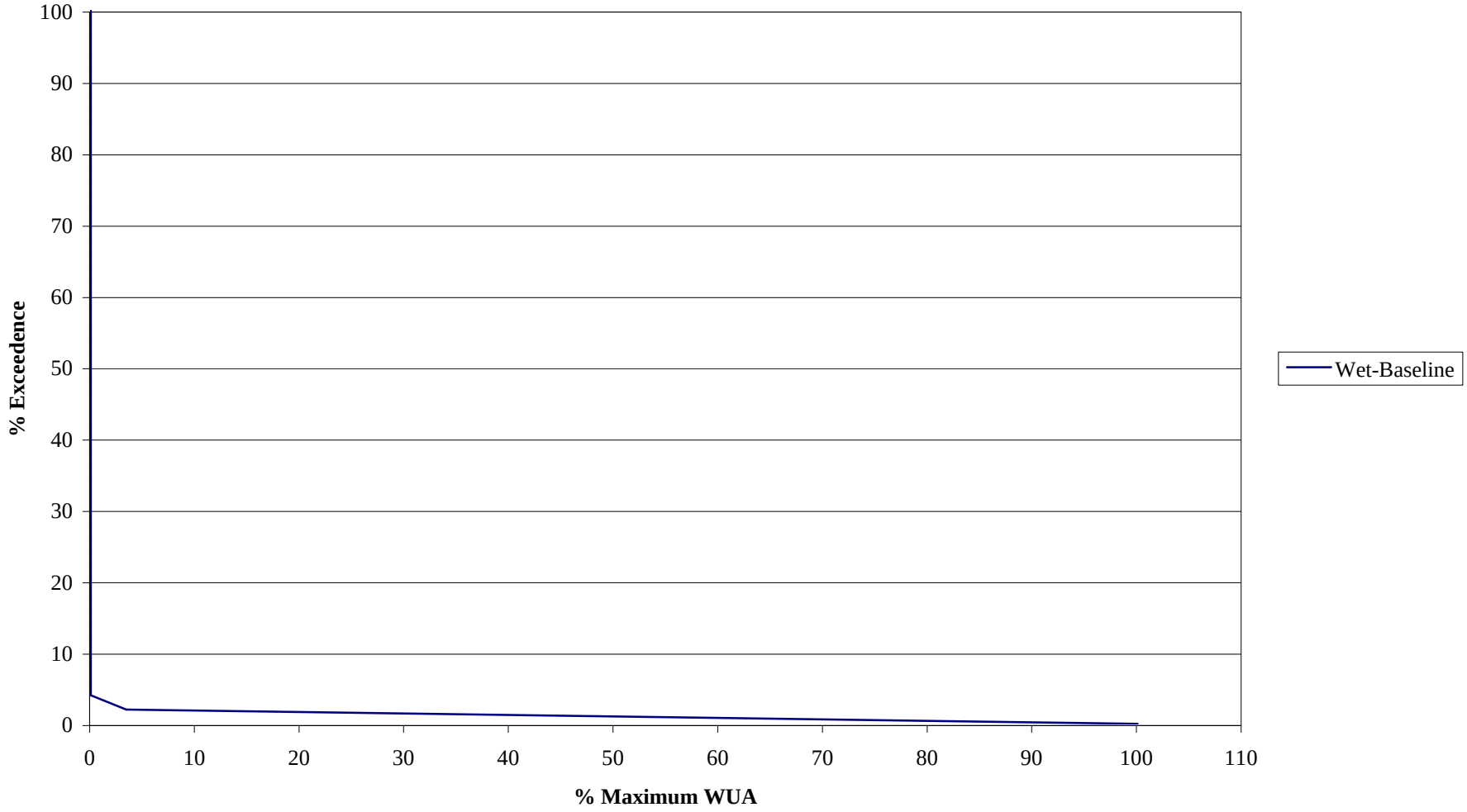

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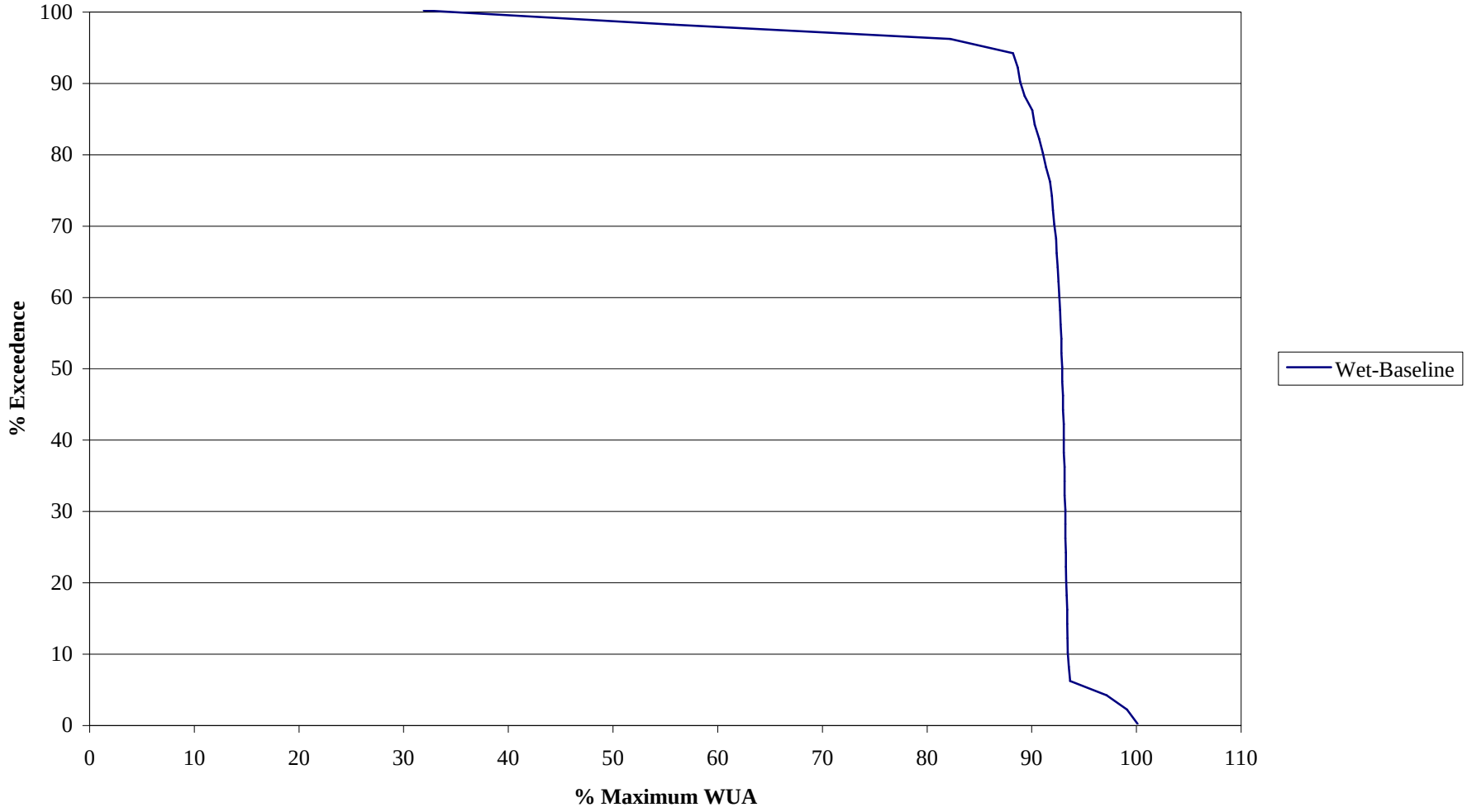

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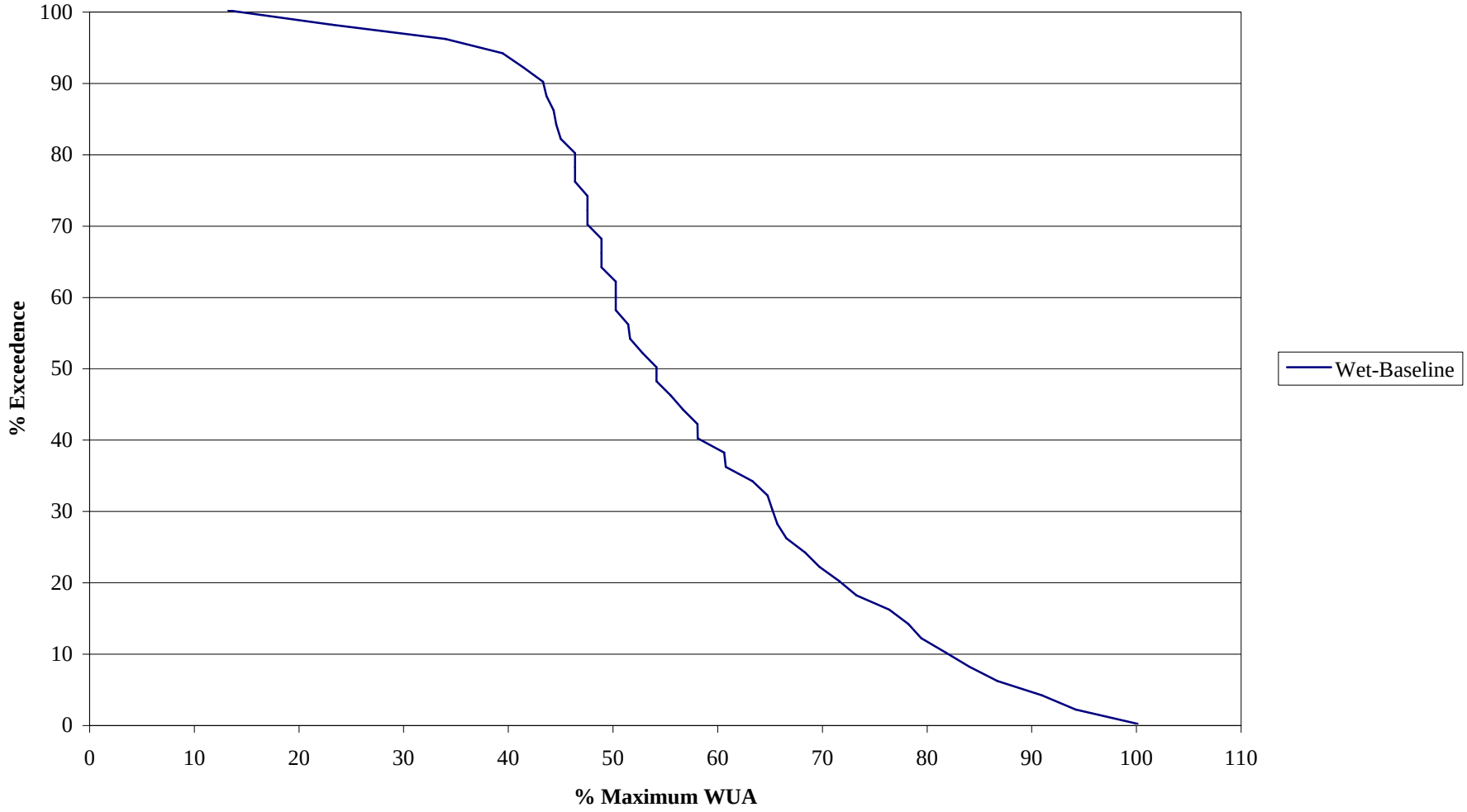

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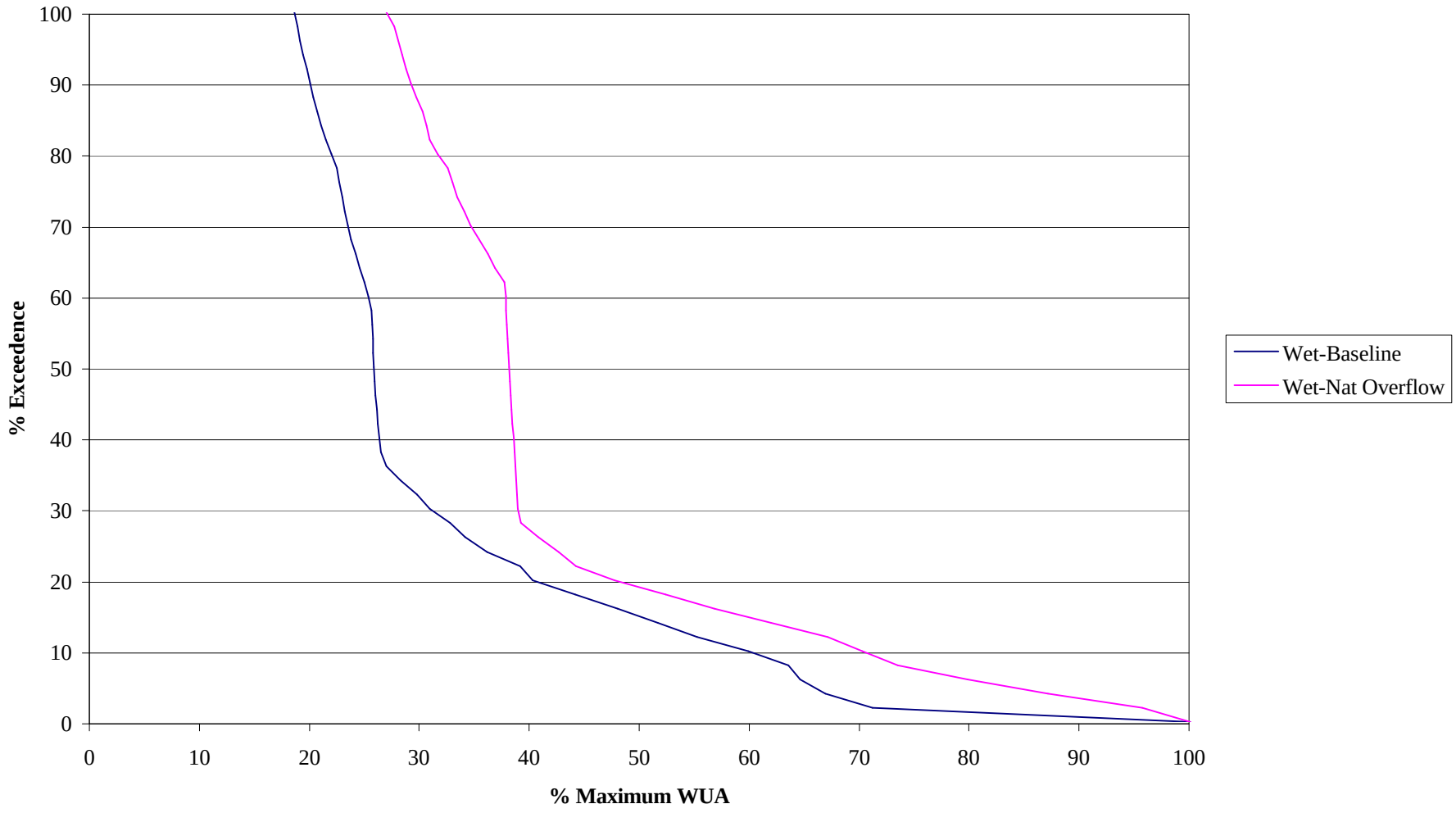

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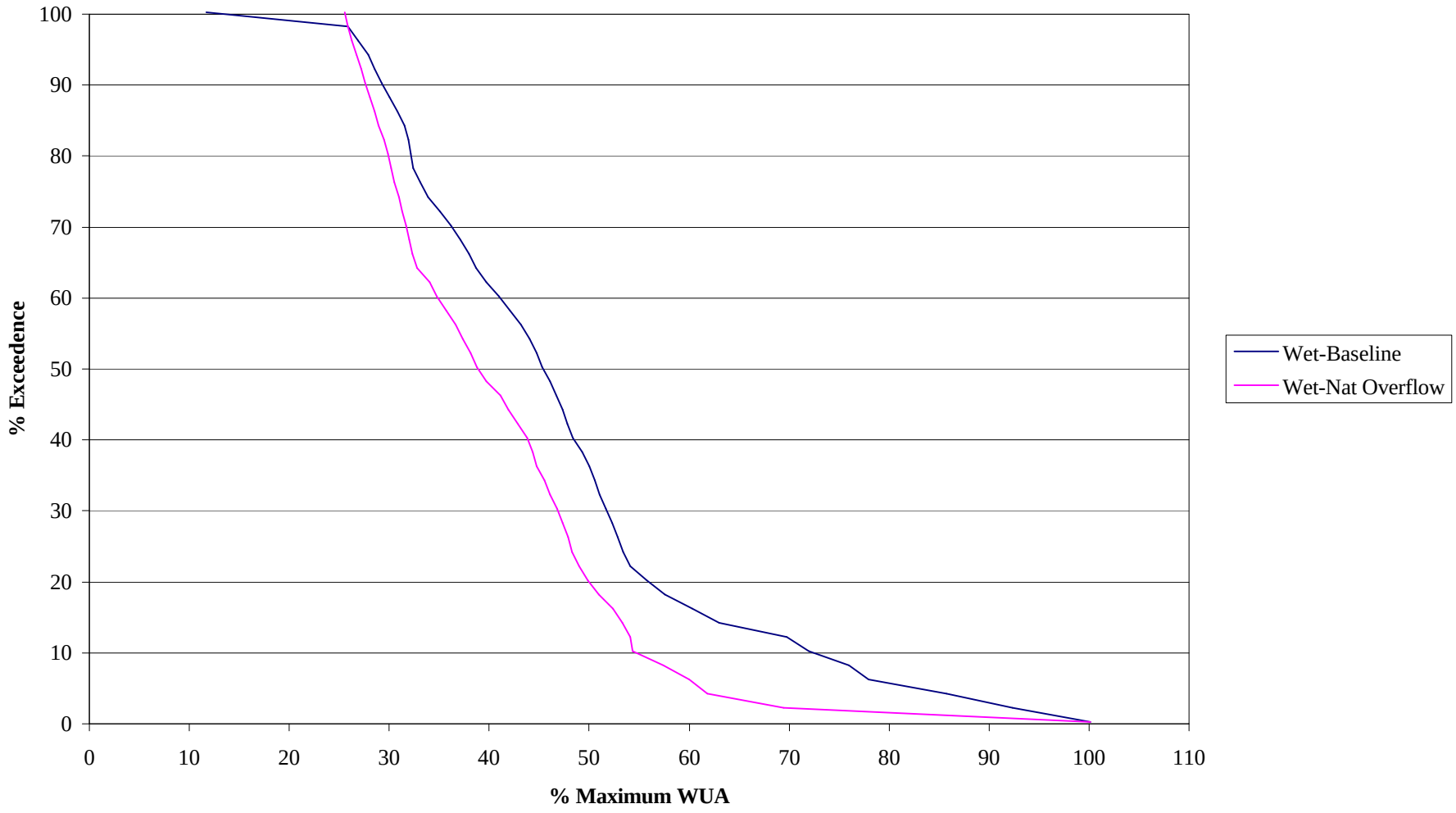

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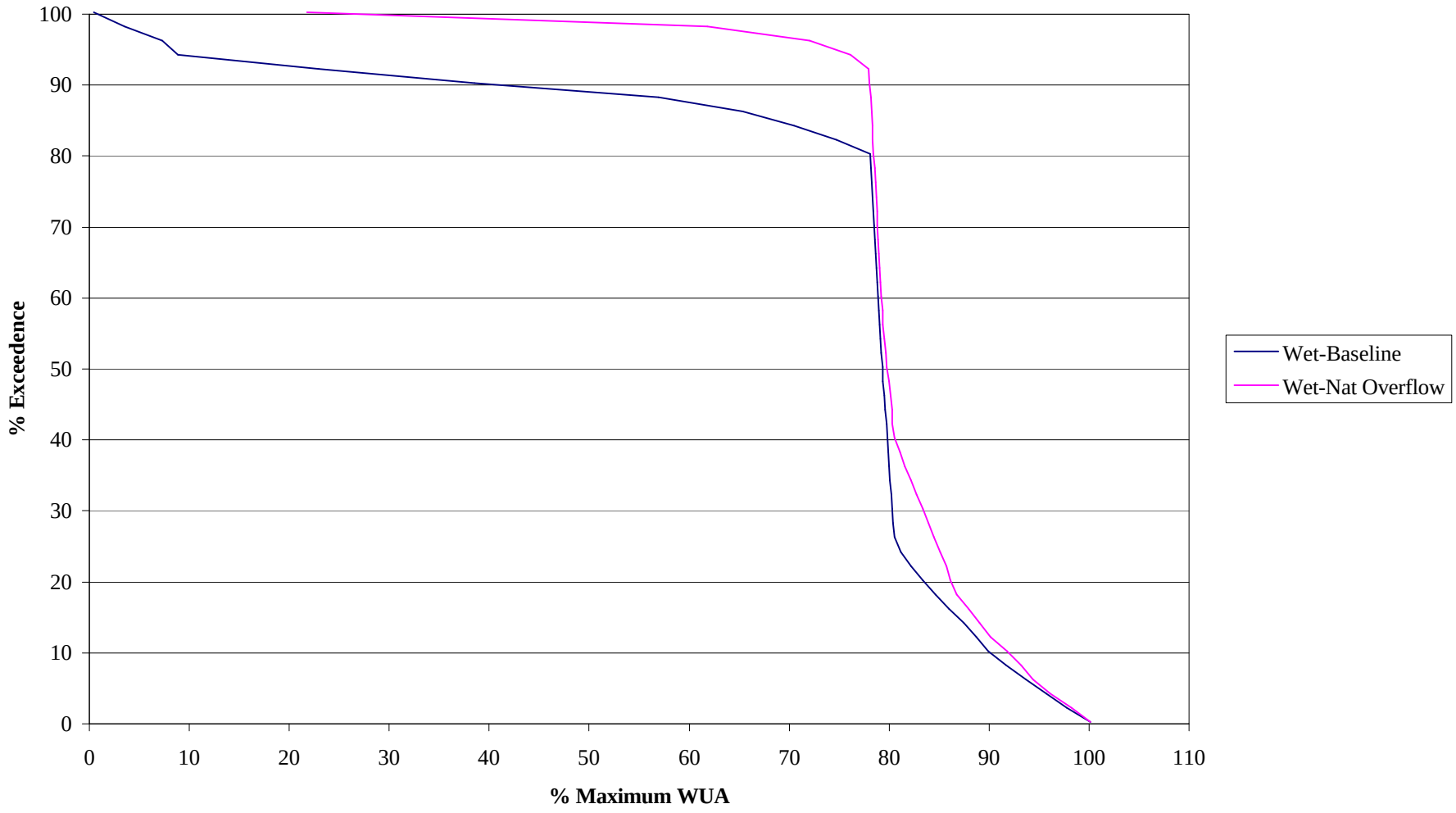

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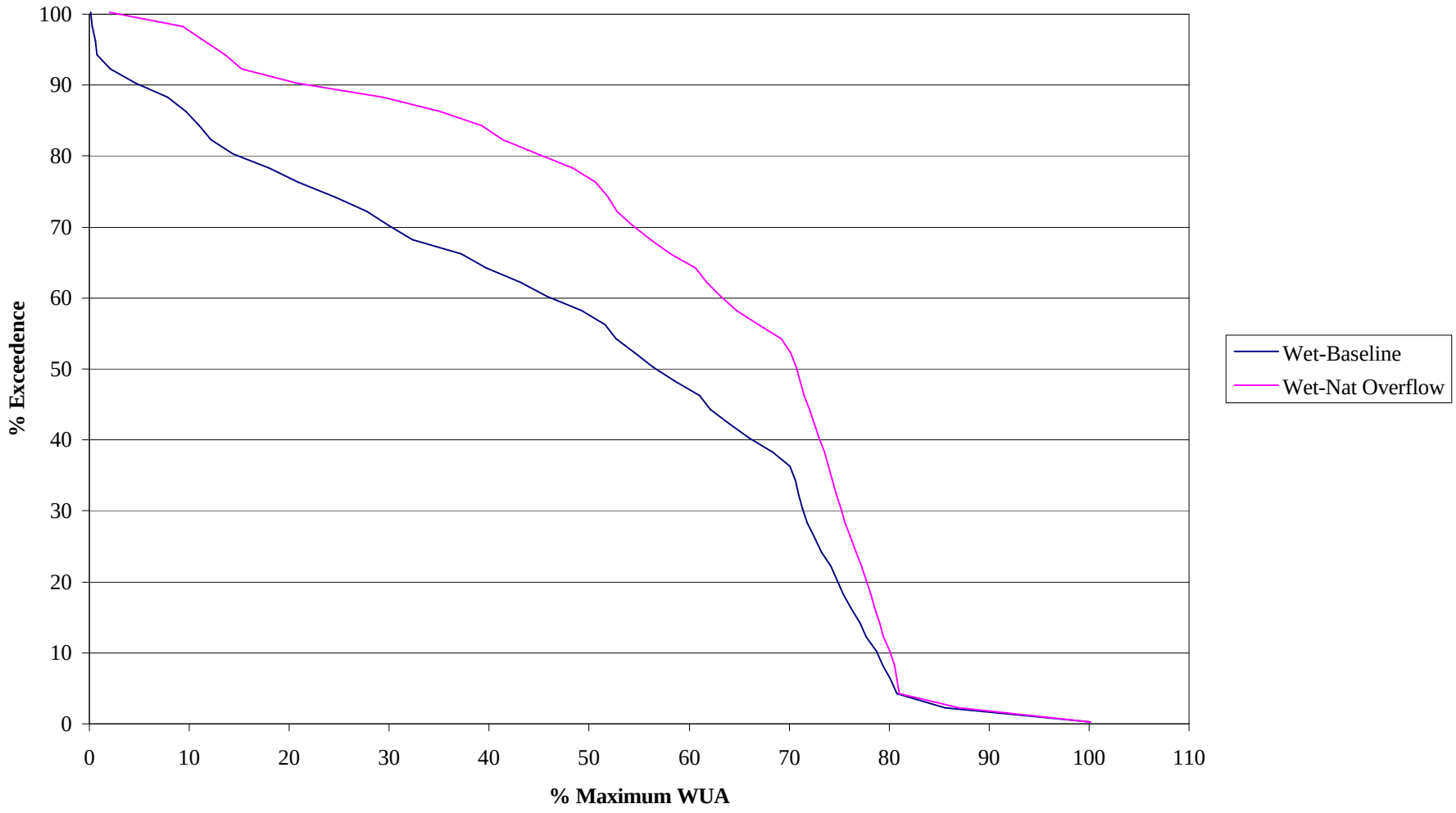

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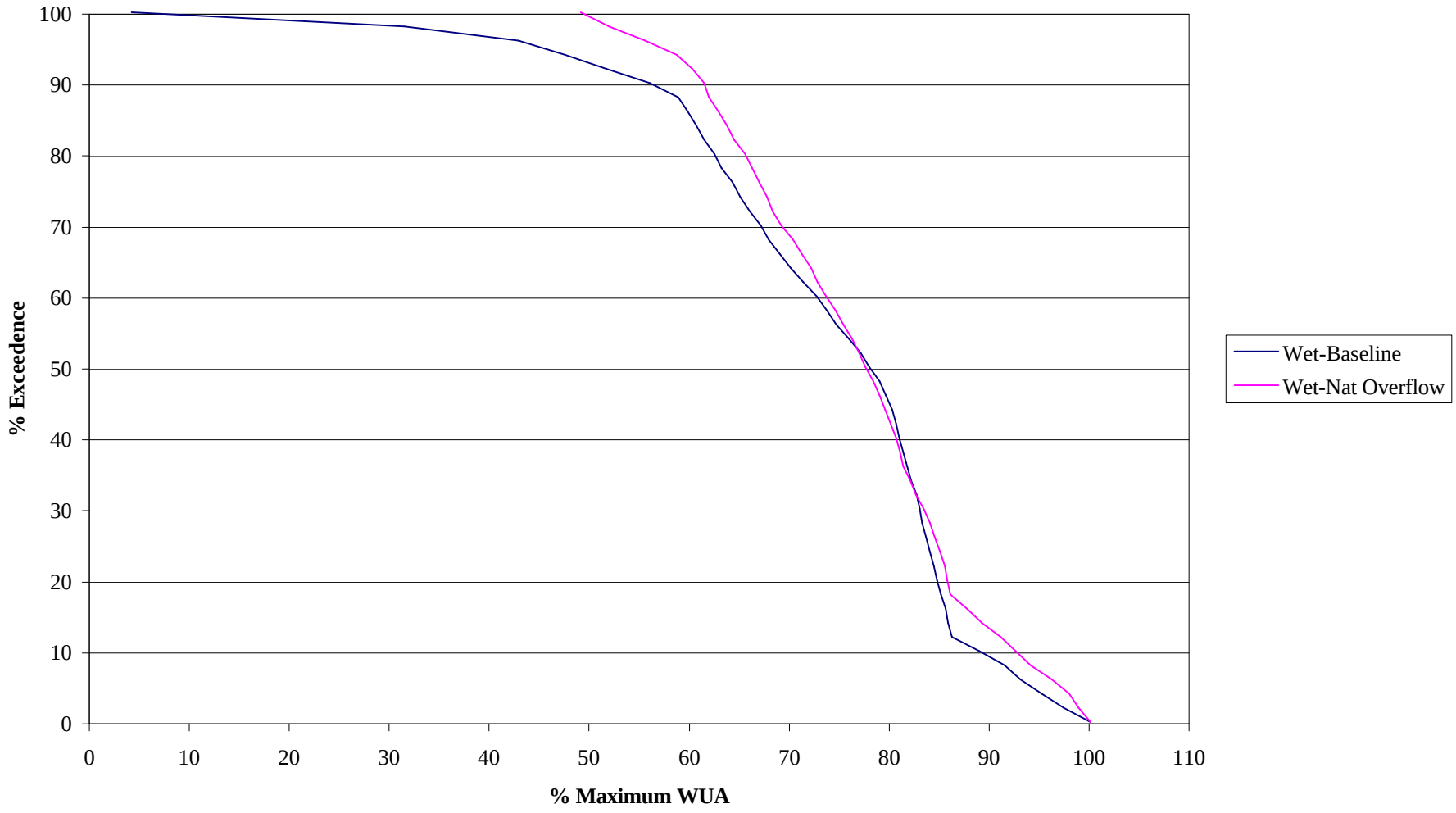

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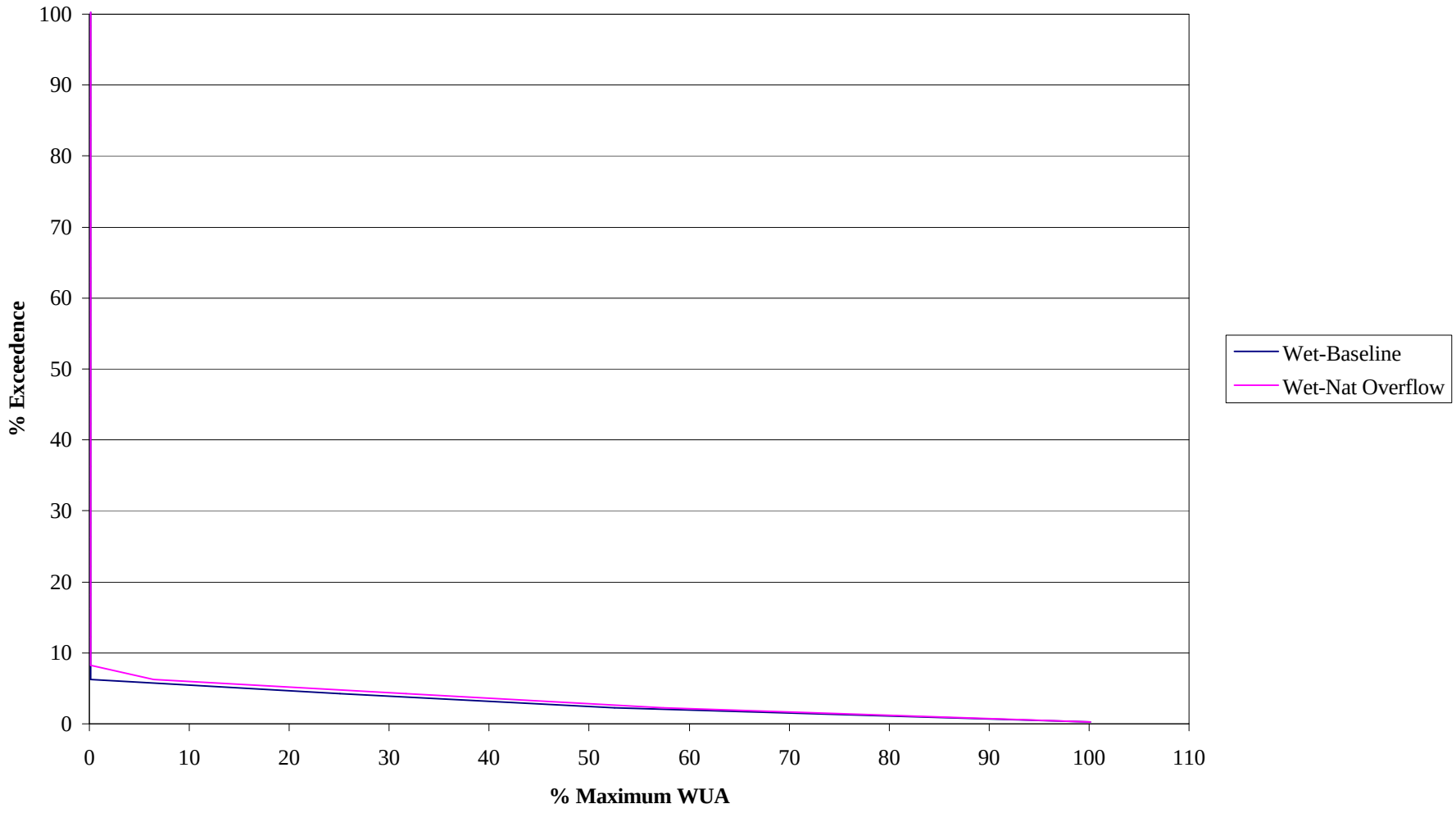

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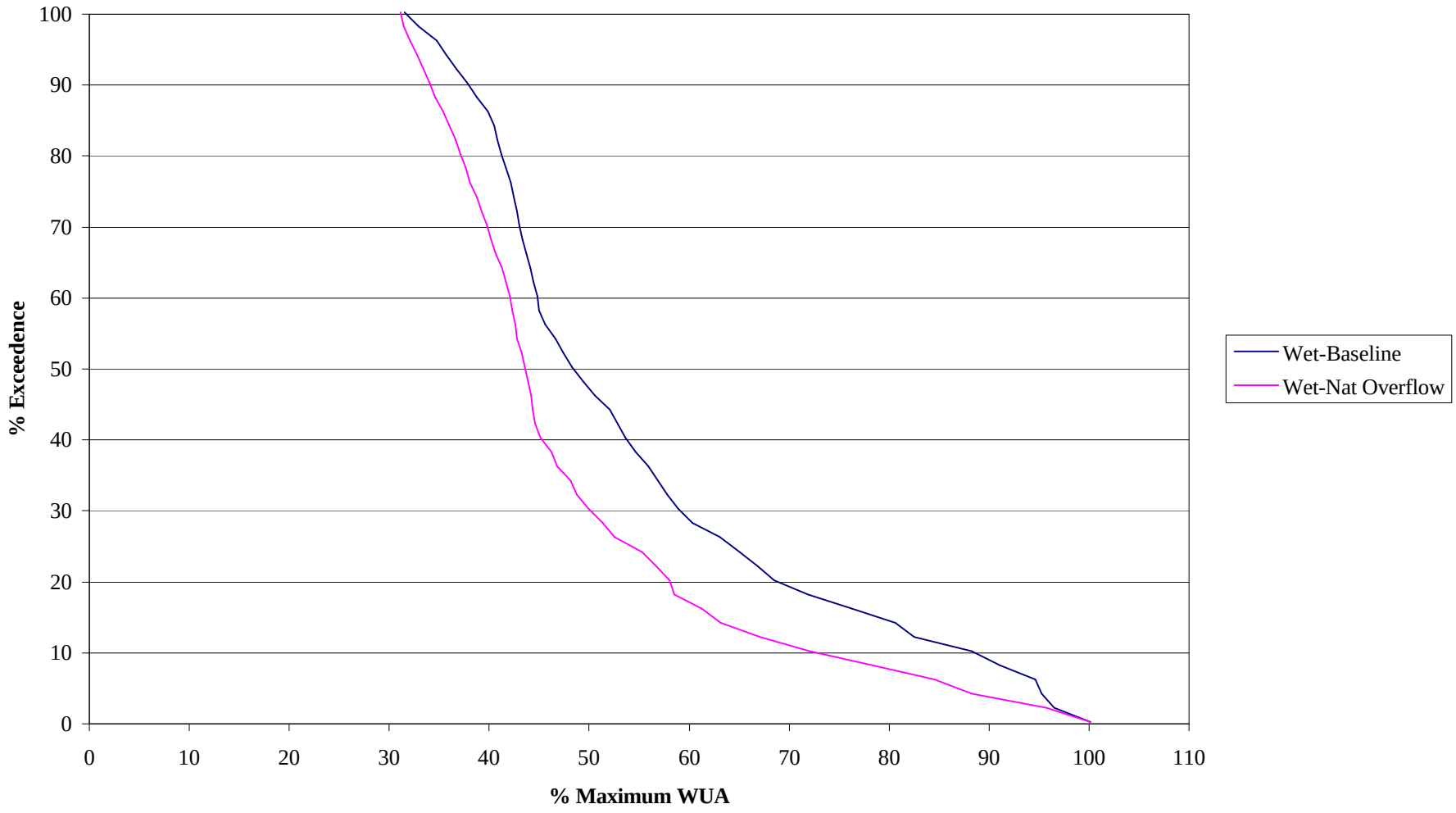

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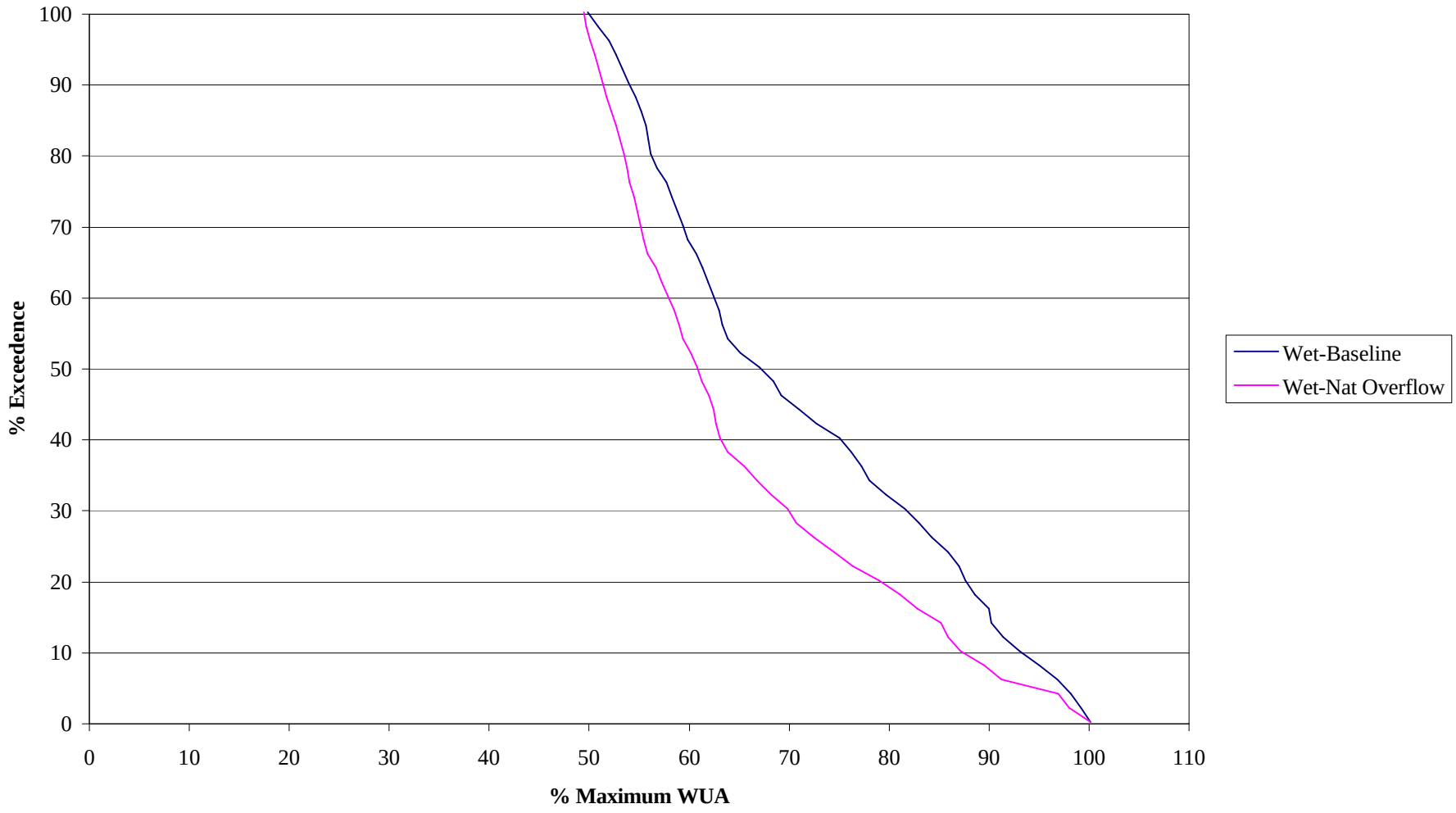

