WATER STORAGE REPORT
WENATCHEE RIVER BASIN

Prepared for

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LIST OF ACRONYMS AND ABBREVIATIONS

ac-ft	acre-feet
CBWTP	Columbia Basin Water Transactions Program
Chelan County NRD	Chelan County Natural Resources Department
cfs	cubic feet per second
Ecology	Washington State Department of Ecology
DEM	digital elevation model
DO	dissolved oxygen
HDPE	high-density polyethylene
LNFH	Leavenworth National Fish Hatchery
µg/L	micrograms per liter
mg/L	milligrams per liter
NAVD	North American Vertical Datum
NGVD	National Geodetic Vertical Datum
NRD	Chelan County Natural Resources Department
POTW	publicly owned wastewater treatment plants
Reclamation	U. S. Bureau of Reclamation
RM	River Mile
SEED	Safety Evaluation of Existing Dams
TMDL	Total Maximum Daily Load
TP	Total Phosphorus
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WDFW	Washington State Department of Fish and Wildlife
WRTS	Water Right Tracking System
WRIA	Water Resource Inventory Area
yr	year

1 INTRODUCTION

1.1 Background

This report provides a summary of potential water storage projects and other water resource management strategies intended to increase water supply and instream flow in the Wenatchee River Basin. The Wenatchee River Basin is part of the Washington State Department of Ecology (Ecology) Water Resource Inventory Area 45 (WRIA 45). The primary water needs in the Wenatchee River Basin include irrigation, domestic water supply, and instream flows for fish passage and habitat.

This report builds on information provided in the *Multi-Purpose Water Storage Assessment in the Wenatchee River Watershed* (MWG 2006) and other recent planning studies that have identified opportunities for improved management of water resources in the Wenatchee River Basin. A comparison the costs and benefits of potential water storage projects with other water management strategies, such as water conservation on irrigation systems and acquisition of water rights, is also included. This report was prepared for Chelan County Natural Resources Department (Chelan County NRD) under a grant (Grant No. G0700037) from the Columbia River Water Management Development Account administered by Ecology.

1.2 Project Description

This section includes a brief description of the scope of work and purpose of this report. In general, this report was prepared to provide background information and a comparison of the costs and benefits associated with potential water management strategies that could be implemented to improve the use of water in the Wenatchee River Basin.

1.2.1 Scope of Work

The scope of work approved by Chelan County and Ecology for development of this report included the following tasks:

1. **Water Storage Analysis – Snow Lakes**
   This task includes a preliminary feasibility analysis of the potential for increasing water storage in the Snow Lakes in the Icicle Creek Subbasin. Increasing the storage

capacity in the Snow Lakes would allow for additional releases during the late summer or during dry years to improve flows in Icicle Creek and the lower Wenatchee River. The additional storage would also improve operations of fish rearing facilities at the Leavenworth National Fish Hatchery (LNFH).

2. **Compare Water Storage Strategies to Water Right Acquisition Strategy to Improve Streamflow in the Wenatchee Watershed**
   This task includes a preliminary comparison of the cost and benefits of potential water storage strategies to a strategy of acquiring water rights.
3. **Analysis of Water Quality Benefits from Increased Flow during Low-flow Periods**
   This task included an analysis of the potential beneficial effect of increasing flows in the lower Wenatchee River on water quality (primarily temperature, dissolved oxygen [DO], and nutrients). A water quality model developed and calibrated by Ecology was used to evaluate water quality impacts. The potential for increasing total phosphorus (TP) loading with additional flow was reviewed.
4. **Fisheries Analysis**
   This task was intended to include a fisheries analysis to supplement engineering and other environmental studies in support of the water storage analyses. However, Ecology and Chelan County NRD determined that the fisheries analysis would not be needed, so this task was not completed and is not summarized in this report.
5. **Water Planning Support**
   This task includes on-going assistance to Chelan County NRD in water planning strategy meetings and with ongoing water planning efforts in WRIA 45.
6. **Evaluation of Potential Irrigation Improvements**
   This task included an evaluation of potential irrigation improvements designed to conserve water and reduce surface water diversions from the Wenatchee River and its tributaries. Preliminary costs and estimates of potential water savings were identified and compared with the costs and benefits of other water management strategies.

2 WATER STORAGE ANALYSIS – SNOW LAKES

2.1 Area Ownership

The Snow Lakes area is part of the Icicle Creek Subbasin of the Wenatchee Watershed and is within the Alpine Lakes Wilderness Area, at Township 23 North, Range 17 East of the Willamette Meridian. Although the Snow Lakes area is contained within the Alpine Lakes Wilderness Area, the lakes and parcels adjacent to the lakes are owned by the U.S. Fish and Wildlife Service (USFWS). Upper and Lower Snow Lakes are operated by USFWS as part of their management of the LNFH. Figure 1 shows a map of the Snow Lakes area with ownership and wilderness boundary information.

2.2 Current Operations

Upper Snow Lake is actively managed by USFWS. Water is released from Upper Snow Lake into Nada Lake through a tunnel. The tunnel captures water from Upper Snow Lake at a depth of approximately 150 feet and discharges to Nada Lake through a 36-inch penstock. The penstock includes a 30-inch gate valve, located in the tunnel about 15 feet downstream of the bulkhead, and a 20-inch butterfly valve, mounted at the end of the penstock. The 20-inch butterfly valve is operated to control releases from Upper Snow Lakes (see Photo 1). The valve remains open during late summer months, typically between mid-July and mid-October, to help supply the LNFH's operational requirements (40 cubic feet per second [cfs] between June and October) and to supplement flow in Icicle Creek. According to the *Management Recommendations for Reservoir Releases from Upper Snow Lake: Leavenworth National Fish Hatchery* (Wurster 2006), the valve was open an average of 77 days each year between 1998 and 2005, with an average annual release of 3,700 acre-feet.

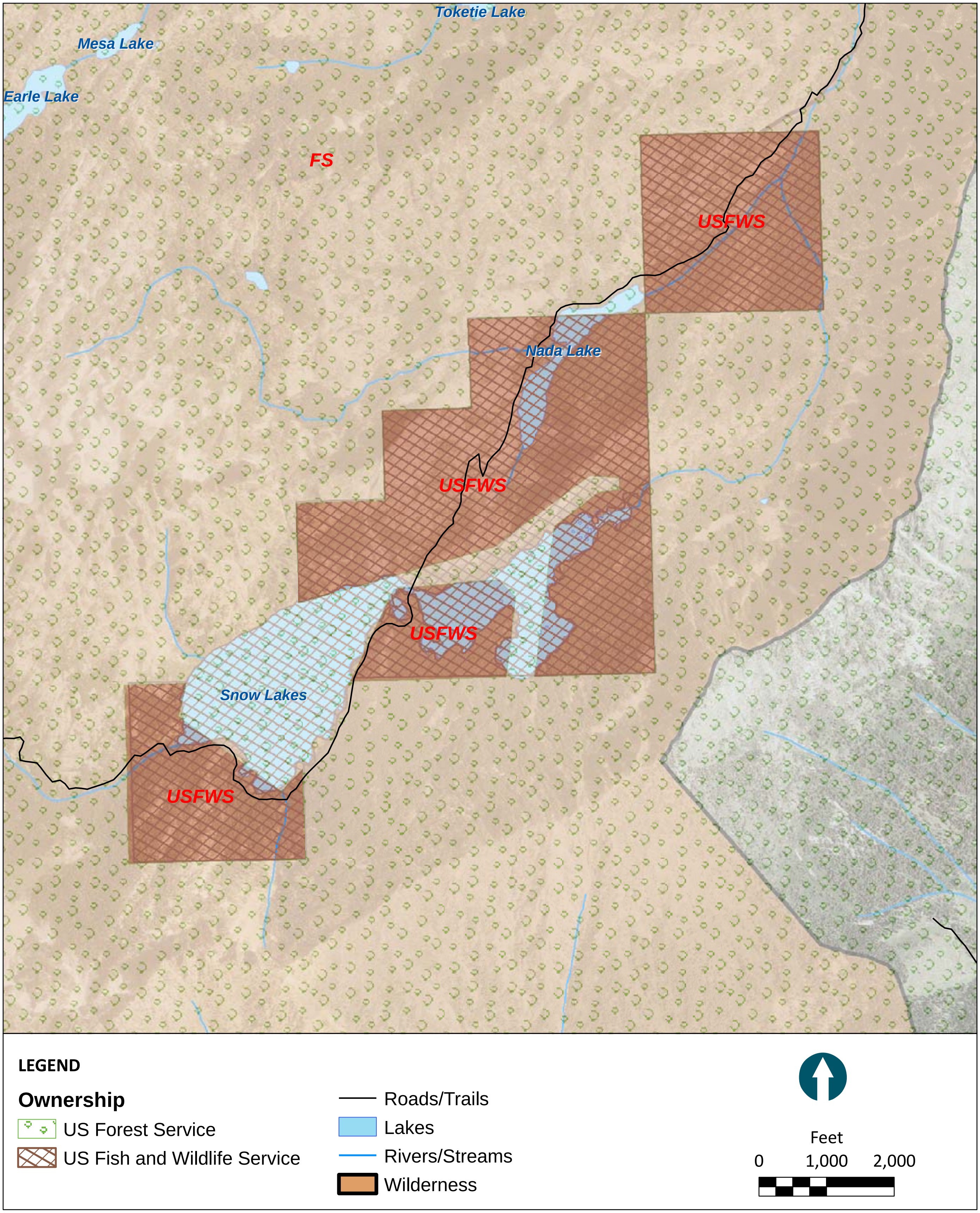

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Figure 1
Ownership and Wilderness Map
Snow Lakes

USFWS indicated that Upper Snow Lake is currently operated according to the recommendations of *Management Recommendations for Reservoir Releases from Upper Snow Lake: Leavenworth National Fish Hatchery* (Wurster 2006). This report recommends that releases from Upper Snow Lake be managed "with the goal of having the lake full during years when runoff in Icicle Creek is anticipated to be similar to 2001 and 2005," which were dry years. During years when runoff in Icicle Creek is closer to the average, the report recommends releases between 6,000 and 7,000 acre-feet so that the probability of refilling the lake is roughly between 60 and 70 percent. USFWS indicated that approximately 7,000 acre-feet are currently released from late July to early October. Releases start around 30 cfs in late July and increase to 60 cfs as natural flows in Icicle Creek drop.