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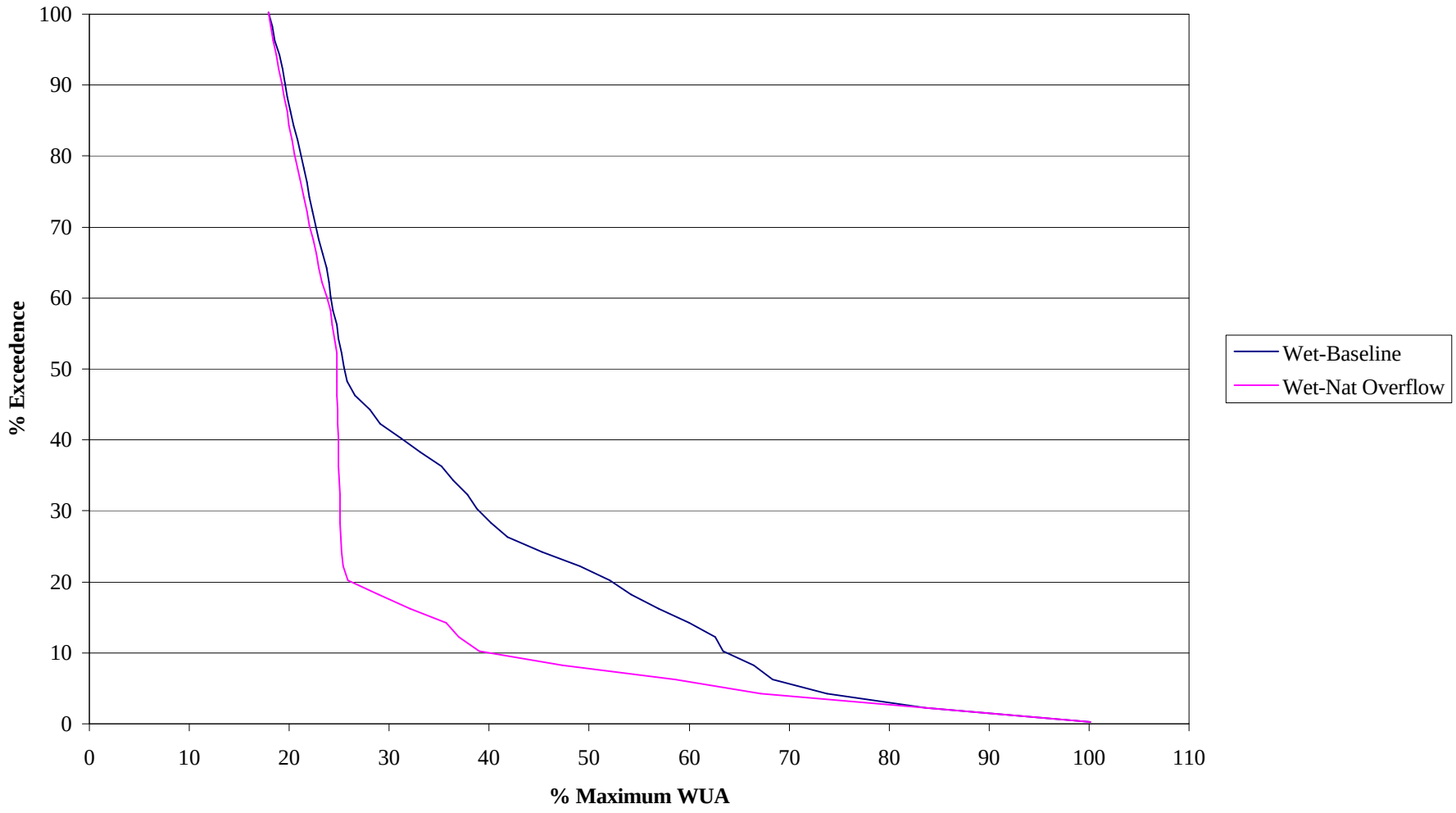

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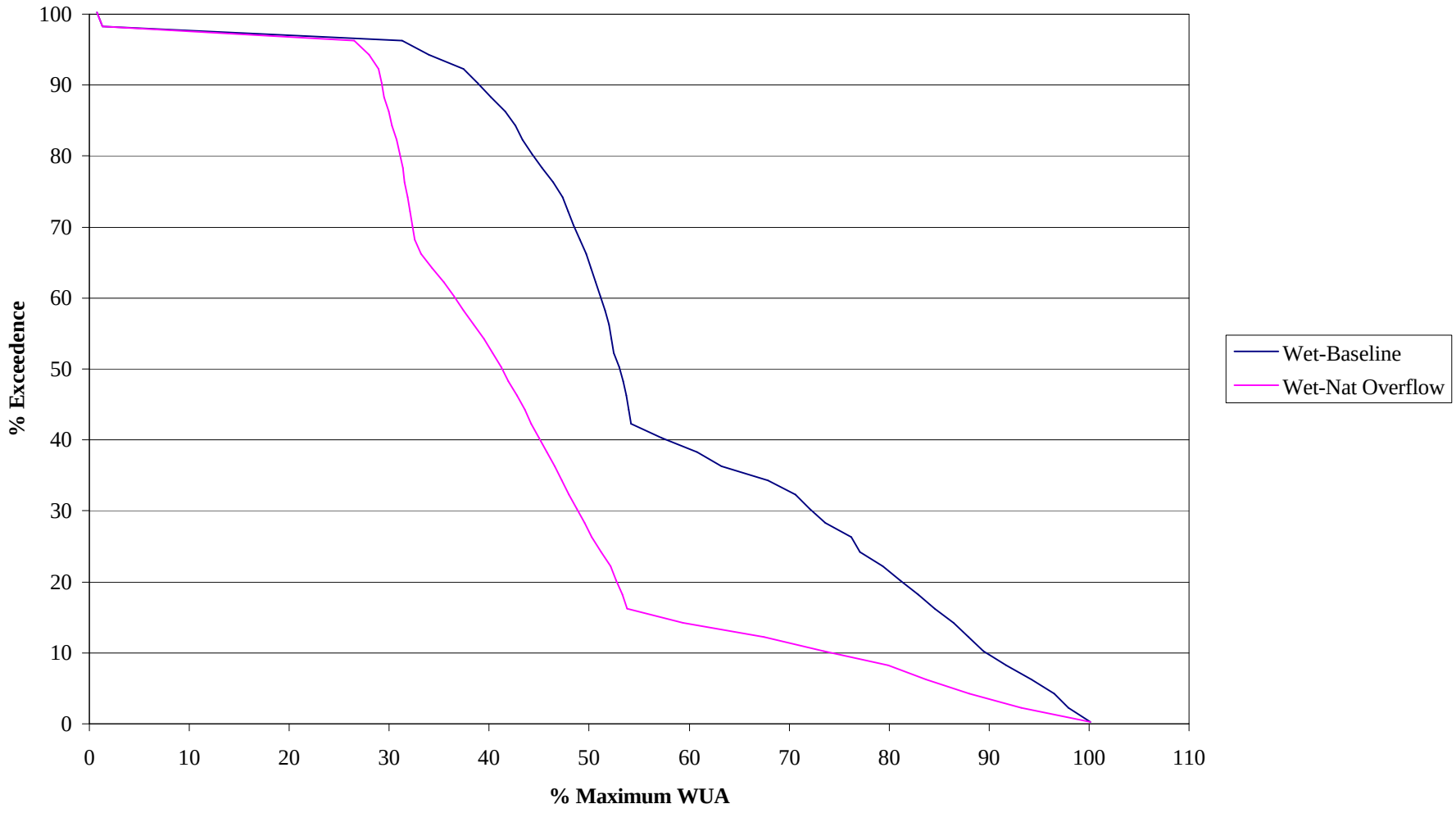

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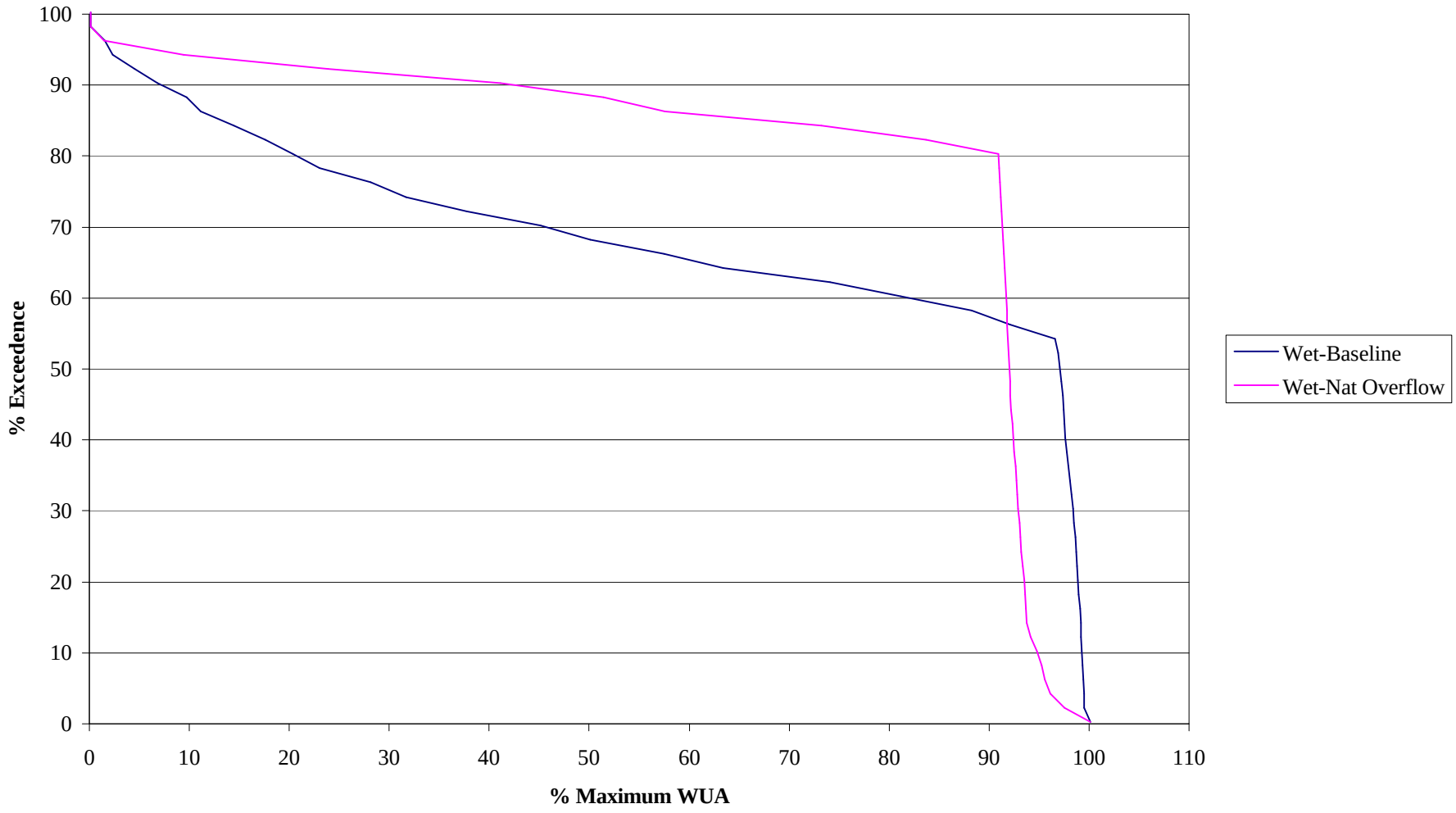

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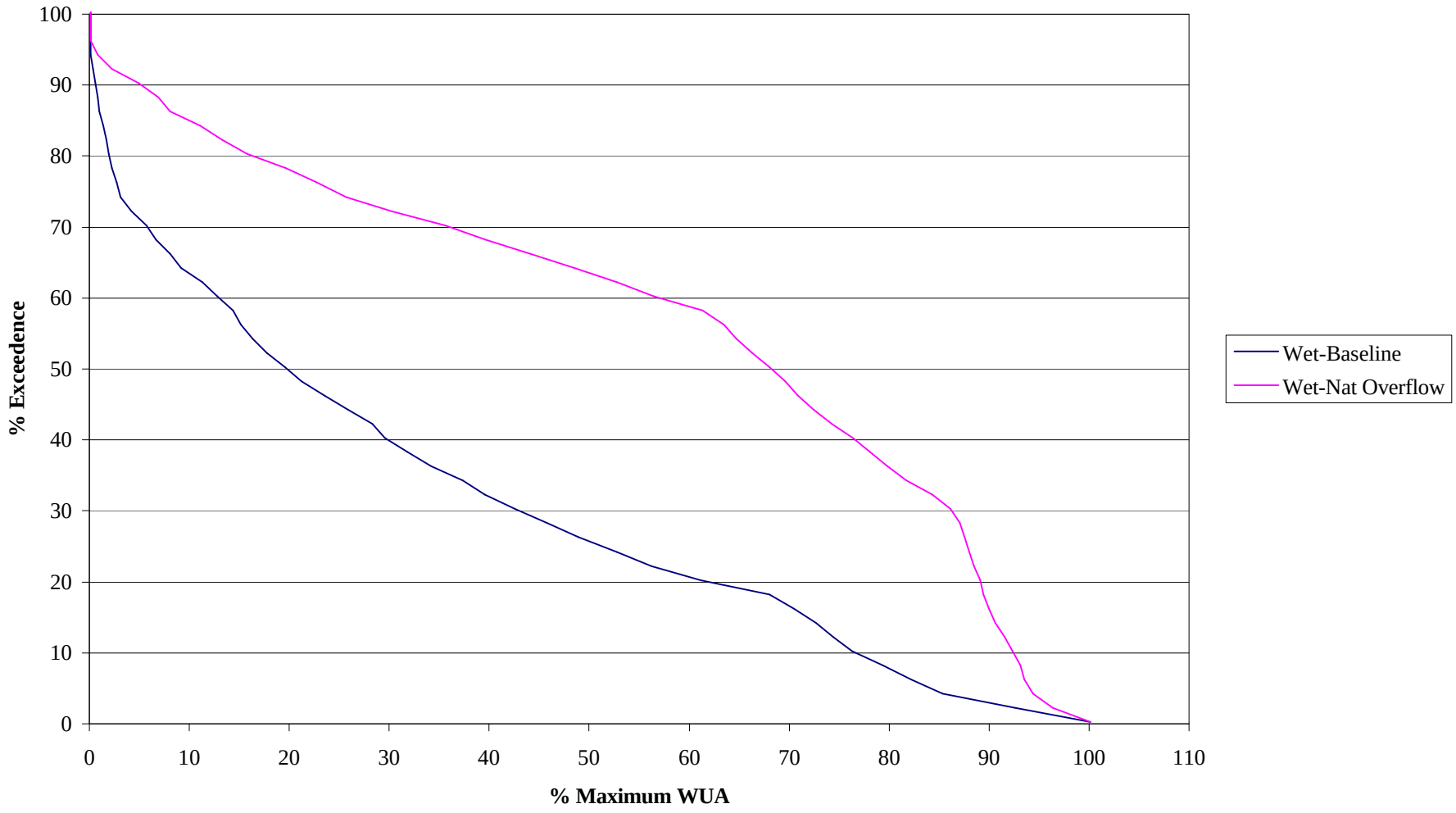

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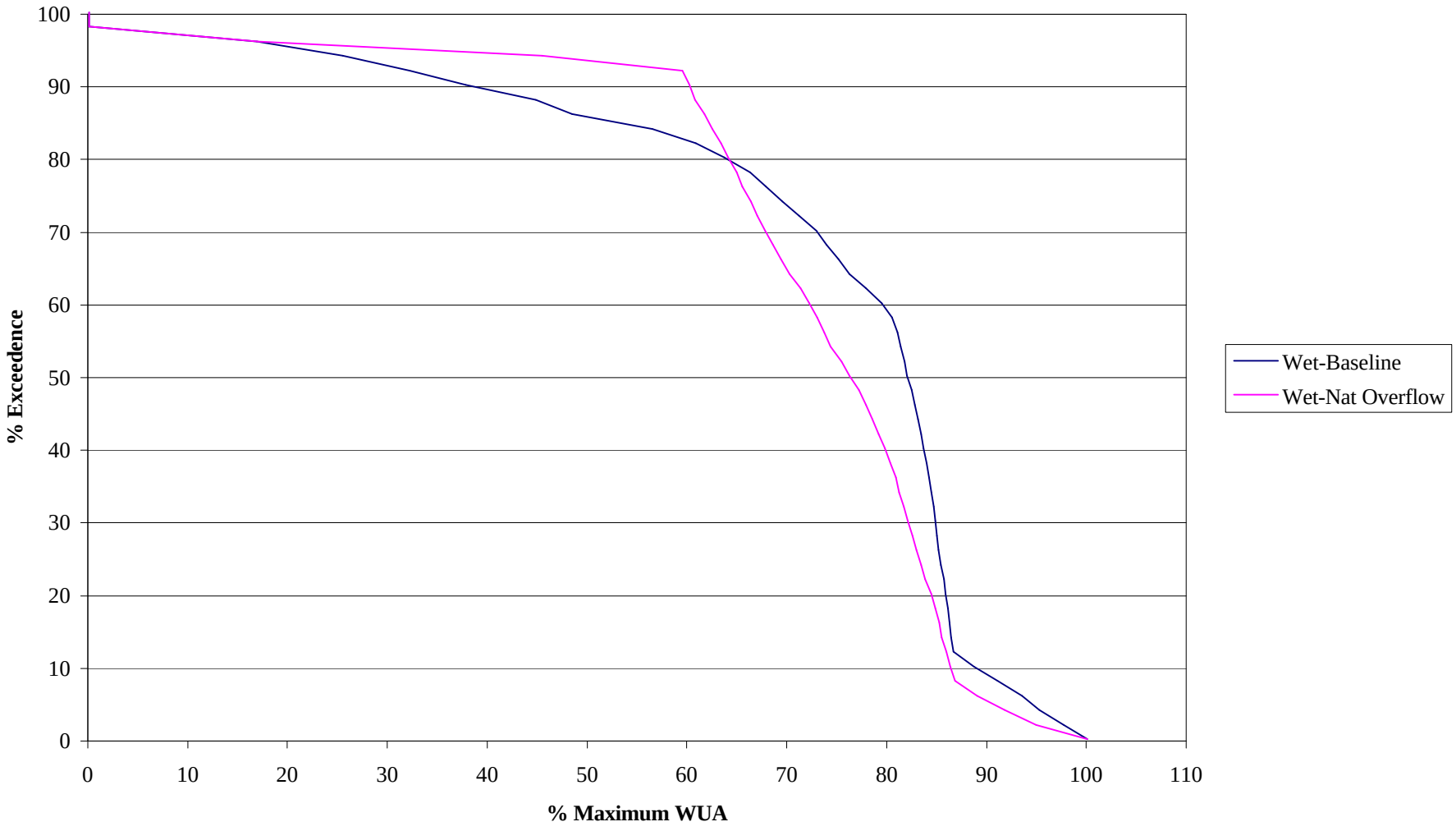

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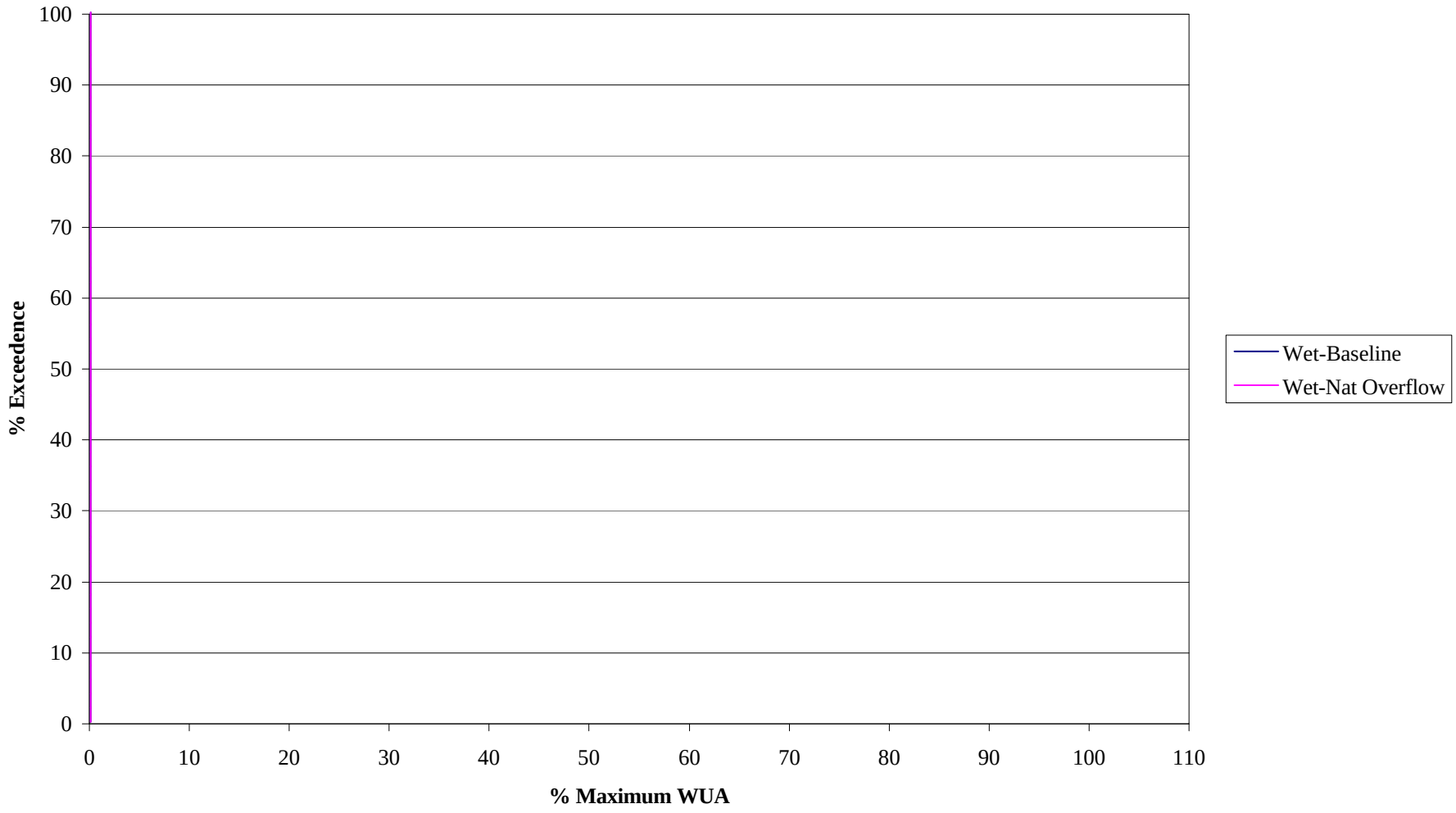

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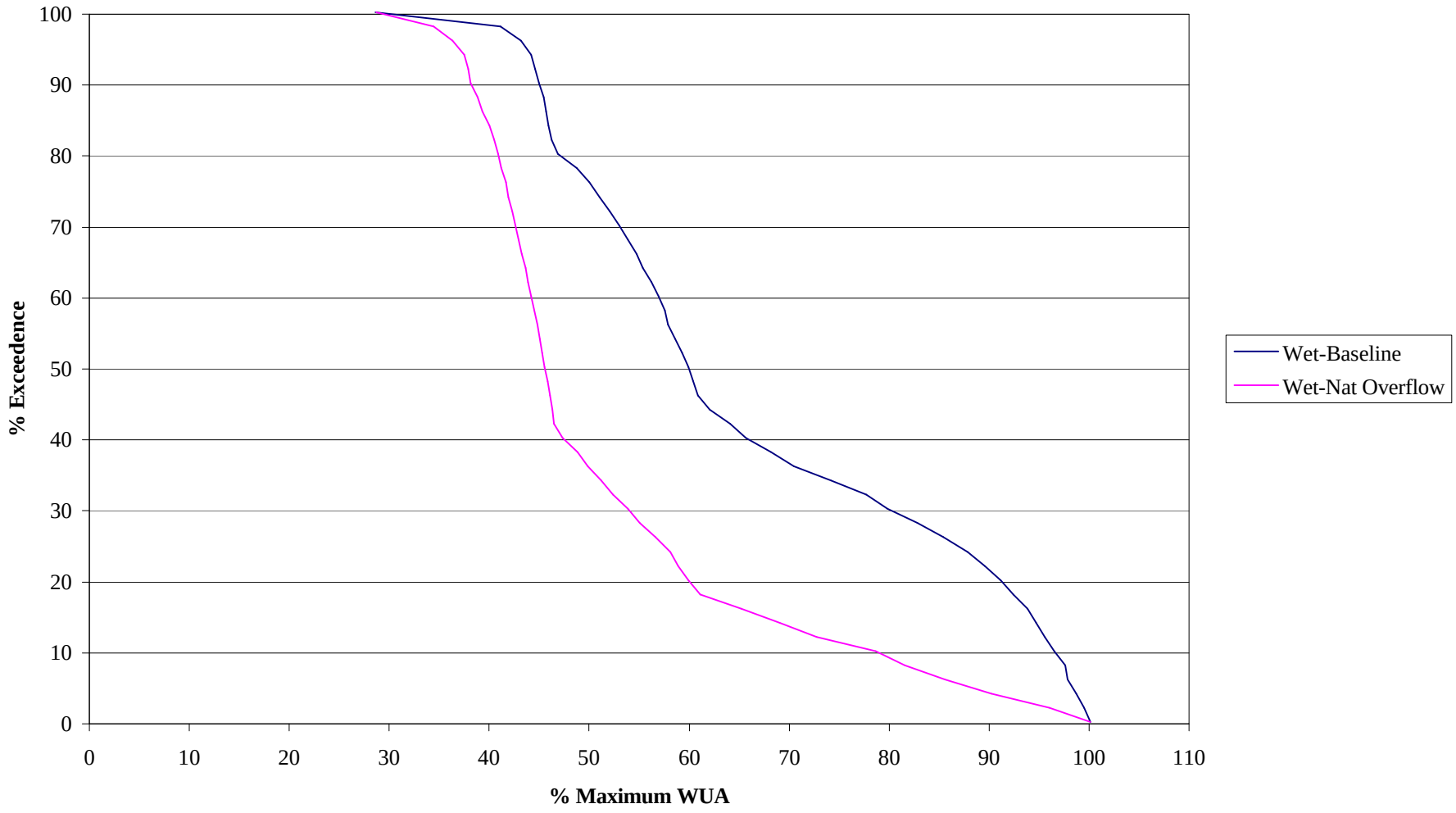

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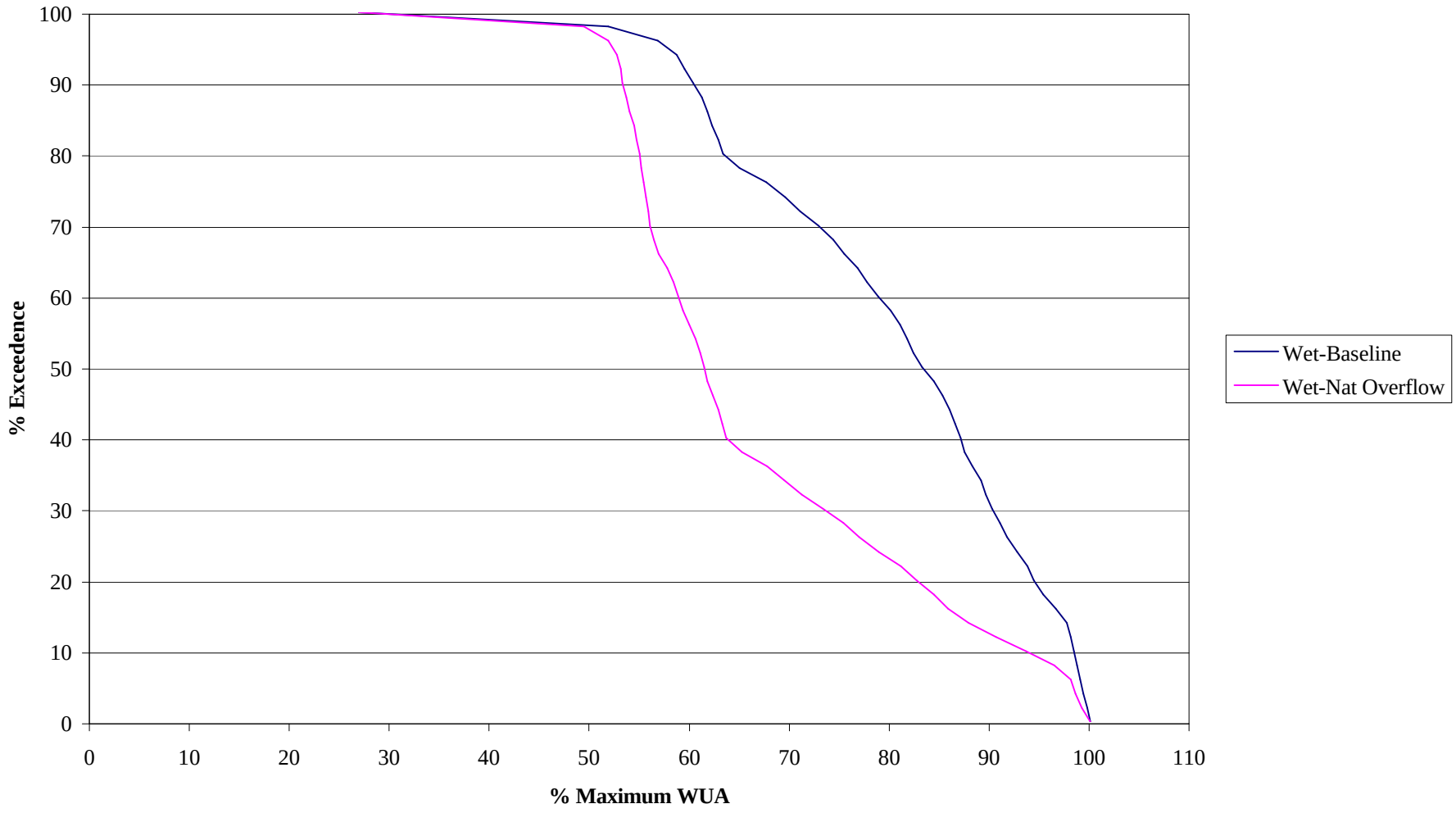

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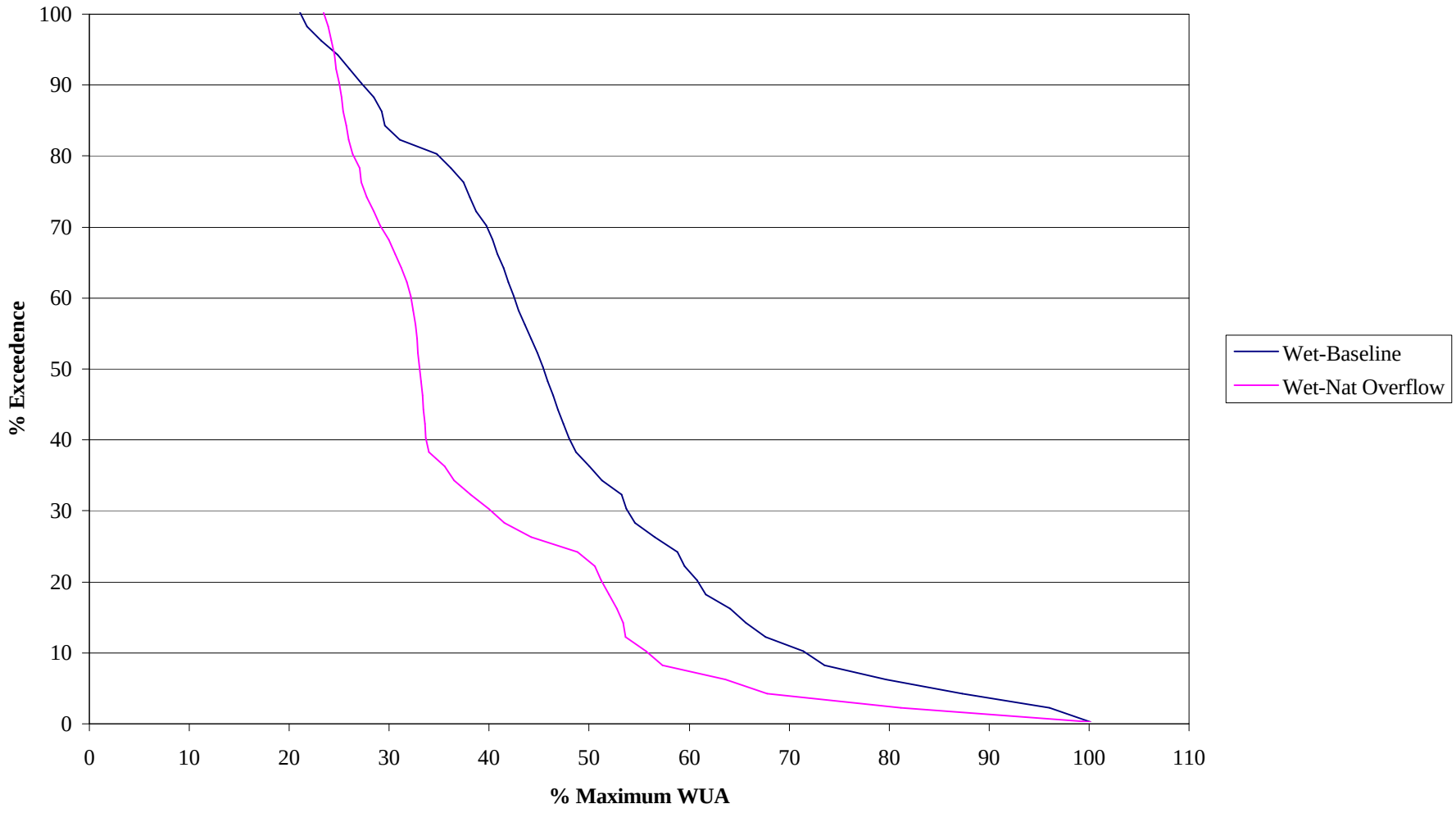

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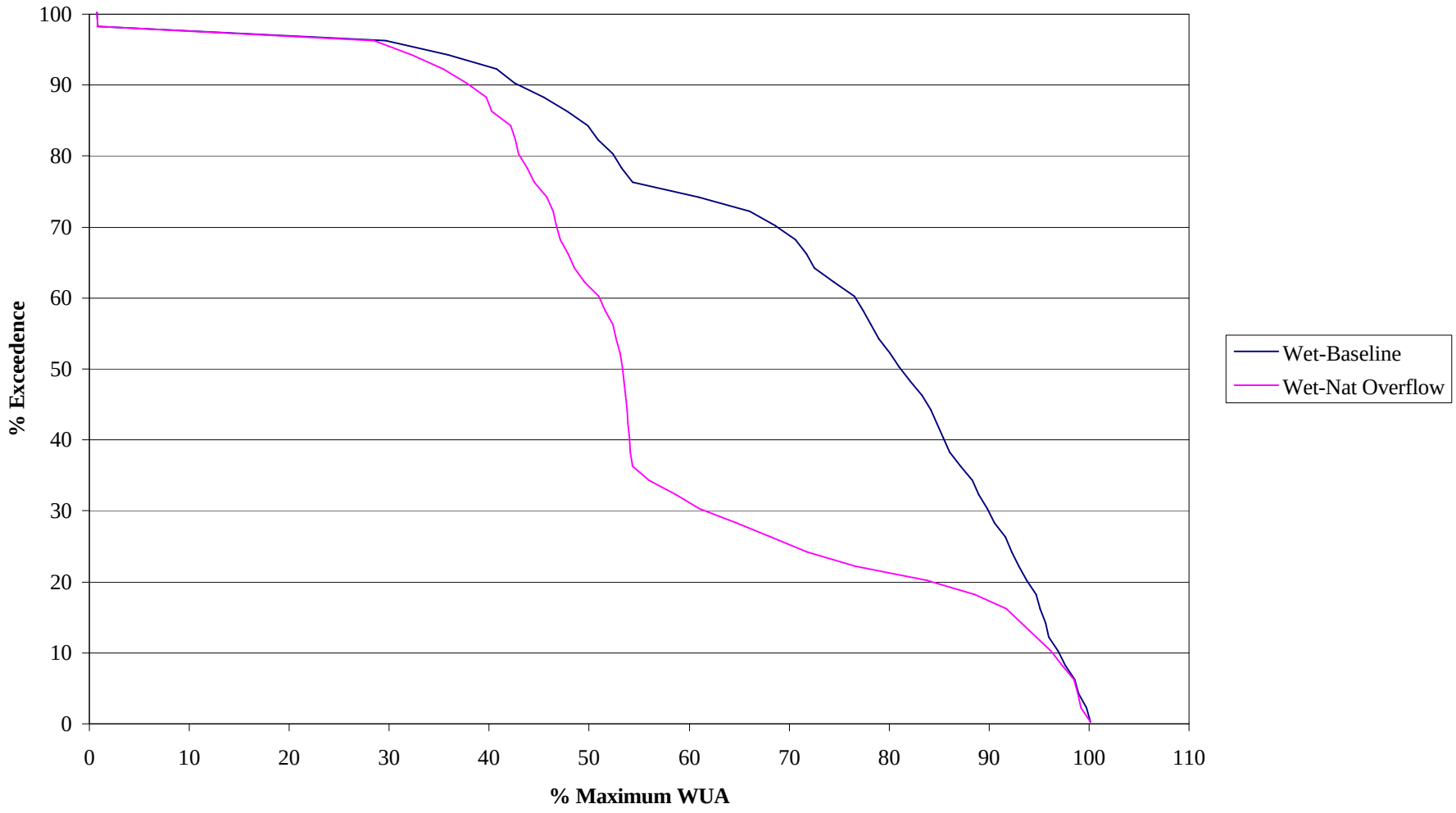

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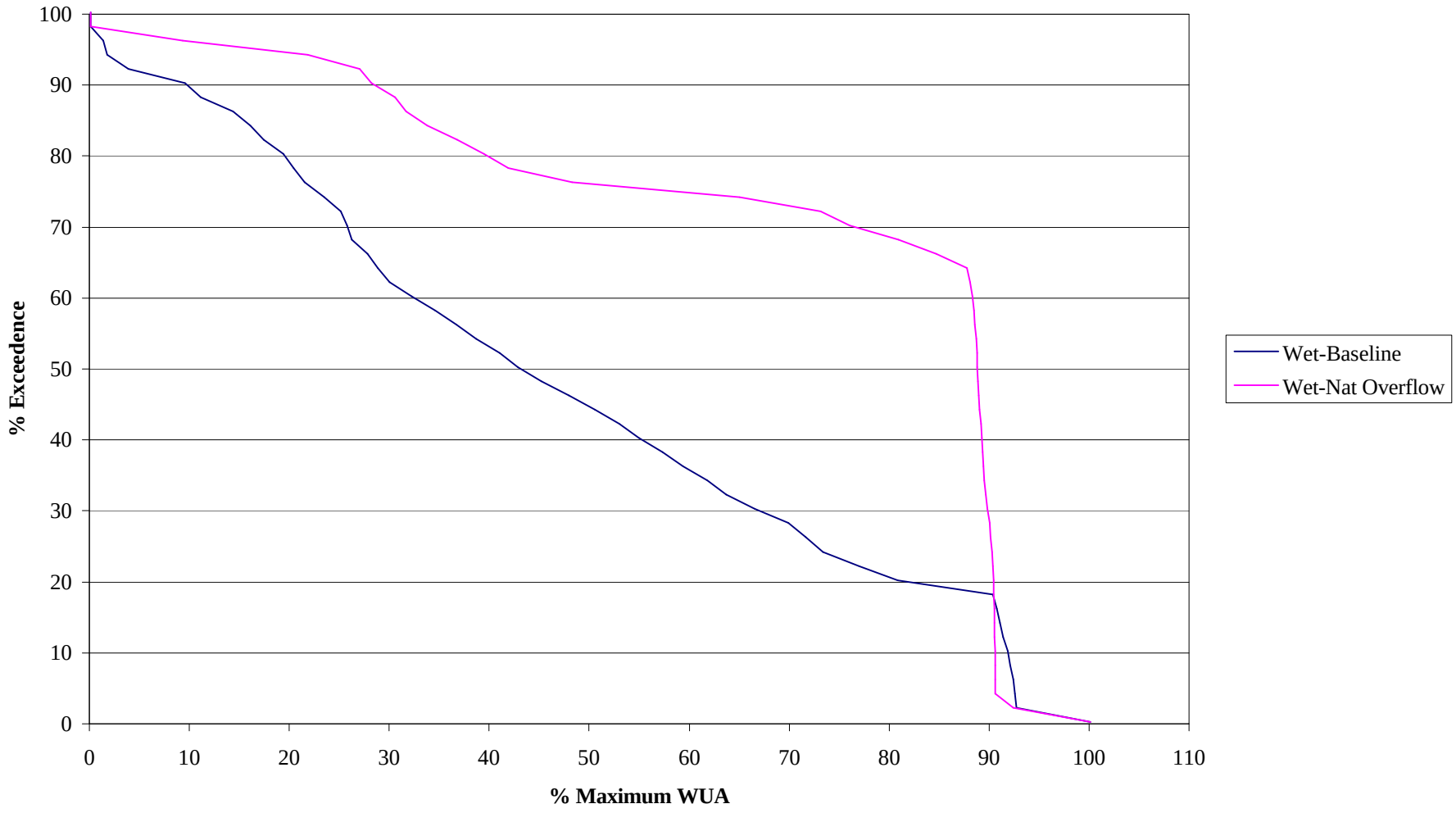

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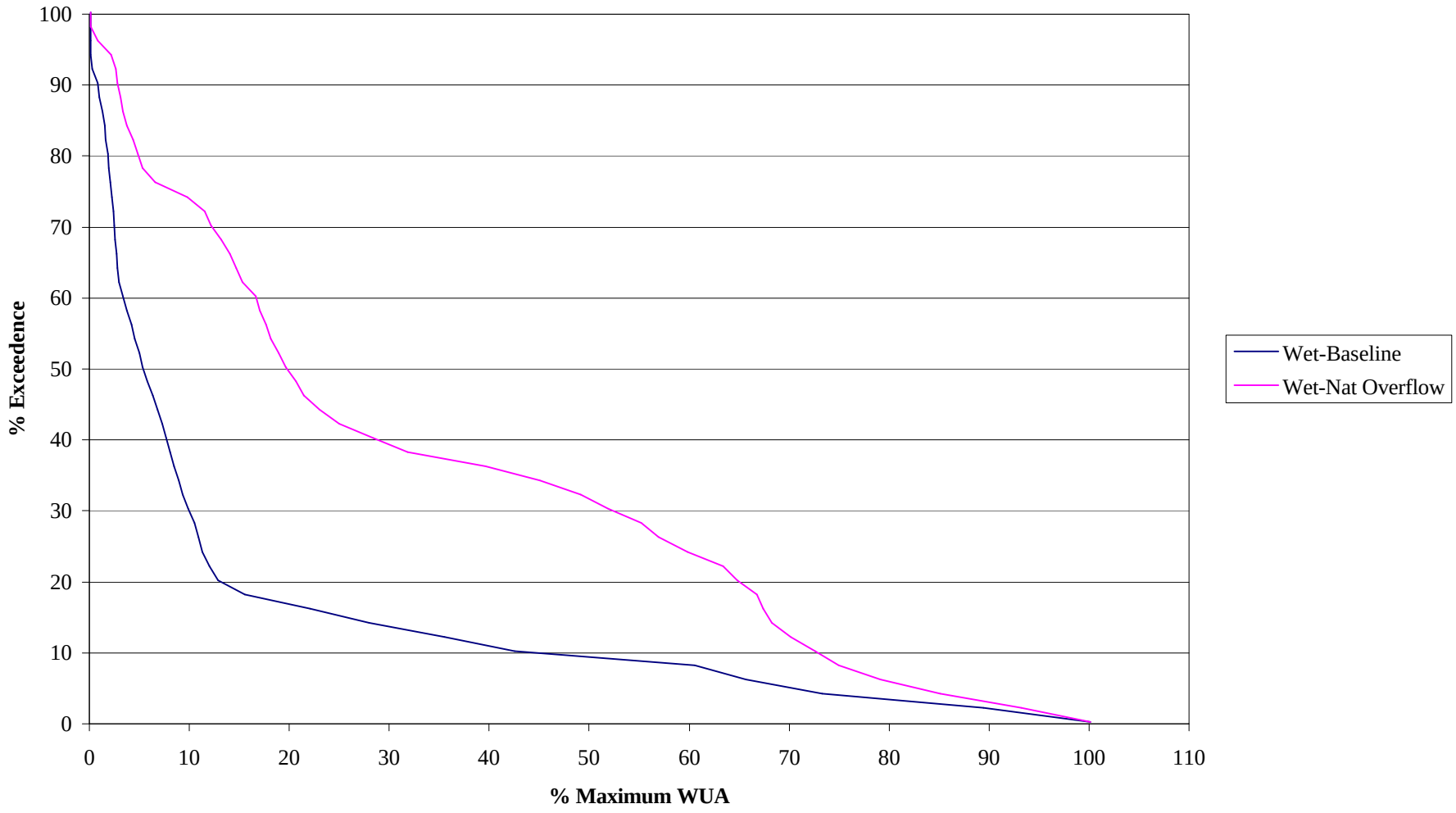

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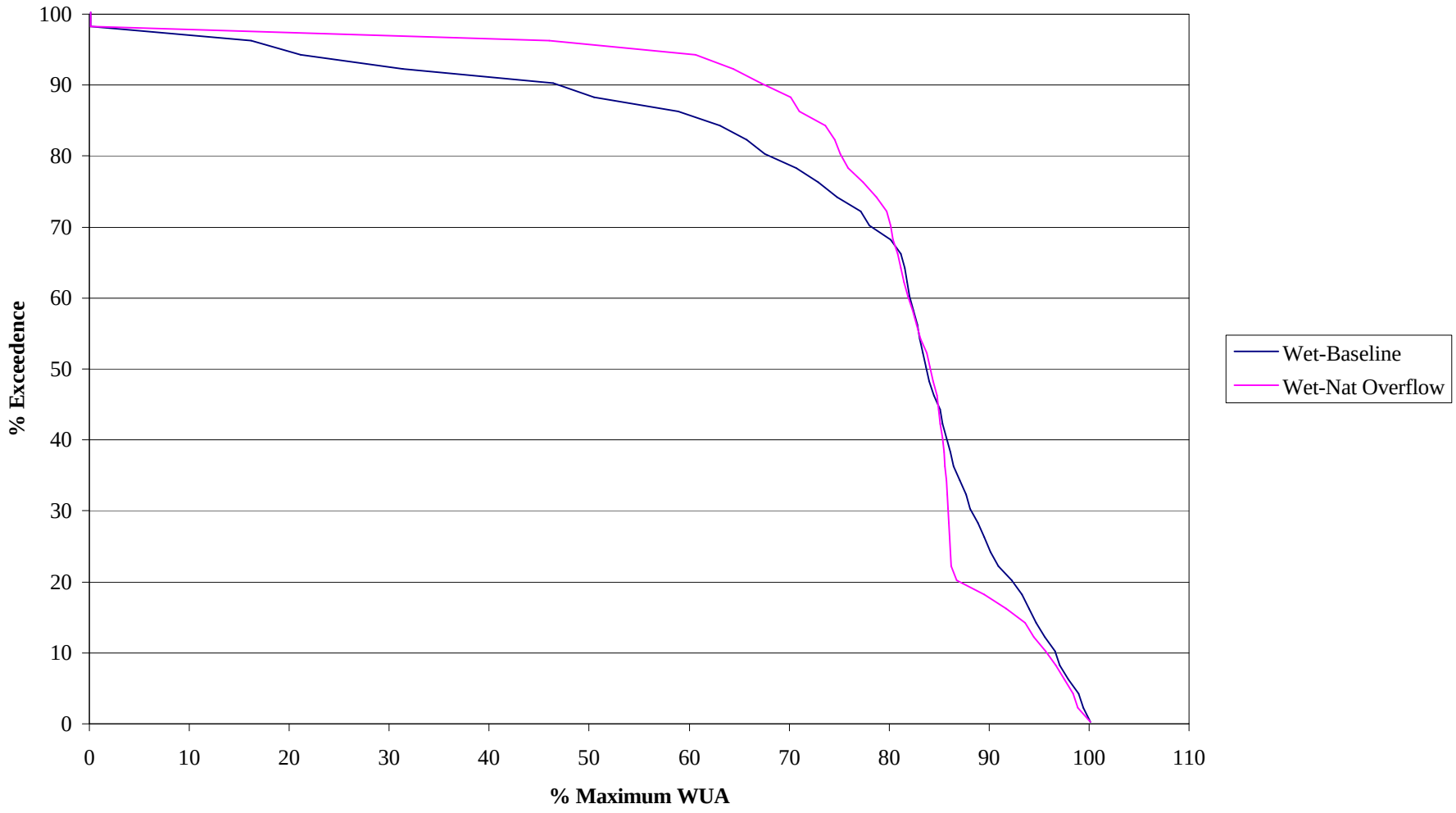

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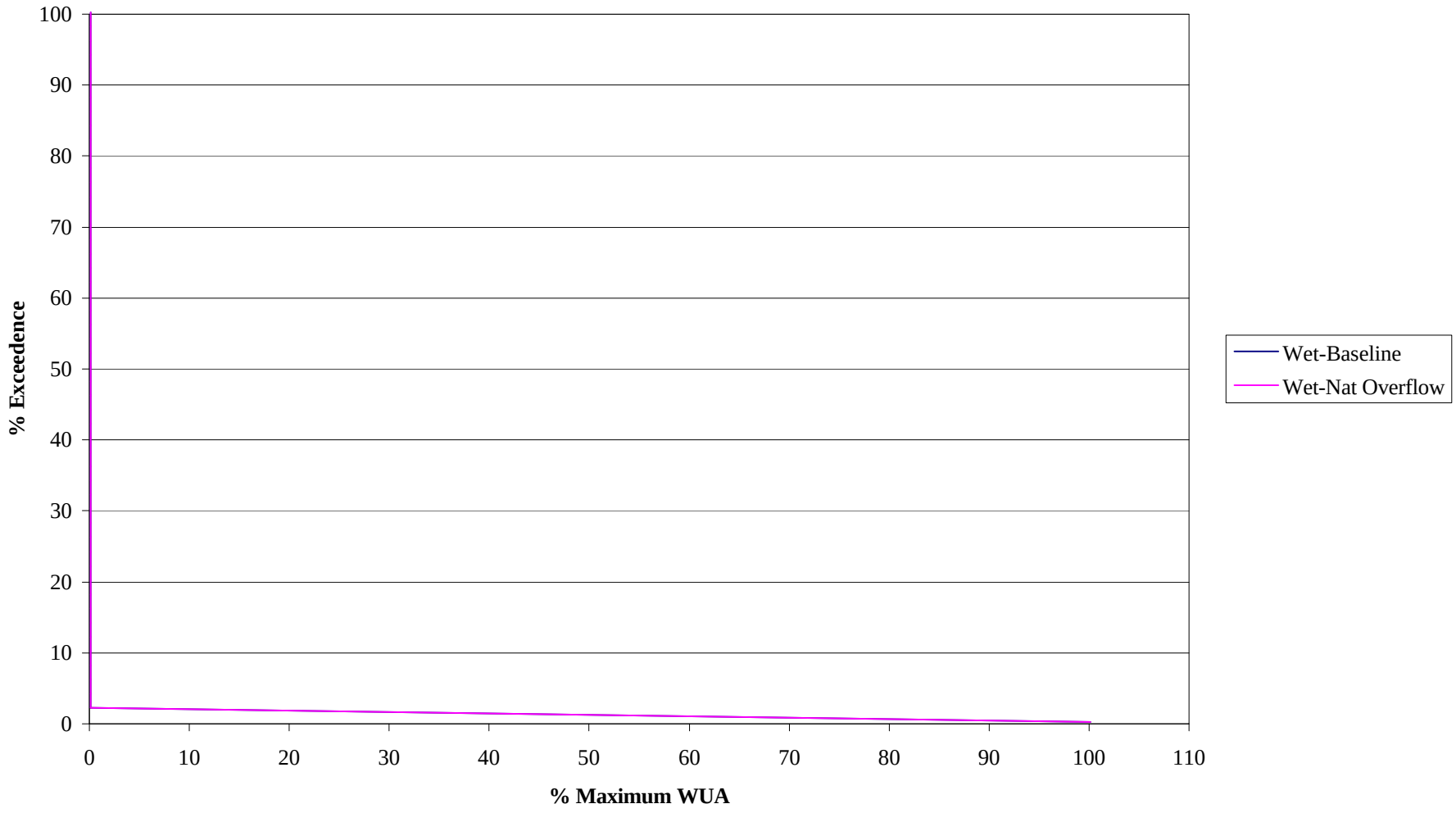

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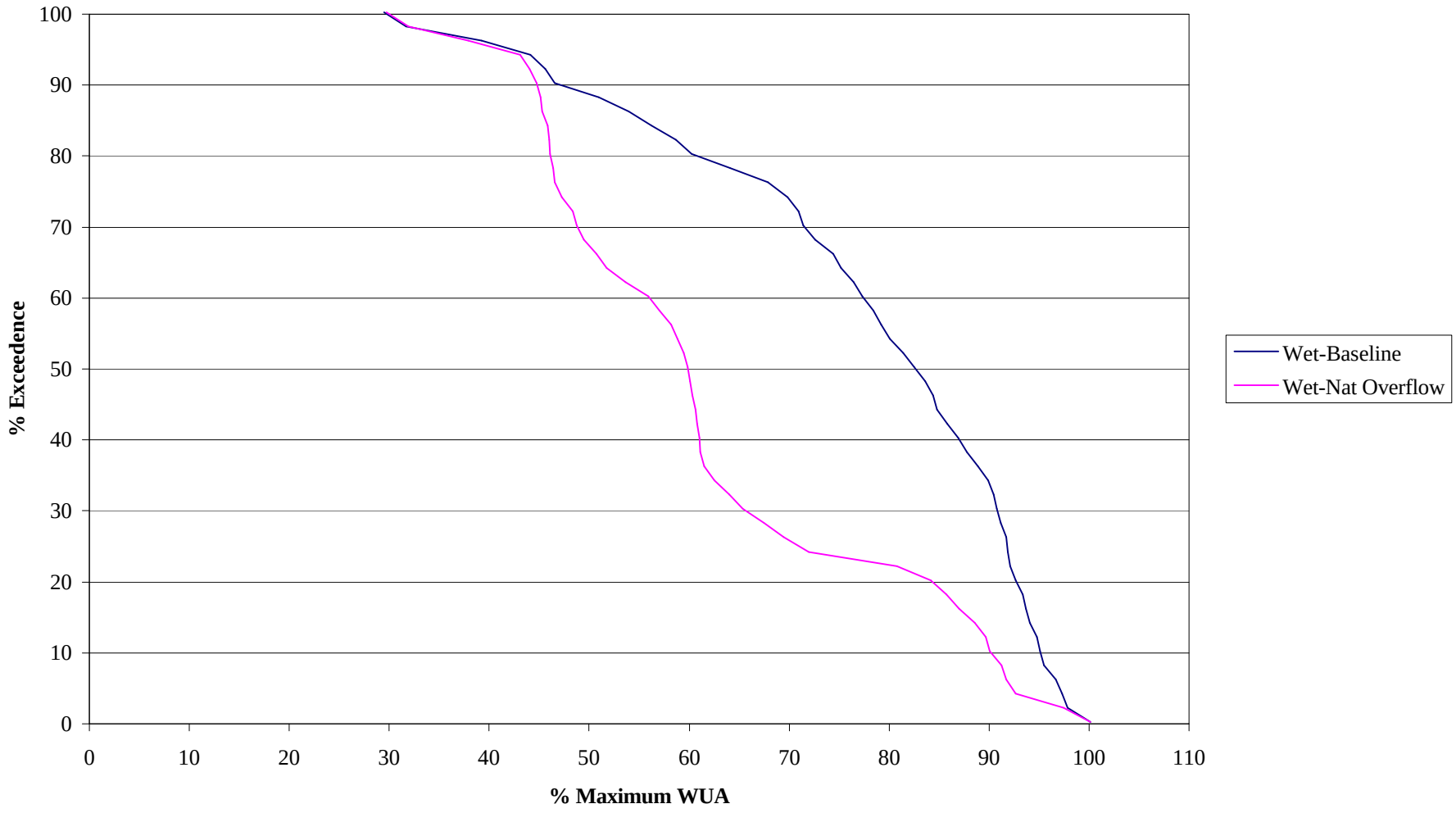

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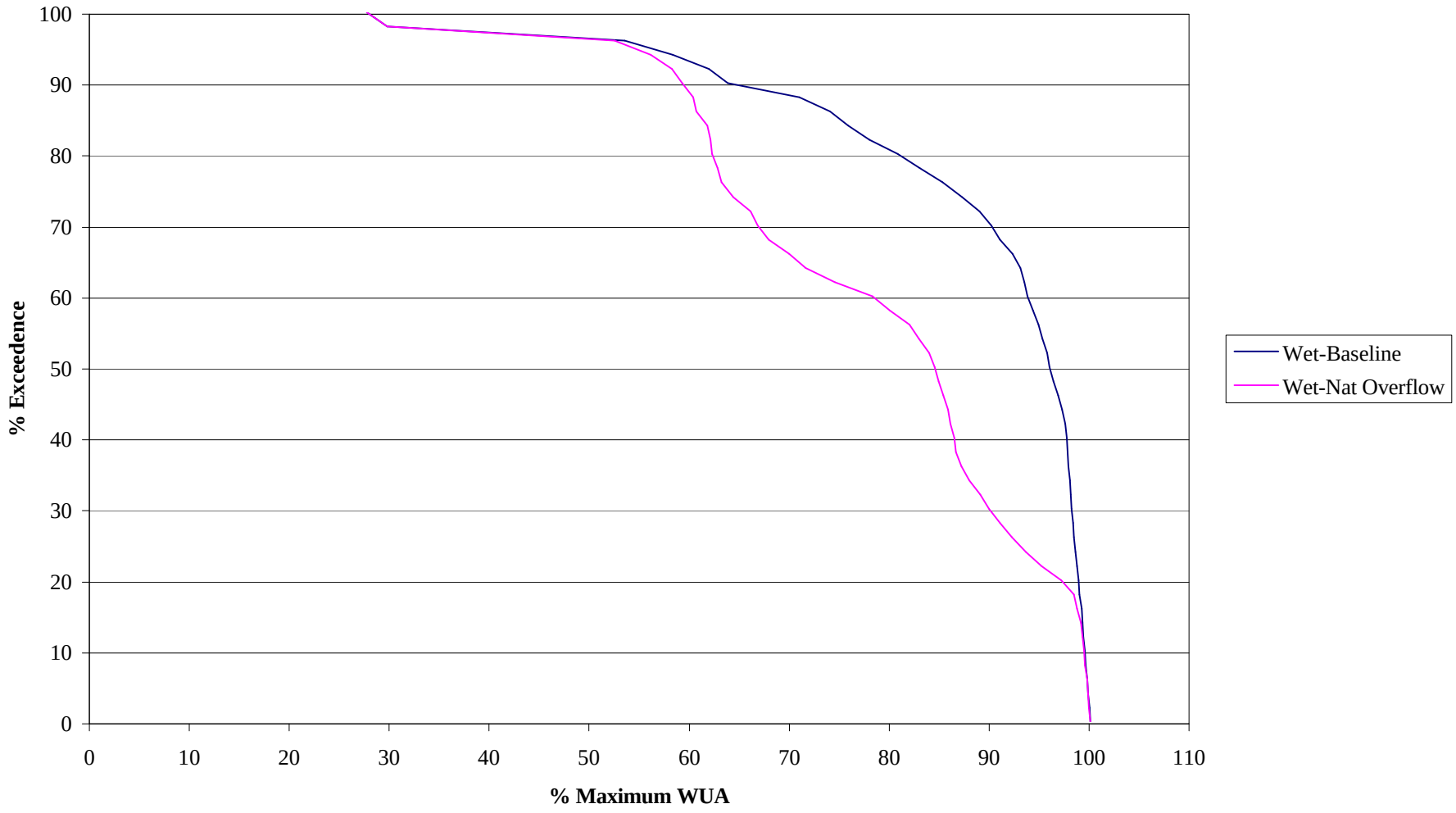
FALL
Final Aquatic Impact Analysis Report



% EXCEEDENCE OF % MAXIMUM WUA FOR HABITAT REACH E SHALLOW POOL SPRING
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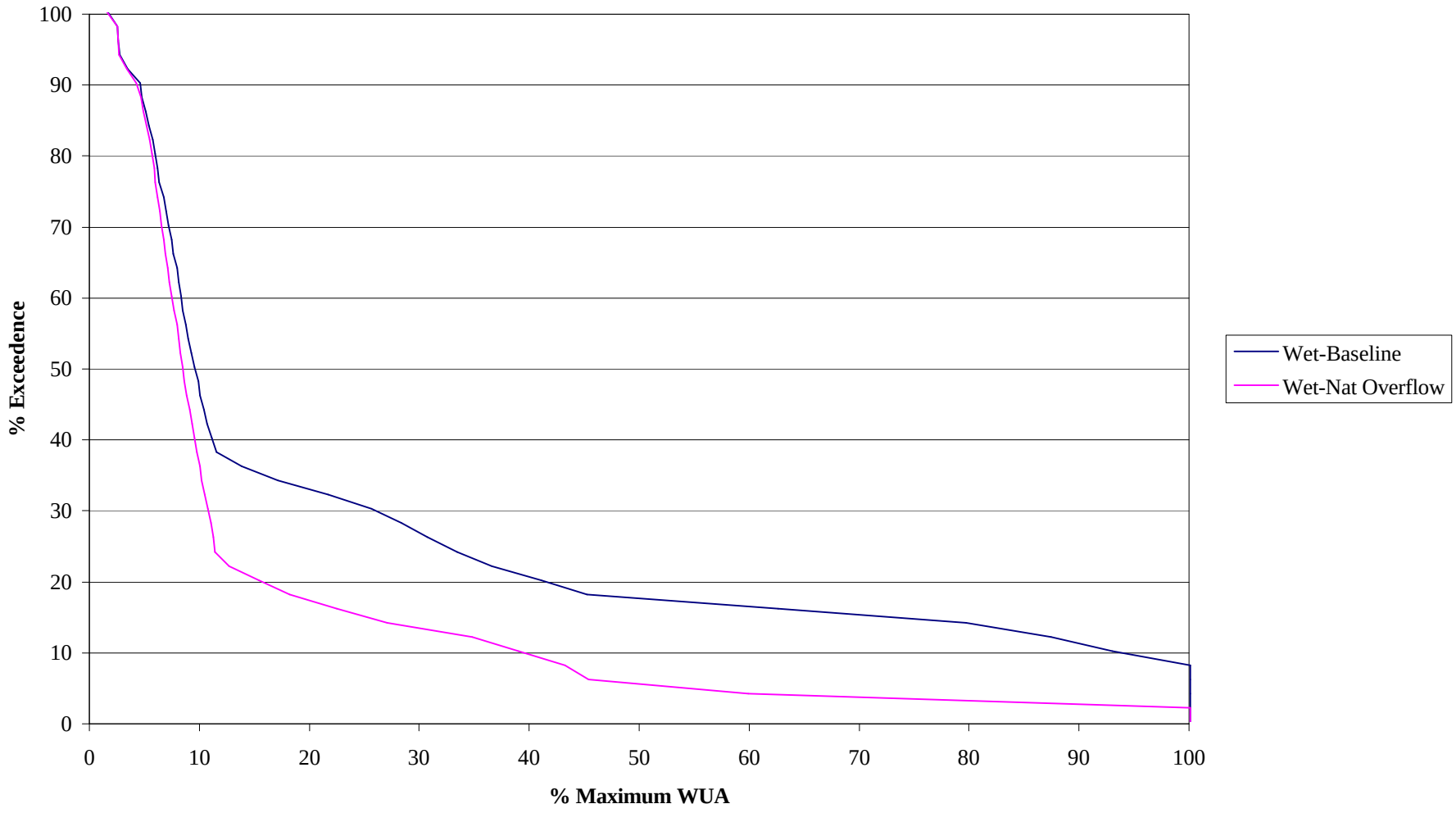

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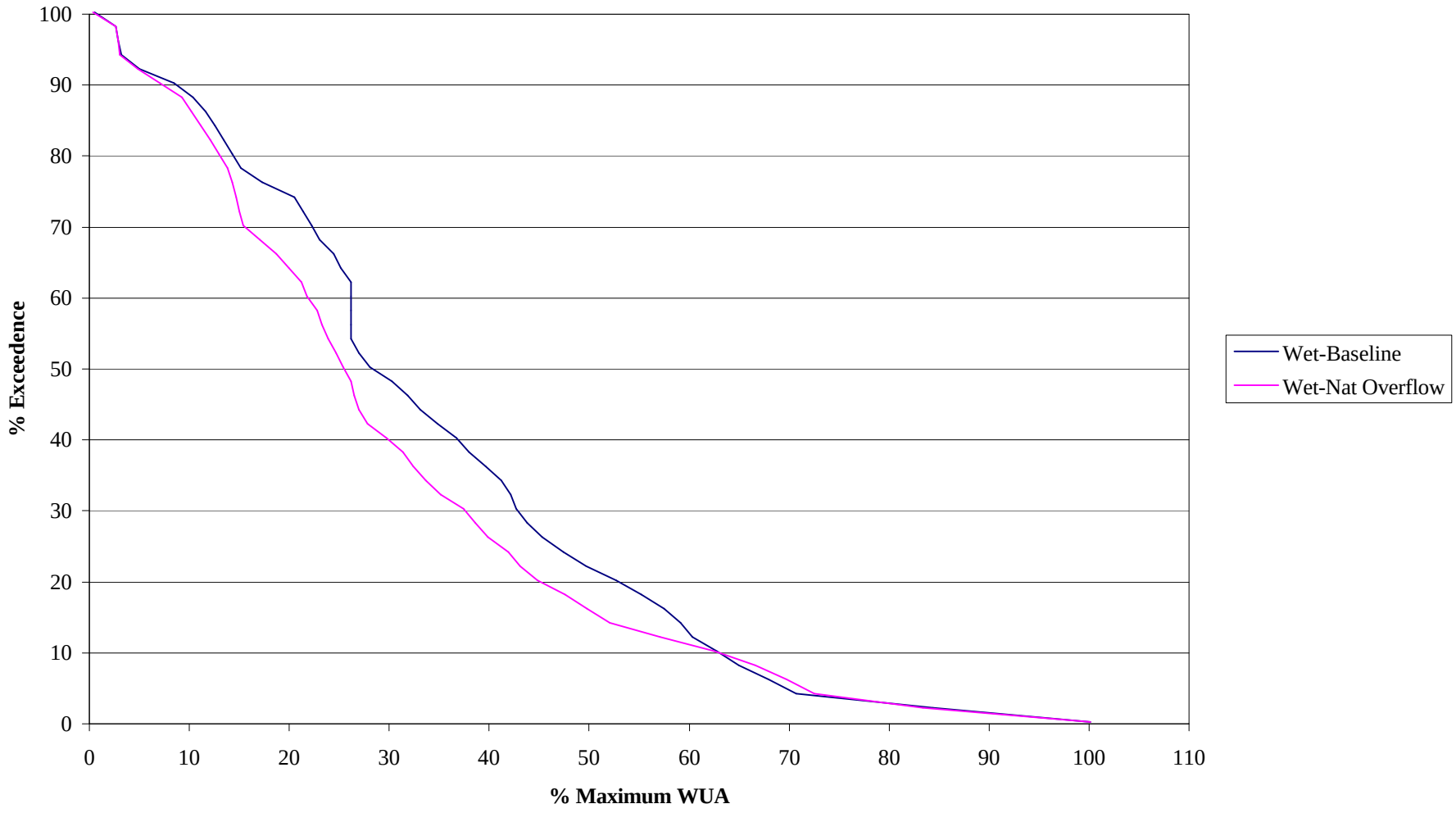

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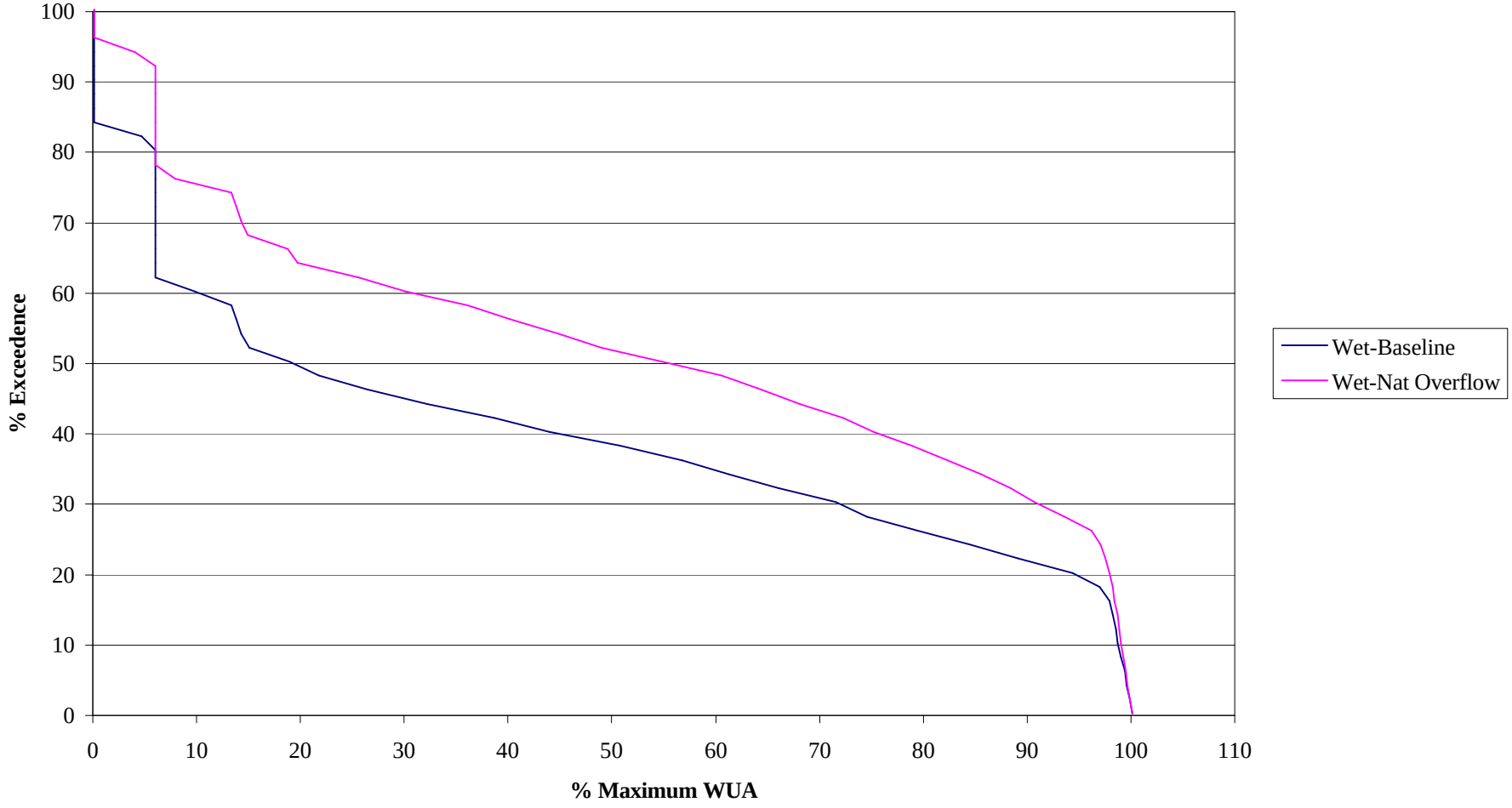

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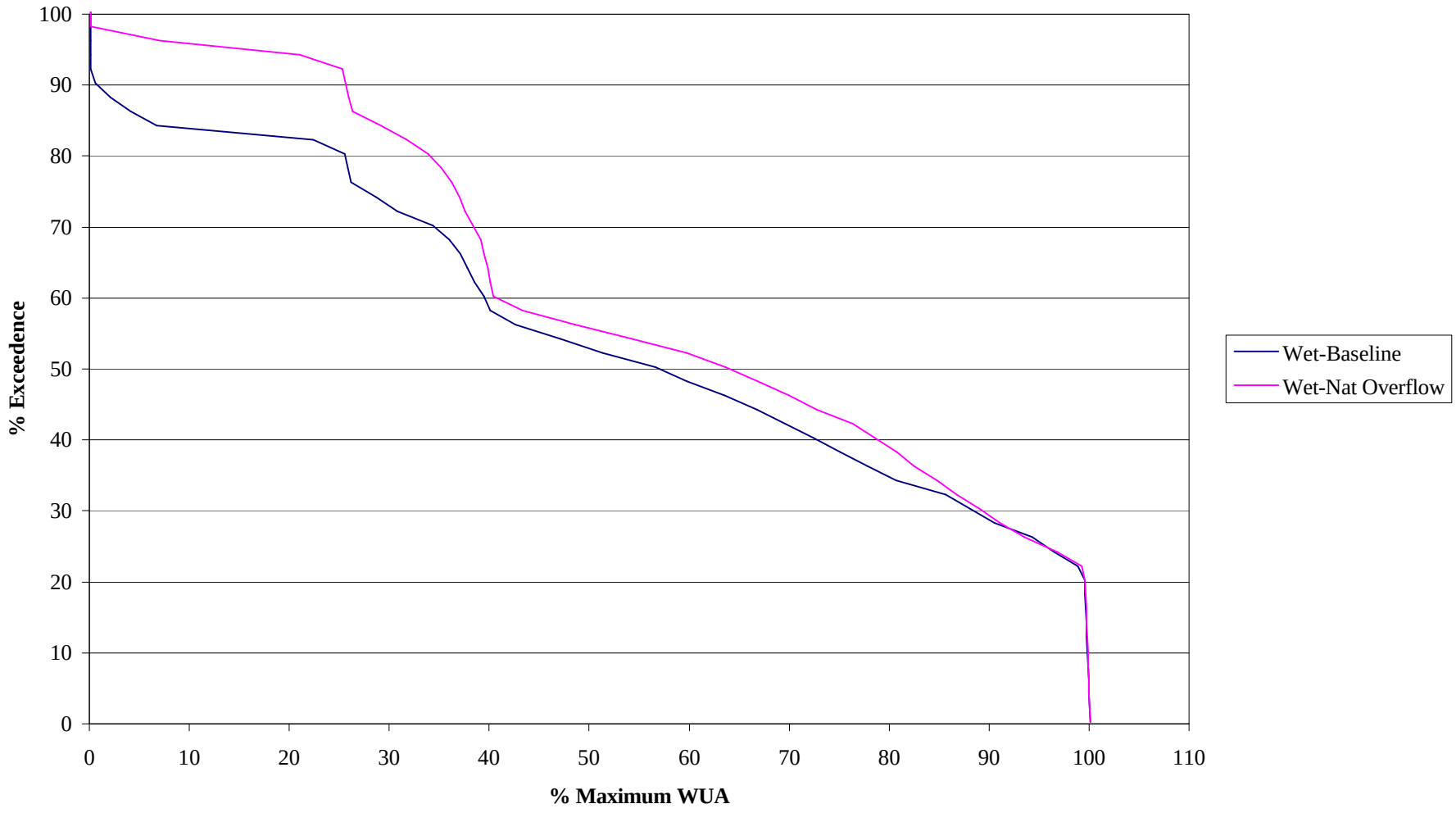

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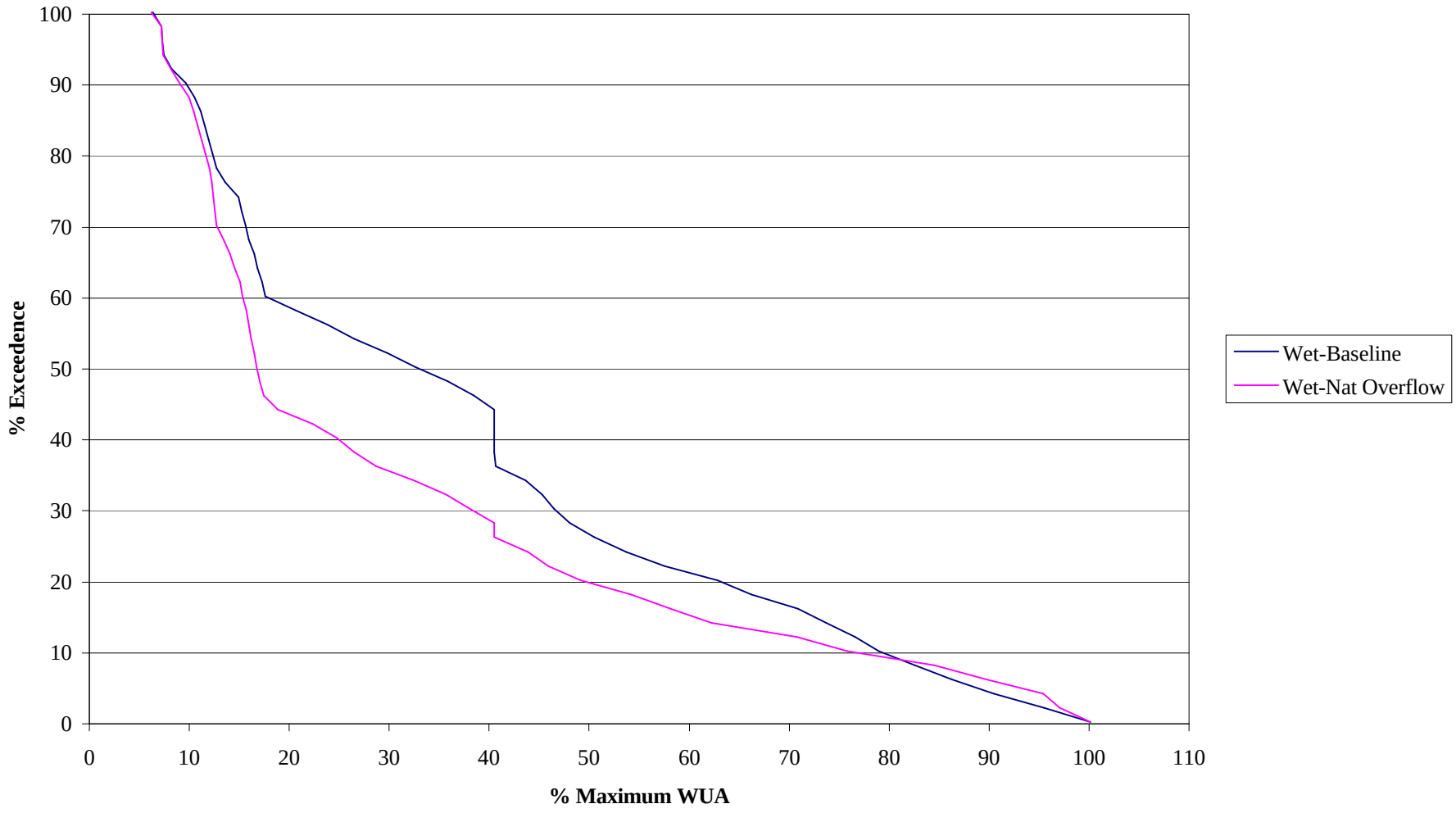

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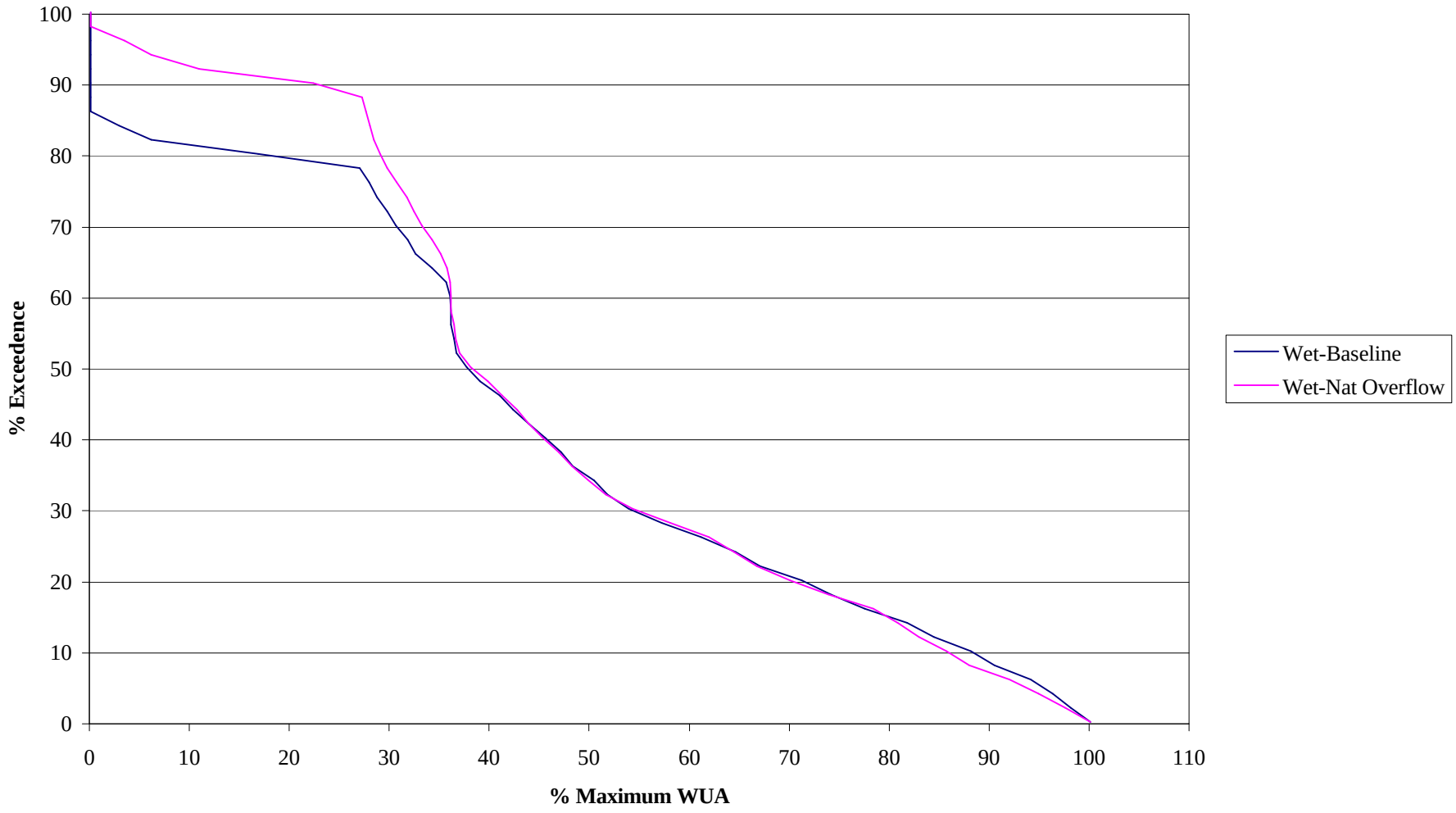

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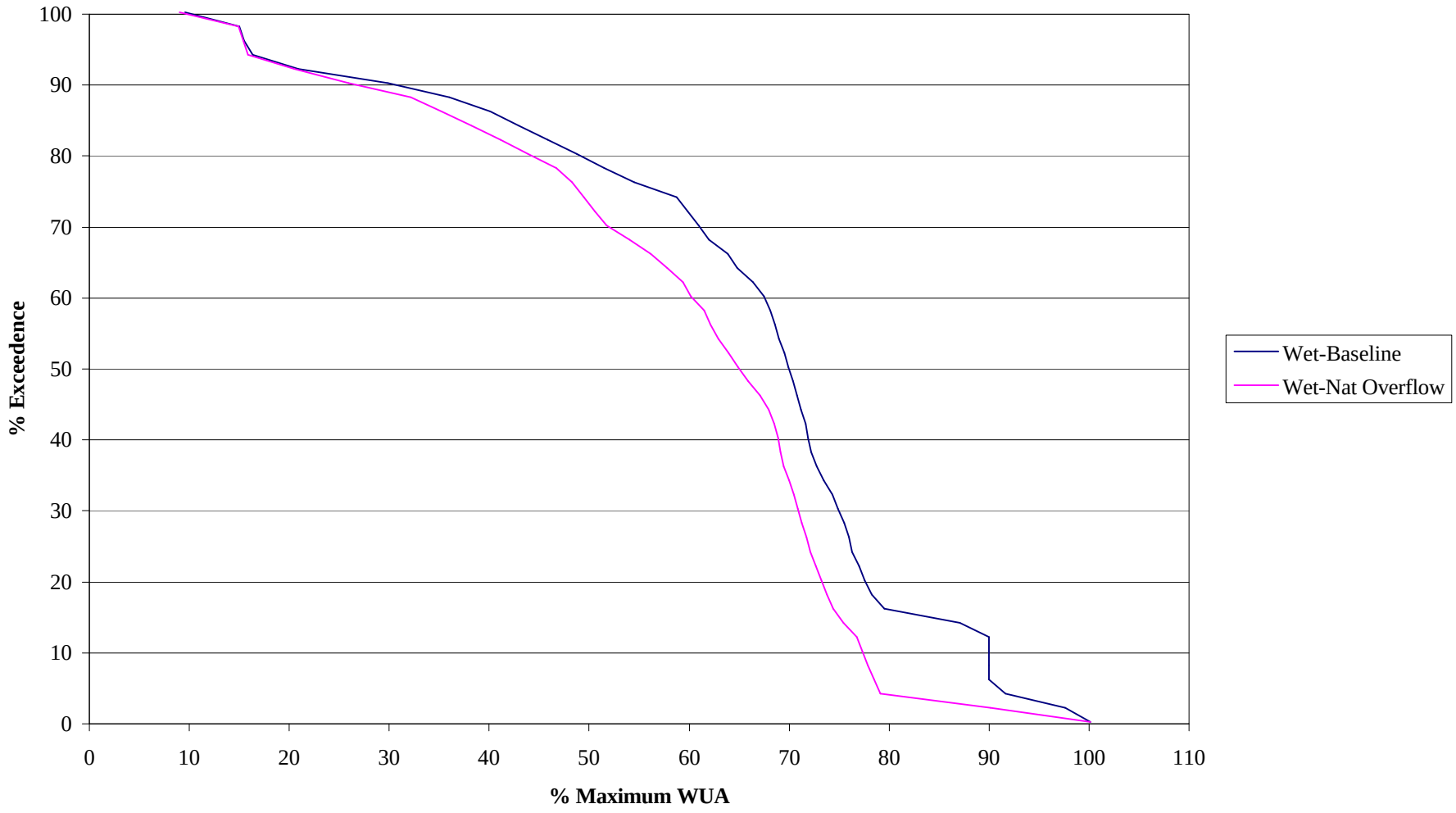