After the valve on the outlet is closed in the fall, Upper Snow Lake refills. For six of the seven years (1998 to 2005, excluding 2000) that were reported in *Management Recommendations for Reservoir Releases from Upper Snow Lake: Leavenworth National Fish Hatchery*, Upper Snow Lake was full by the time the valve was opened the following summer. The only year when Upper Snow Lake did not fully refill was 2001, which was a drought year.

The Upper Snow Lake Dam is a small masonry structure which appears to have been constructed out of cement and locally derived rock at the natural outlet of Snow Lake. The dam is designed to retain water at an elevation that is approximately 10 feet higher than the natural water surface of the lake. The *Upper and Lower Snow Dams Screening Level Risk Assessment* (Reclamation 2010) indicates that the Upper Snow Lake Dam has a maximum height of approximately 10 feet and a crest length of 119 feet. The crest elevation is 5,428 feet NAVD 88 datum. The entire dam functions as an overflow spillway for Upper Snow Lake.

At the end of the summer, when Upper Snow Lake has been drained, water flows from Lower Snow Lake to Upper Snow Lake through a small (approximately 9-square-foot) hole at the base of Upper Snow Lake Dam (see Photo 2). According to the *Management Recommendations for Reservoir Releases from Upper Snow Lake*, flow through the hole is dependent on the water level in both Lower and Upper Snow Lakes. A flapper gate on the opening in Upper Snow Lake Dam is designed to pass water only from Lower Snow Lake to

Upper Snow Lake; however, USFWS indicated that the gate leaks. In 2005, it was estimated that approximately 200 acre-feet of water passed through the opening.

Lower Snow Lake is not actively managed by USFWS. The Lower Snow Lake Dam is also a small masonry dam constructed at the north end of Lower Snow Lake (see Photo 4) where Lower Snow Lake naturally flows to Snow Creek. The *Upper and Lower Snow Dams Screening Level Risk Assessment* (Reclamation 2010) indicates that the Lower Snow Lake Dam has a maximum height of approximately 6 feet and a crest length of 112 feet. The crest elevation is 5,423 feet North American Vertical Datum (NAVD) 88. The dam consists of a 42-foot long overflow section with a 2-foot wing dike extending to right abutment.

USFWS indicated that when Lower Snow Lake is full, water spills over the dam or discharges to Snow Creek through a breach that was identified on the east side of the dam during the 2008 Safety Evaluation of Existing Dams (SEED) inspection (WW Wheeler and Associates 2009a). Water was observed in the channel downstream of dam (see Photo 5) during a site visit on September 25, 2009, and the water level behind the dam was 2 to 3 feet lower than the crest of the dam. This confirms that even when the water level is lower than the crest of the dam, water still flows from the lake through a breach or through leaks in the dam. The dam crest elevation appears to correspond approximately to high water levels in the lake (see Photo 6).

2.3 Water Rights

Both the LNFH and Icicle Irrigation District have storage water rights for the Snow Lakes. Table 2-1 lists the storage water rights listed for the Icicle Creek Subbasin in Ecology's Water Rights Tracking System (WRTS) database. LNFH has a storage right of 16,000 acre-feet, which was originally issued to the U.S. Bureau of Reclamation (Reclamation). USFWS indicated that the storage right applies to Upper Snow Lake, Lower Snow Lake, and Nada Lake. Icicle Irrigation District reported that it had given up its storage rights to LNFH when the reservoir was expanded (Christensen 2010), but this has not been confirmed. The WRTS database indicates that Icicle Irrigation District has storage rights of 1,000 acre-feet and 2,000 acre-feet. The total storage volume listed in these storage rights (19,000 acre-feet) exceeds the current storage capacity of Upper Snow Lake, which is 12,450 acre-feet.

Table 2-1
Storage Water Rights — Snow Lakes

Water Right Holder	Water Right Document	Amount (ac-ft)	Priority Year
U.S. Bureau of Reclamation	R4-*05672ABBCWRIS	16,000	1942
Icicle Irrigation District	R4-*01924ACCWRIS	1,000	1926
	R4-*02752CWRIS	2,000	1929

Notes:
ac-ft = acre feet

Several entities have water rights for diverting surface water from Icicle Creek. The largest surface water diversions belong to Icicle Irrigation District, Peshastin Irrigation District, the City of Leavenworth, Cascade Orchards, and Reclamation (listed as the water right holder on the LNFH right). Table 2-2 lists the major water rights holders for diversions from Icicle Creek.

Table 2-2
Storage Water Rights — Icicle Creek

Water Right Holder	Water Right Document	Amount (cfs)	Amount (ac-ft)	Priority Year
Icicle Irrigation District	S4-CV1P224	1.75		1910
	S4-*35002ABBJWRIS	81.6	25,000	1910
	S4-*01825BACWRIS	50.0		1926
	S4-*01824CWRIS	25.0		1926
	S4-*01825AACWRIS	25.0		1926
	S4-*02751CWRIS	25.0		1929
	S4-*01924BBVCWRIS	10.0		1926
Peshastin Irrigation District	S4-CV1P260	2.4		1923
	S4-*00329CWRIS	34.4		1919
City of Leavenworth	S4-*16124CWRIS	1.5		1960
	S4-*35004JWRIS	1.5		1912
	S4-28122	3.2	636.0	1983
Cascade Orchards	S4-*35001JWRIS	11.9	2064.5	1905
U.S. Bureau of Reclamation	S4-*05671CWRIS	42	NA	1942

Notes
NA = Not applicable

2.4 Available Water Supply

Upper Snow Lake can store approximately 12,450 acre-feet at its current full capacity. Figure 2 shows the storage curve of Upper Snow Lake, as well as starting and ending storage values for various years. The source of the curve data is Reclamation (2010).

From 1994 to 2005, the average annual runoff within the Upper Snow Lake watershed was estimated to be 8,600 acre-feet. In 2001 (a drought year), the estimated annual runoff within the watershed was 4,400 acre-feet.

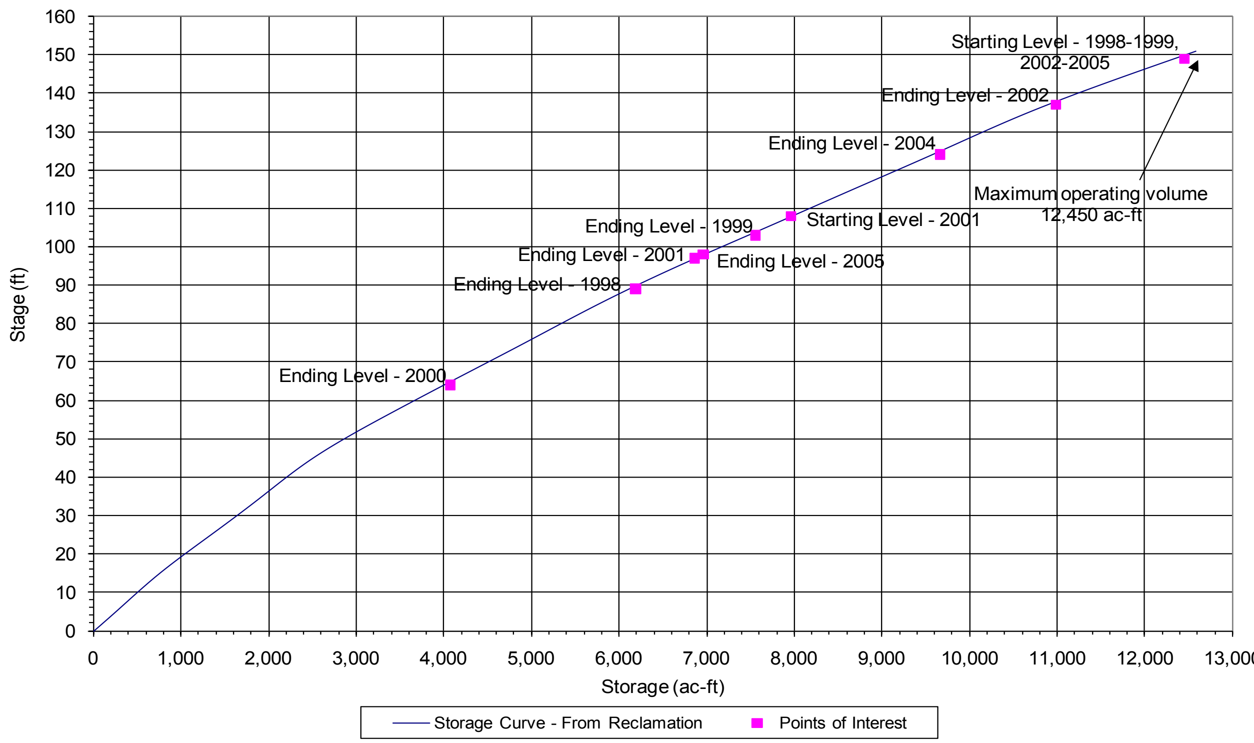

Figure 2
Storage Curve — Upper Snow Lake

The *Management Recommendations for Reservoir Releases from Upper Snow Lake* (Wurster 2006) assumes, based on hydrologic monitoring data, that all water released from Upper Snow Lake reaches Icicle Creek. As part of that report, the exceedance probability of inflows into Upper Snow Lake from October through July was estimated using estimated runoff between 1994 and 2005. The report also indicated that the period from October to

July was critical in making lake management decisions, because the hatchery needs to know how much water comes into the lake when the valve is normally closed, from late October to early July. Figure 3 presents a graphical representation of the exceedance probability of inflows into Upper Snow Lake from October through July.