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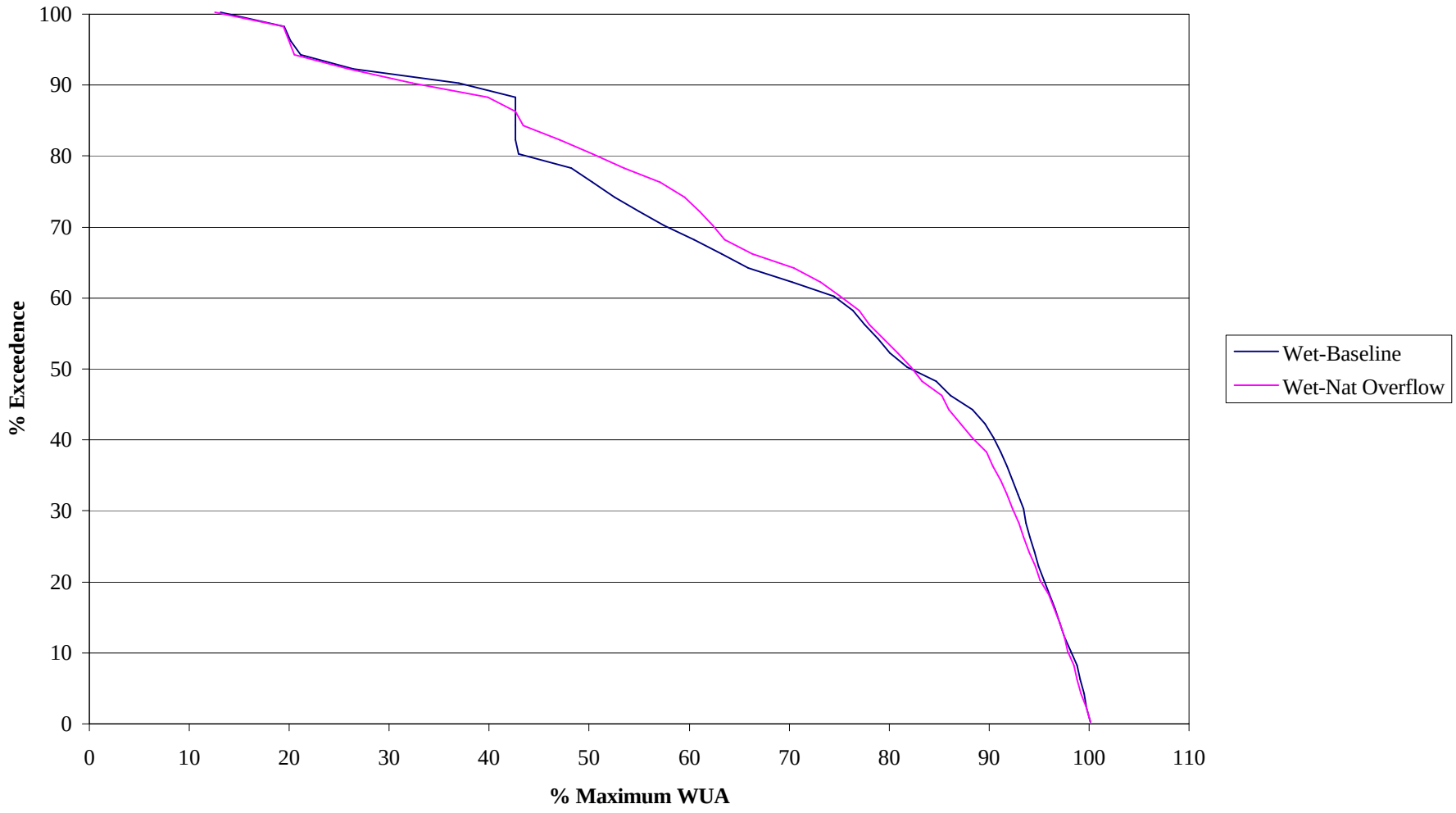
Final Aquatic Impact Analysis Report



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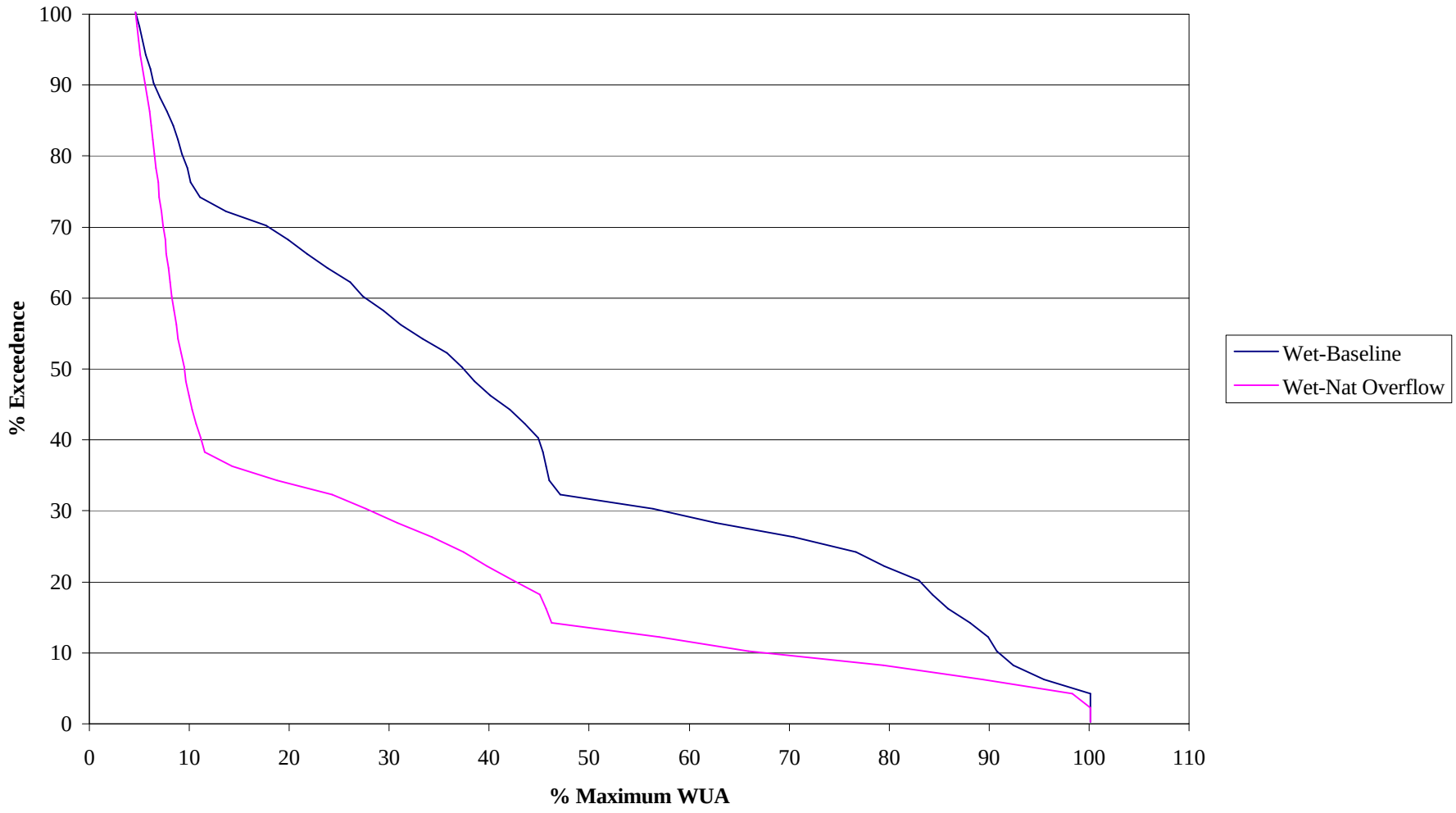

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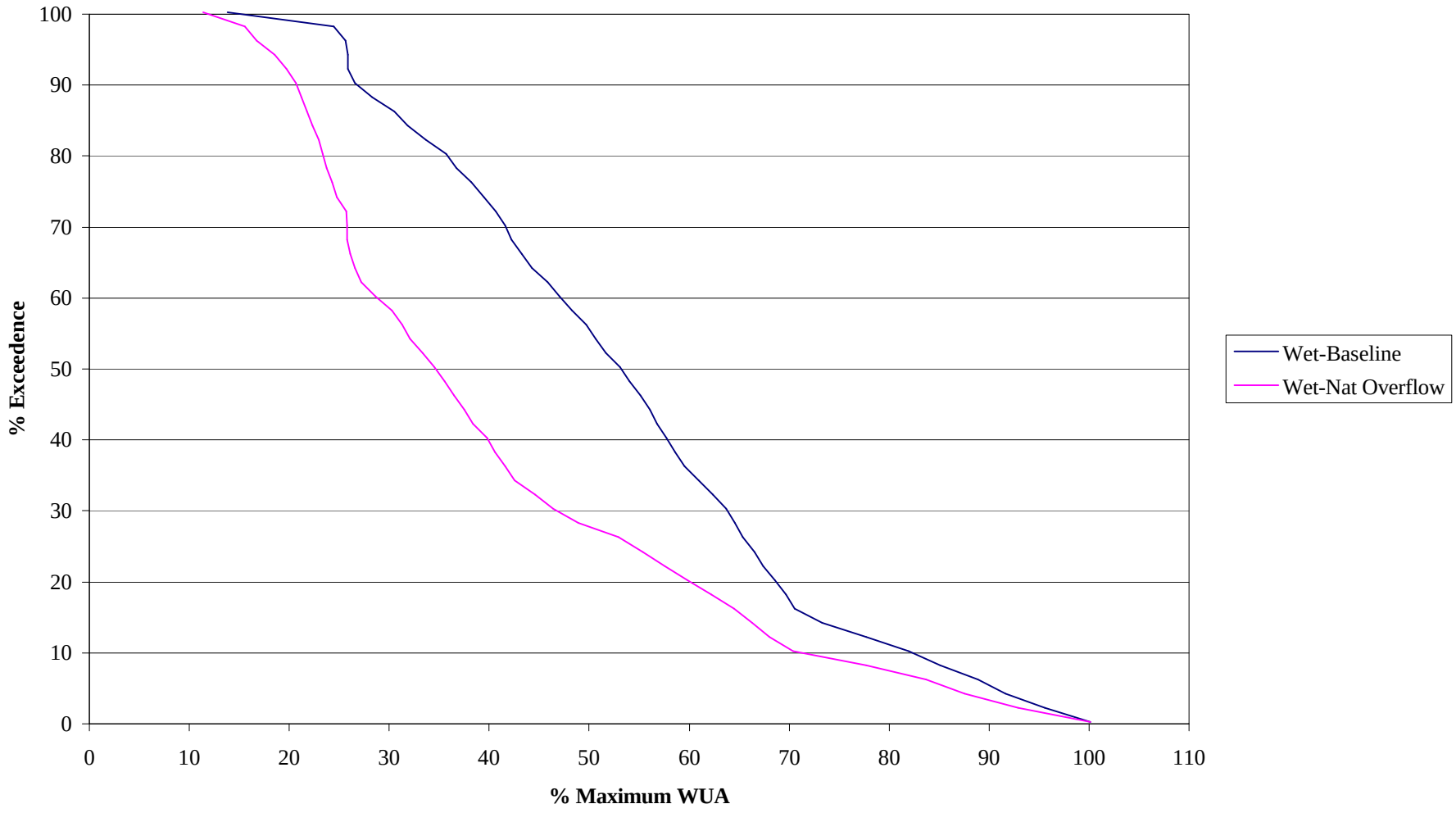

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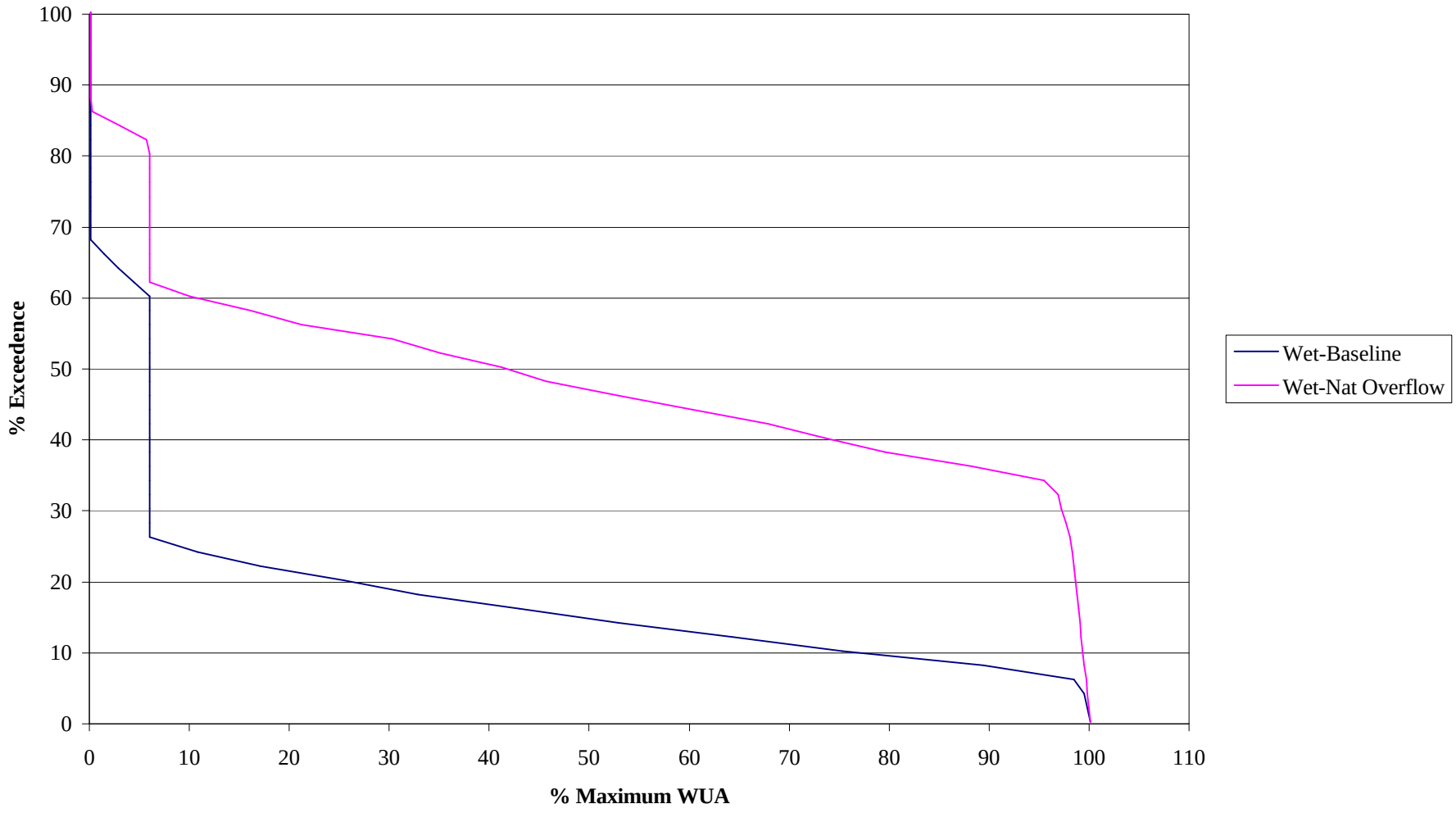
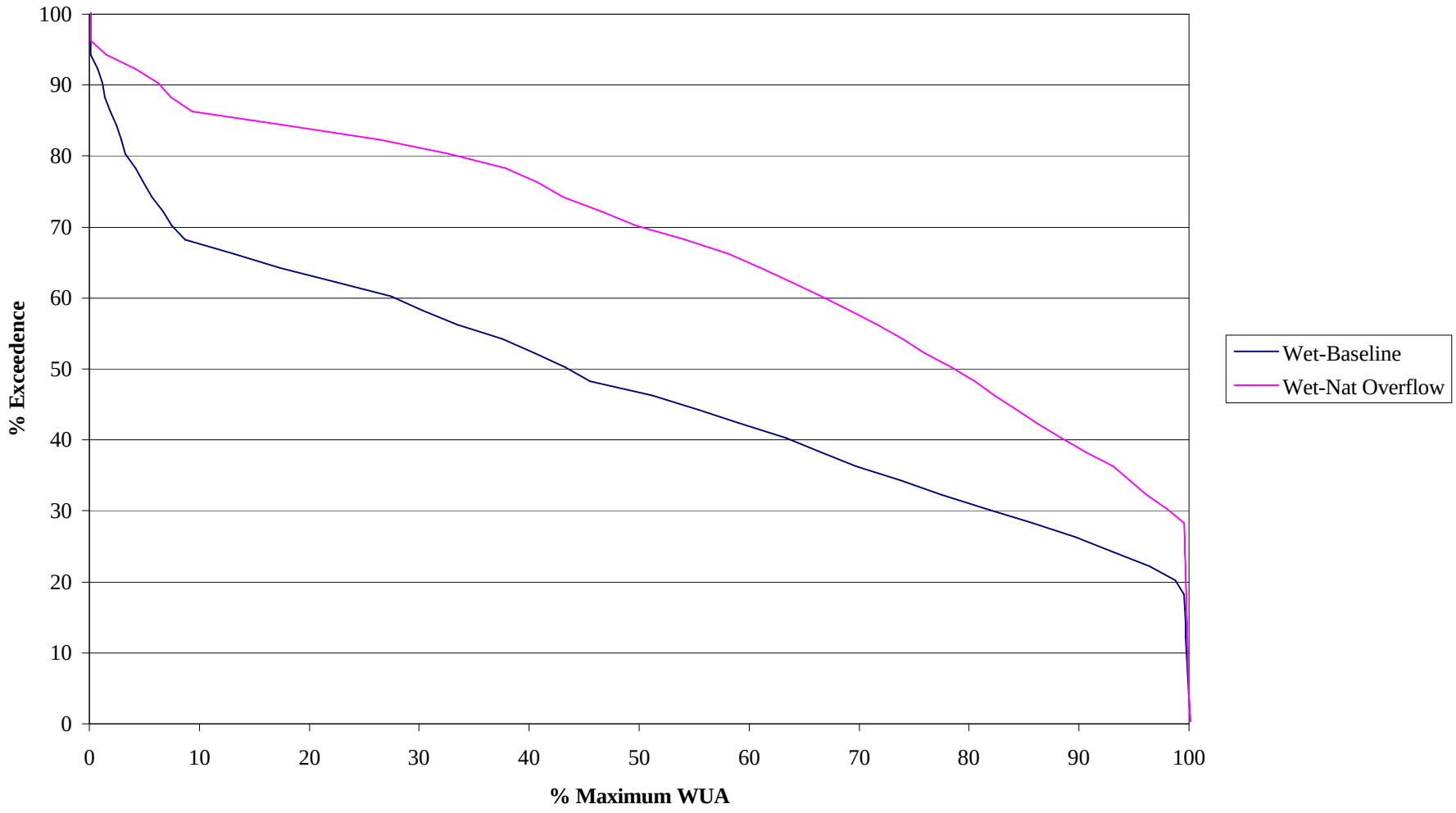


% EXCEEDENCE OF % MAXIMUM WUA FOR HABITAT REACH E RACEWAY SUMMER

Final Aquatic Impact Analysis Report



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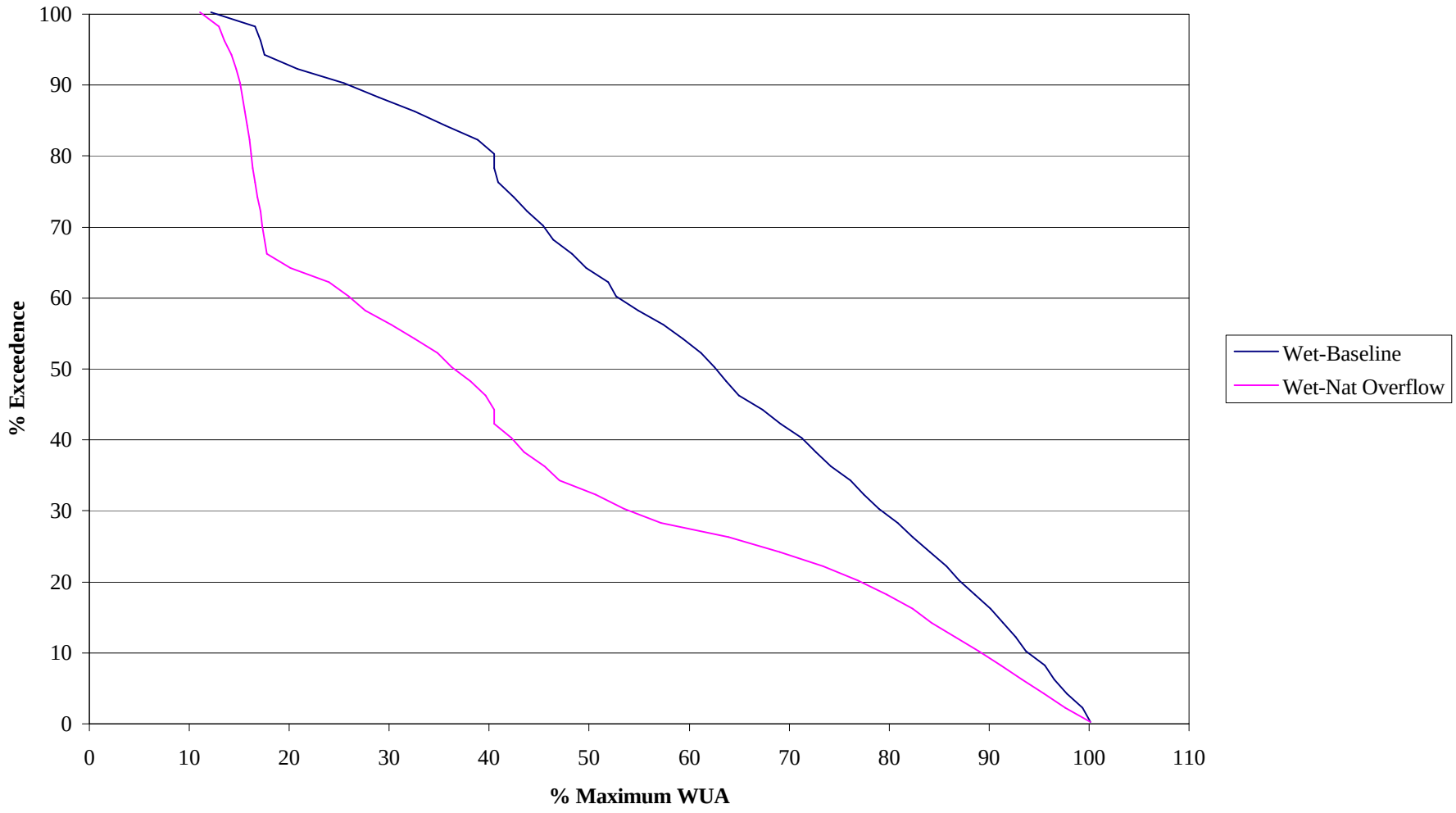

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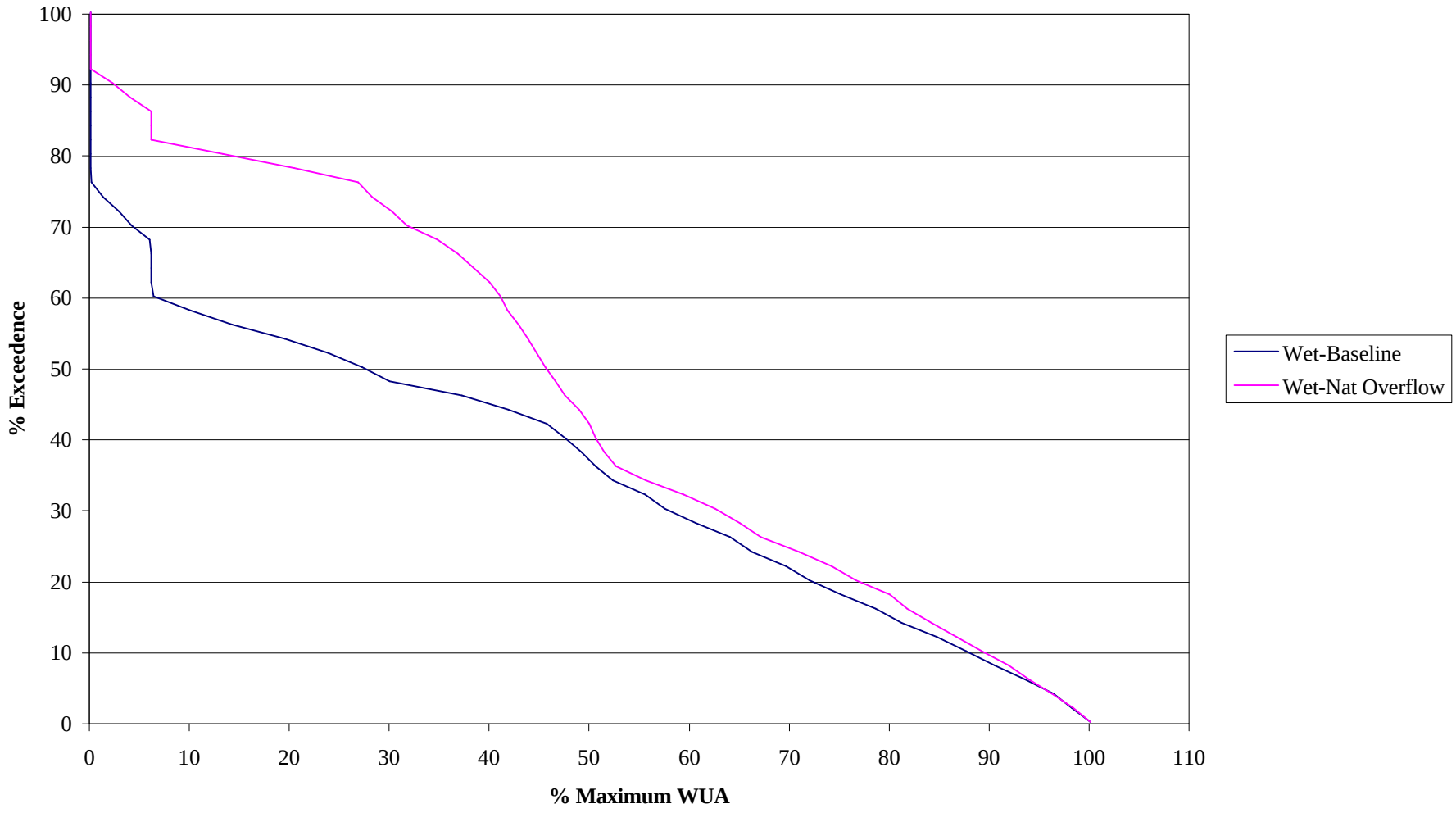

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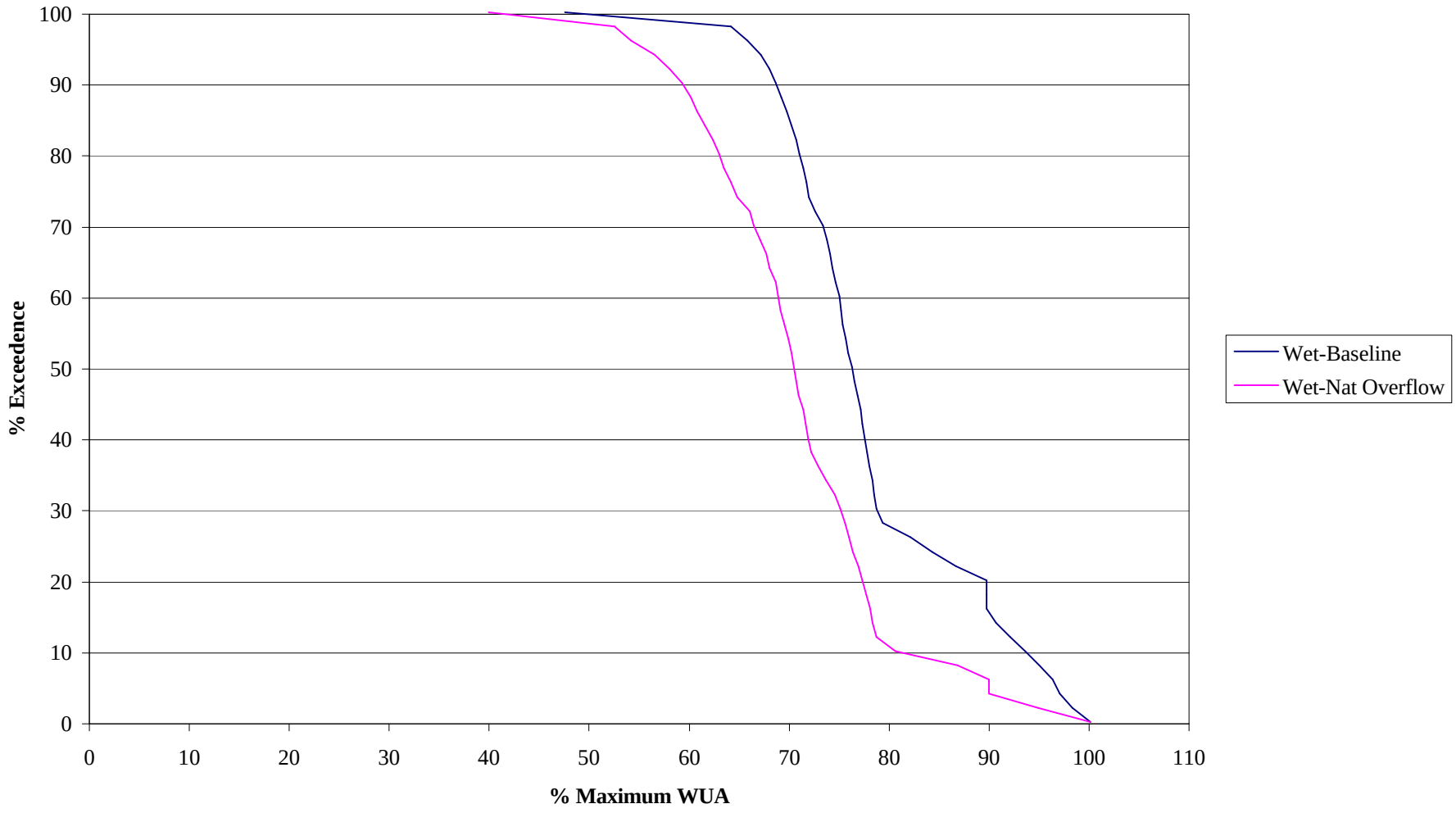

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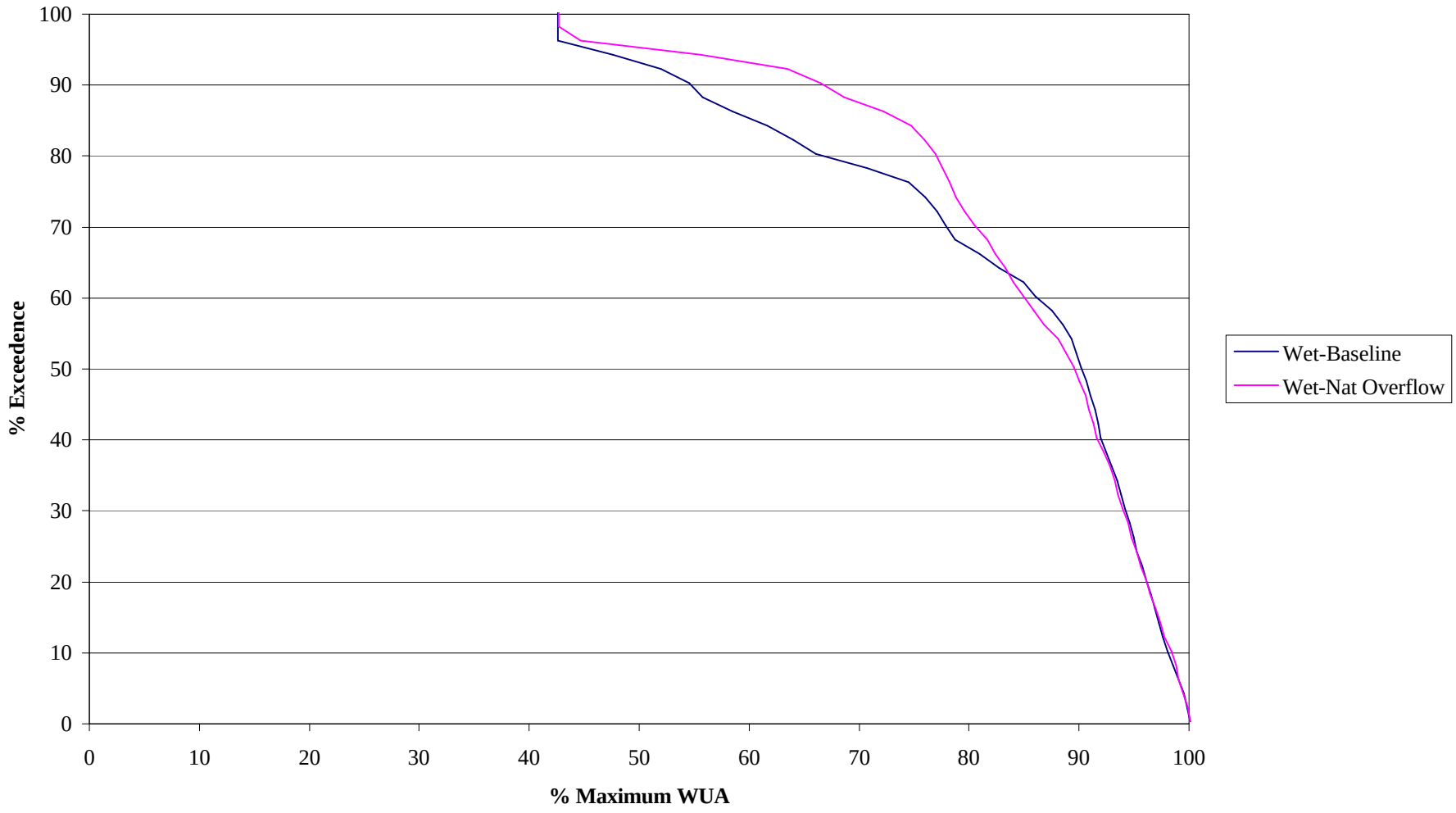

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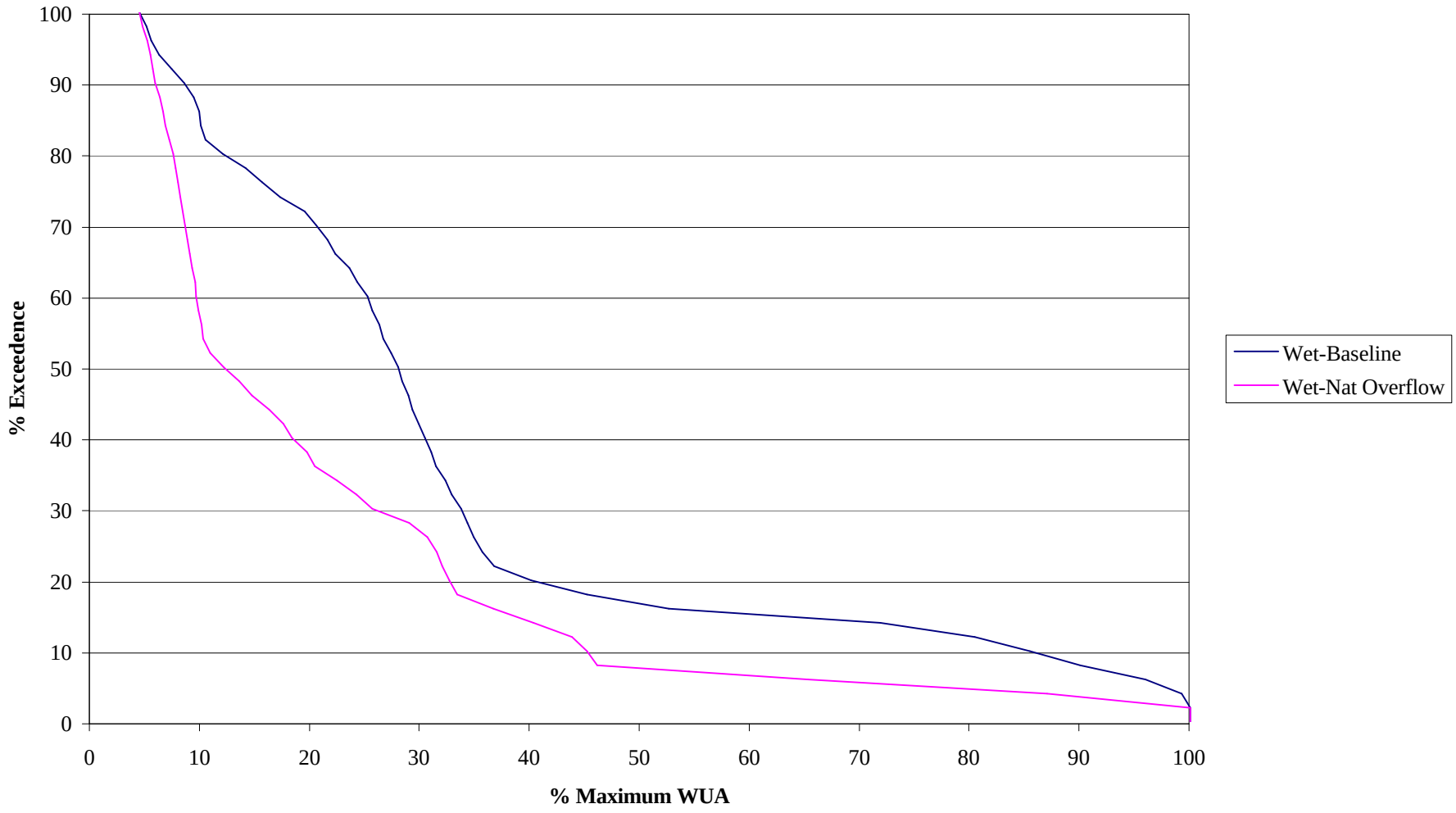
Final Aquatic Impact Analysis Report



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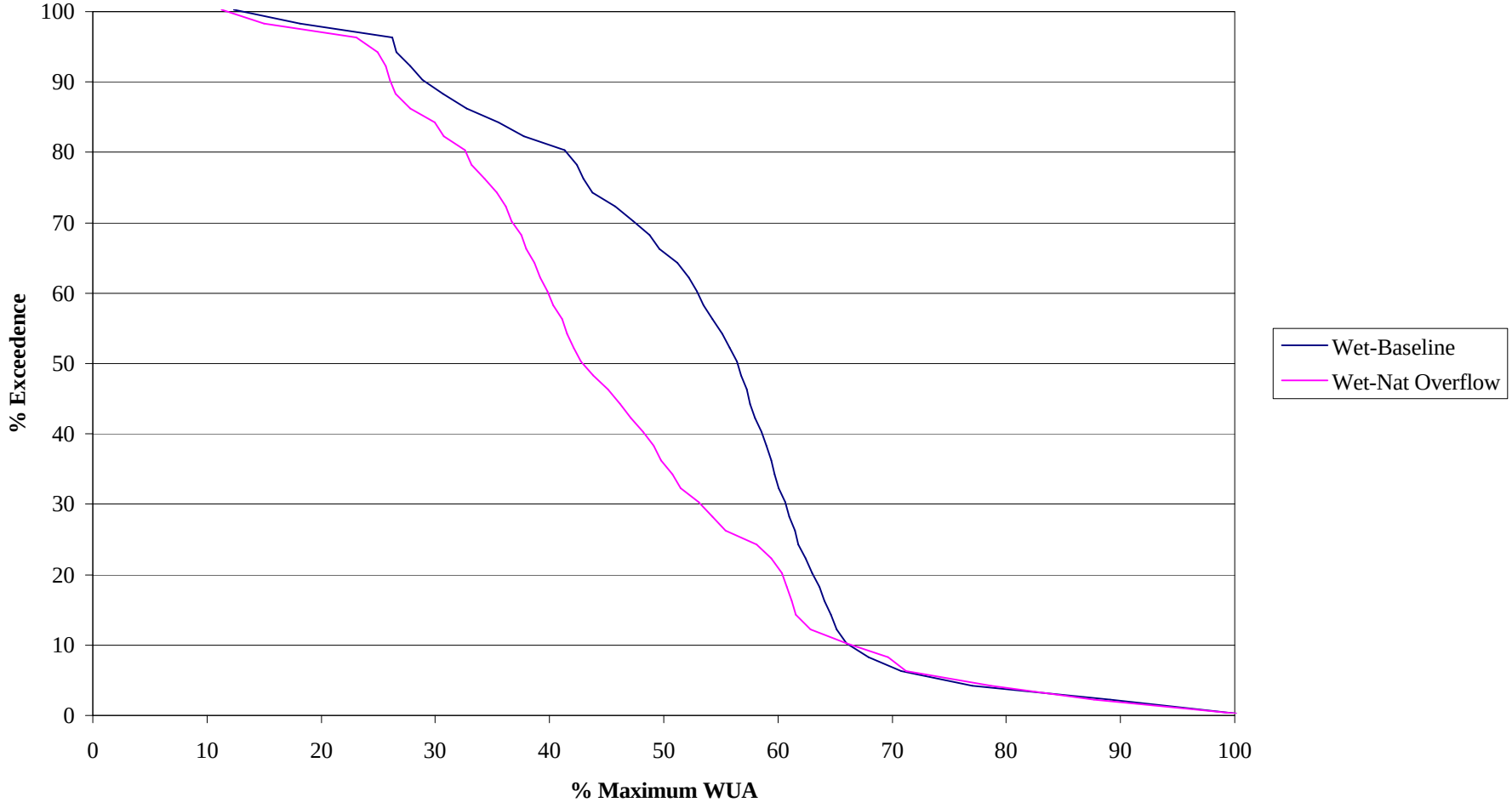
Final Aquatic Impact Analysis Report