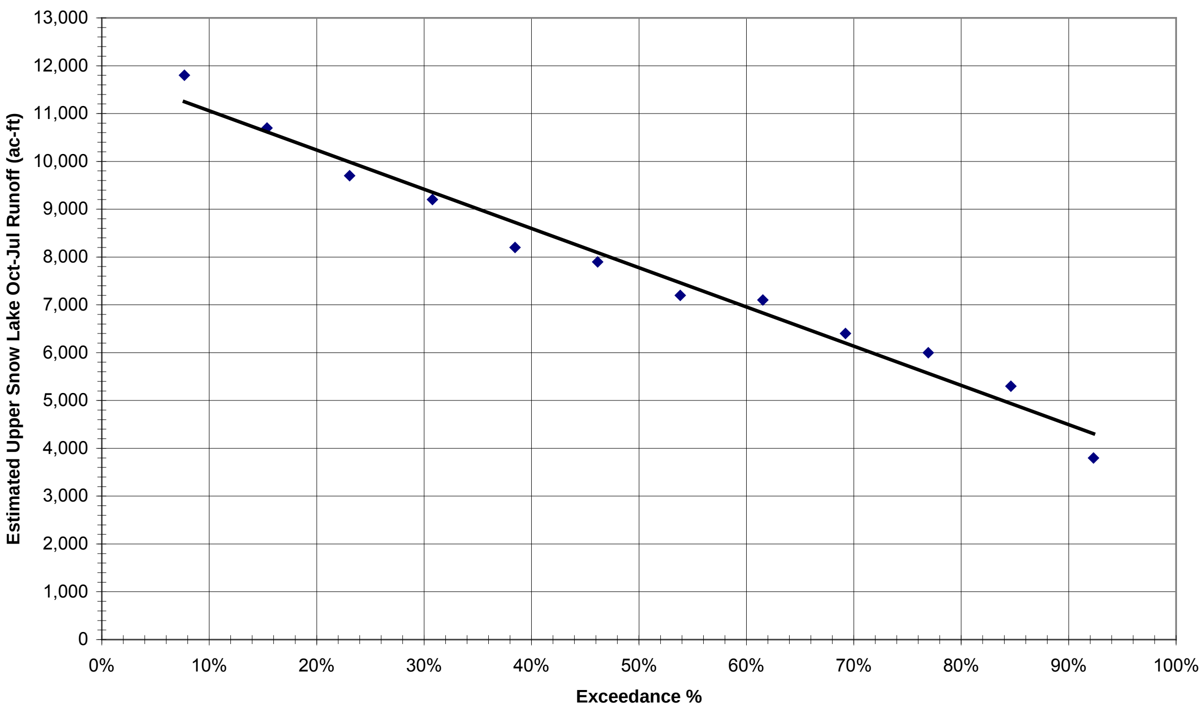

Figure 3
Estimated Exceedance Probability — Upper Snow Lake, October to July Runoff

During an average year (50 percent exceedance), the estimated runoff is from the watershed above Snow Lakes is estimated to be 7,800 acre-feet. This is equivalent to 49 cfs over 80 days, which is higher than the 40 cfs diversion required by LNFH for hatchery operation. During a wet year (10 percent exceedance), the need for water is less and the runoff is more (11,000 acre-feet, or 69 cfs over 80 days). Additionally, Upper Snow Lake has refilled every year when data was collected except during 2001, which was a drought year.

From this data, it appears that additional water could be released from Upper Snow Lake and that storage would be refilled during most years. The *Management Recommendations for Reservoir Releases from Upper Snow Lake* (Wurster 2006) recommended that additional flow be released to provide supplemental flow in Icicle Creek in September. The report posed a scenario that would result in the release of an average of 40 cfs in August and 60 to 70 cfs in September. That scenario would result in the release of about 6,200 acre-feet and would have a probability of refill in the following year of about 68 percent. The report also recommended that LNFH manage Upper Snow Lake so that the lake is full going into a drought year, which would allow for a release of between 6,000 and 7,000 acre-feet. This would supplement flow in Icicle Creek by up to 40 cfs in September. USFWS indicated that Snow Lakes are currently being operated according to the *Management Recommendations for Reservoir Releases from Upper Snow Lake*'s recommendations.

Another option to the scenario recommended by *Management Recommendations for Reservoir Releases from Upper Snow Lake* would be to increase storage in Snow Lakes and use the storage during drought years to supplement flow in Icicle Creek and the Wenatchee River. If the additional storage was used only in drought years, there would be a high likelihood of refill before the next drought year.

2.5 Potential Alternatives for Increasing Water Storage

2.5.1 Upper Snow Lake

Topographic data was reviewed to determine the additional storage potential in Upper Snow Lake if the dam between Upper and Lower Snow Lake was raised. Contours generated from 10-meter digital elevation model (DEM) data derived from U.S. Geological Survey (USGS) topography maps were used to estimate the additional storage potential. Reservoir areas were estimated at various elevations to approximate additional storage volume available. Table 2-3 presents the findings from this analysis. An elevation of 5,420 feet (datum National Geodetic Vertical Datum [NGVD] 29) was recorded on the USGS topographic maps as the lake level for Upper Snow Lake and was assumed to be the existing high water surface elevation for this analysis.

Table 2-3
Upper Snow Lakes Water Storage

Elevation (feet)	Reservoir Area (acres)	Estimated Storage (acre-feet)	Additional Dam Height Required (feet)	Additional Storage Available (acre-feet)	Additional Supply for 30 Days (cfs)	Additional Supply for 60 Days (cfs)
5,420	114.3	12,450	0	0	0	0
5,422	121.3	12,686	2	236	4.0	2.0
5,424	124.7	12,932	4	482	8.1	4.1
5,425	126.0	13,057	5	607	10.2	5.1
5,426	127.3	13,184	6	734	12.4	6.2
5,428	129.5	13,441	8	991	16.7	8.3
5,430	131.6	13,702	10	1,252	21.1	10.5

It should be noted that the *Upper and Lower Snow Dams Screening Level Risk Assessment* (Reclamation 2010) reported a dam crest elevation at Upper Snow Lakes of 5,428 feet, which is 8 feet higher than the high water surface elevation assumed for this analysis. The discrepancy is likely due to a difference in the datum and accuracy of the data used for this analysis. The contours used for this analysis were generated from USGS 10-meter DEM data, which is based on the NGVD 29 vertical datum and is less accurate than actual topographic survey data. The crest elevations reported by Reclamation were surveyed and appear to be based on the NAVD 88 datum. The difference between the NGVD 29 and NAVD 88 datum at Snow Lakes is approximately 4.4 feet. Despite discrepancy in elevations, this analysis still provides a reasonable estimate of the additional storage capacity that would be available by raising the high water surface elevation of the lake because the estimated surface areas are reasonably accurate. Ultimately, a more detailed topographic survey would need to be completed to more precisely estimate the additional capacity that could be made available by raising the high water surface elevation at Upper Snow Lake.

To check the results of the analysis, the storage elevation-capacity curve developed by Reclamation as part of the original 1939 design study was reviewed. USFWS recently confirmed the accuracy of the original storage elevation-capacity curve by comparing measured changes in lake levels with known changes in storage (Wurster 2006). According to the storage elevation-capacity curve, a 1-foot increase in water elevation near the top of

Upper Snow Lake would increase the storage capacity by about 125 acre-feet. Based on the storage curve, the estimates presented in Table 2-3 appear to be reasonable.

2.5.2 Lower Snow Lake

As previously noted, Lower Snow Lake is not actively managed; however, water stored in Lower Snow Lake is used annually to meet fish production needs at LNFH. No studies are available that give estimates of available water storage. During a site visit on September 25, 2009, a 2- to 3-foot difference between high and low water levels in Lower Snow Lake was observed. During the late summer, when Upper Snow Lake has been drained, water flows from Lower Snow Lake to Upper Snow Lake through a flapper gate on the opening in the Upper Snow Lake Dam. Water also flows from Lower Snow Lake to Snow Creek over the dam crest and through the breach that was identified during the 2008 SEED inspection.

Topographic data was reviewed to determine the additional storage capacity that could be available in Lower Snow Lake if the dam at the outlet was raised and the additional storage was actively managed. Contours from 10-meter digital DEM data derived from USGS topography maps were used to estimate the increased storage potential. An elevation of 5,415 feet NGVD 29 was recorded on the USGS topography maps for the lake level for Lower Snow Lake and was assumed as the high water surface elevation for this analysis. Reservoir areas were estimated at various elevations to approximate the additional water storage volume that would result from raising the lake level. Table 2-4 presents the findings from this analysis.

Table 2-4
Lower Snow Lake Water Storage

Elevation (feet)	Reservoir Area (acres)	Estimated Additional Dam Height Required (feet)	Additional Storage Available (ac-ft)	Additional Supply for 30 Days (cfs)	Additional Supply for 60 Days (cfs)
5,415	57.2	0	0	0	0.0
5,416	58.2	1	58	1.0	0.5
5,418	62.0	3	178	3.0	1.5
5,420	64.6	5	305	5.1	2.6
5,422	66.8	7	436	7.3	3.7
5,424	68.7	9	571	9.6	4.8
5,426	70.5	11	711	12.0	6.0
5,428	72.2	13	853	14.4	7.2
5,430	73.9	15	1000	16.8	8.4

For this analysis, a discrepancy exists between the high water surface elevation assumed for the analysis (5,415 feet NGVD 29) and the dam crest elevation (5,423 feet NAVD 88) reported in the *Upper and Lower Snow Dams Screening Level Risk Assessment* (Reclamation 2010). The discrepancy is due to a difference in the datum and accuracy of the data used for this analysis, similar to the analysis of additional storage capacity for the Upper Snow Lake Dam. A more detailed topographic survey would need to be completed at Lower Snow Lake to more precisely estimate the additional capacity that could be made available by raising the high water surface elevation at Upper Snow Lake.

An alternative to raising Lower Snow Lake Dam would include installing a low-level outlet to allow Lower Snow Lake to be further drawn down. Although the storage currently available in Lower Snow Lake is unknown, the reservoir area can be extrapolated to approximate the supply available with a certain amount of drawdown. For this analysis, a linear extrapolation was assumed; Table 2-5 presents the findings. A total drawdown of 5 feet was assumed. Lower Snow Lake is relatively shallow; however, based on the reported dam height of 6 feet, 5 feet of drawdown appears to be a reasonable assumption. Ultimately, accurate bathymetry data would be needed to develop a more precise estimate of the additional storage that could be made available by actively managing the water storage in Lower Snow Lake to allow for additional drawdown of the lake.

Table 2-5
Lower Snow Lake Estimated Supply from Drawdown

Elevation (feet)	Estimated Reservoir Area (acres)	Estimated Drawdown (feet)	Additional Storage Available (acre-feet)	Additional Supply for 30 Days (cfs)	Additional Supply for 60 Days (cfs)
5,415	57.2	0	0	0.0	0.0
5,414	56.2	1	57	1.0	0.5
5,412	54.2	3	167	2.8	1.4
5,410	52.2	5	274	4.6	2.3

2.5.3 Automation of Existing Outlet Valve

The existing butterfly valve on the penstock that discharges water from Upper Snow Lake to Nada Lake is opened manually in July and closed in October. Because the valve is remote and requires a 2- to 3-hour hike to access, it is only occasionally adjusted. If the valve could be operated remotely and adjusted to more closely meet water demands at LNFH, water could better be conserved for use in late summer and fall to further supplement in-stream flows in Icicle Creek and the Wenatchee River. Adding the capability of remote operation of the valve would require that the valve be retrofitted with a motorized actuator and power source (such as batteries recharged through solar panels). The valve actuator would need to be linked via satellite or radio to the LNFH for remote operation. Reclamation researched the potential for remote communication on behalf of LNFH and found that the satellite connection at Snow Lakes is poor. Reclamation also indicated that construction of at least two radio repeater stations would likely be required to establish radio communication between LNFH and Snow Lakes. Additional research would be needed to determine the exact requirements for remote control of the existing valve.