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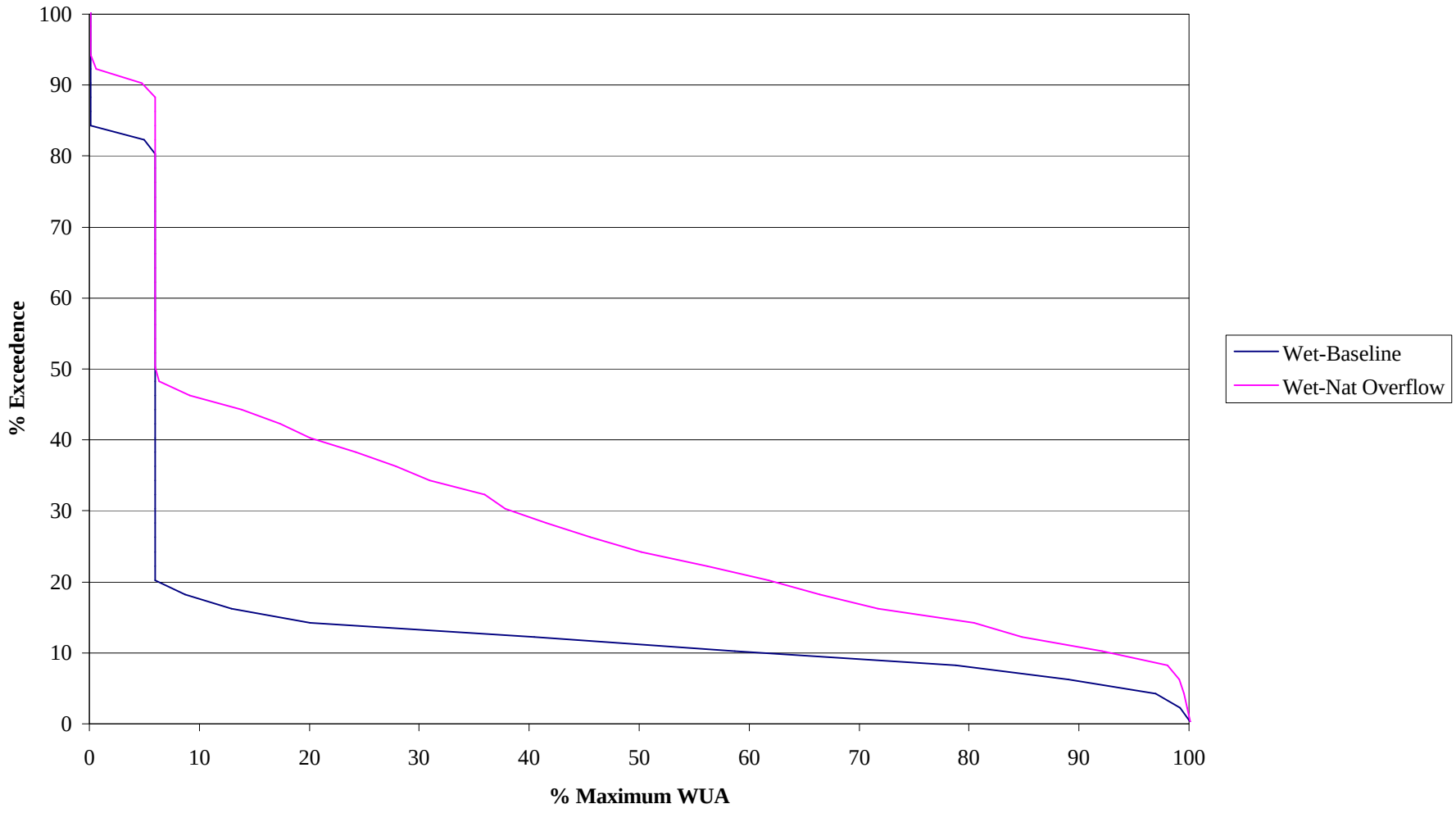

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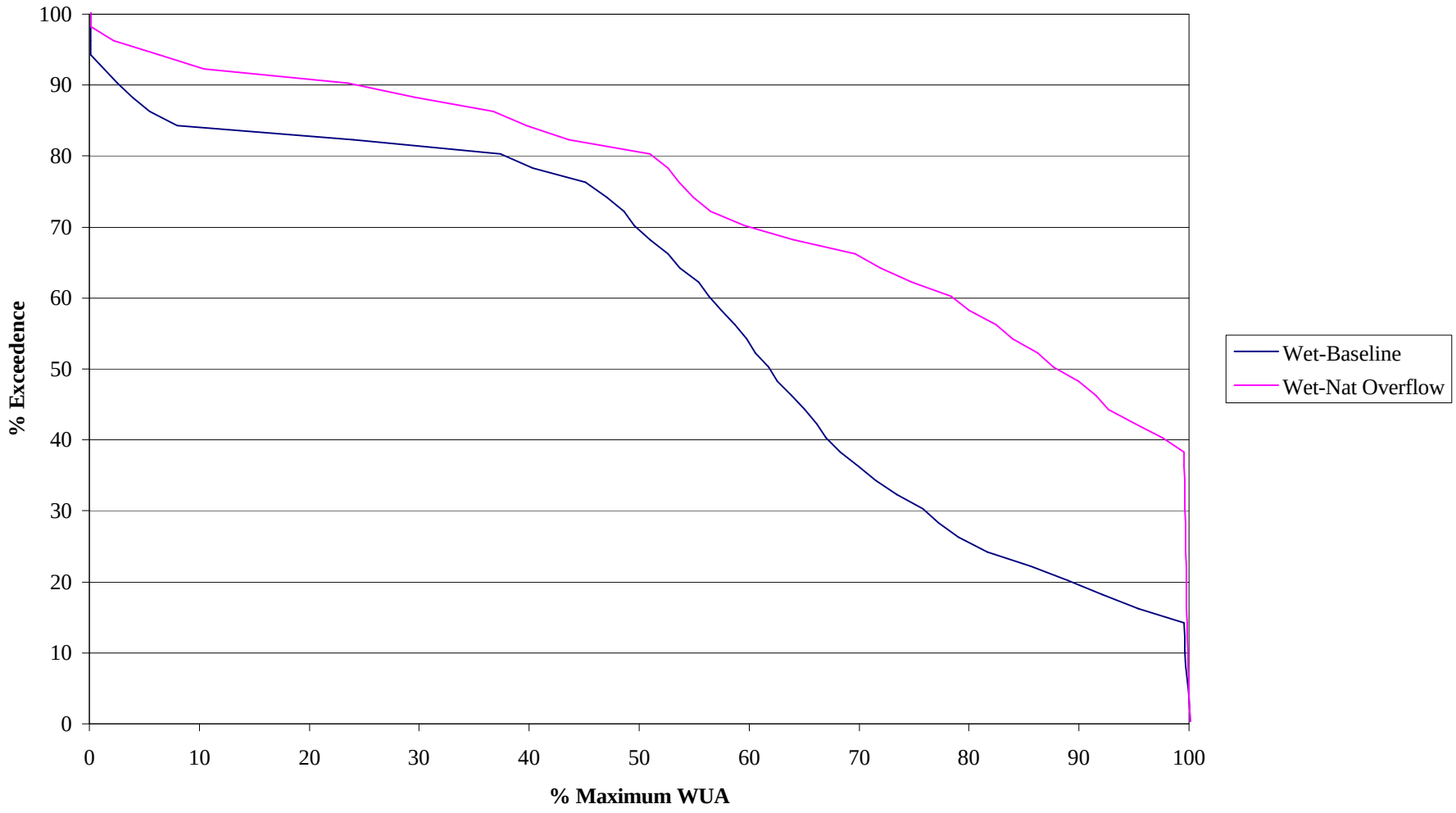
FALL
Final Aquatic Impact Analysis Report



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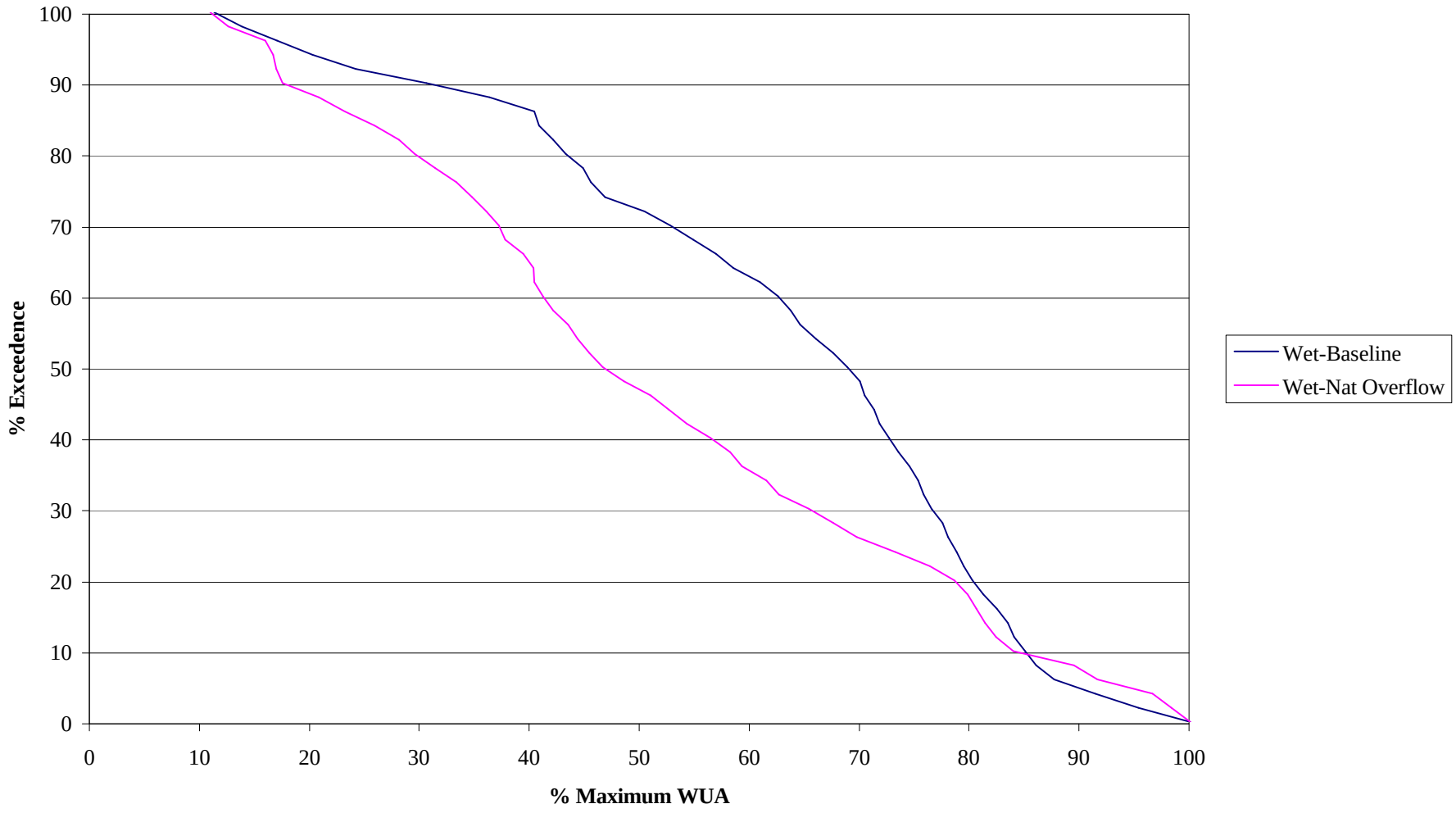

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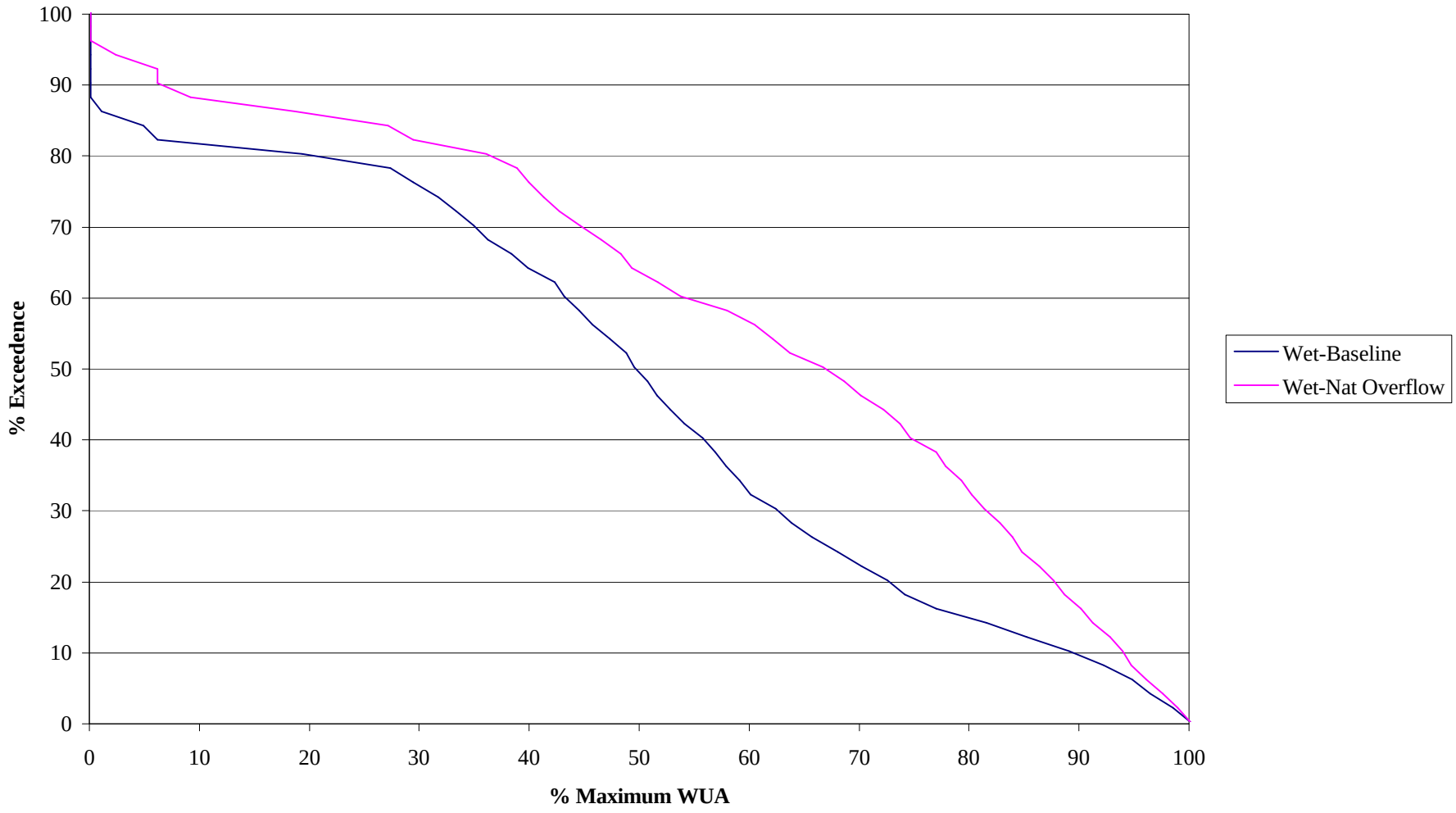
FALL
Final Aquatic Impact Analysis Report



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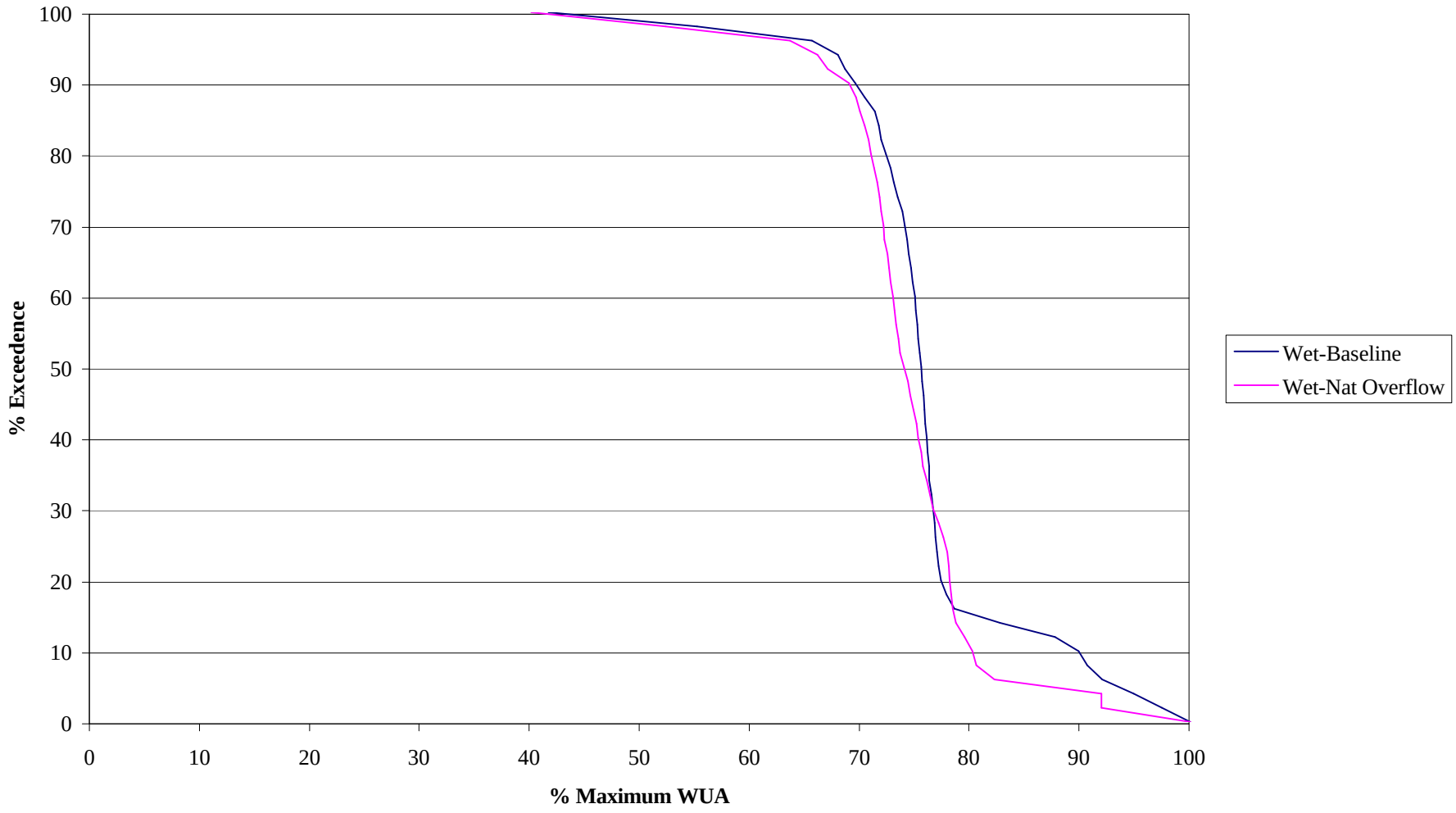

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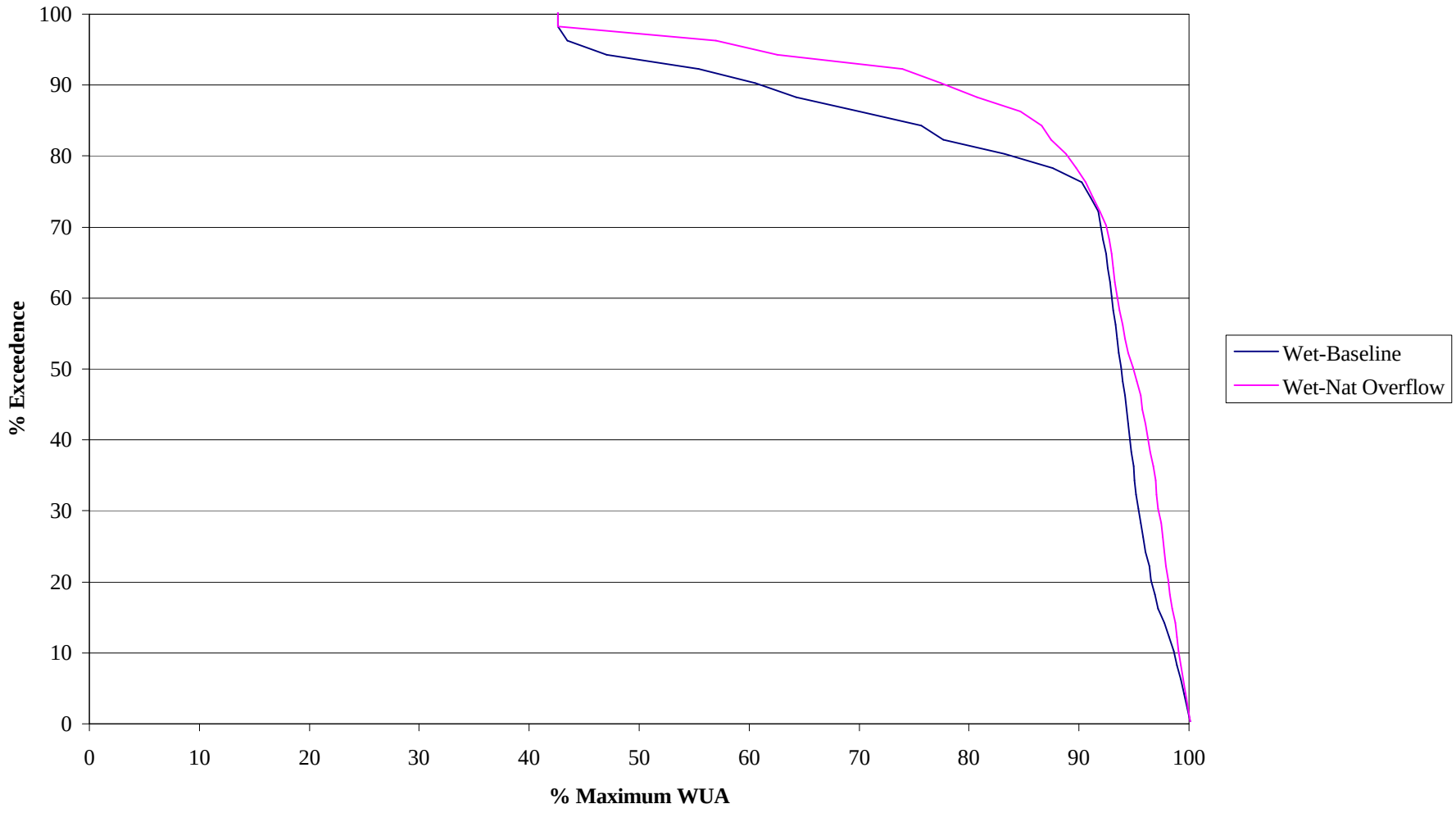
FALL
Final Aquatic Impact Analysis Report



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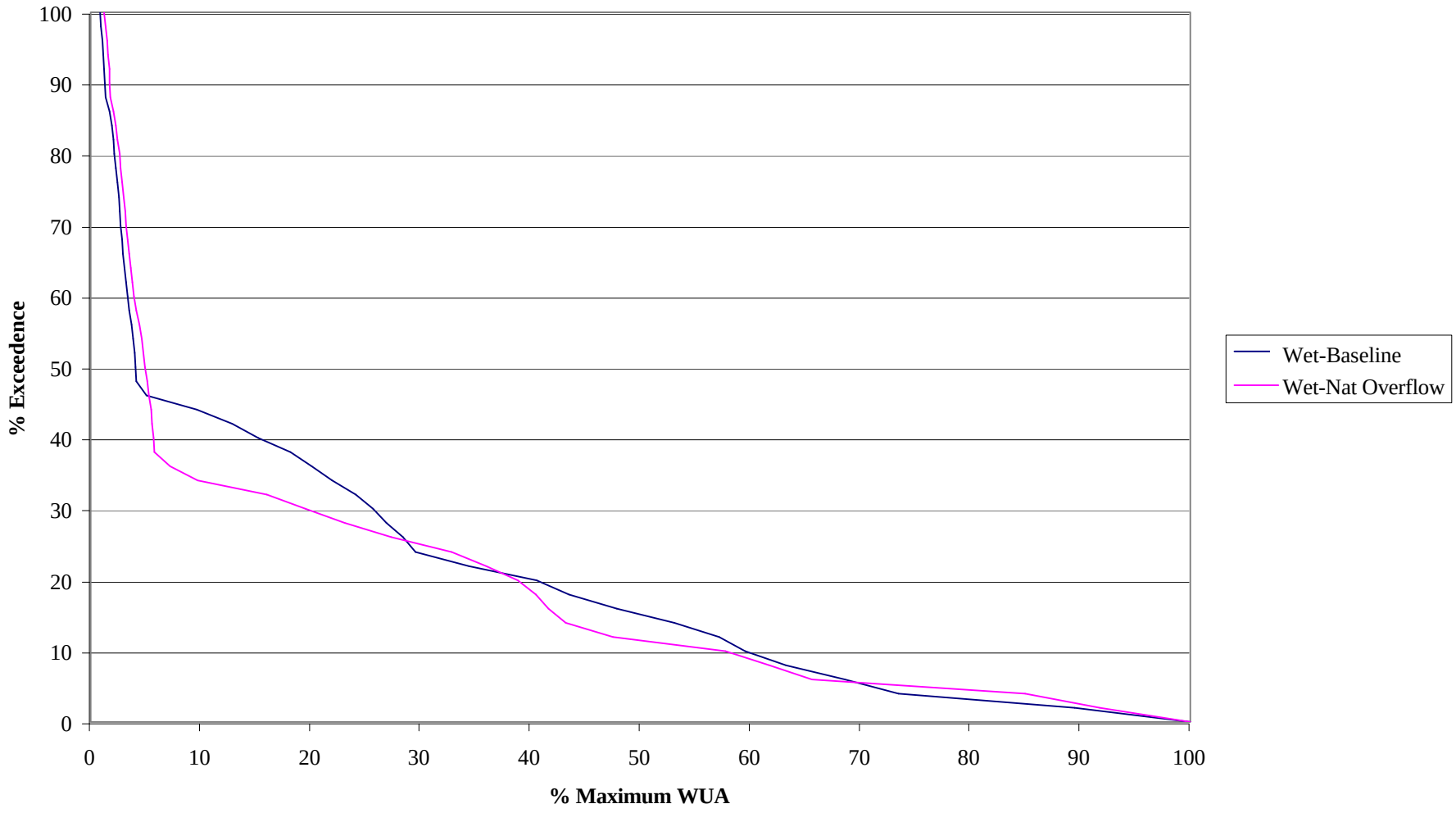

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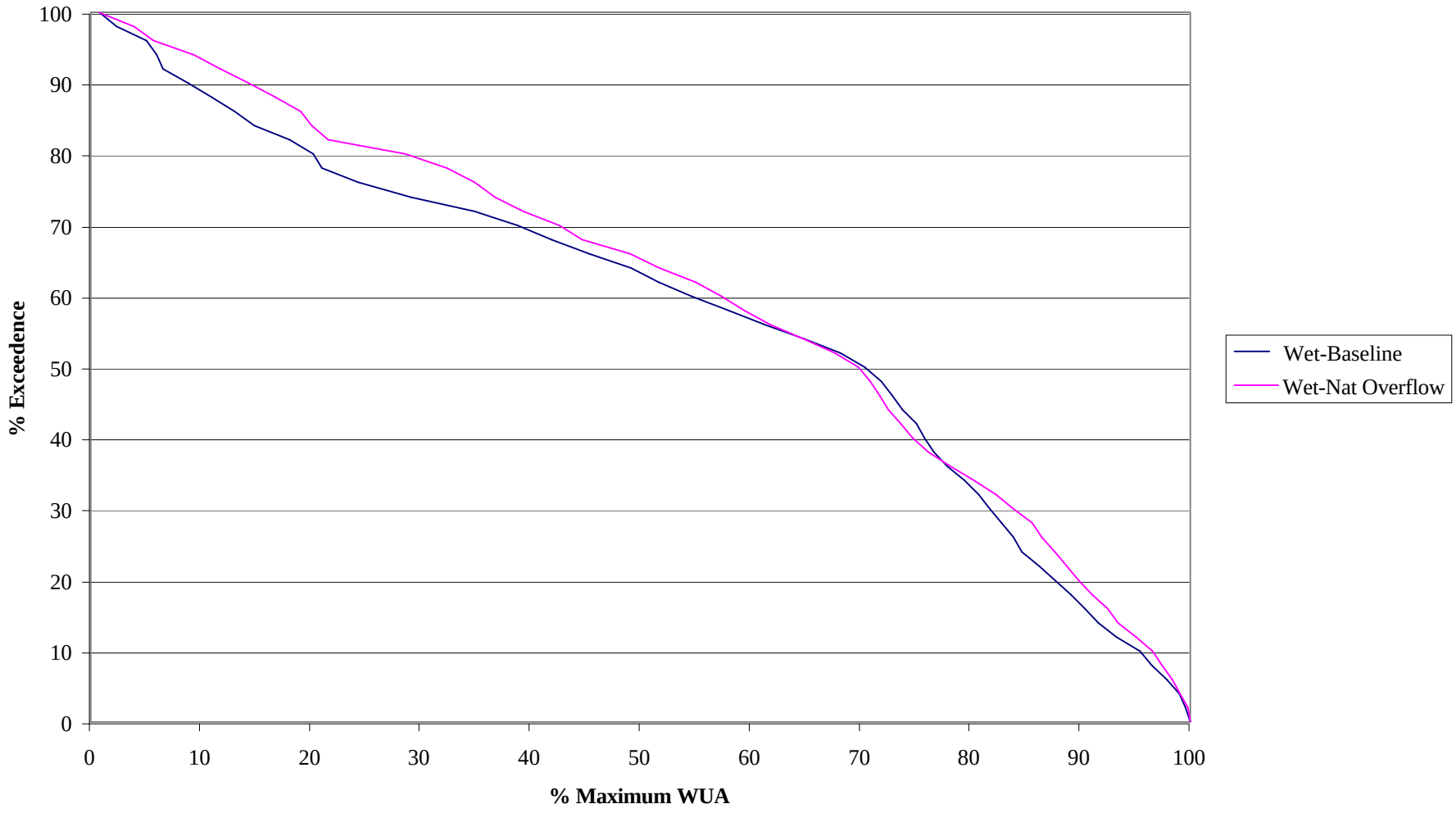

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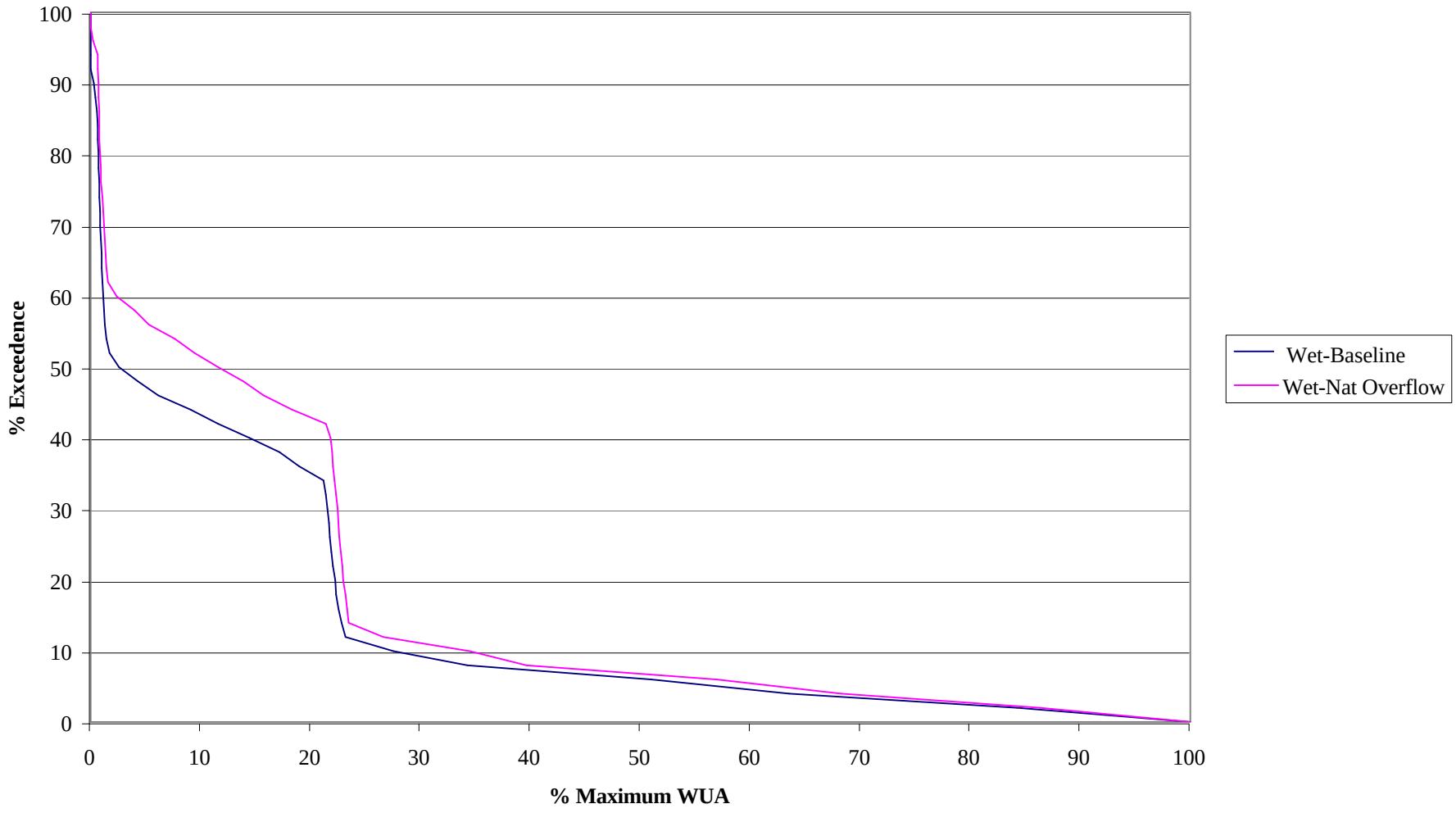
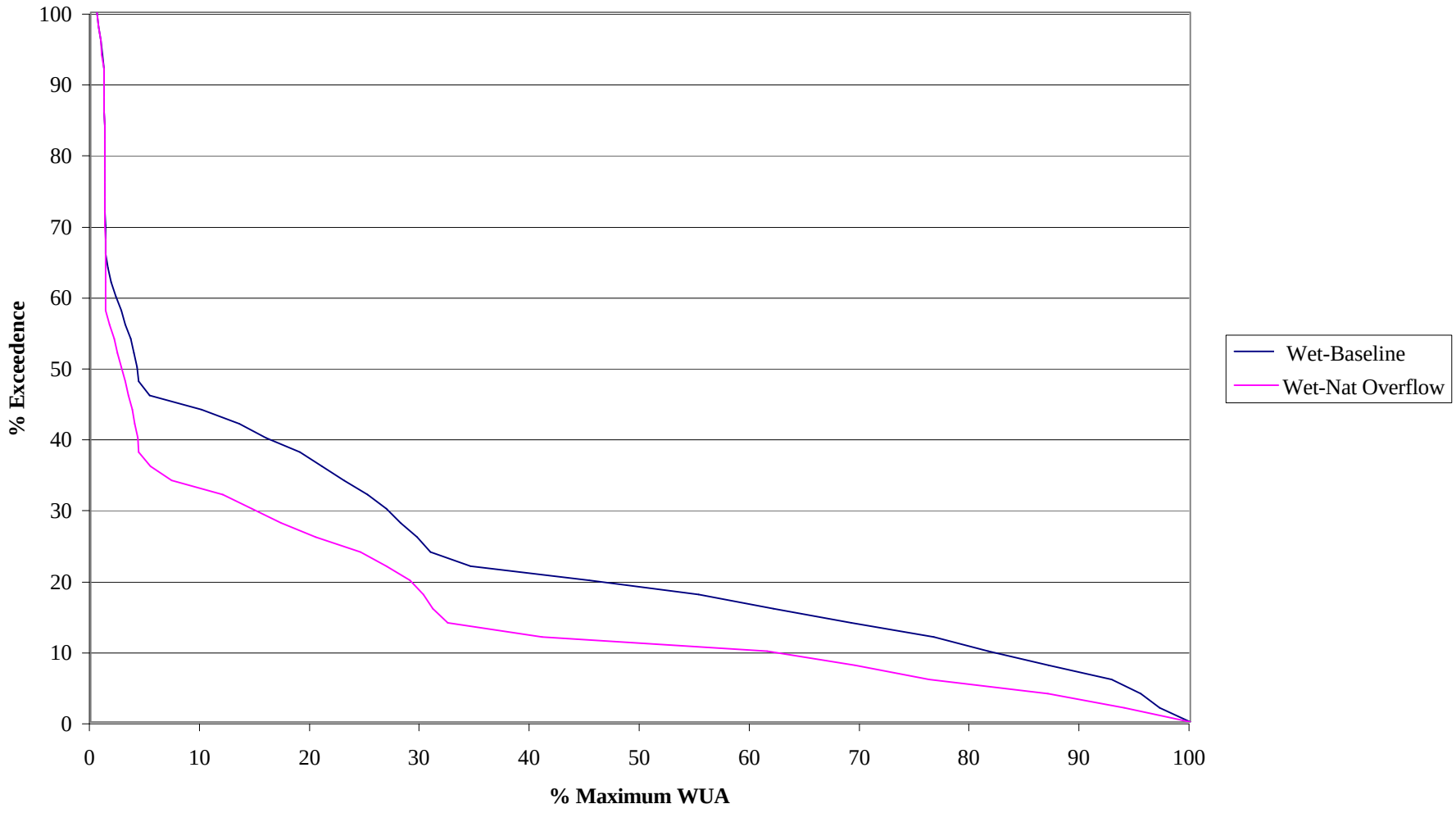


% EXCEEDENCE OF % MAXIMUM WUA FOR HABITAT REACH B MEDIUM POOL SPRING

Final Aquatic Impact Analysis Report



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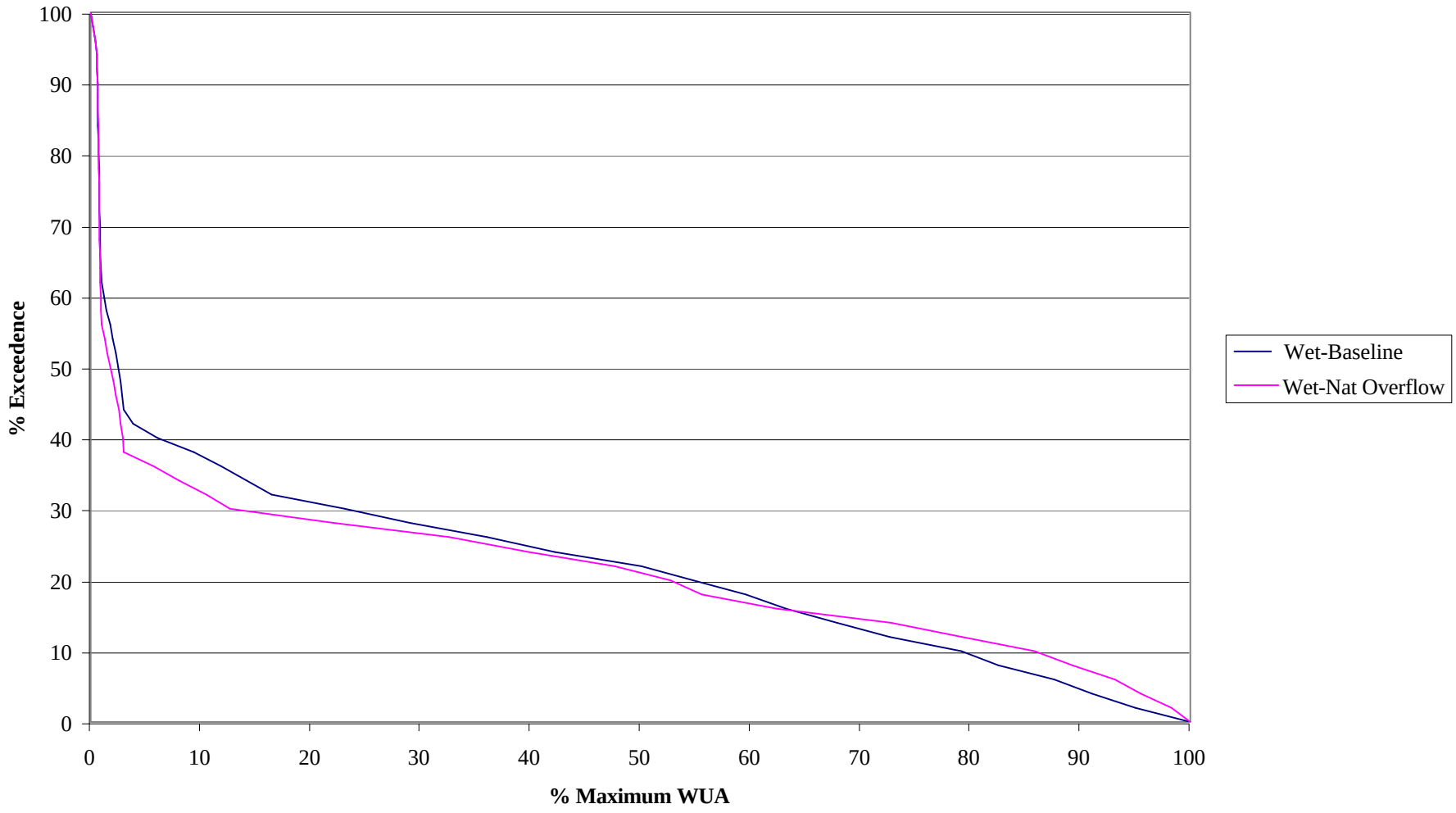