Automation and remote control of the valve at LNFH would not eliminate the need for manual valve operation at the beginning and end of the storage release each season. Visual monitoring of the initial valve opening is required to ensure that no one is in front of the valve when it opens. Manual operation and monitoring is also necessary to ensure that the valve is working properly, that the valve is not leaking excessively, and that cavitation does not occur. It is anticipated that remote operation would enable slight adjustments during the release period to more closely match water needs downstream and that the valve would be manually opened and closed at the beginning and end of each release period.

2.6 Facilities Required To Store Additional Water and Cost Estimate

2.6.1 Selection of Water Storage Increase to Study

Figure 4 shows the current lakes and the estimated footprints of the lakes that would result from raising the maximum water surface elevation at Upper Snow Lake by 10 feet and raising the maximum water surface elevation at Lower Snow Lake by 15 feet. The estimated change in lake surface area would be approximately 17.3 acres for Upper Snow Lake and 16.7 acres for Lower Snow Lake. Photos 6 and 7 show shoreline conditions along Upper and Lower Snow Lake. The increased inundation would require the removal of trees and vegetation along the shoreline. Upper Snow Lake appears to have steeper side slopes and its shoreline is currently more impacted by water level fluctuations. Slopes above the water surface are relatively steep with little vegetation, especially on the west side of the lake. At Lower Snow Lake, some side slopes are gentler and the removal of more trees and vegetation would be required relative to the increase in water level than for Upper Snow Lake; however, a raise of that magnitude (10 to 15 feet) would be difficult to permit and construct. A smaller increase (less than 5 feet) on both lakes may be more feasible and is reviewed further in this report. A 3-foot drawdown of Lower Snow Lake also appears feasible and is reviewed in this report.

The volume of water that could be stored and supplied by the projects is listed in Table 2-6. The total volume available is estimated to be 1,079 acre-feet, which could result in an increase in instream flow of 18 cfs for 30 days or 9 cfs for 60 days.

Table 2-6
Summary of Water Supply Benefits from 5-foot Increase in Storage

Project	Additional Storage Available (ac-ft)	Additional Supply for 30 Days (cfs)	Additional Supply for 60 Days (cfs)
Increase Storage in Upper Snow Lake by 5 feet	607	10.2	5.1
Increase Storage in Lower Snow Lake by 5 feet	305	5.1	2.6
Drawdown Lower Snow Lake by 3 feet	167	2.8	1.4
Totals	**1,079**	**18.1**	**9.1**

Property ownership is also mapped on Figure 4 relative to an increase in storage to the 5,430-foot NGVD 29 elevation. The property boundaries were obtained from a GIS layer provided by USFWS. Metes and bounds descriptions of the boundaries were not available from USFWS. An inquiry to the U.S. Forest Service (which manages the Alpine Lakes Wilderness Area) was not successful in obtaining those descriptions. The GIS coverage shows the potential flooded area may cross over the property boundaries. The exact location of those flooded areas relative to property boundaries will need further study.

2.6.2 New Facilities Required at Upper Snow Lake

In order to raise the water surface of Upper Snow Lake, a new dam with a higher crest could be constructed at the natural outlet to Upper Snow Lake, at or just downstream of the existing dam. An outlet pipe and flap gate would be installed near the base of the dam to control the flow from Lower Snow Lake to Upper Snow Lake. The new dam would have a longer crest length than the existing dam. The trail that traverses the dam would need to be relocated over the new dam, and it appears the trail would not need relocating elsewhere. The existing tunnel and penstock that discharge water from Upper Snow Lake to Nada Lake would not need to be modified as long as the pipe and valves can accommodate the additional pressure head that would result from raising the lake.

It is recommended that the existing butterfly valve that controls flow through the penstock to Nada Lake be automated and linked via telemetry to the LNFH to optimize water management of the lake. As was noted previously, Reclamation has indicated that establishing radio communication to Snow Lakes would likely require the installation of at least two repeater stations.

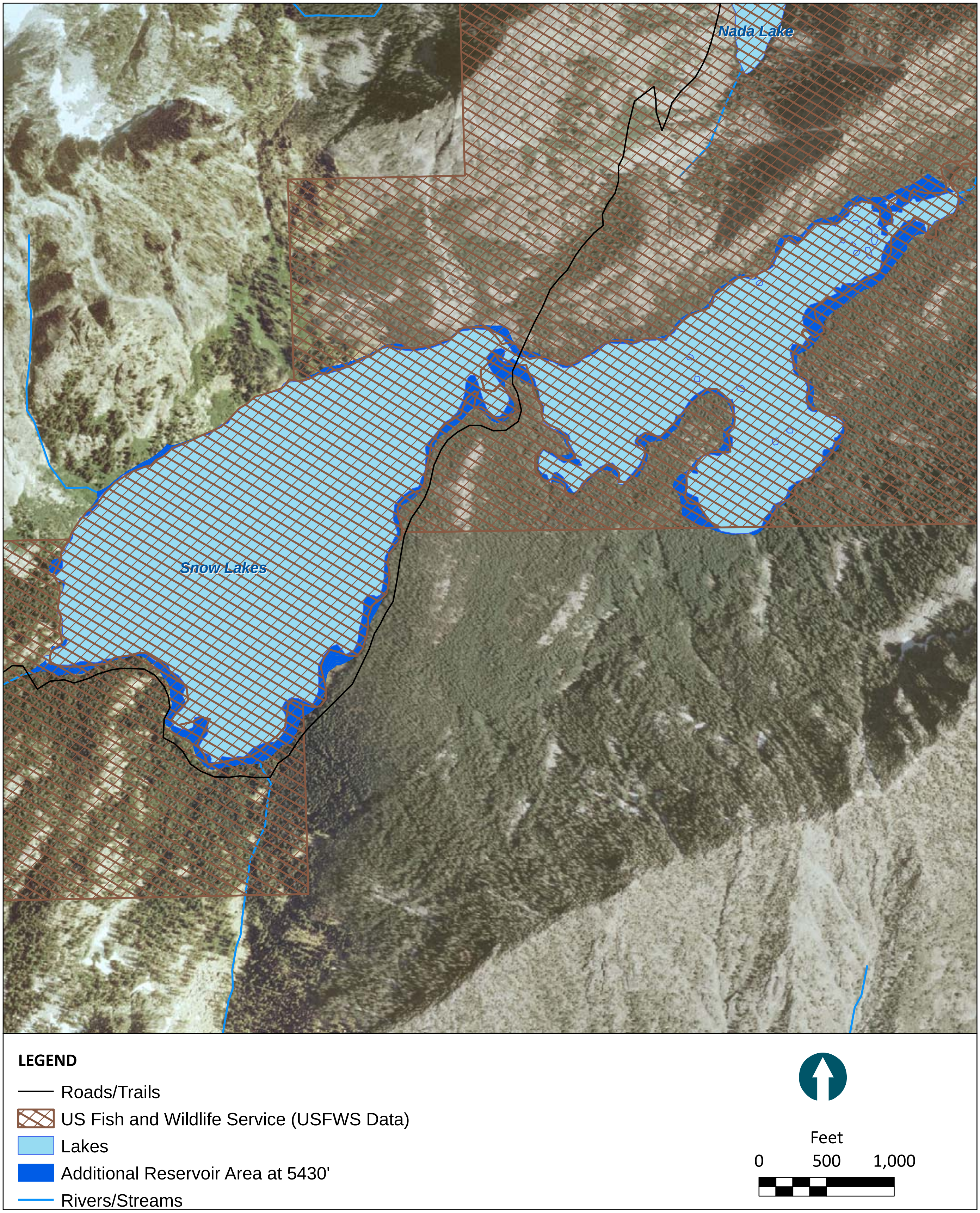

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Figure 4
Reservoir Area Map
Snow Lakes

2.6.3 New Facilities Required at Lower Snow Lake

In order to raise the water surface of Lower Snow Lake, a new dam with a higher crest could be constructed at the north end of the lake, just downstream of the existing dam. An outlet pipe with a gate would be installed near the base of the dam. The new gate on the outlet of the dam could also be linked via telemetry to the LNFH, to provide the capability of operating the gate remotely to optimize water management Lower Snow Lake, or the gate could remain closed and opened manually when additional flow is desired.

2.6.4 Opinion of Probable Costs

A preliminary opinion of probable costs was prepared for improvements that would increase the storage capacity and improve the management of Snow Lakes. This includes costs to:

- Replace the existing Upper Snow Lake Dam with a dam that has a crest elevation 5 feet higher than the existing dam
- Replace the Lower Snow Lake Dam with a dam that has a crest elevation 5 feet higher than the existing dam
- Install a new outlet pipe and gate at the new Upper Snow Lake Dam
- Install a new outlet pipe and gate at the Lower Snow Lake Dam
- Automation of the operation of the existing valve that controls flow through the Penstock from Upper Snow Lake to Nada Lake
- Automation of a gate at Lower Snow Lake Dam

The new outlet at the Lower Snow Lake Dam would be designed to allow for a 3-foot drawdown of the lake from current levels. The costs also include an allowance for work required to install two repeater stations and telemetry equipment at the valve on the penstock from Upper Snow Lake and at the gate on the new Lower Snow Lake Dam. Table 2-7 presents a summary of the opinion of probable cost.

The overall project cost includes an allowance for mobilization/demobilization, including a 7.5 percent allowance for miscellaneous mobilization/demobilization costs plus an allowance for haul of materials and equipment to the site via helicopter. Columbia Helicopters was contacted for preliminary budget information on the cost of hauling equipment and materials to the site via helicopter. They provided the following:

- A helicopter with a hauling capacity of 6,500 to 7,000 pounds at 5,000-foot altitude and a temperature of 70° F would cost approximately $5,500 per hour to rent plus $10,000 to $15,000 to mobilize to the Wenatchee area.
- A helicopter with a hauling capacity of 20,000 to 30,000 pounds at 5,000-foot altitude and a temperature of 70° F would cost approximately $11,000 per hour to rent plus $10,000 to $15,000 to mobilize to the Wenatchee area.

The costs in Table 2-7 assume that the helicopter with the larger hauling capacity would be used to allow for hauling of small equipment (a small excavator and a small track loader) to the site to facilitate the work, and that concrete materials would be mixed on site. The estimated costs summarized in Table 2-7 assume that haul of equipment and materials would require approximately 1 to 2 total days of helicopter rental. The alternative would be to haul ready-to-pour concrete via helicopter to the site, which would likely be accomplished with a smaller helicopter and more helicopter trips. The overall project cost also includes a contingency of 30 percent; and allowance for engineering, permitting, and administration of 20 percent; and an allowance for sales tax of 8.0 percent

Table 2-7
Preliminary Opinion of Probable Project Costs

Project	Opinion of Probable Project Cost
Site Work	$93,000
Raise Upper Snow Lakes Dam	$187,000
Automation of Existing Upper Snow Lake Outlet Valve	$35,000
Raise Lower Snow Lakes Dam and Install Controlled Outlet	$174,000
Telemetry	$65,000
Subtotal	**$554,000**
Miscellaneous Mobilization/Demobilization (7.55%)	$42,000
Helicopter Mobilization/Demobilization/Rental	$162,000
Construction Subtotal	**$758,000**
Contingency (30%)	$227,000
Engineering, Permitting and Administration (15%)	$152,000
Sales Tax (8%)	$91,000
Total Project Cost	**$1,228,000**

A more detailed breakdown of costs is provided in Appendix A. The costs should be considered preliminary; development of more precise costs would require additional design analysis.

2.7 Challenges Faced With Nada Lake Dam Reconstruction

A dam reconstruction project was completed at Nada Dam, downstream of Upper and Lower Snow Lakes, in 2009. Some of the challenges related to that project were outlined in *Nada Dam: Reconstructing a Concrete Dam in the Wilderness* (WW Wheeler Associates 2009b), and included:

- **Funding, Permitting and Coordination** –
  Several permits and approvals, including a U.S. Army Corps of Engineers (USACE) Nationwide Maintenance Permit, Washington State Department of Fish and Wildlife (WDFW) Hydraulic Permit Approval, Ecology Approval, and Chelan County Approval were required.
- **Construction Window –** The project had to be completed within a very narrow July 2009 construction window to accommodate snow cover and releases to Icicle Creek.
- **Hours of Work –** Construction operations were limited to a 12-hour window to minimize disruption to U.S. Forest Service campsites in the area.
- **Construction Logistics –** Construction required coordination with the U.S. Forest Service to reserve a nearby camp site for construction personnel use.
- **Concrete and Materials –** Concrete was delivered ready-to-pour via helicopter and dumped directly into forms at a rate of one-third-cubic-yard per trip and one trip every 10 minutes.
- **Dewatering –** A temporary Aqua Dam coffer dam and bypass piping were installed to control and route flows through the construction area.

Many of these same challenges would be encountered as part of construction of improvements at Upper and Lower Snow Lakes. Provided the project is feasible and funded, permitting and coordination would need to take place well in advance of construction. The construction window would likely be longer for the Snow Lakes improvements than for the Nada Dam reconstruction because releases from Upper Snow Lake could be maintained while improvements are being constructed. The construction window would likely start after the Upper Snow Lake has been drawn down a few feet, in early August, and extend until snow starts to fall in early October. Construction would require coordination with the U.S. Forest Service for construction personnel use, helicopter operation, and determination of hours of work. The project would also require advance planning for delivery of and staging of materials and dewatering of the construction area.

2.8 Summary of Snow Lakes Water Storage Analysis

A 5-foot increase in water levels on Upper and Lower Snow Lakes was reviewed. A summary of the additional volume of water that could be stored and supplied by this project is included in Table 2-6.

It is estimated that the improvements would make an additional 1,079 acre-feet of storage available annually for discharge to Icicle Creek via Snow Creek. This is equal to a flow rate of 18 cfs for 30 days or 9 cfs for 60 days. The overall cost of the project, which would include increasing storage by replacing the existing dams to raise Upper and Lower Snow lake levels 5 feet, drawing down Lower Snow Lake by 3 feet and automating the existing control valve at the outlet from Snow Lakes, was estimated to be $1,228,000. The unit cost is estimated to be $1,138 per acre-foot of additional storage available.

Additional considerations beyond the cost and water supply benefit will determine if the project is feasible and can be implemented. Additional evaluation will need to be completed to identify potential fatal flaws or other issues that might impact the feasibility of the potential improvements to the Snow Lakes facilities. Issues that should be addressed through additional study include:

- **Land ownership –** Additional work is needed to determine the exact boundaries of the parcels owned by USFWS to determine whether the project can proceed without encroaching on the Alpine Lakes Wilderness Area.
- **Permitting –** The permitting requirements will need to be determined through discussions with USFWS, LNFH, U.S. Forest Service, Chelan County, and fish agencies.

- **Downstream hazard evaluation –** Modification of the dams at the site will require additional study to determine changes to the current hazard classification. An increased hazard classification could potentially increase operational requirements and risk exposure by the owner of the dams.
- **Telemetry –** Additional analysis is needed to determine what would be required to automate operation of the existing outlet valve from Upper Snow Lake and the proposed outlet gate at Lower Snow Lake.
- **Operations and Maintenance –** Additional discussion and coordination between Chelan County, LNFH, and the irrigation districts is needed to identify who will be responsible for construction, operations, and maintenance.
- **Water Rights –** Additional work is needed to determine whether the project would impact existing storage water rights.
- **Funding –** Additional work is needed to identify possible funding sources for construction, operations, and maintenance of the proposed project.
- **Technical and Constructability Issues –** A more detailed evaluation is needed to develop design details and understand construction related challenges.

3 ANALYSIS OF WATER QUALITY BENEFITS FROM INCREASED FLOW DURING LOW-FLOW PERIODS

The Wenatchee River and portions of Icicle Creek are on the State of Washington's 303(d) list of impaired waterbodies for DO, pH, and temperature excursions. The lower Wenatchee River downstream of the City of Leavenworth and Icicle Creek below the LNFH have a phosphorus Total Maximum Daily Load (TMDL) in effect. The TMDL analysis of the Wenatchee River focused on phosphorus because it was determined to be the limiting nutrient for algal growth in the lower river and is the primary concern for water quality degradation.

The TMDL analysis undertaken by Ecology advocates the implementation of a phased load reduction from point and non-point sources to prevent water quality excursions during critical low-flow conditions occurring in summer and fall (Carroll et al. 2006; Carroll and Anderson 2009). The Wenatchee River upstream of Leavenworth is presently not included in Washington State's 303(d) list for DO and pH violations (Carroll and Anderson 2009); however, the Ecology TMDL document has recommended a limit for the total phosphorus (TP) loads entering the lower Wenatchee River from sources upstream of Leavenworth to address water quality degradation in the lower section of the Wenatchee River where the TMDL is in effect.

An alternative to lowering the TP loading to improve water quality in the lower Wenatchee River is to improve streamflow and dilute the existing TP loads. This section describes the potential effect on water quality in the Wenatchee River from increasing the flow in the Wenatchee River that could result from additional water storage described in this report. The QUAL2K model used in the TMDL study for developing phosphorus load allocations to the Wenatchee River and Icicle Creek by Ecology (Carroll et al., 2006; Carroll and Anderson 2009) was used for the analysis.

Potential improvement in Wenatchee River water quality that could result from increased flow was evaluated by simulating water quality changes under 7-day duration, 10-year recurrence (7Q10) low flow conditions using Ecology's QUAL2K model. Three scenarios with flow increases of 10, 50, and 100 cfs over the 7Q10 low flow were simulated. For each flow increment phosphorus loads from publicly-owned wastewater treatment plants (POTWs) were progressively increased beyond the 90 micrograms per liter (µg/L) allocation recommended in the TMDL. The increase in total phosphorus modeled was an additional 10, 30, and 60 µg/L. All other sources were set to maximum natural conditions as determined in the revised TMDL (Carroll and Anderson 2009).

Model simulations indicated that for flow increases of up to 50 cfs improvement in water quality in the lower Wenatchee River was negligible. For a 100 cfs flow increase, the model results suggested that lower Wenatchee River could assimilate POTW discharges of up to 120 µg/L of total phosphorus without violating the 0.1-unit measurable change (over natural conditions) criterion for pH and 0.2 milligrams per liter (mg/L) maximal decline criterion for dissolved oxygen.

Graphs showing the results of the modeling for a 100 cfs increase in flow in the Wenatchee River starting at Lake Wenatchee are provided in Appendix B. Figure B-1 shows the flow starting at the upstream extent of the model (outlet of Lake Wenatchee), Figure B-2 shows the change in DO, Figure B-3 the change in pH, Figure B-4 the change in temperature, Figure B-5 the change in TP and Figure B-6 the change in bottom algal density. Figure B-7 shows the results of comparing modeled results to natural conditions to determine the level at which the 0.1-unit measureable change criterion for pH occurs and the 0.2-mg/L maximal decline for DO occurs. The figure shows the change in pH criterion is barely met downstream of the City of Cashmere POTW for a loading of 120 µg/L (30 µg/L greater than the allocation for POTW in the TMDL) plus 100 cfs additional flow. The change in minimal DO is less than 0.1 mg/L for the entire reach modeled.

The results of the modeling indicate the flows would have to be substantially increased to provide much change in water quality. None of the water storage projects studied have the capacity to discharge an additional 100 cfs, so a strategy of increasing instream flows to a level to benefit water quality is not likely to be successful.

4 EVALUATION OF POTENTIAL IRRIGATION IMPROVEMENTS TO INCREASE STREAMFLOW IN THE WENATCHEE RIVER

This section summarizes the potential improvements to irrigation district infrastructure in the Wenatchee River Basin intended to reduce diversions and improve streamflows in the Wenatchee River and some of its tributaries. The costs associated with these improvements are also summarized for comparison with the other potential projects identified in this report that would also improve streamflows in the Wenatchee River and some of its tributaries.

4.1 Existing Diversions

Water metering data was collected from the Ecology for all entities that divert water within the Wenatchee River basin downstream of Leavenworth, as well as for a few large water users that divert water from tributaries to the Wenatchee River. The data was reviewed to identify the largest water users, with the intent of identifying potential diversions that could be reduced to increase streamflow by implementing water conservation improvements, such as piping or lining of open irrigation ditches to reduce water losses. The diversion data collected from Ecology is summarized by entity in Table 4-1. The large diversion by LNFH from Icicle Creek and groundwater by the hatchery is not included in Table 4-1 as it is non-consumptive; it is discharged back to Icicle Creek with very little loss of water.