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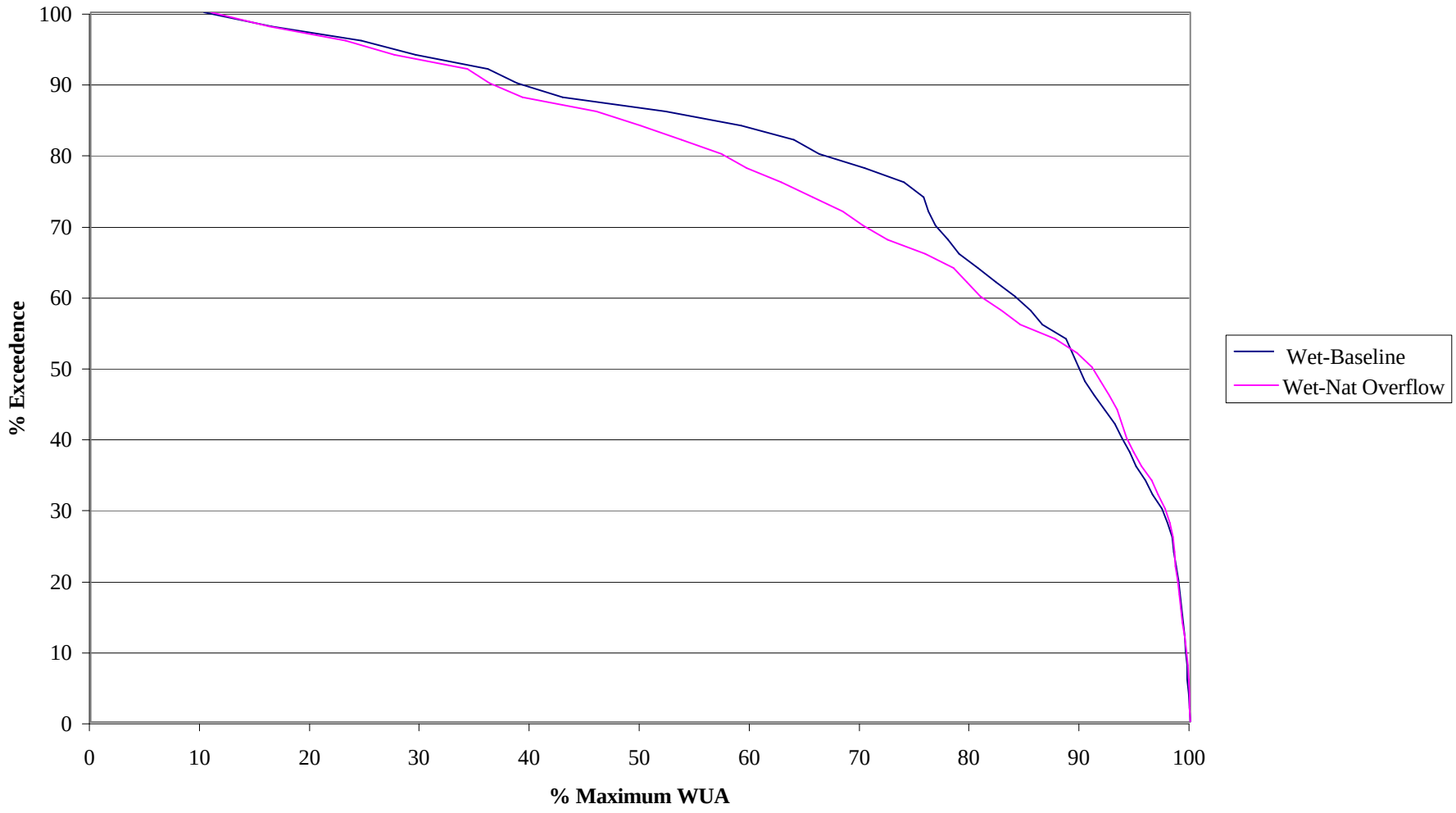

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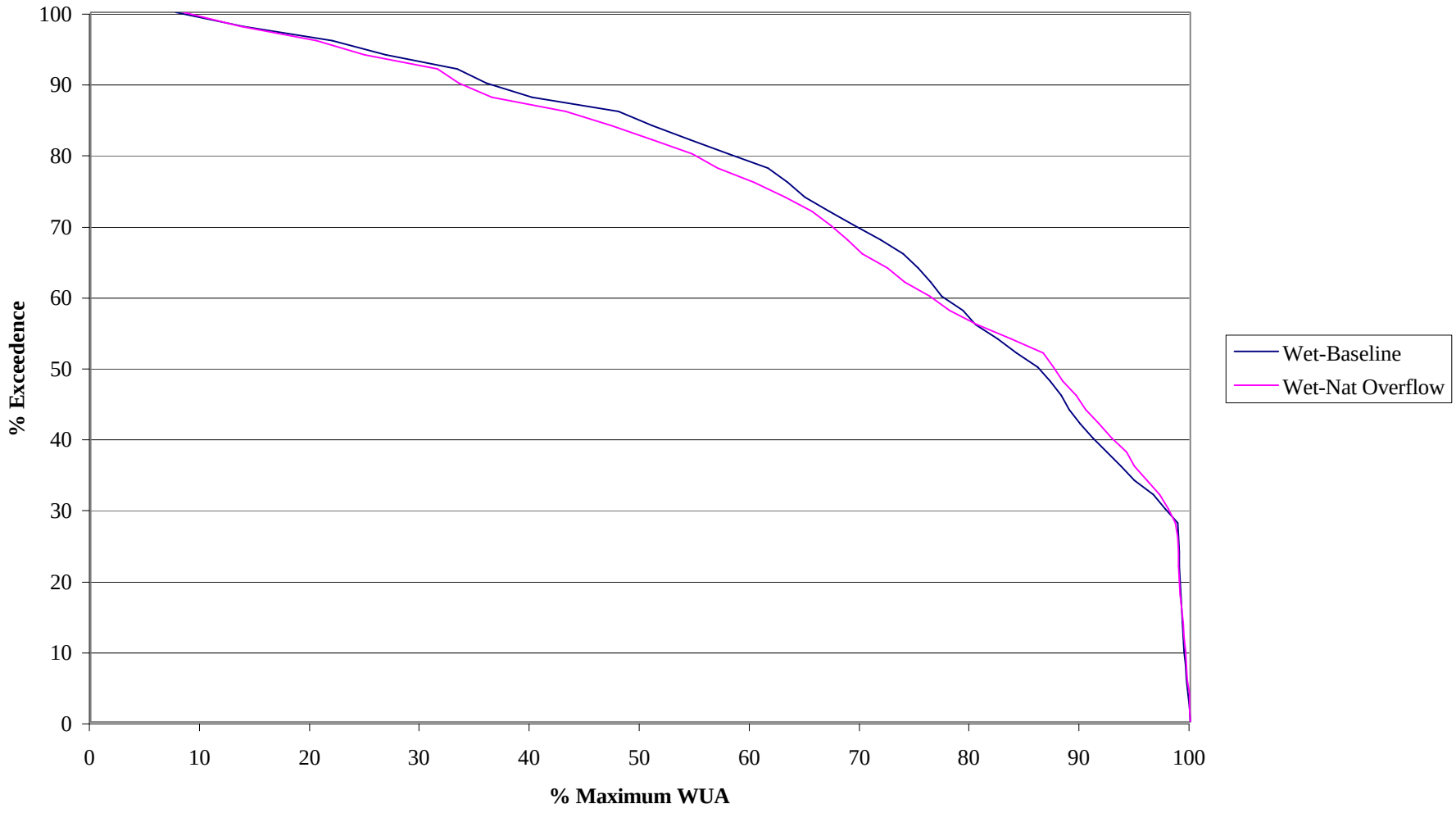
Final Aquatic Impact Analysis Report



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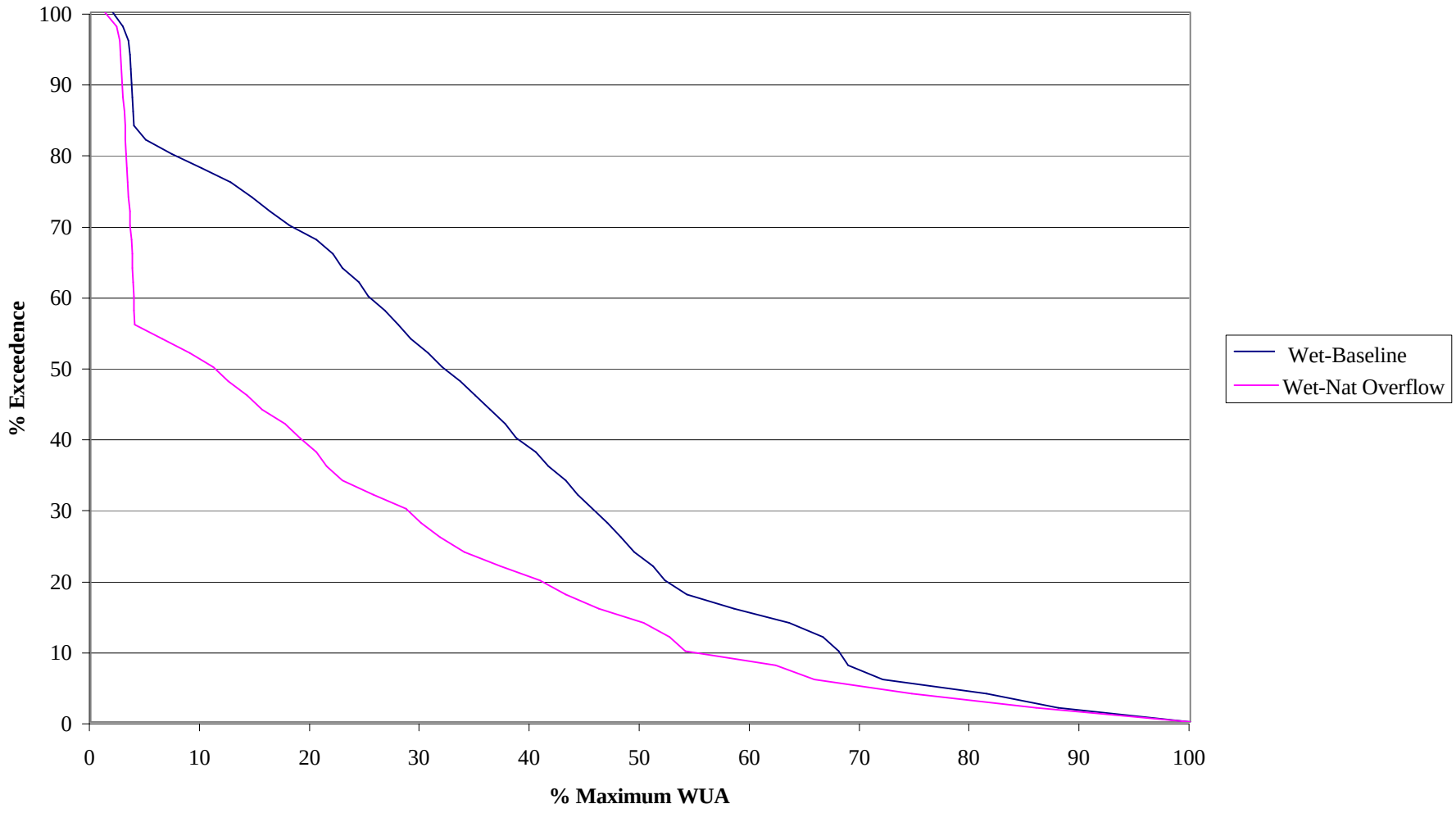

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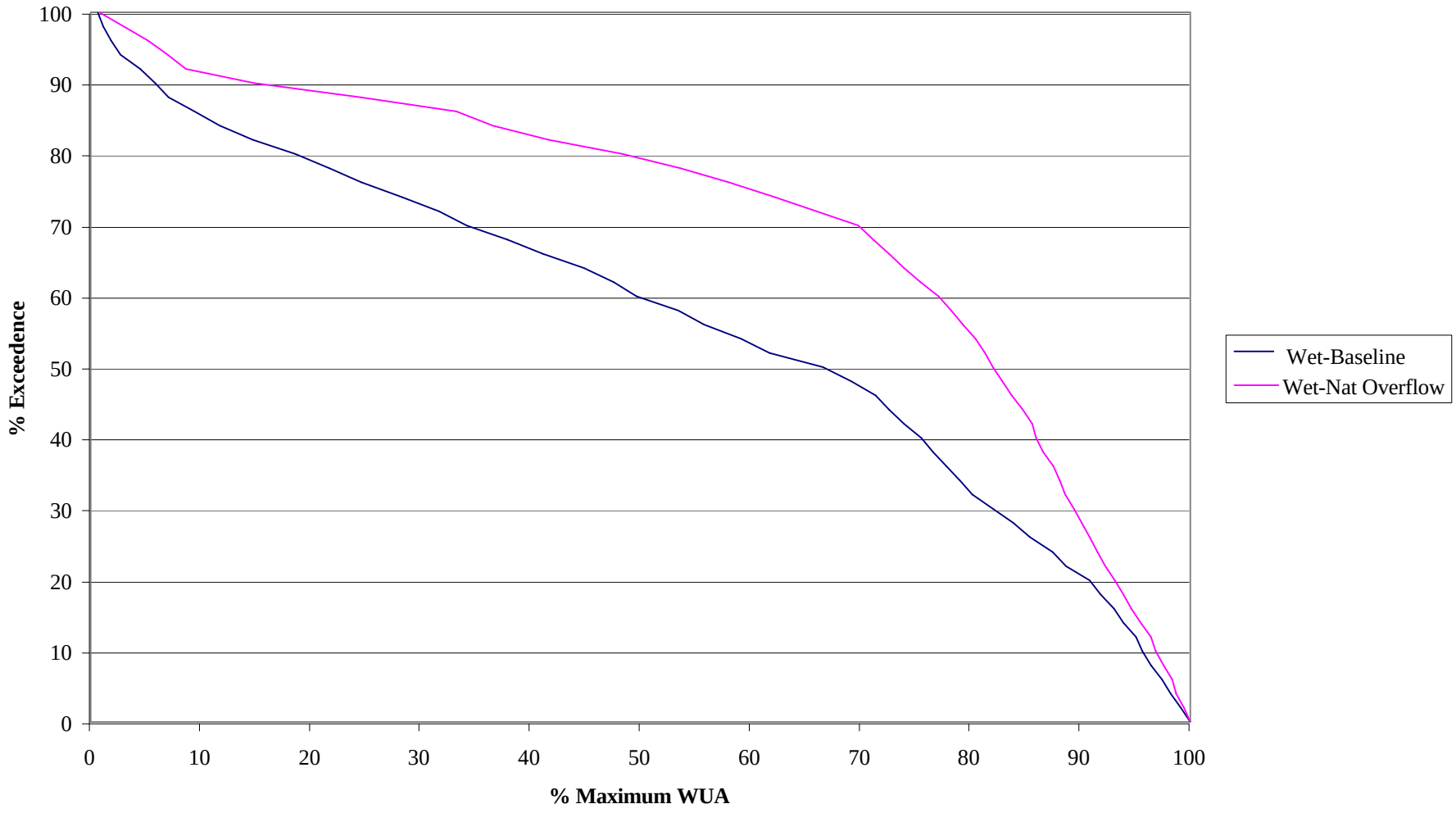

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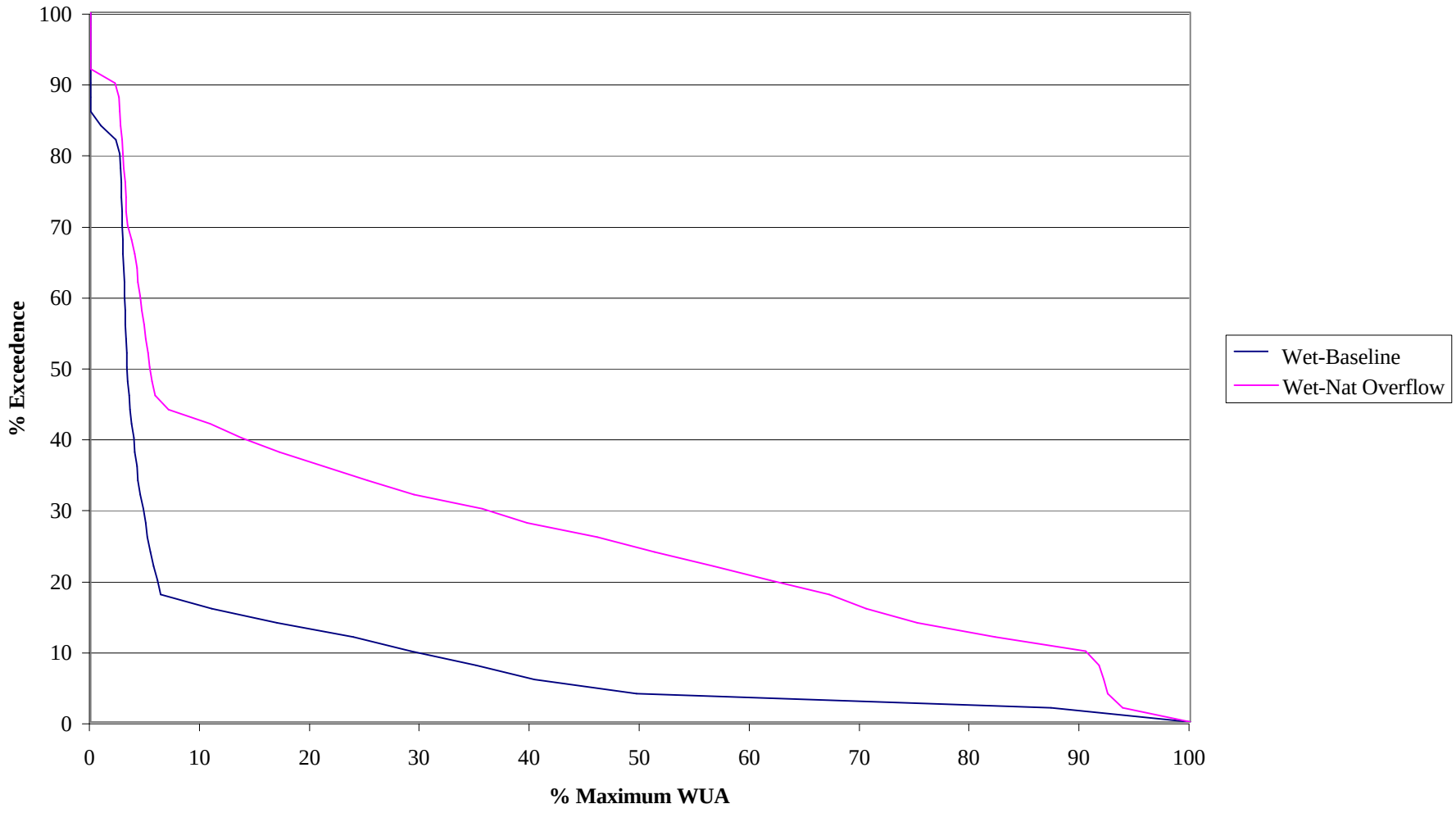
Final Aquatic Impact Analysis Report



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SUMMER
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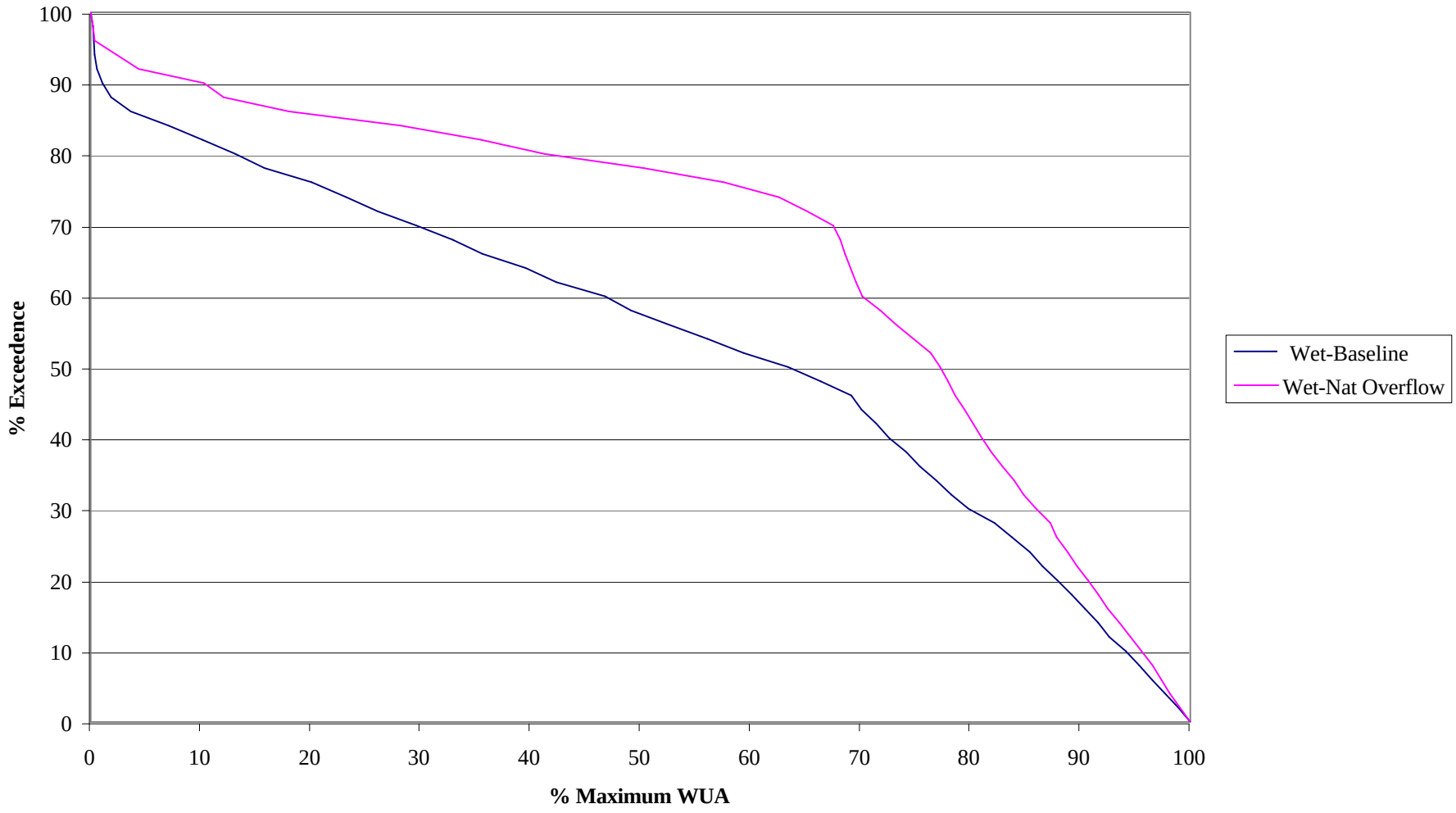

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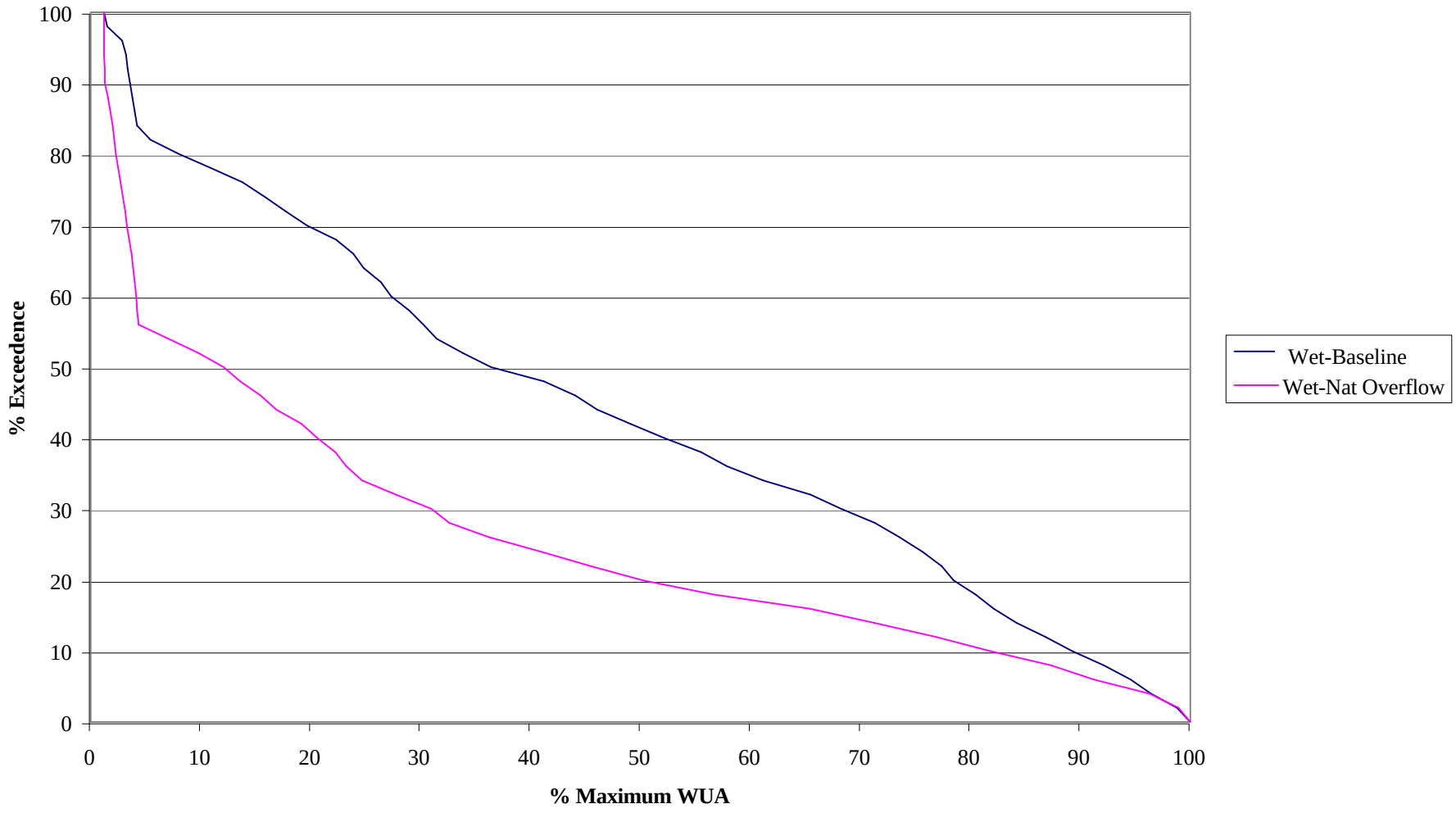

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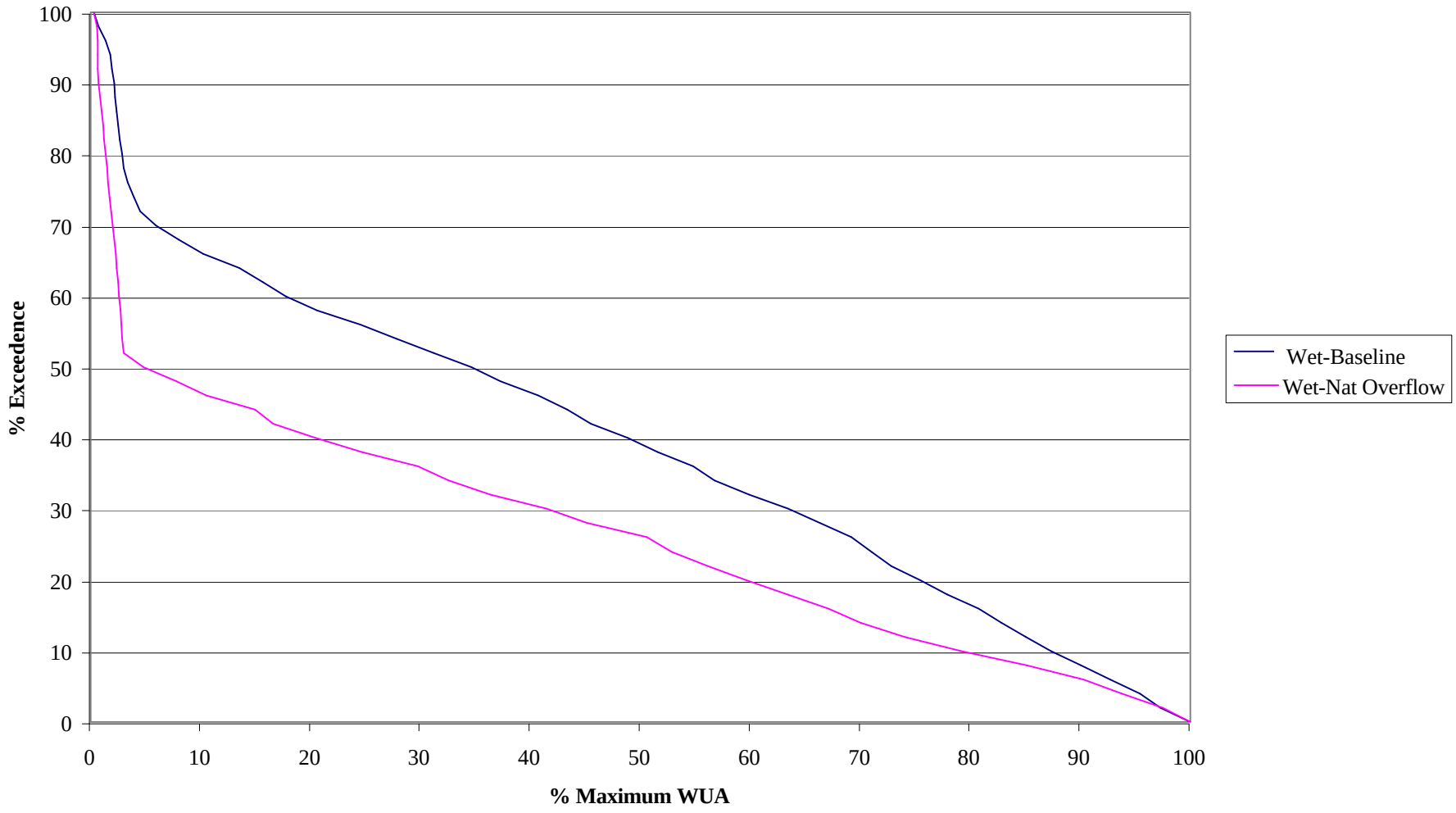

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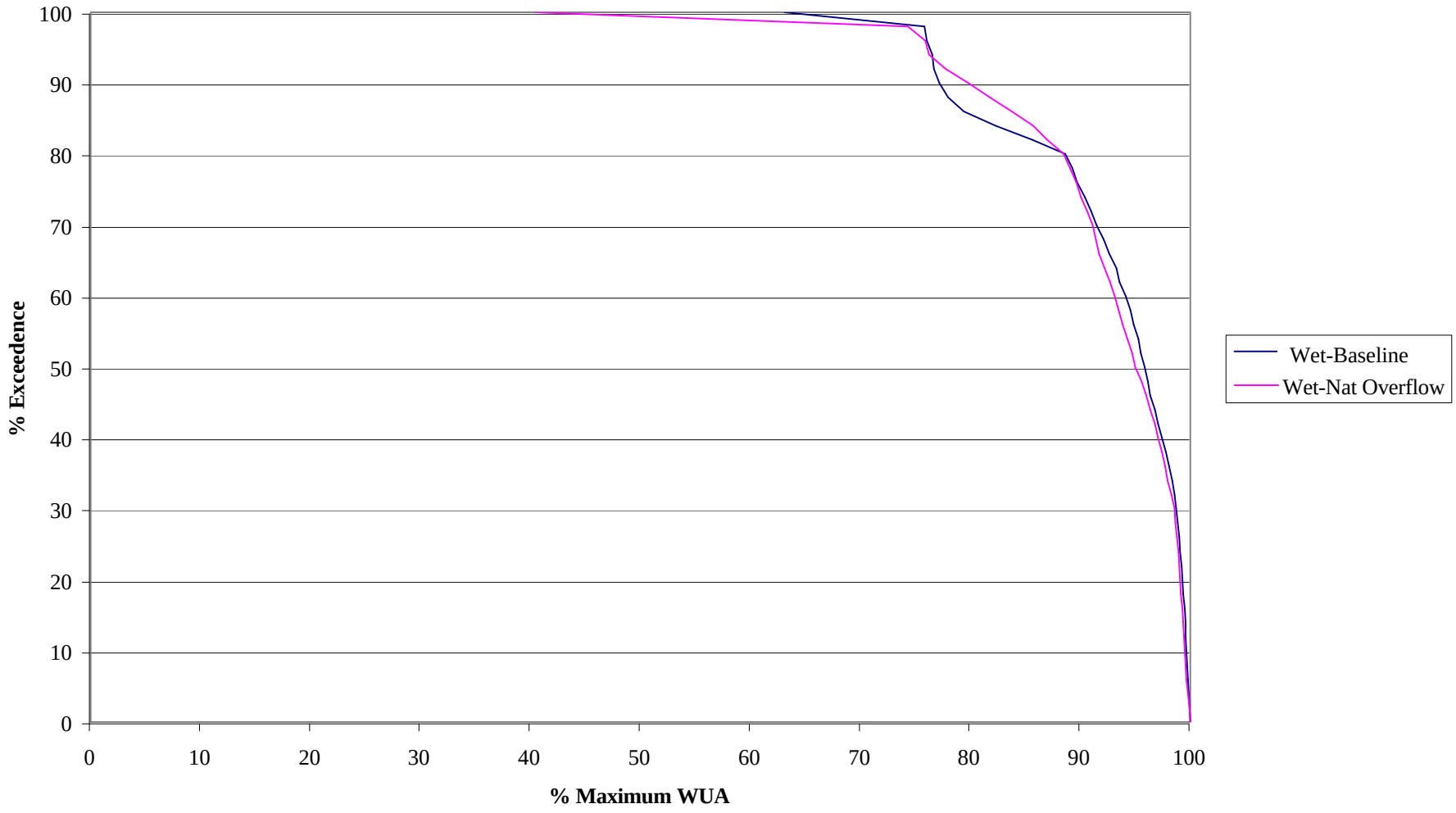
Final Aquatic Impact Analysis Report



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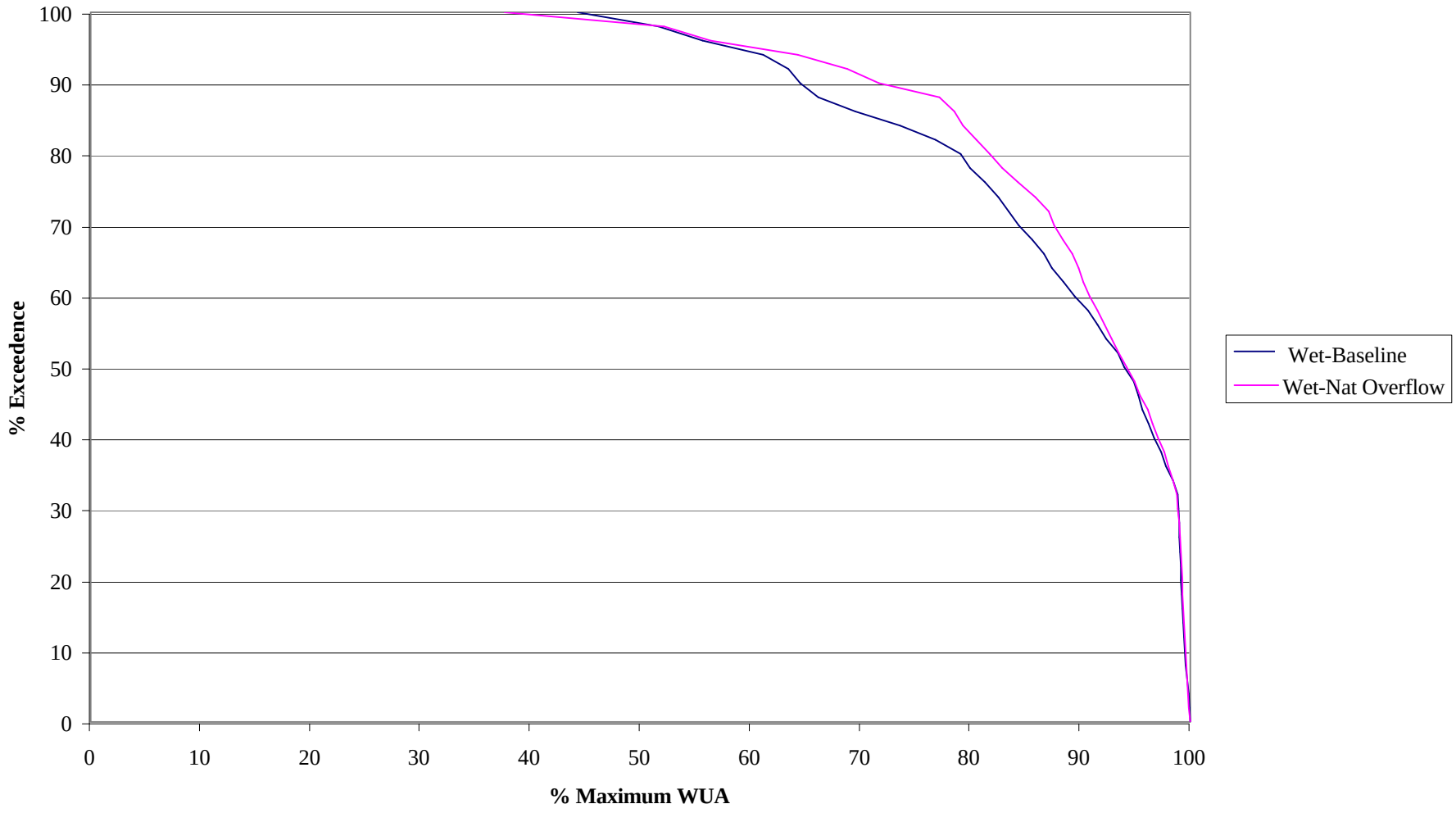
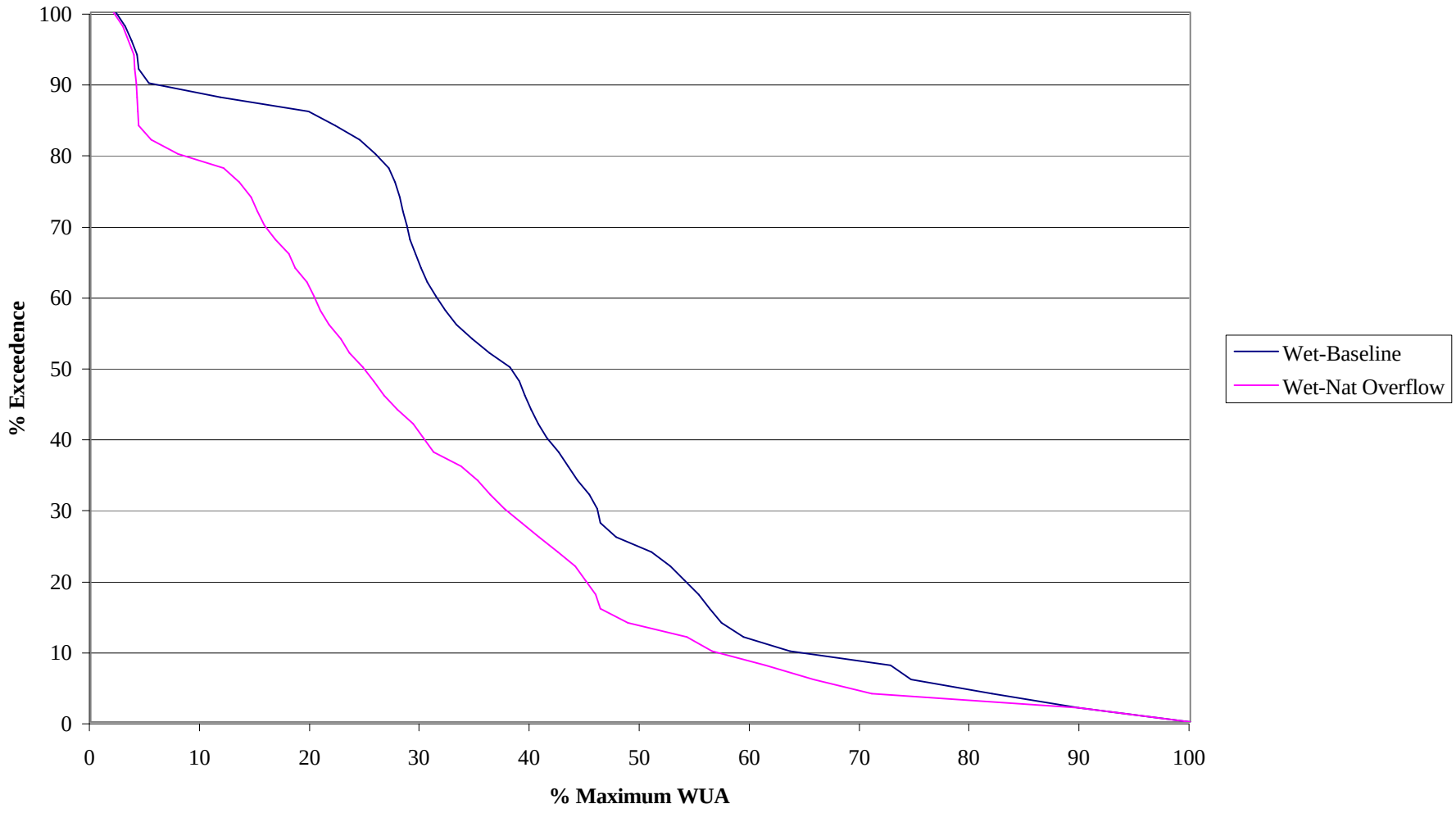
Final Aquatic Impact Analysis Report



% EXCEEDENCE OF % MAXIMUM WUA FOR HABITAT REACH B SHALLOW POOL
FALL
Final Aquatic Impact Analysis Report