Based on an evaluation of the diversion data included in Table 4-1 and consultation with Chelan County NRD, six entities were identified that divert largest volumes of surface water from the Wenatchee River or its tributaries. These entities include:

- Wenatchee Reclamation District
- Pioneer Water Users Association
- Jones-Shotwell Ditch Company
- Peshastin Irrigation District
- Icicle Irrigation District
- Wenatchee-Chiwawa Irrigation District

Potential improvements to infrastructure owned and operated by these entities are evaluated further in this section. The potential improvements are intended to improve irrigation operations and efficiency so that diversions are reduced and streamflows are increased.

Table 4-1

Washington State Department Ecology Water Metering Reports — Summary of Diversions

Entity	Volume of Water Used by Year (ac-ft)						
	2002	2003	2004	2005	2006	2007	2008
Lower Wenatchee River Subbasin (Below Leavenworth)							
City of Wenatchee (4 wells)			11,761	10,943			
Wenatchee Reclamation District	50,999	49,459	51,542	50,818	53,714	53,095	51,464
Weythman Ranch/J&W Orchards			26	32			
Pioneer Water Users Association			5,347	4,162	4,667	2,213[1]	5,031
Jones-Shotwell Ditch Company			2,162	2,640			
Fromm Family Partnership (2 locations)		289	358	213	146	207	154
Double P Orchard				295		145	
City of Cashmere (2 wells)		186	126	189	356	432	391
City of Cashmere (2 WTP)		1,013	992	913	767	710	529
Peshastin Creek Subbasin							
Peshastin Irrigation District	6,866	6,095[2]					
Icicle Creek Subbasin							
Icicle/Peshastin Irrigation District		29,637	28,249	30,940	25,340		
Cascade Orchards Irrigation Company		1,842	1,951	1,835	1,937	2,035	1,864
City of Leavenworth (Surface diversion)				429	363	249	127
City of Leavenworth (2 wells)				527	587	746	917
Chiwawa River Subbasin							
Wenatchee-Chiwawa Irrigation District				6,980	7,489	7,240	8,548

Notes:

1 Data before June 27 was missing. Normal diversions begin in early April. Data for this year was not used to calculate averages listed in Table 4-3.

2 Data was missing for the last half of May. The total volume includes an estimate of missing diversion data. The averages listed in Table 4-3 are also based on an estimate of missing diversion data.

The six irrigation diversions identified for further evaluation were mapped using Ecology's Water Right Tracking System (WRTS), which includes their water rights or claims, point of diversion or withdrawal, and place of use. Figure 5 shows the points of diversion and places of use for each irrigation entity, as mapped from Ecology's WRTS database. Table 4-2 summarizes the water right and claim data for each of these surface water diversions as listed in Ecology's WRTS database.

Table 4-2

Washington State Department of Ecology Water Right Tracking System Data

Entity	Water Right Document	Purpose	Flow Rate	Flow Volume	Area
Wenatchee Reclamation District	CS4-CCVOL1-4P341	Irrigation	200.0 cfs		13,120 acres
Pioneer Water Users Association	S4-022119CL	Domestic General, Irrigation	16.0 cfs	1,920 ac-ft	480 acres
	S4-117629CL	Domestic General, Irrigation	10.0 cfs	360 ac-ft	521 acres
Jones-Shotwell Ditch Company	S4-054495CL	Irrigation	15.0 cfs	2,000 ac-ft	400 acres
	S4-CV2P818	Irrigation	0.5 cfs		
Peshastin Irrigation District	S4-064985CL	Irrigation	4.4 cfs	550 ac-ft	110 acres
	S4-113257CL	Irrigation	3.1 cfs	620 ac-ft	155 acres
	S4-064984CL	Irrigation	50.0 cfs	15,000 ac-ft	2,258 acres
	S4-CV1P260	Irrigation	2.4 cfs		60 acres
	S4-*00329CWRIS	Irrigation	34.4 cfs		2,063 acres
Icicle Irrigation District	S4-CV1P224	Irrigation	1.75 cfs		
	S4-*35002ABBJWRIS	Irrigation	81.6 cfs	25,000 ac-ft	5,000 acres
	S4-*01825BACWRIS	Irrigation	50.0 cfs		7,000 acres
	S4-*01824CWRIS	Irrigation	25.0 cfs		7,000 acres
	S4-*01825AACWRIS	Irrigation	25.0 cfs		7,000 acres
	S4-*02751CWRIS	Irrigation	25.0 cfs		7,000 acres
	S4-*01924BBVCWRIS	Irrigation	10.0 cfs		
	R4-*01924ACCWRIS	Irrigation		2,000 ac-ft	
	R4-*02752CWRIS	Irrigation		1,000 ac-ft	
Wenatchee-Chiwawa Irrigation District	S4-200111CL	Irrigation, Stock	33.0 cfs	4,725 ac-ft	1,500 acres
	S4-28160NWRIS	Irrigation	33.3 cfs	4,725 ac-ft	1,350 acres

The diversion records summarized in Table 4-1 were used to estimate the average diversion volume and peak flow rate diverted by each irrigation entity. Average diversion volumes and flow rates for the period of record for which data was available are presented in Table 4-3.

Table 4-3
Water Use Estimates from Ecology Water Metering Reports

Entity	Years Data Available	Average Water Use	Average Diversion Days	Average Water Flow Rate	Peak Flow Rate
Wenatchee Reclamation District	2002 to 2008	51,584 ac-ft/yr	189	138 cfs	200 cfs
Pioneer Water Users Association	2004 to 2008	4,797 ac-ft/yr	193	12.6 cfs	16.4 cfs
Jones-Shotwell Ditch Company	2004 to 2005	2,401 ac-ft/yr	209	5.8 cfs	10.0 cfs
Peshastin Irrigation District	2002 to 2003	6,481 ac-ft/yr	151	21.7 cfs	39.9 cfs
Icicle Irrigation District	2003 to 2006	28,542 ac-ft/yr	168	85.7 cfs	107.8 cfs
Wenatchee-Chiwawa Irrigation District	2005 to 2009	7,578 ac-ft/yr	149	25.7 cfs	35.7 cfs

Notes:
yr = year

4.2 Potential Irrigation Improvements

The following includes brief summary of some potential irrigation improvements identified for the irrigation systems listed in the previous tables that would increase efficiency, reduce diversions, and improve streamflows in the Wenatchee River Basin. The summaries include a description of available opinions of cost, in terms of total cost and in terms of cost per acre-foot of water conserved.

4.2.1 Pioneer Water Users Association

Washington Rivers Conservancy and Chelan County NRD are working to upgrade the conveyance system and change the point of diversion for the Pioneer Water Users Association to add 15 cfs of instream flow to the lower 5.9 miles of the Wenatchee River. The project will decommission the surface diversion on the Wenatchee River located at

River Mile (RM) 5.9 and move the diversion to the Columbia River. The project will also convert 25,000 feet of open canal and 10,000 feet of older leaky pipes to 38,780 feet of pressurized pipe, which is expected to reduce the amount of water diverted to less than 7 cfs. The project is expected to cost approximately $5 million and is anticipated to be completed in 2011. Based on these costs and the estimated water use from Ecology's water metering reports, the estimated unit cost of the improvements is $1,042 per acre-foot of water annually left in the lower 7.5 miles of the Wenatchee River.

4.2.2 Jones Shotwell Ditch

The Jones-Shotwell Ditch Company has a more confined project area along the Wenatchee River, 7.6 miles upstream from the confluence of the Wenatchee and Columbia rivers. Relocating the diversion and installing a pipeline similar to the Pioneer Water Users Association project would probably not be cost-effective. However, water conservation measures on their system appear to have potential for reducing diversions as their current diversion is approximately 6 acre-feet per acre served. Crop irrigation requirements typically range from 2.5 to 3 acre-feet per acre for turf and fruit crops in the Wenatchee area (USDA 1984). Assuming 70 percent crop irrigation efficiencies for low-efficiency impact-type sprinklers, the total water deliveries should be about 4 acre-feet per acre. Based on these assumptions, it is roughly estimated that potential water savings from conservation improvements would be approximately 2 acre-foot per acre, or one-third of current diversions. That equates to an average flow rate of 1.9 cfs.

According to GIS information provided by Chelan County, the Jones Shotwell Ditch is approximately 14,500 feet long. The diversion is located on the Wenatchee River just north of the town of Monitor. The ditch extends south and east through the valley on the south side of the Wenatchee River. Based on a review of available aerial photography, it is estimated that approximately 10 percent of the ditch, or about 1,500 feet, is currently in pipe. Piping the rest of the ditch would reduce water loss and improve efficiency. A brief review of exiting topography indicates that the ditch is relatively flat from the diversion to the downstream end. In order to convey the peak diverted flow rate with a relatively flat pipeline, the size of the pipeline would need to be approximately 30-inches in diameter; however, reducing seepage loss would likely reduce the peak diversion rate, and may allow for a smaller pipeline.

Based on recent experience with pipeline projects in the area, it is anticipated that the cost of constructing 13,000 feet of 30-inch diameter pipe and appurtenances would be approximately $90 to $100 per foot, or $1.2 million to $1.3 million. With an allowance for mobilization and demobilization (10 percent); contingency (15 percent); engineering, administration, and permitting (15 percent); and taxes (8 percent), the total cost of the project would be approximately $1.8 million to $2.0 million. The resulting cost per amount of water conserved would be approximately $900,000 to $1.1 million per cfs, or $2,250 to $2,500 per acre-foot of water returned to the Wenatchee River. These unit prices may justify implementation of more targeted or less expensive conservation measures, such as only piping selected segments of the ditch where seepage loss is greatest, lining the ditch, or implementing a combination of lining and piping projects to maximize water savings while minimizing the cost of the project.

4.2.3 Wenatchee Reclamation District

Figure 5 shows the location of the Wenatchee Reclamation District's diversion and place of use. Although the diversion of the Wenatchee Reclamation District is further upstream at Dryden (RM 17.5), the place of use is spread along the downstream end of the Wenatchee River and the Columbia River. A project that has been discussed is moving the point of diversion for the service area in East Wenatchee to the Columbia River. Approximately 50 cfs is delivered to East Wenatchee through a pipeline and bridge over the Columbia River. If some or all of that delivery was pumped from the Columbia River, the flow in the Wenatchee River would be improved for the lower 17.5 miles. The project would require upgrades of the district's main canal to operate at a lower diversion rate, replacement of the canal system in East Wenatchee and construction of a pumping station on the Columbia River. Besides the infrastructure required, the district would not want to pay for the additional operational costs of the pump station. At this time, that potential project has not progressed and would not without support from the Wenatchee Reclamation District.

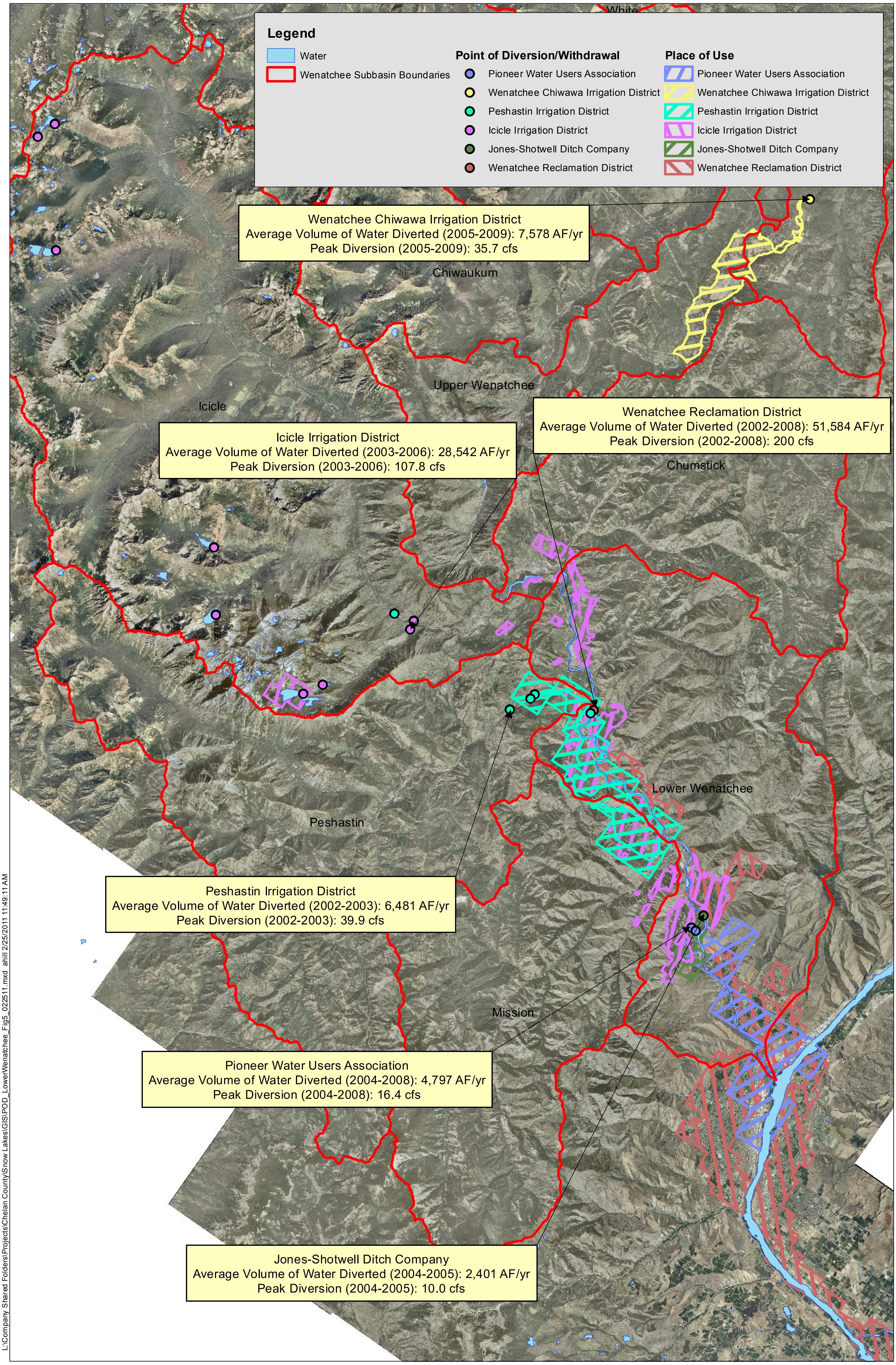

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Figure 5
Points of Diversion and Area of Use
for Large Surface Water Users
Wenatchee River Basin Storage Study

4.2.4 Peshastin Irrigation District

Peshastin Irrigation District diverts water from Peshastin Creek, approximately 2.5 miles upstream of its confluence with the Wenatchee River. The Peshastin Irrigation District Ditch extends from the diversion approximately 13 miles along the south side of the Wenatchee River Valley to the town of Cashmere. Peshastin Irrigation District has been actively working on improving their ditch system. They have replaced more than 10,000 feet of their existing ditch with 36-inch and 24-inch diameter corrugated HDPE pipe downstream of the Brender Canyon Spill. An additional 4,000 feet of pipeline has been designed and is scheduled to be constructed following the 2011 irrigation season. That project will complete piping of the Peshastin Irrigation District Ditch downstream of Brender Canyon.

The *Peshastin Irrigation District Comprehensive Conservation Plan* (Klohn Leonoff 1993) indicated that eliminating seepage and operational spills by completely piping or lining the Peshastin Irrigation District Ditch could save approximately 10 cfs during peak flows. Estimated water savings from piping projects that have been installed or are slated for construction downstream of Brender Canyon are estimated at approximately 3 cfs. Piping or lining the Peshastin Irrigation District Ditch upstream of Brender Canyon could result in an additional 7 cfs of water savings, or 2,093 acre-feet over a 151-day irrigation season.

The most recently constructed project included 6,000 feet of 36-inch diameter low-head corrugated high-density polyethylene (HDPE) pipe. Based on the bids received for that project, the estimated cost of installing 36-inch diameter pipeline with all associated items and appurtenances is within the range of $105 to $135 per linear foot. The estimated cost of constructing 36-inch diameter pipe in the 55,000 feet of open ditch upstream of Brender Spill would be approximately $5.8 million to $7.4 million. With an allowance for mobilization and demobilization (10 percent); contingency (15 percent); engineering, administration, and permitting (15 percent); and taxes (8 percent), the total cost of the project would be approximately $9.0 million to $11.4 million. The resulting cost per amount of water conserved would be approximately $1.3 million to $1.6 million per cfs, or $4,300 to $5,500 per acre-foot of water returned to the Peshastin Creek. These unit prices may also justify implementation of more targeted or less expensive conservation measures, such as only piping selected segments of the ditch where seepage loss is greatest, lining the ditch, or implementing a combination of lining and piping projects to maximize water savings while minimizing the cost of the project.

4.2.5 Icicle Irrigation District

Icicle Irrigation District diverts water from Icicle Creek, approximately 5.7 miles upstream of its confluence with the Wenatchee River. Icicle Irrigation District includes approximately 37 total miles of ditches, tunnels, and pipeline on both the north and south sides of the Wenatchee River, extending from the diversion on Icicle Creek down to Monitor on the Lower Wenatchee River. The ditch system is divided up into 6 divisions, as follows:

- Division 1 includes the main ditch from the diversion to a spill at the Wenatchee River on the south side of Leavenworth.
- Division 2 includes the main ditch from the Leavenworth Spill to a siphon at Peshastin Creek.
- Division 3A includes the main ditch from the Peshastin Siphon to another siphon at Brender Canyon.
- Division 3B includes the remaining portion of the main ditch, from Brender Canyon to the end of the canal south of the town of Monitor.
- Division 4 includes a branch of the ditch on the north side of the Wenatchee River from a siphon under the Wenatchee River to the downstream end of the ditch at Williams Canyon.
- Division 5 includes another branch of the ditch on the north side of the Wenatchee River that extends from the Wenatchee River Siphon to the north side of Leavenworth

The *Icicle Irrigation District Comprehensive Conservation Plan* (Klohn Leonoff 1993) provided an estimate of conveyance efficiencies for each division of the ditch system and recommended improvements to increase efficiency. The following summarizes the capacity and estimated conveyance efficiency of each division, as identified in the Conservation Plan:

- **Division 1 –** The capacity of Division 1 was estimated at 125 cfs upstream and 100 cfs downstream. The estimated loss was 4 percent.
- **Division 2 –** The capacity of Division 2 was estimated at 75 cfs upstream and 65 cfs downstream. The estimated loss was 10 percent.

- **Division 3A –** The capacity of Division 3A was estimated at 30 cfs upstream and 26 cfs downstream. The estimated loss was 7 percent.
- **Division 3B –** The capacity of Division 3B was estimated at 18 cfs upstream. The estimated loss was 5 percent upstream of Mission Spill and 23 percent downstream.
- **Division 4 –** The capacity of Division 4 was estimated at 22 cfs upstream. The estimated loss was 20 percent.
- **Division 5 –** The capacity of Division 5 was estimated at 9 cfs upstream. The estimated loss was 27 percent.

Recommendations were made for piping or lining unlined portions of the ditch system, with priority given to Division 3A downstream of Mission Spill, Division 4, and Division 5. Icicle Irrigation District has indicated that a portion of the main ditch along Butler Hill, in Division 3B, has been piped; however, they indicated that additional improvements are needed in Division 3B from Brender Canyon to Mission Spill, and downstream of the piping installed at Butler Hill. Icicle Irrigation District also indicated that approximately 80 percent of Division 4 downstream of Derby Canyon has now been piped. Additional piping upstream of Derby Canyon would further reduce losses. Approximately half of Division 5 is already piped, but additional piping of open segments of the ditch would also further reduce losses. A more comprehensive review of Icicle Irrigation District has been recommended and will likely be completed in the near future to provide a more detailed list of recommended improvements and opinions of cost for those improvements. For the sake of comparing the cost of potential improvements for this report, the following projects have been identified:

- Replace approximately 6 additional miles of ditch in Division 3B downstream of Brender Canyon with pipe. It is assumed the pipe would range in size from 8-inch to 24-inch diameter. At an average cost of approximately $70 to $80 per foot, the additional pipe would cost approximately $2.2 million to $2.5 million to construct.
- Replace approximately 5.5 additional miles of ditch in Division 4 with pipe. It is assumed that the pipe would range in size from 8-inch to 30-inch diameter. At an average cost of approximately $80 to $90 per foot, the additional pipe would cost approximately $2.3 million to $2.6 million to construct.
- Replace approximately 1.4 additional miles of ditch in Division 5 with pipe. It is assumed that the pipe would range in size from 8-inch to 18-inch diameter. At an

average cost of approximately $50 to $60 per foot, the additional pipe would cost approximately $370,000 to $440,000.