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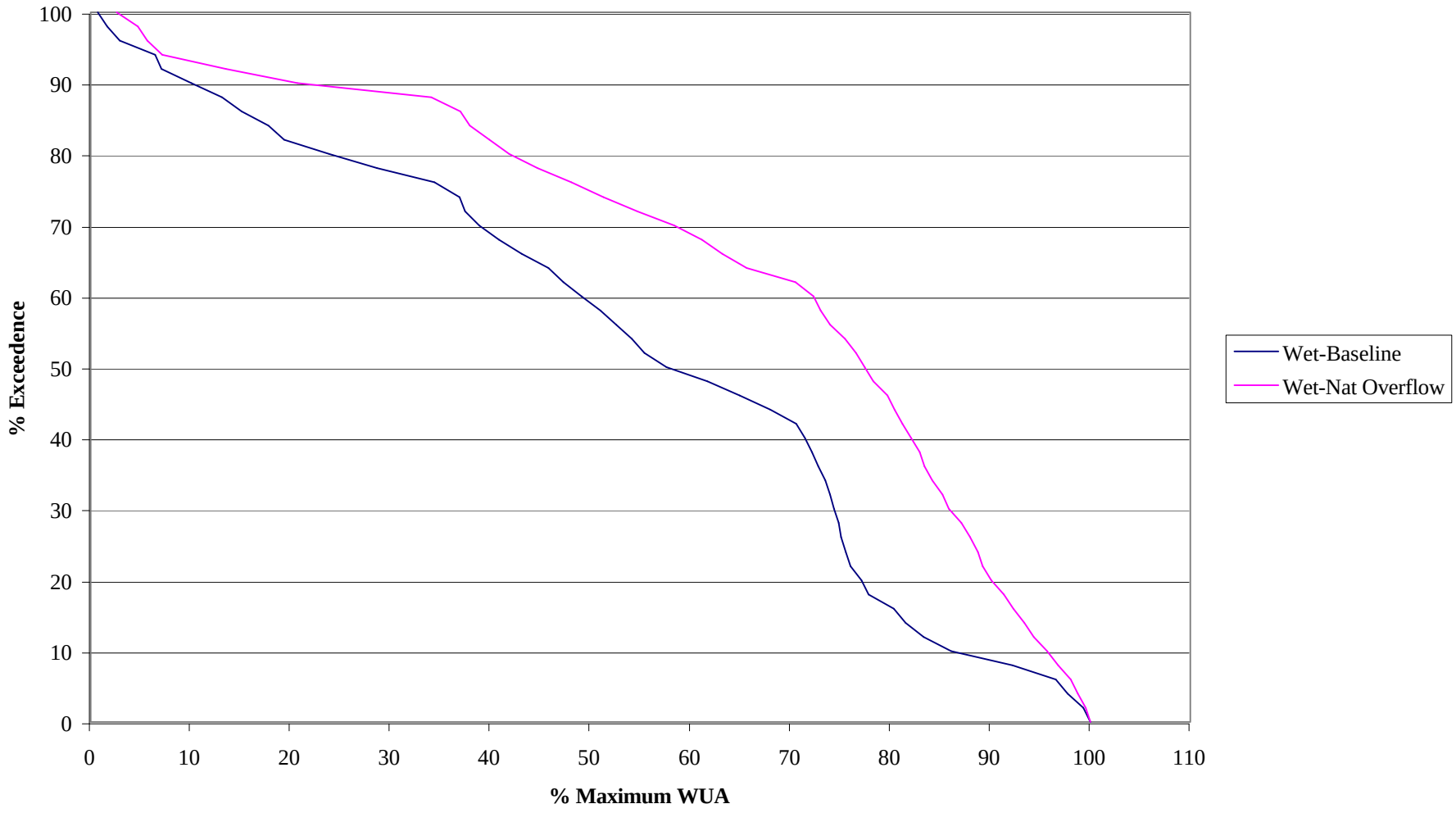
FALL
Final Aquatic Impact Analysis Report



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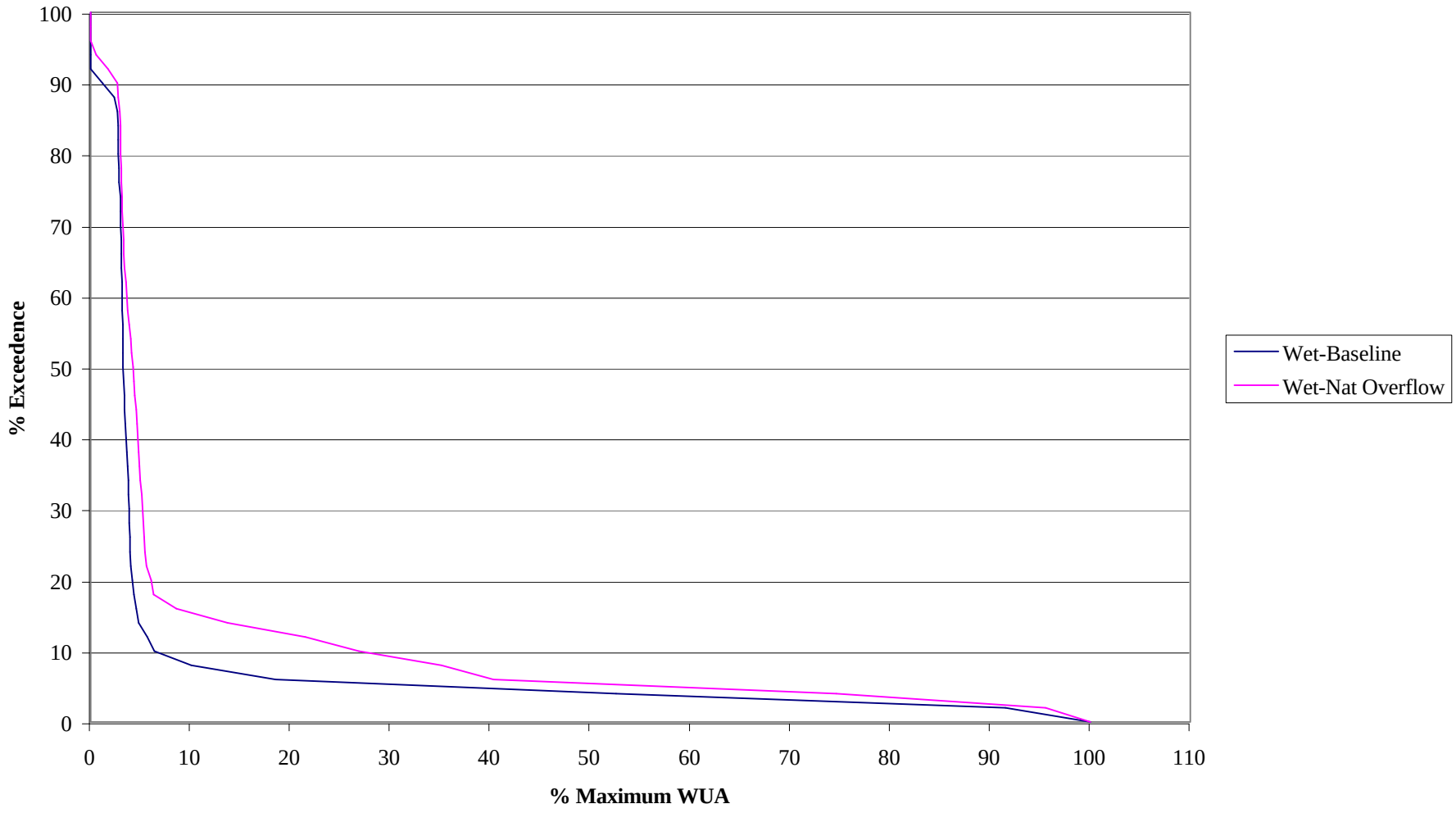
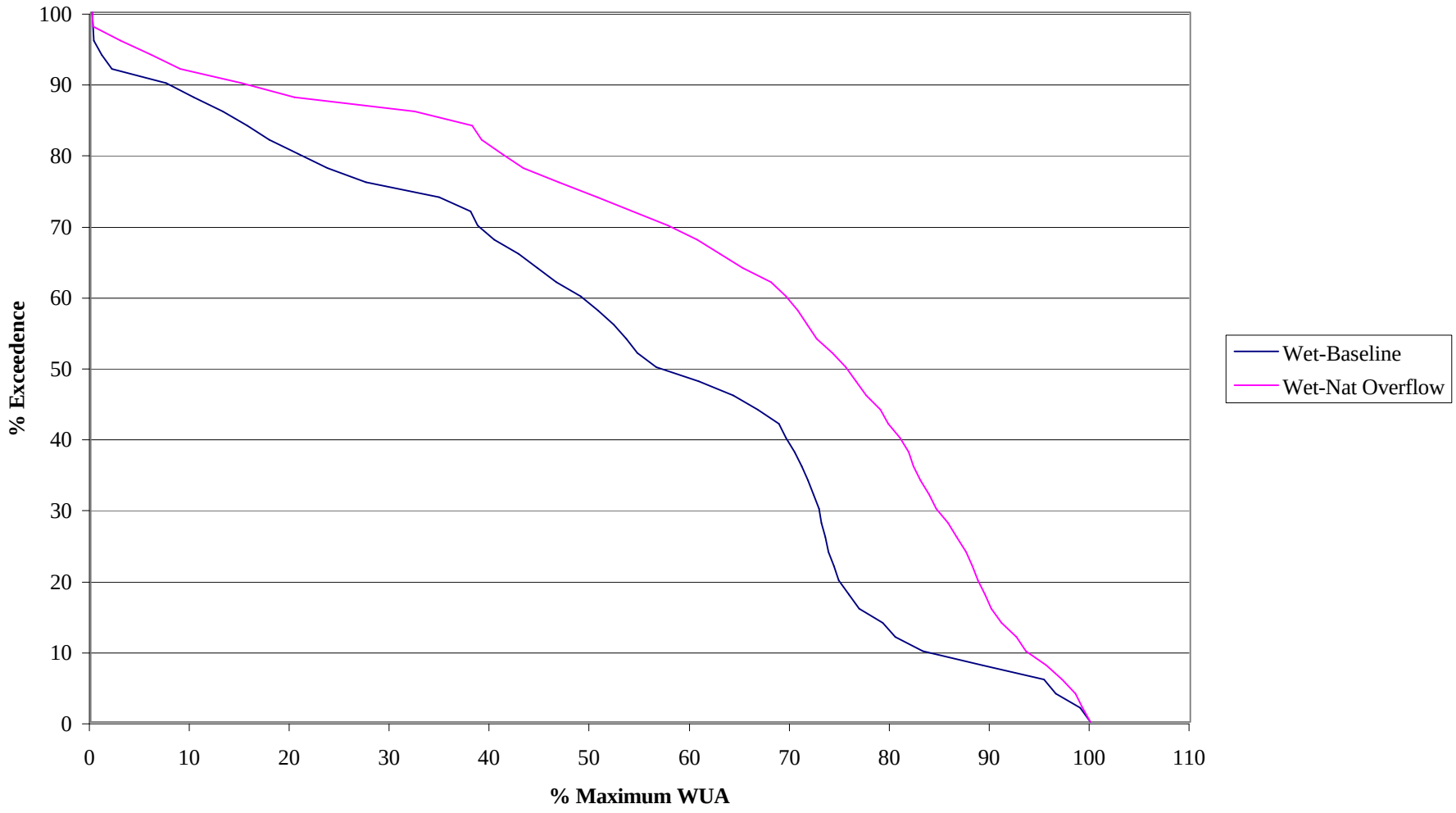


% EXCEEDENCE OF % MAXIMUM WUA FOR HABITAT REACH B RACEWAY
FALL
Final Aquatic Impact Analysis Report



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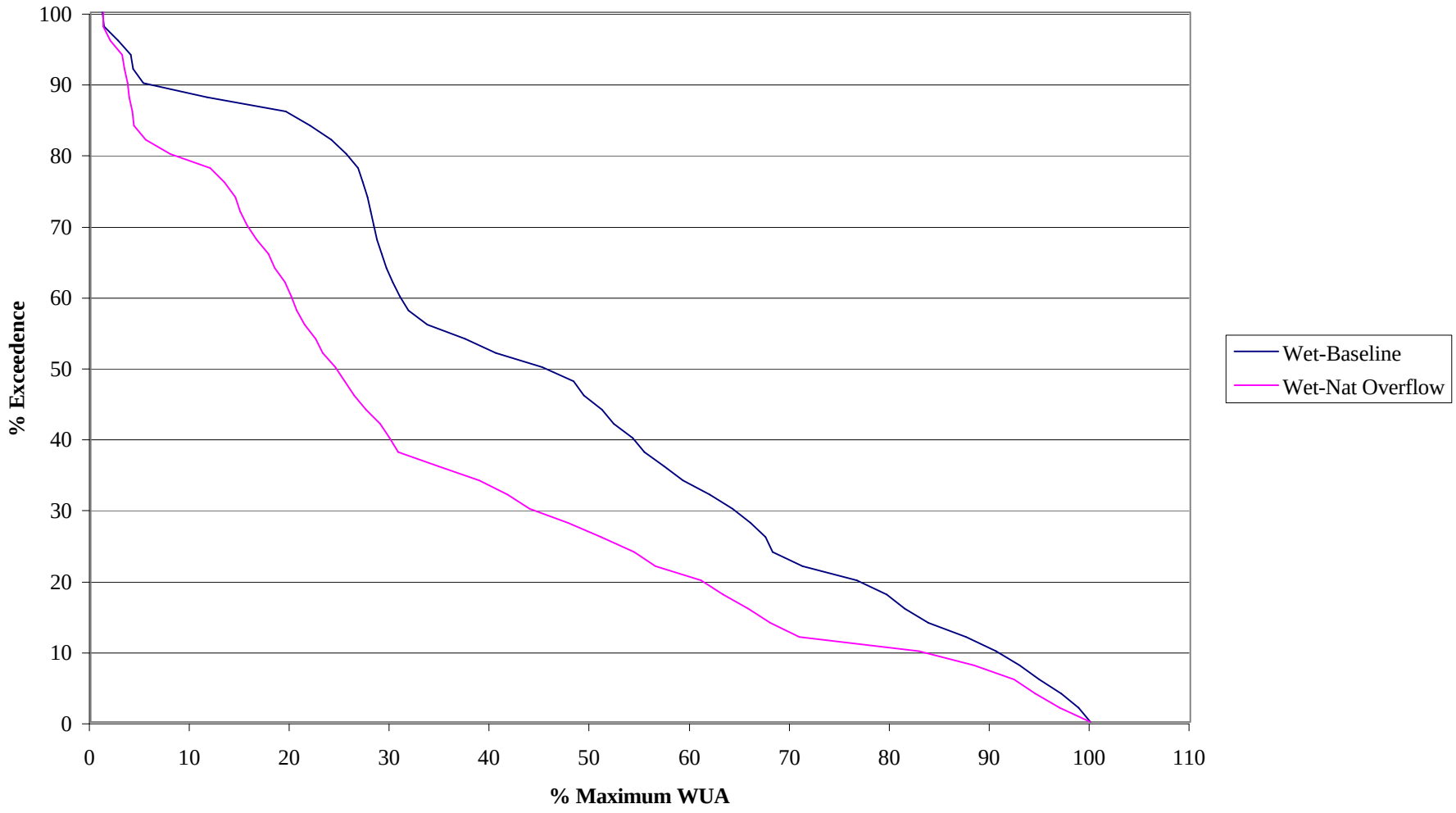

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FALL
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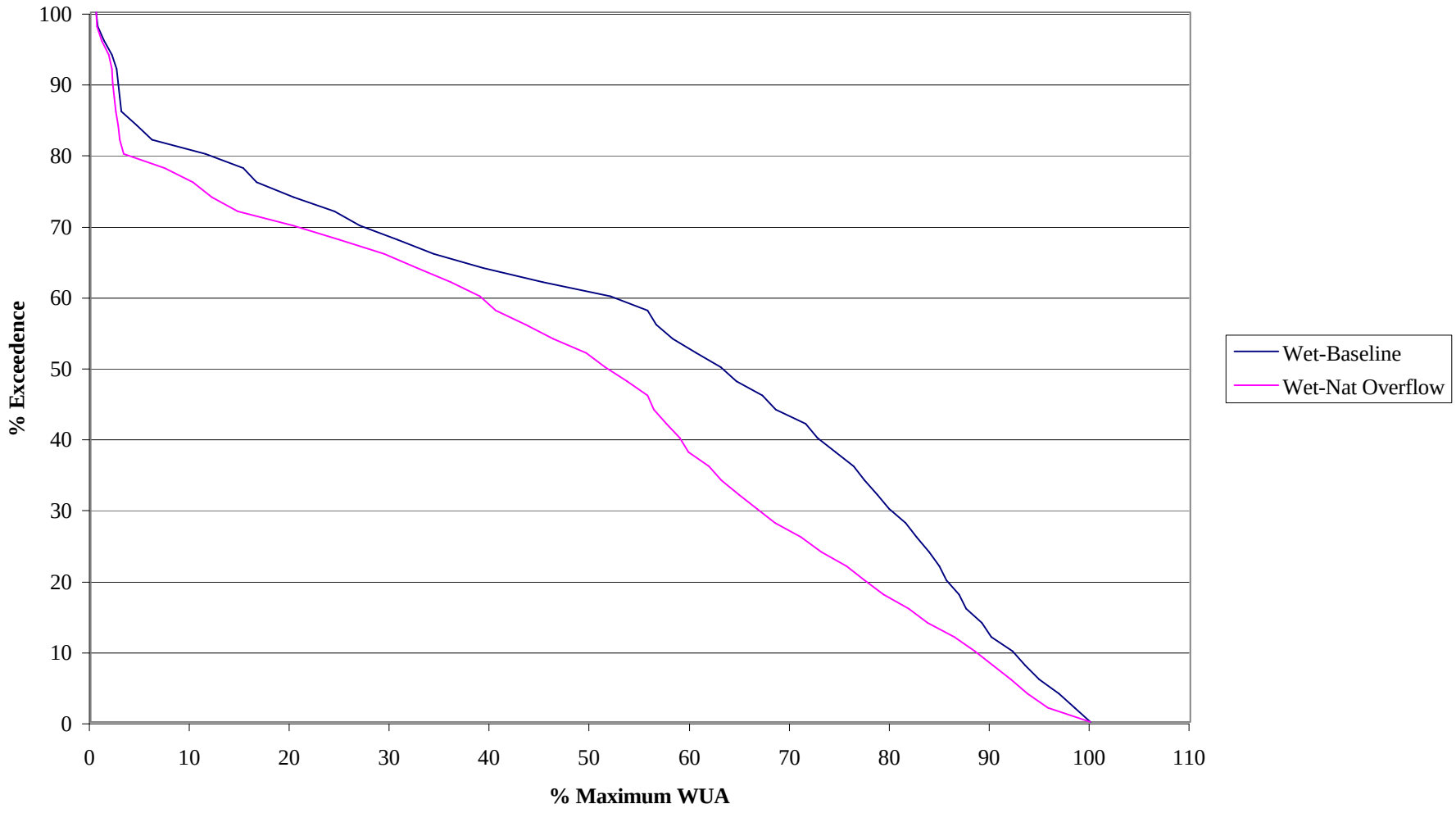

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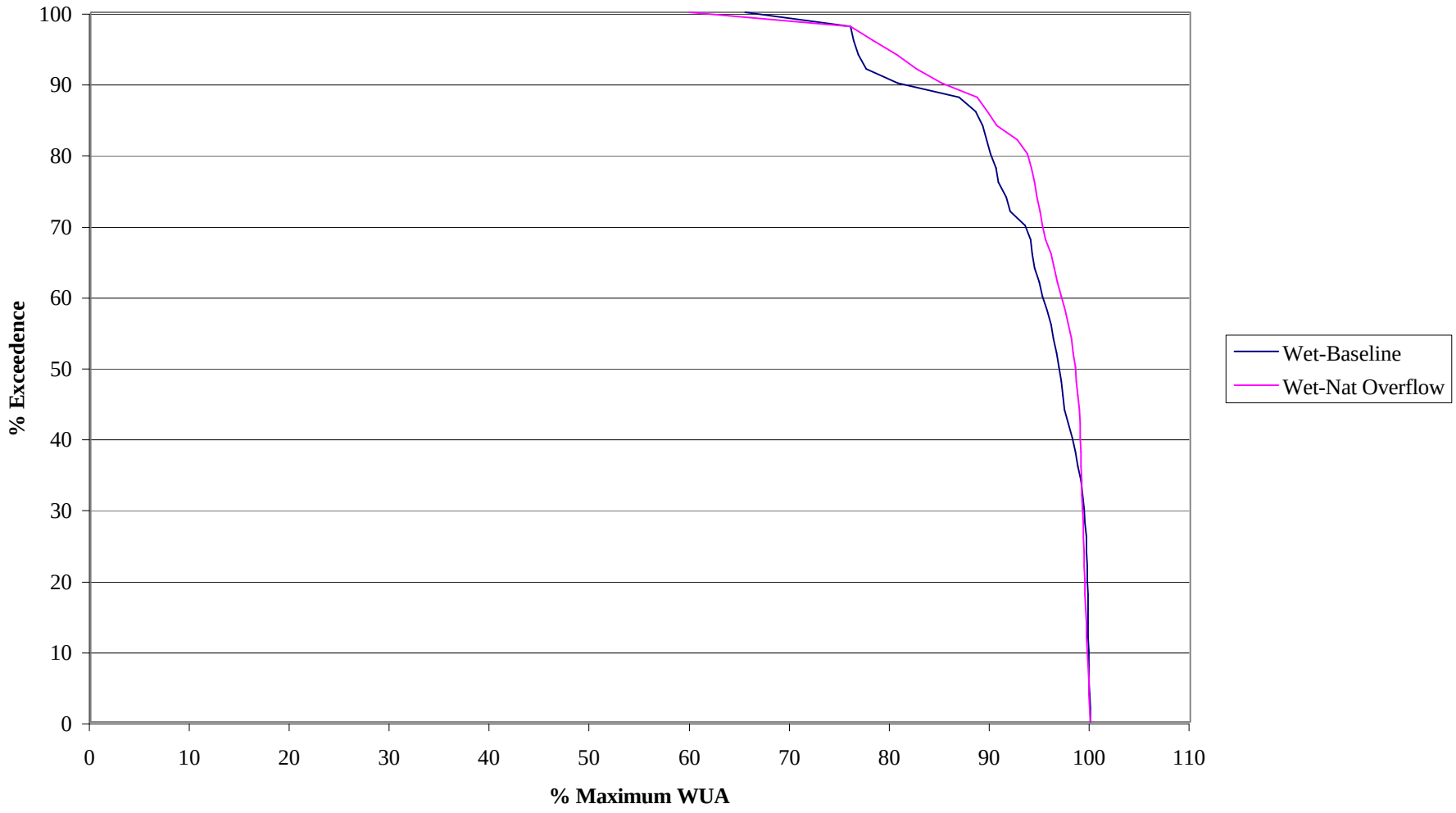
Final Aquatic Impact Analysis Report



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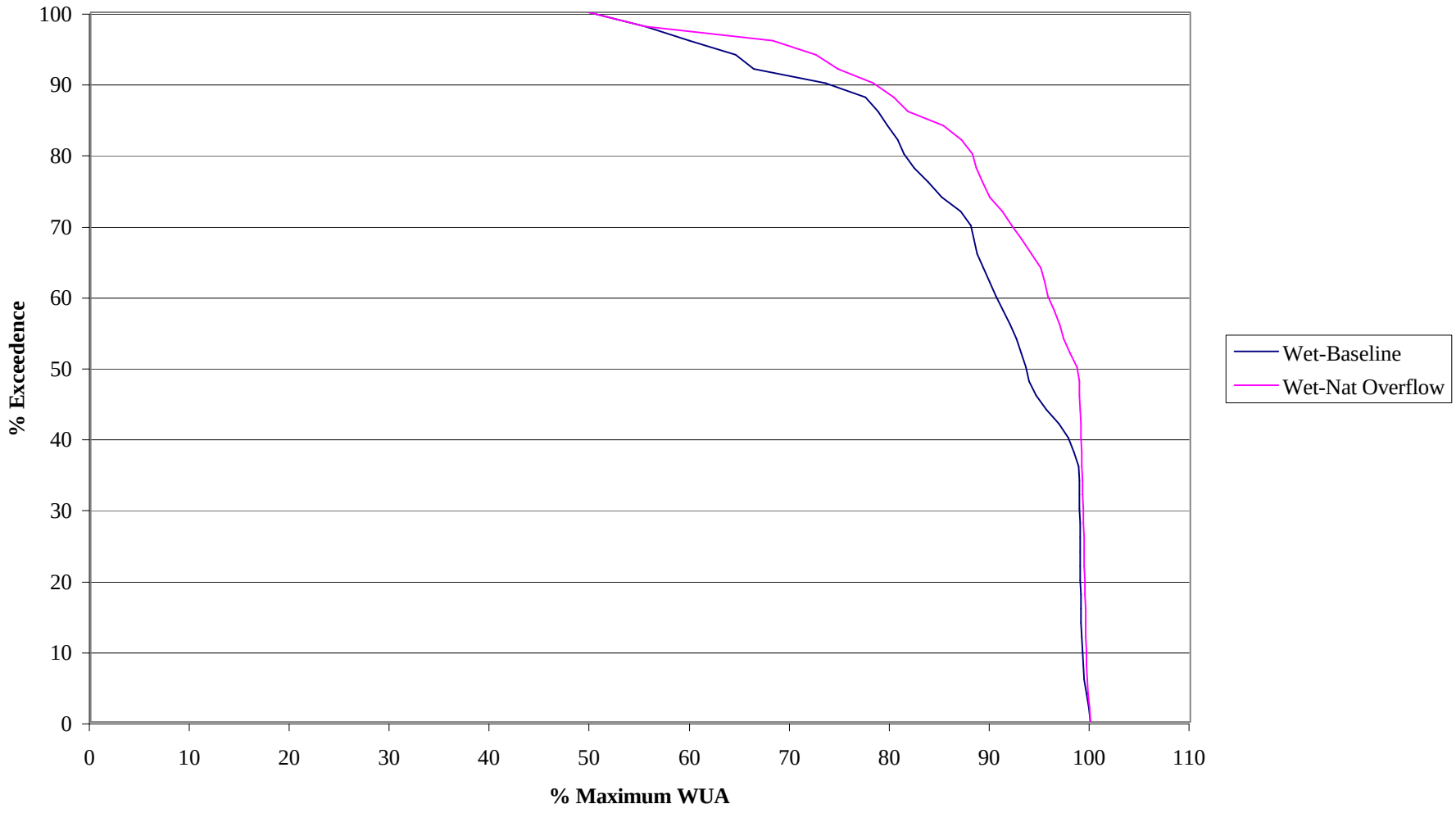
FALL
Final Aquatic Impact Analysis Report



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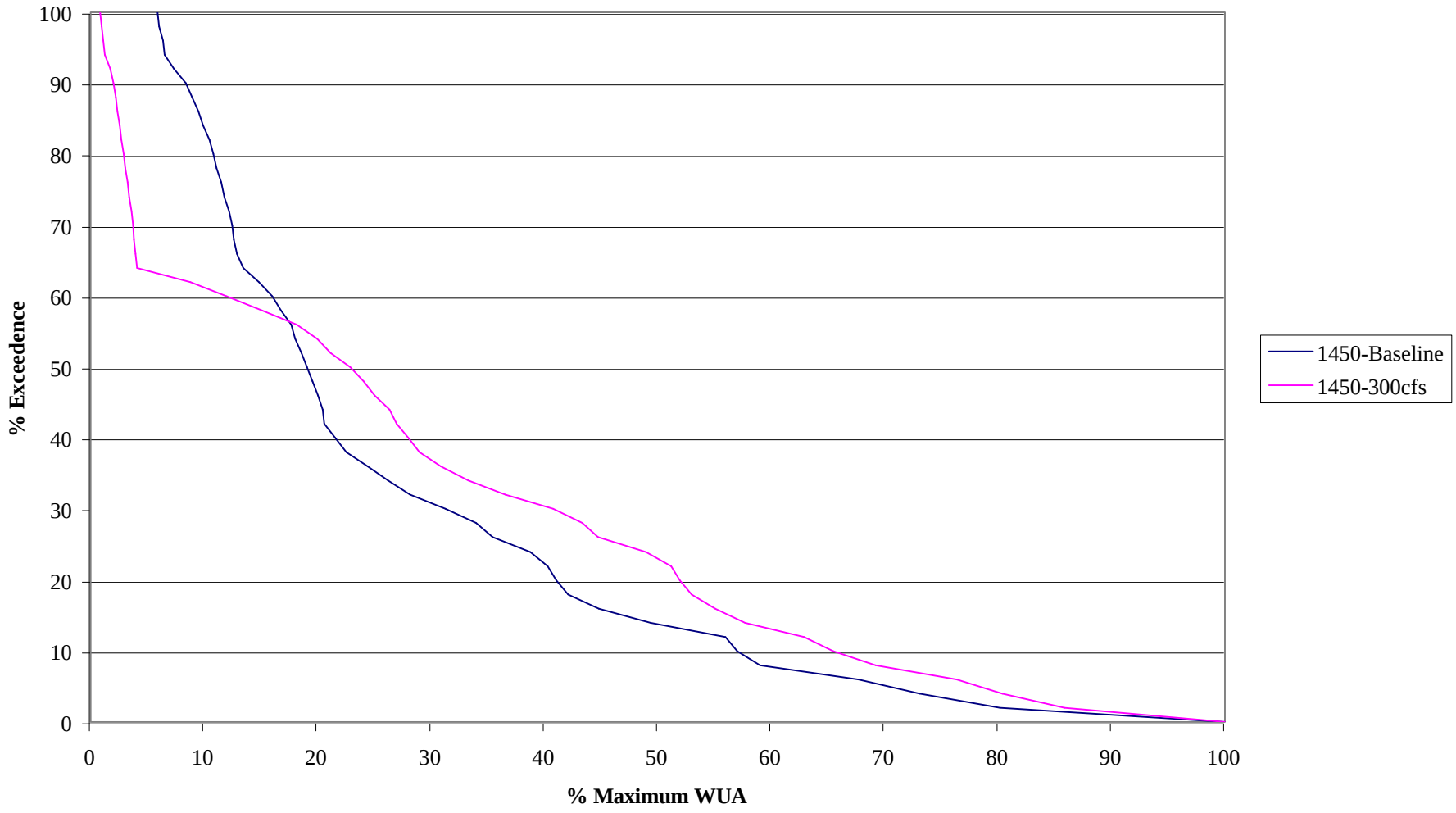
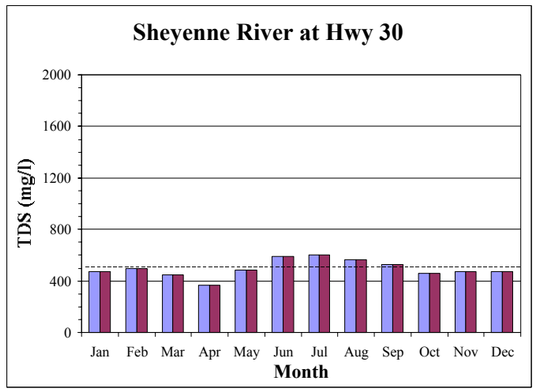
Final Aquatic Impact Analysis Report

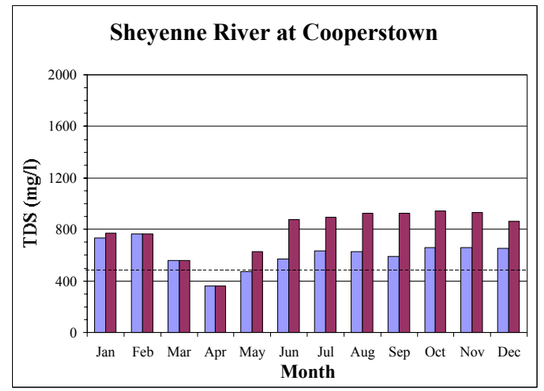


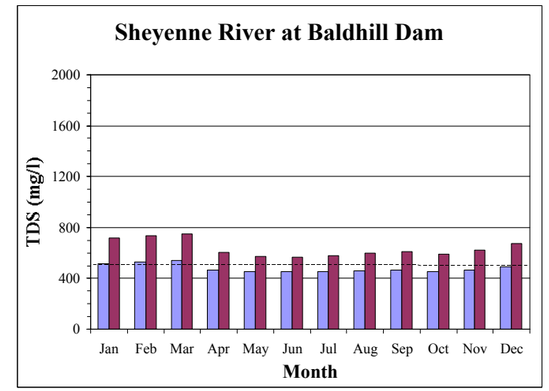
APPENDIX M

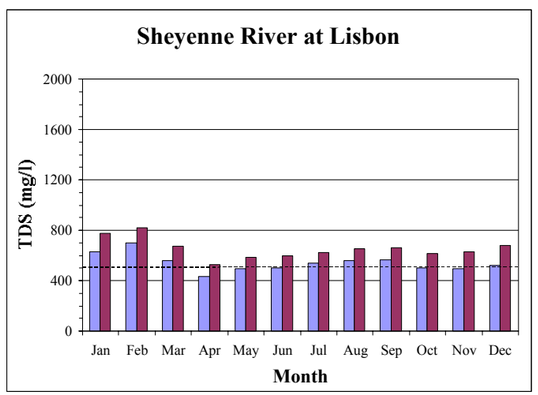
COMPARISON OF MONTHLY AVERAGE TDS, SULFATE, AND CHLORIDE BETWEEN BASELINE AND PUMPING/OVERFLOW

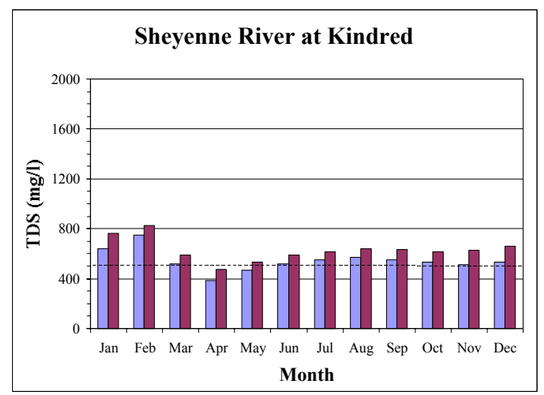
APPENDIX M-1
COMPARISON OF MONTHLY AVERAGE TDS BETWEEN MOD50 AND 300MOD50, 2005-2015
Final Aquatic Impact Analysis Report

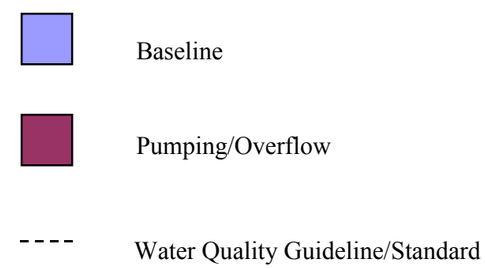


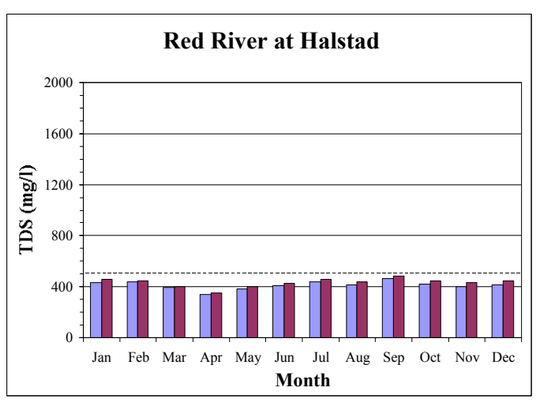


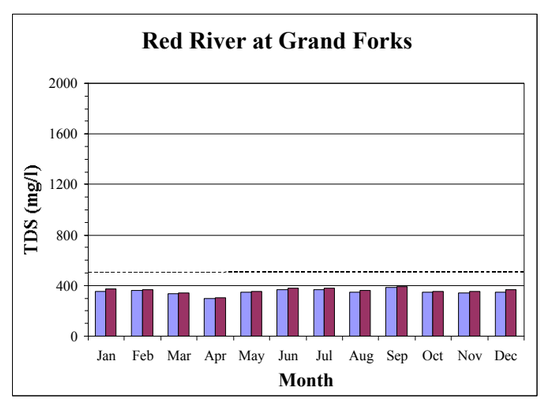


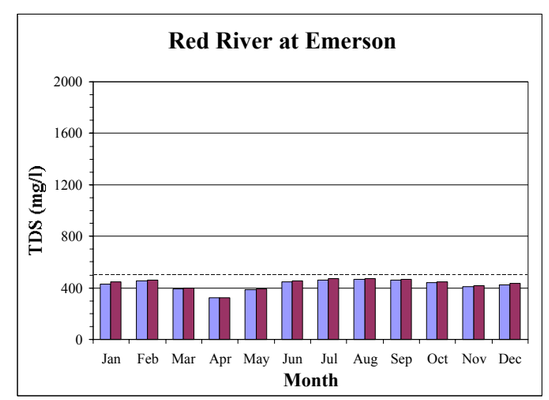




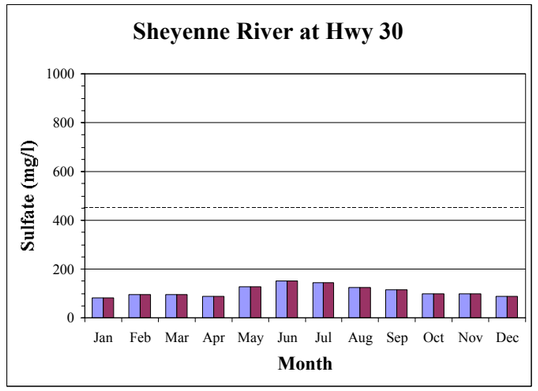


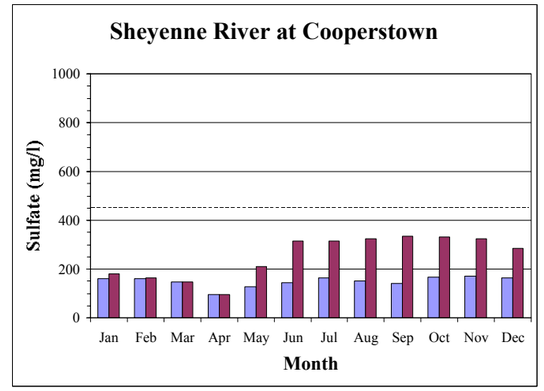


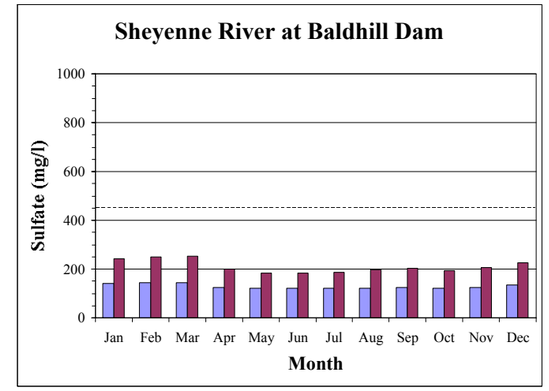


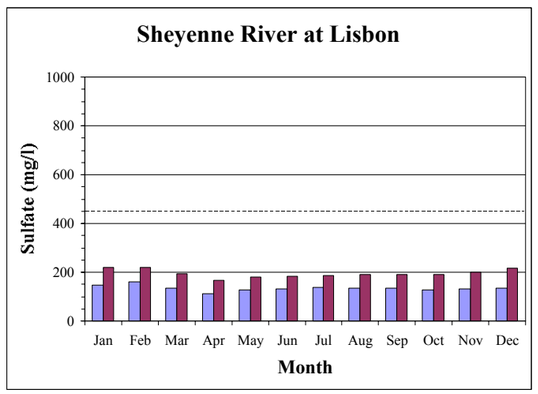


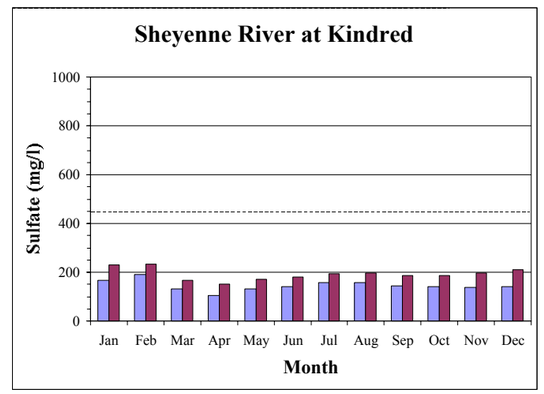
APPENDIX M-2
COMPARISON OF MONTHLY AVERAGE SULFATE BETWEEN MOD50 AND 300MOD50, 2005-2015
Final Aquatic Impact Analysis Report

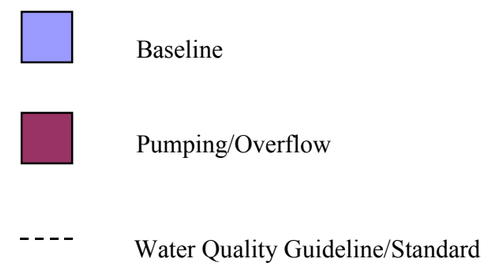


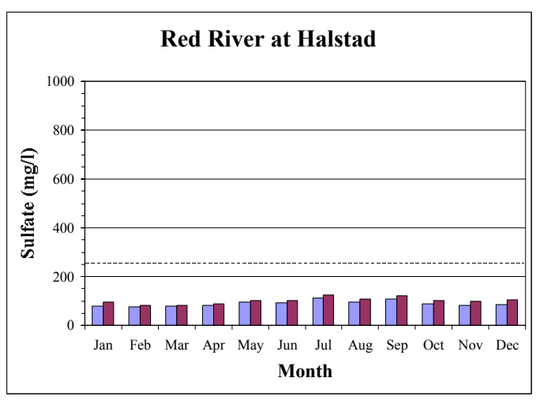


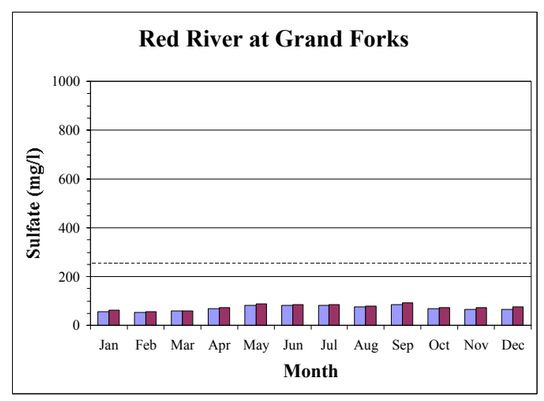


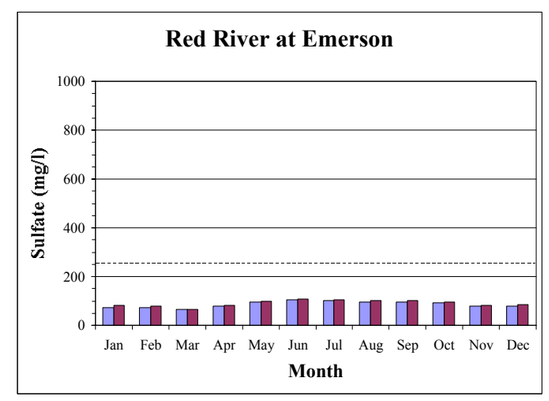




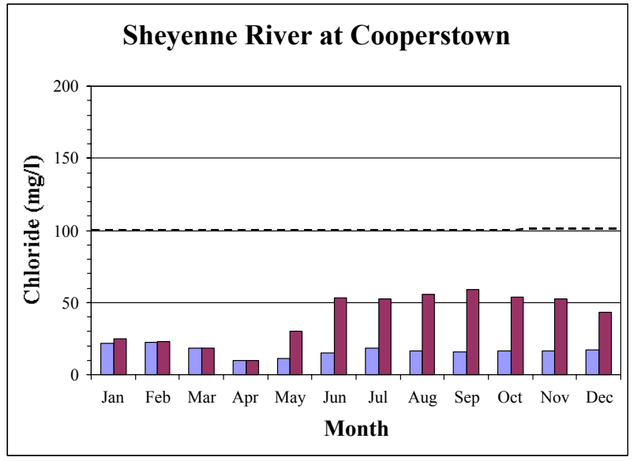


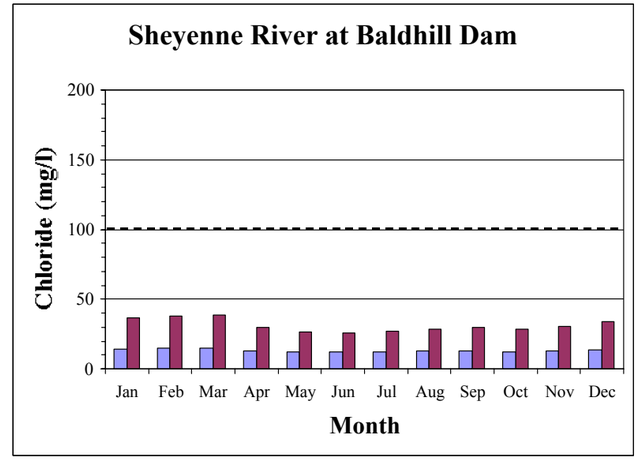


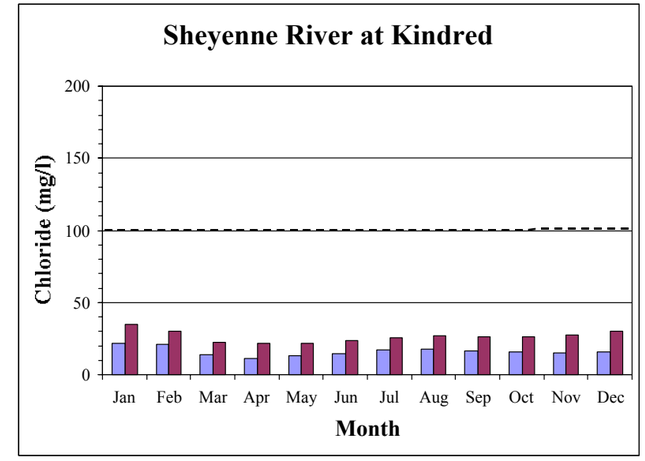


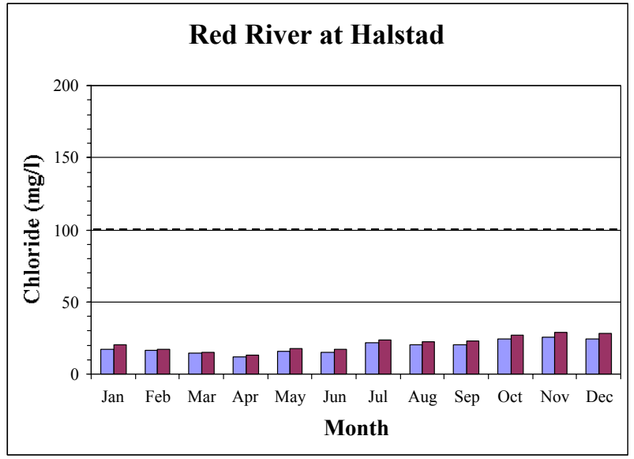


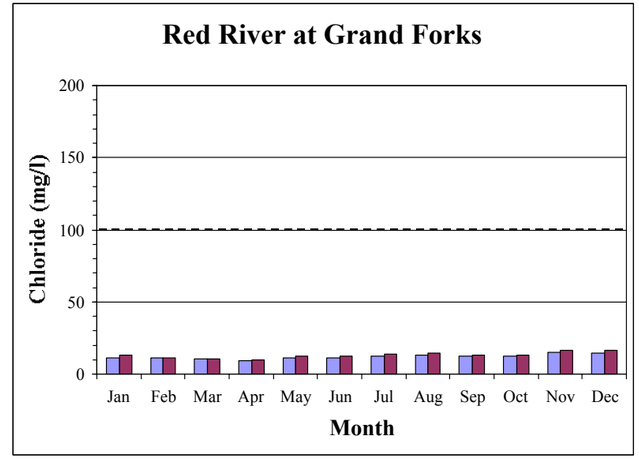
APPENDIX M-3
COMPARISON OF MONTHLY AVERAGE CHLORIDE BETWEEN MOD50 AND 300MOD50, 2005-2015
Final Aquatic Impact Analysis Report

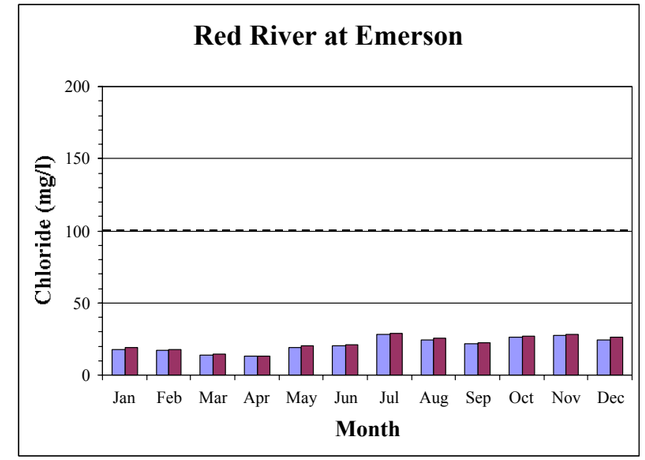






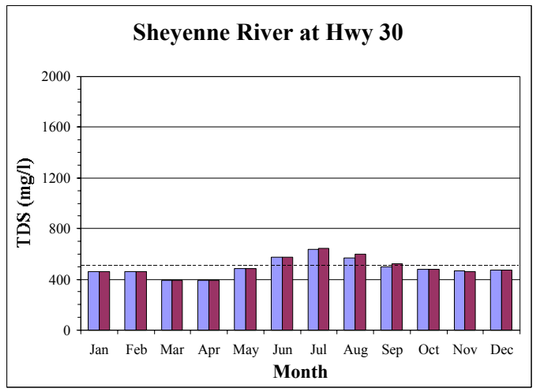


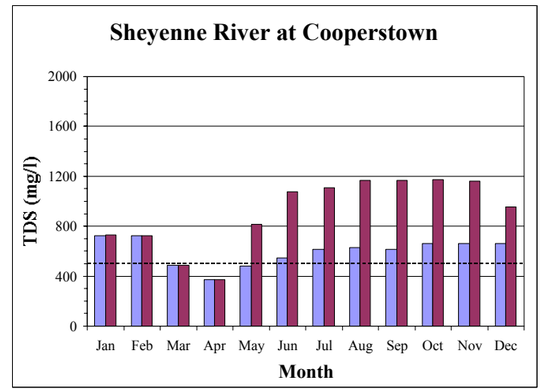


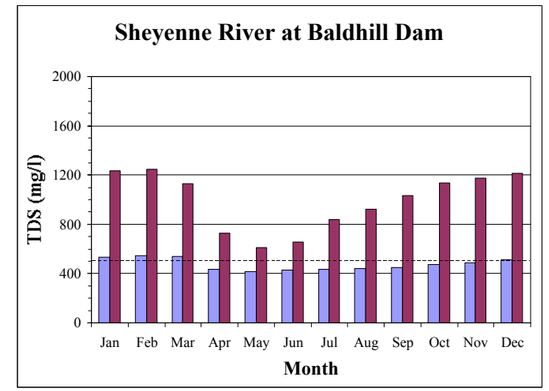


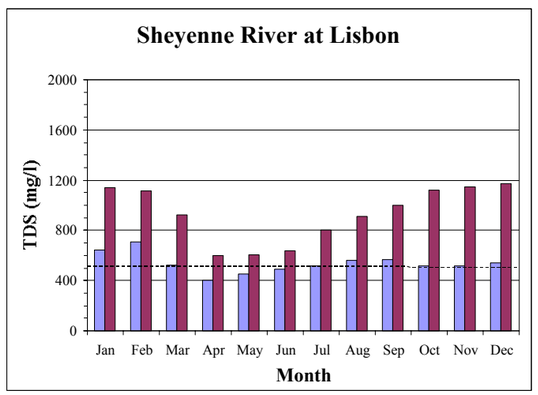
Baseline | Pumping/Overflow | ---- Water Quality Guideline/Standard

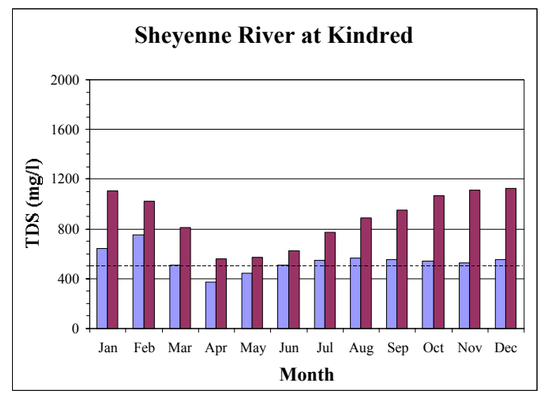
APPENDIX M-4
COMPARISON OF MONTHLY AVERAGE TDS BETWEEN MOD55 AND 480MOD55, 2005-2015
Final Aquatic Impact Analysis Report







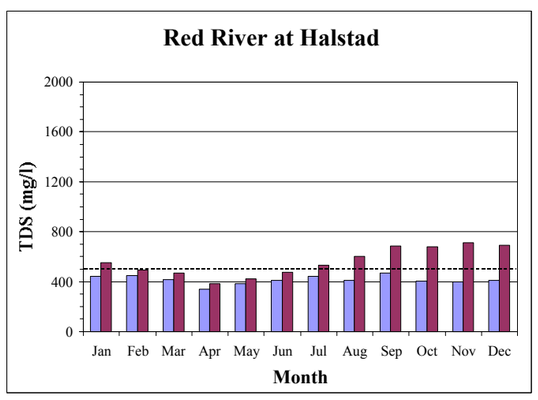


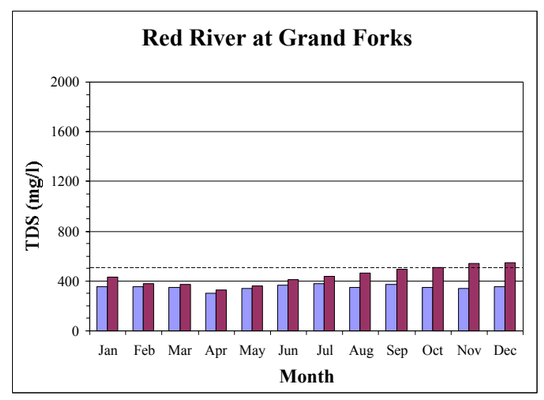


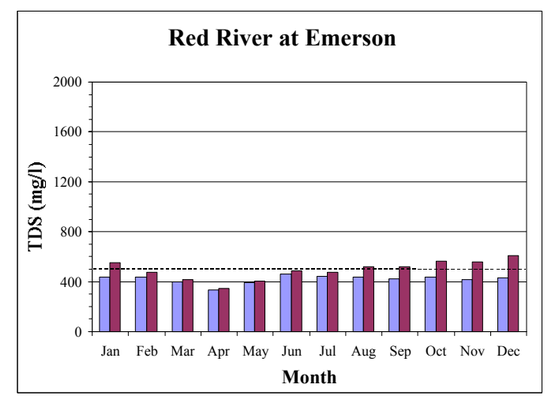
Baseline

Pumping/Overflow

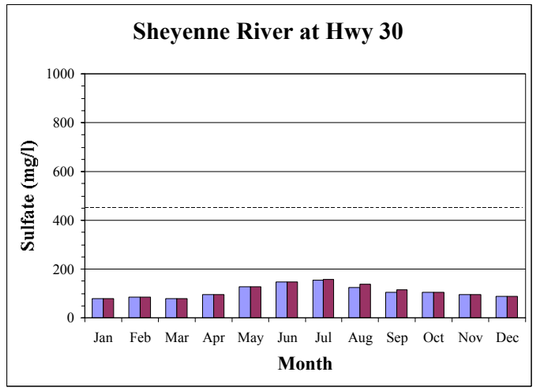
Water Quality Guideline/Standard

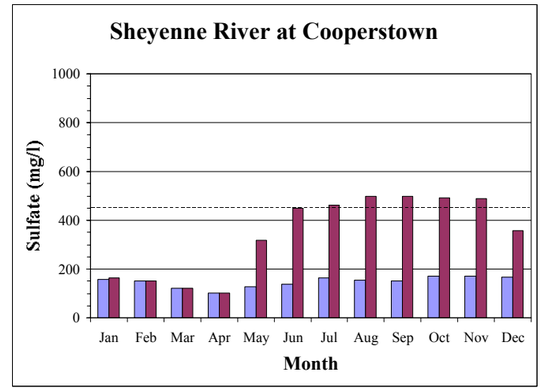


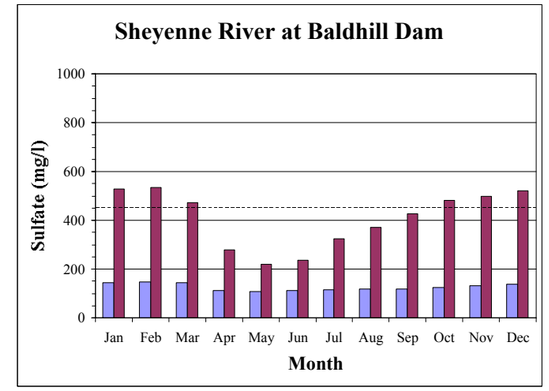


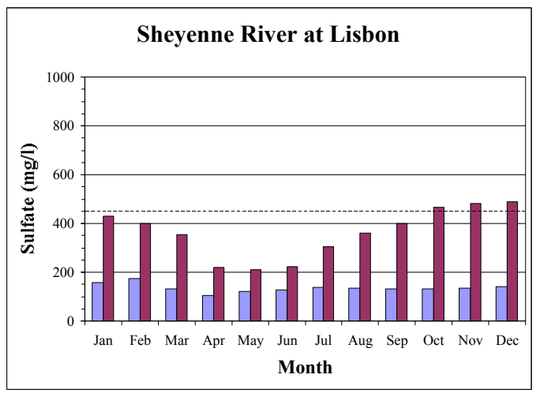


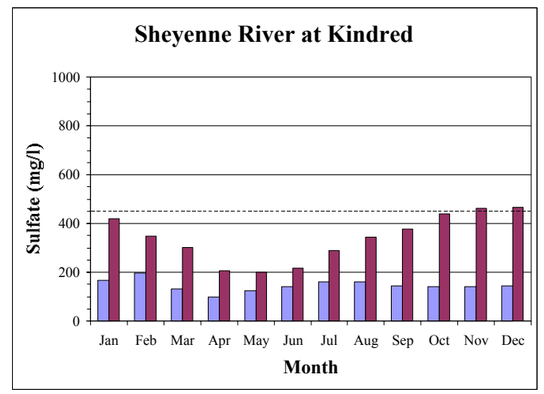
APPENDIX M-5
COMPARISON OF MONTHLY AVERAGE SULFATE BETWEEN MOD55 AND 480MOD55, 2005-2015
Final Aquatic Impact Analysis Report

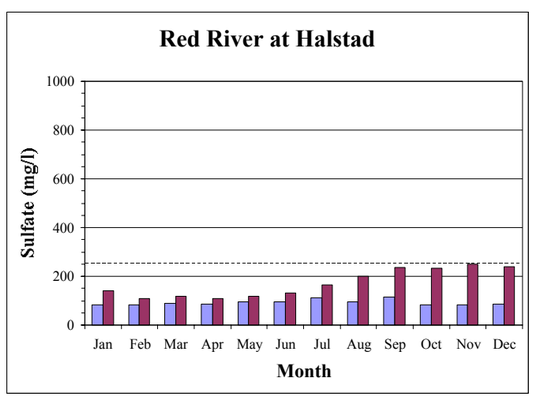


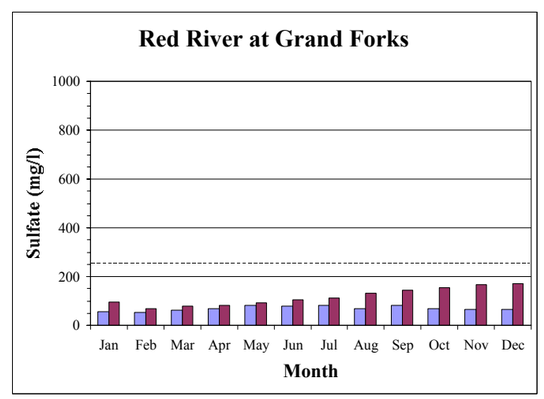


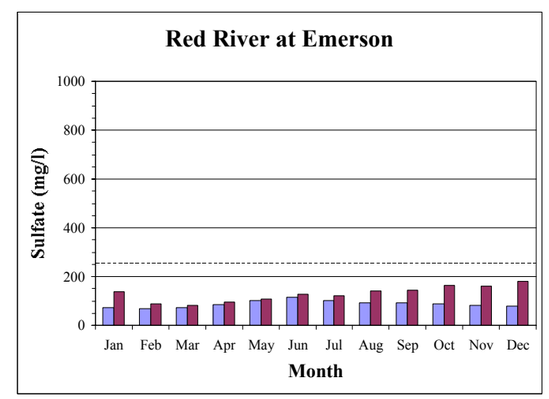


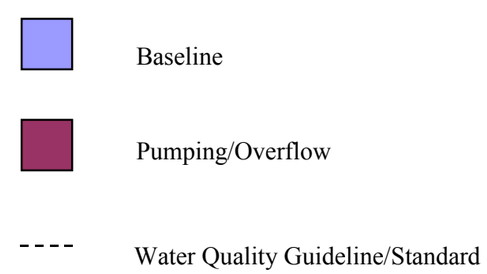




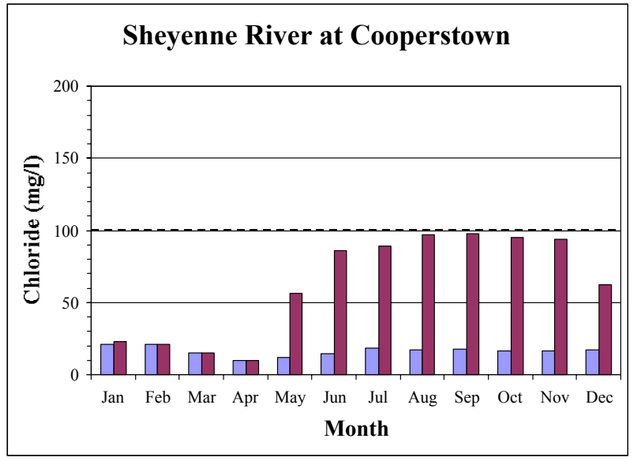


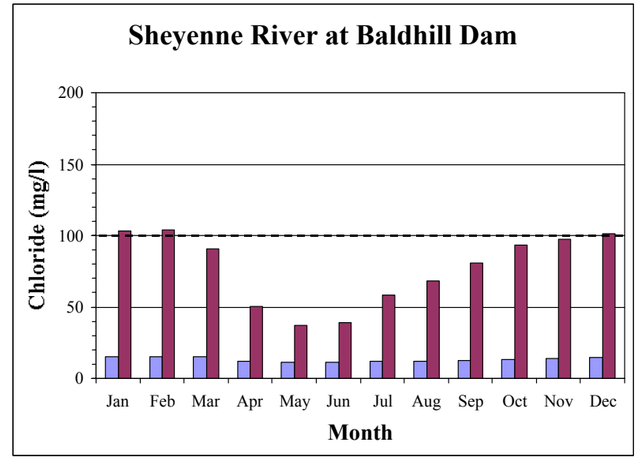


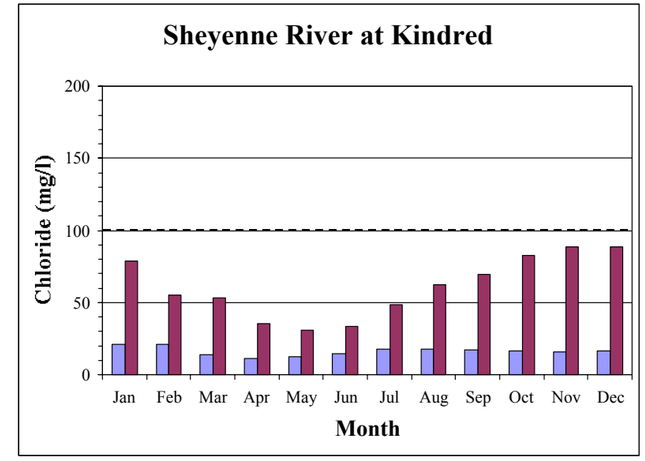


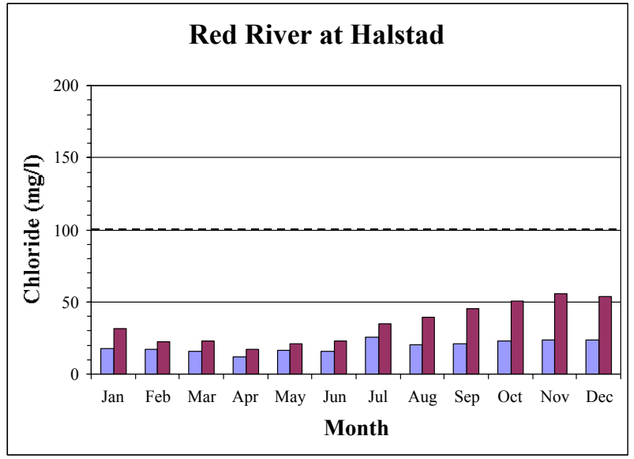


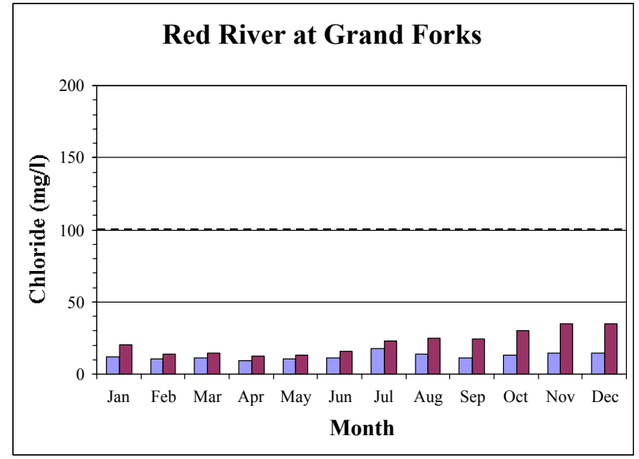
APPENDIX M-6
COMPARISON OF MONTHLY AVERAGE CHLORIDE BETWEEN MOD55 AND 480MOD55, 2005-2015
Final Aquatic Impact Analysis Report

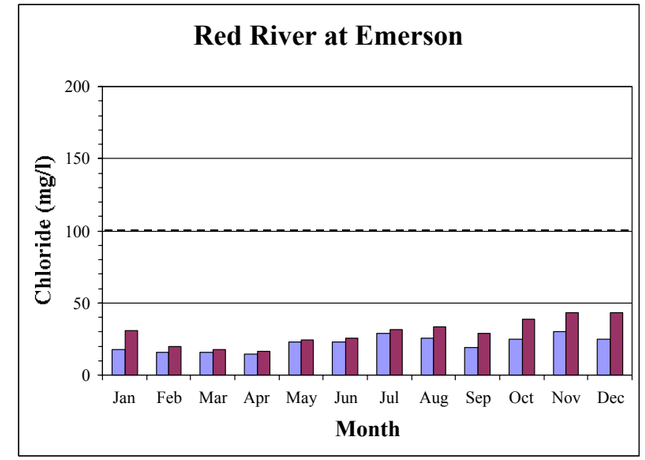






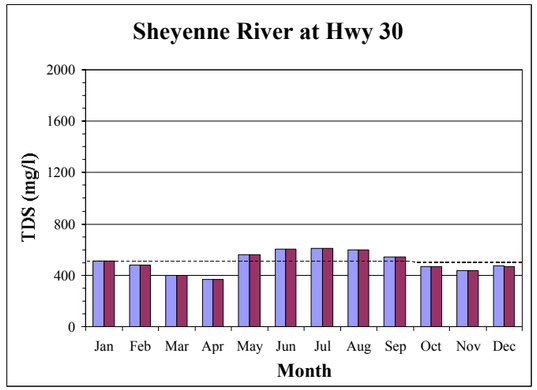


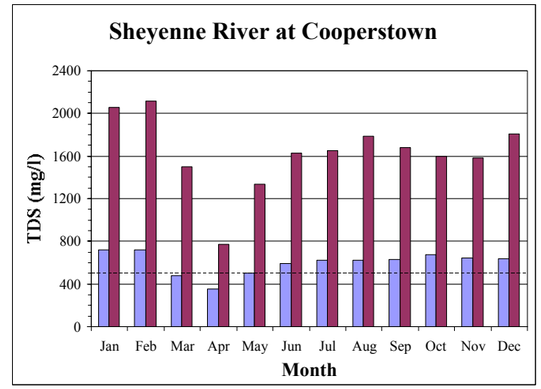


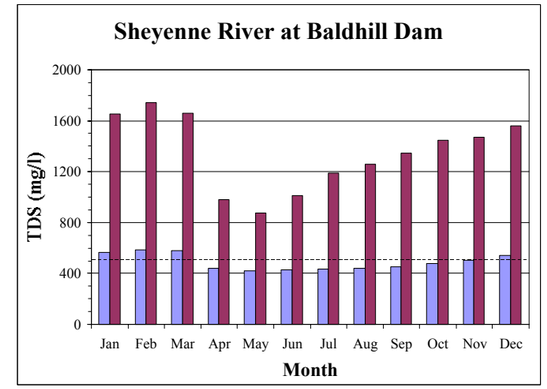


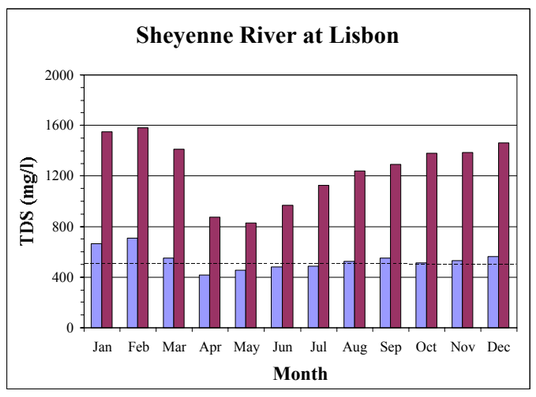
Baseline | Pumping/Overflow | ---- Water Quality Guideline/Standard

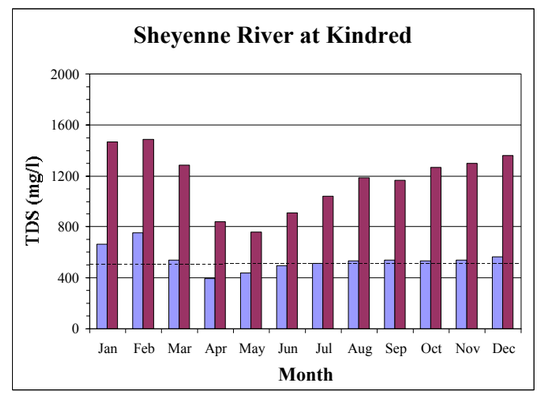
APPENDIX M-7
COMPARISON OF MONTHLY AVERAGE TDS BETWEEN WET AND WETOF, 2015-2025
Final Aquatic Impact Analysis Report

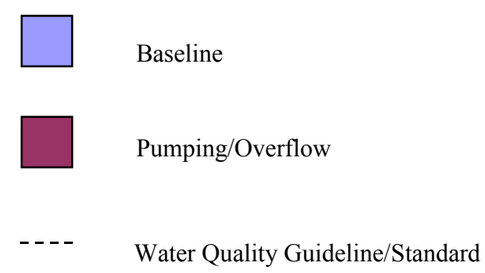


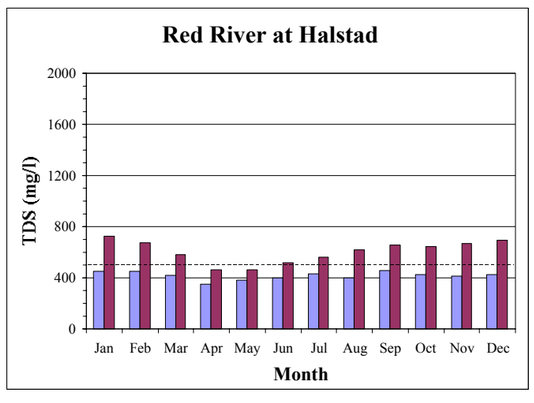


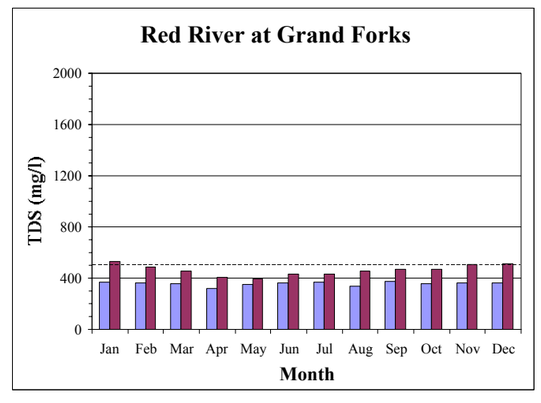


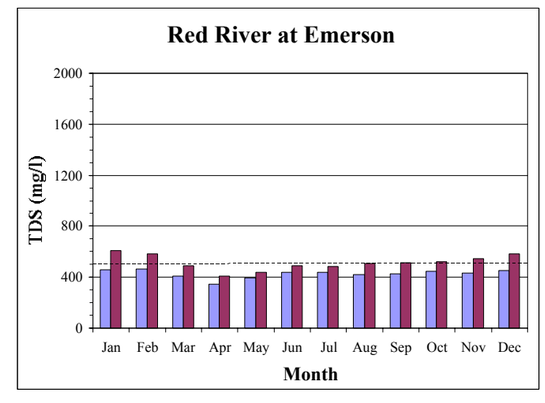




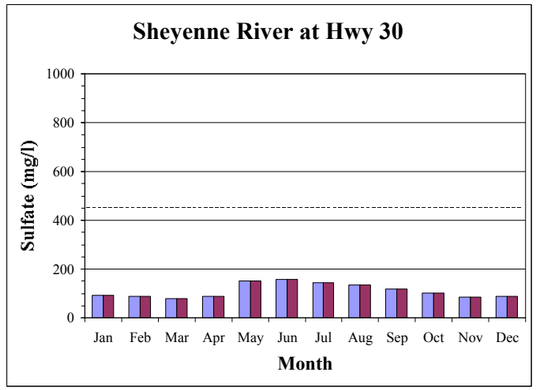


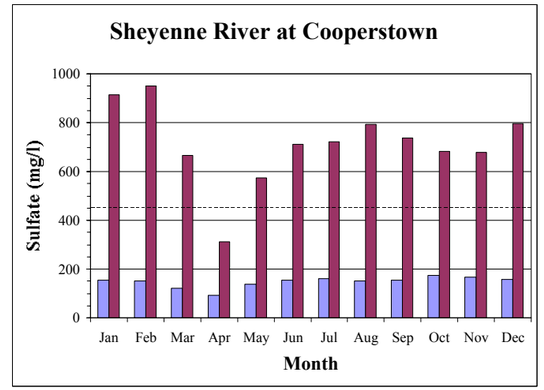


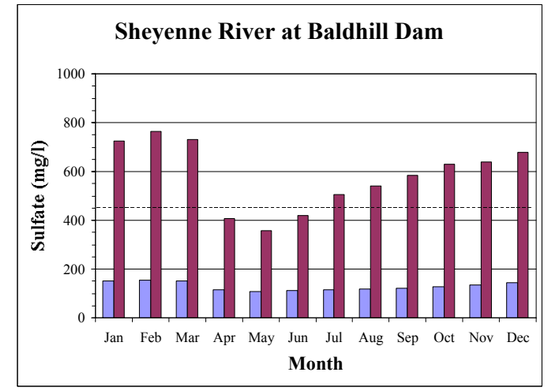


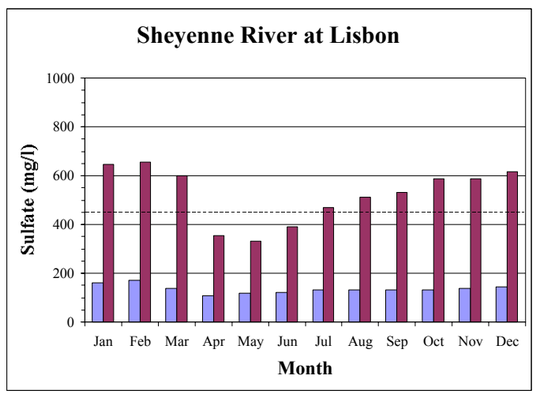


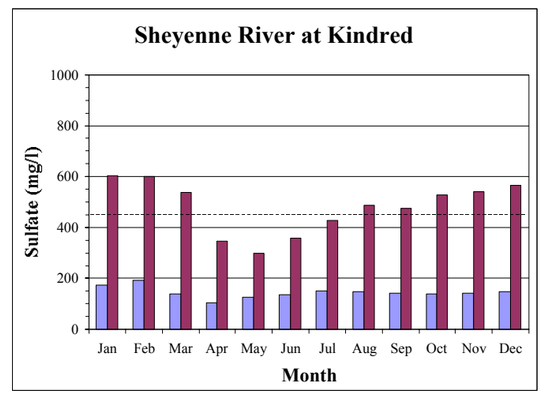
APPENDIX M-8
COMPARISON OF MONTHLY AVERAGE SULFATE BETWEEN WET AND WETOF, 2015-2025
Final Aquatic Impact Analysis Report

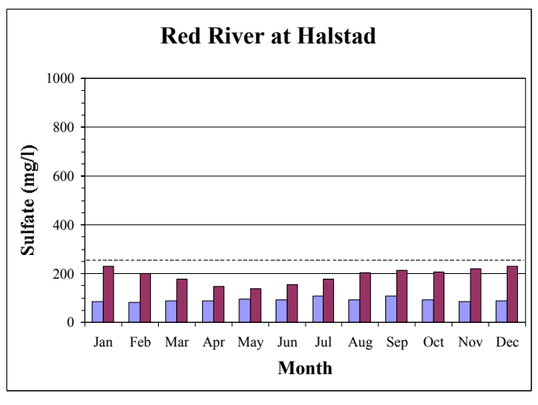


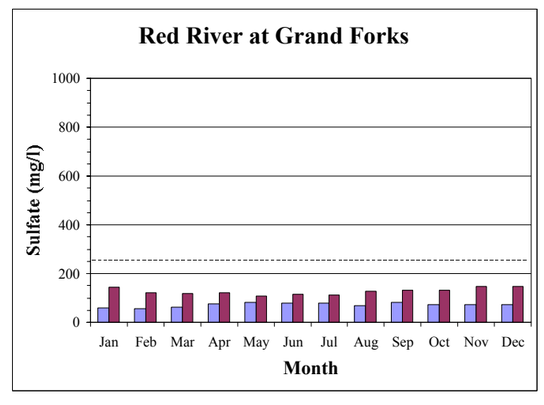


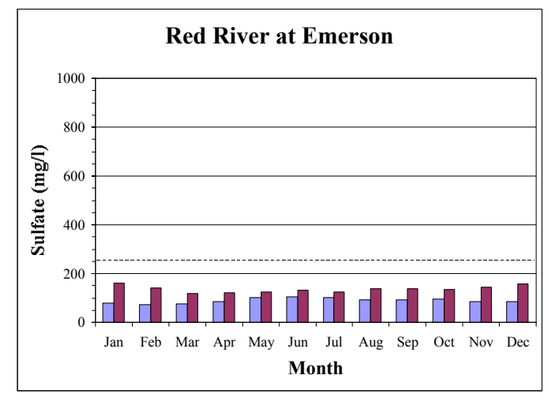










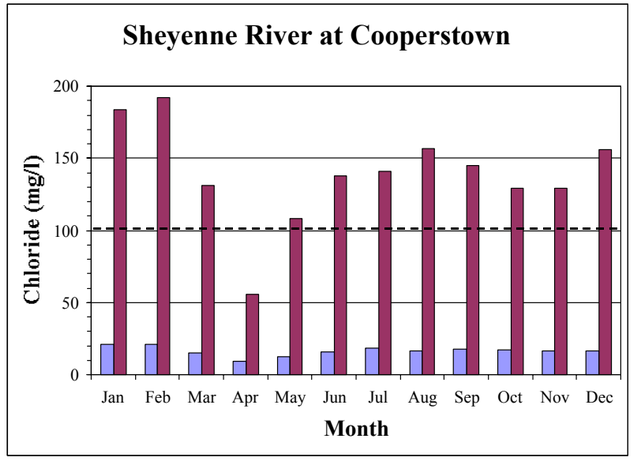


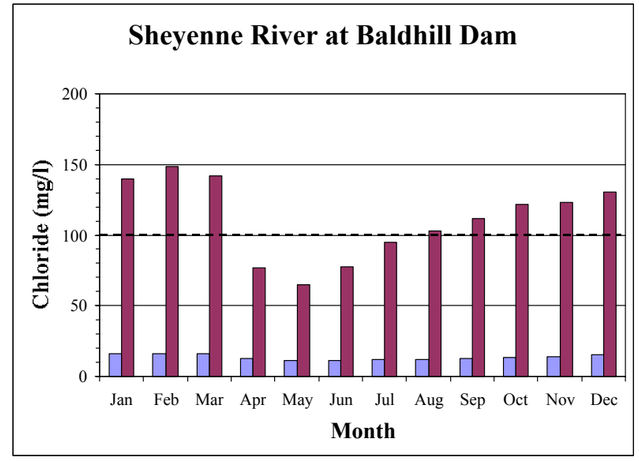
Baseline

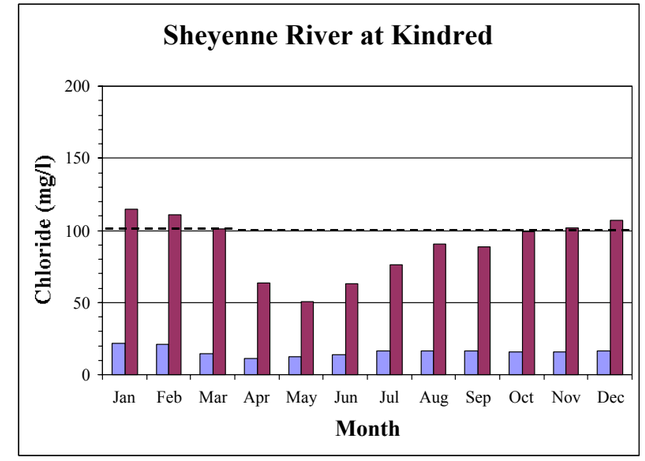
Pumping/Overflow

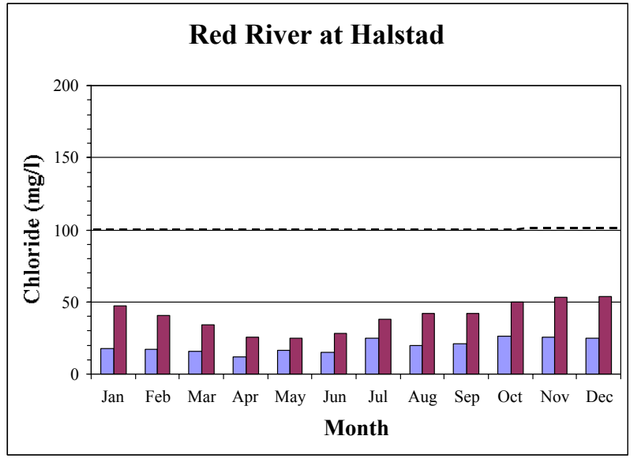
Water Quality Guideline/Standard

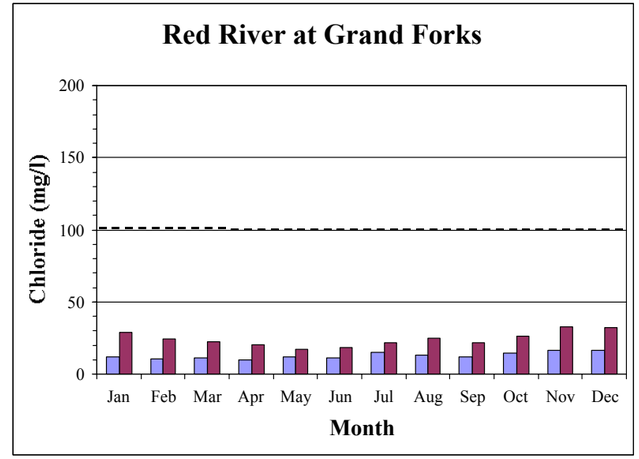
APPENDIX M-9
COMPARISON OF MONTHLY AVERAGE CHLORIDE BETWEEN WET AND WETOF, 2015-2025
Final Aquatic Impact Analysis Report

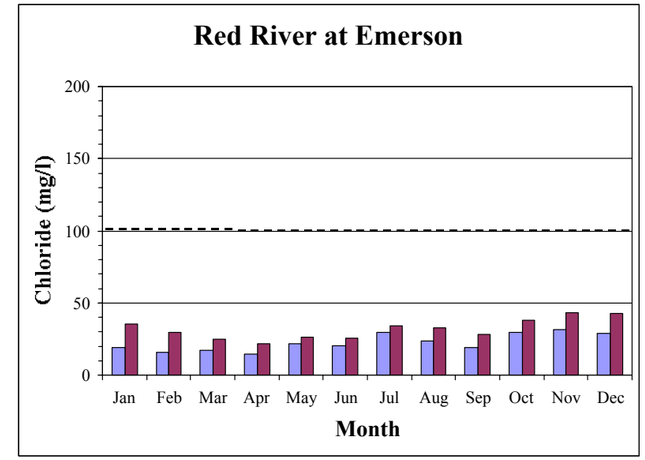












Baseline Pumping/Overflow ---- Water Quality Guideline/Standard