The total estimated cost of constructing all of these piping projects would range from approximately $4.9 million to $5.6 million. With an allowance for mobilization and demobilization (10 percent); contingency (15 percent); engineering, administration, and permitting (15 percent); and taxes (8 percent), the total cost of the project would be approximately $7.6 million to $8.6 million. It is anticipated that the proposed improvements would likely reduce loss by as much as 6 cfs, or approximately 2,000 acre-feet through a 168-day irrigation season. The water saved would remain in Icicle Creek. The cost would be approximately $1.3 million to $1.4 million per cfs, or $3,800 to $4,300 per acre foot of water returned to Icicle Creek. Additional study is recommended to evaluate improvements in more detail to determine which improvements will most effectively increase conveyance efficiency and improve the operation of the Icicle Irrigation District ditch system.

4.2.6 Wenatchee-Chiwawa Irrigation District

Wenatchee-Chiwawa Irrigation District diverts water from the Chiwawa River, approximately 2.5 miles upstream of its confluence with the Wenatchee River. The Wenatchee-Chiwawa Irrigation District system includes nearly 12 total miles of ditch and pipe, extending from the diversion on the Chiwawa River to tailwater locations on the Wenatchee River south of the town of Plain. During the summertime, Wenatchee-Chiwawa Irrigation District typically maintains a diversion of approximately 33 cfs. Of the 33 cfs diverted, approximately 18 cfs is conveyed through the fish screen to the Wenatchee-Chiwawa Irrigation District ditch system. The remaining flow is returned to the river via a spillway or via the fish bypass at the fish screen. An effort is currently underway to assess the needs of the District and provide some preliminary recommendations for improvement. That effort will be summarized in the *Draft Wenatchee-Chiwawa Irrigation District Preliminary Needs Assessment* (Anchor QEA 2011). Wenatchee-Chiwawa Irrigation District has observed the following deficiencies:

- The head gates at the Wenatchee-Chiwawa Irrigation District's intake structure are old and difficult to operate. The concrete structure is old and will need to be repaired or replaced.

- The diversion canal between the intake structure and the fish screen is not screened and fish use the canal. Improvements to the spillway and diversion canal are needed to improve the access to and from the diversion canal for fish.
- The District's system includes more than 9 miles of open ditch. The District has expressed interest in replacing the upstream 2.4 miles of their main ditch with pipe.

As part of the *Draft Wenatchee-Chiwawa Irrigation District Preliminary Needs Assessment* (Anchor QEA 2011), a list of recommended improvements and opinions of cost for those improvements will be provided. The recommendations in the draft version of that report include a set of "First Priority" improvement projects that would include replacement of the existing diversion structure, upgrades to the spillway and diversion channel, and piping of approximately 12,840 feet of existing ditch from the Wenatchee-Chiwawa Irrigation District fish screen to Shugart Flats Road. The estimated cost to construct these first priority improvements would be approximately $2.45 million. Piping of an additional 9,640 feet of existing ditch from Shugart Flats Road to the Mountain Springs Siphon is recommended as a "Second Priority" improvement project, at a cost of approximately $1.81 million.

The "First Priority" projects would likely return about 3 cfs on average, or 887 acre-feet per year, to the Chiwawa River. The water savings would cost approximately $817,000 per cfs, or $2,760 per acre-foot of water saved. The "Second Priority" projects would likely return an additional 3 cfs or 887 acre-feet, on average, to the Chiwawa River. The water savings would cost approximately $603,000 per cfs, or $2,040 per acre-foot of water saved.

A final report for the Wenatchee-Chiwawa Irrigation District study will be issued in March 2011. It is anticipated that grant funding will be pursued in 2011 to implement at least a portion of the "First Priority" improvements. A refined list of recommendations and an opinion of probable costs will be included in the final version of the report. Improvements will be selected to balance costs with Wenatchee-Chiwawa Irrigation District's needs and the potential for improving the efficiency of the conveyance system.

5 COMPARE WATER STORAGE PROJECTS TO WATER RIGHT ACQUISITION STRATEGIES TO IMPROVE STREAMFLOW IN THE WENATCHEE WATERSHED

A comparison of water storage projects to other strategies, such as water right acquisition is desired to ensure that the most cost effective method of improving streamflow in the Wenatchee Watershed is pursued. This section outlines the estimated costs of several water storage concepts that have been studied as a basis for comparison of water right acquisition.

5.1 Water Storage Projects

Several potential water storage projects have been identified within the Wenatchee River Basin. The potential projects have been reviewed in several reports, including Section 1 of this report. The following sections provide a brief summary of potential storage projects within the Wenatchee River Basin.

5.1.1 Lake Wenatchee

The *Lake Wenatchee Water Storage Feasibility Study* (Montgomery Watson Harza 2003) evaluated the feasibility of placing a rubber dam near the mouth of Lake Wenatchee in order to store water in the early summer for release in the late summer. Two different maximum lake levels were studied. It was concluded that storing water at the higher level would be difficult to implement due to impacts to property and wetlands. The study indicated that storing water at the lower level would have had a total estimated cost of $7.9 million at the time of the study. At an increase of storage of 6,750 acre-feet, the total cost per acre-foot of storage would have been $1,170. The estimated water storage benefit would be 75 cfs over a 30-day period (Montgomery Watson Harza 2003).

5.1.2 Various Storage Reservoirs

The *Multi-Purpose Water Storage Assessment in the Wenatchee River Watershed* (MWG 2006) identified and evaluated 17 potential water storage projects. Opinions of probable cost were developed and water storage benefits were summarized. The projects identified in the storage assessment are listed in Table 5-1 in order of estimated cost per acre-foot of storage. The reservoirs that were identified varied in size from 5 acre-feet to 1,363 acre-feet. Estimated cost per acre-foot of storage varied from $4,917 per acre-foot to $176,159 per acre-foot (in 2006 dollars).

Table 5-1
Summary of Wenatchee Watershed Storage Projects

Project	Volume (ac-ft)	Estimated Cost (2006 dollars)	Estimated Cost (dollars/ acre-foot)	Instream Flow Benefit (cfs/30 days)
Mill Creek Instream Reservoir	1,363	6,703,000	4,917	18.9
Negro Creek Instream Reservoir	437	3,471,000	7,944	5.9
Little Camas Creek Reservoir	926	7,443,000	8,042	12.9
SW Eagle Creek Tributary Lakes	54	860,000	15,822	0.6
Eagle Creek Tributary Lakes	79	1,263,000	15,963	1.0
Campbell Creek Off-Channel Reservoir	504	9,800,000	19,454	7.1
Upper Wenatchee to Chumstick — Option 1	210	4,518,000	21,554	3.2
Upper Reach Mission Creek Lakes	51	1,259,000	24,674	0.5
Nahahum Canyon Off-Channel Reservoir	165	4,226,000	25,623	2.3
Ingalls Creek Off-Channel Reservoir	258	6,645,000	25,724	3.5
East Van Creek Off-Channel Reservoir	99	3,026,000	30,685	1.3
Tronsen Creek Off-Channel Reservoir	175	8,629,000	49,397	2.4
East Fork Mission Creek Reservoir	95	5,494,000	57,995	1.2
Williams Canyon Off-Channel Reservoir	68	4,980,000	73,424	0.9
Derby Canyon Off-Channel Reservoir	17	1,824,000	106,387	0.2
Typical 5-ac-ft Reservoir	5	633,000	126,600	0.07
Ollala Canyon Off-Channel Reservoir	9	1,614,000	176,159	0.1

Source: MWG 2006

5.1.3 Campbell Creek Reservoir

One of the reservoirs identified in Table 4-1, Campbell Creek Reservoir, has been evaluated in subsequent studies. Additional evaluations of Campbell Creek Reservoir were completed for the *Peshastin Subbasin Needs and Alternatives Study* (Anchor 2007) and the *Campbell Creek Reservoir Feasibility Study* (Anchor QEA 2010). The recently-completed feasibility study concluded that the project could not progress beyond conceptual design at this time due to property owner concerns; however, costs updated for the feasibility study indicated that the proposed 1,000 acre-foot reservoir would cost approximately $18.4 million dollars, or $18,400 per acre-foot of storage. The water supply benefit would be approximately 16 cfs for 30 days if all the water in the reservoir were dedicated to increasing instream flow.

5.1.4 Snow Lakes Storage

The potential Snow Lakes storage project described in Section 1 could provide 1,079 acre-feet of storage at a cost of approximately $1,138 per acre-foot. The water supply benefit would be 18 cfs for 30 days.

5.2 Water Right Acquisition Strategy

For this strategy, water rights would be acquired by purchasing or leasing existing rights from willing sellers in the Wenatchee Watershed. The cost of purchasing or leasing a water right is dependent on priority date and whether it can be impaired by more senior water users, the amount of consumptive use, the point of diversion, the owner's access to alternative water sources, and the transferability of the water right to other places of use. The water right must be shown to not have been abandoned or relinquished due to non-use. Assuming the water rights acquired will be used to increase in-stream flows in the source river/creek (a non-consumptive use that would substantially enhance or protect the quality of the natural environment), Ecology would process an application to change the use to instream purposes using an expedited process.

The Columbia Basin Water Transactions Program (CBWTP) was started in 2002 to support water transactions that improve flows to streams and rivers within the Columbia River Basin. The program's website (http://www.cbwtp.org/; CBWTP 2010) lists past water rights transactions that have used program funding to purchase or lease water rights for instream flows. No transactions are listed within the Wenatchee Watershed; other watersheds in Washington State have water right transactions listed on the website. Table 5-2 lists water right transactions from the CBWTP website for Washington State (CBWTP, 2010).

Table 5-2

Summary of Area Water Right Transactions through Columbia Basin Water Transactions Program

Date of Transaction Submission	Primary Benefited Stream	River Tributary	Instream Use Time Period	Length of Term (yrs)	Primary Instream Flow Increase (cfs)	Primary Instream Flow Volume Increase (ac-ft/yr)	Secondary Instream Flow Increase (cfs)	Secondary Instream Flow Volume Increase (ac-ft/yr)	Water Cost	Cost per Primary ac-ft Increase	Cost per Secondary ac-ft Increase
2/19/2010	Teanaway River	Yakima River	5/1 to 9/15	1	1.80	291.8	0.51	86.6	$11,670	$40 $40/yr	$135 $135/yr
2/17/2010	Teanaway River	Yakima River	5/1 to 9/15	1	4.80	1,527.5	2.50	431.8	$71,205	$47 $47/yr	$165 $165/yr
1/15/2010	Touchet River	Walla Walla River	5/1 to 11/5	1	2.08	239.0	2.00	239.0	$7,768	$33 $33/yr	$33 $33/yr
10/21/2009	Salmon Creek	Okanogan River	4/1 to 9/30	9	29.9	1200	0	0	$777,600	$648 $72/yr	-
10/15/2009	Beaver Creek	Methow River	8/1 to 9/15	100 (Permanent)	0.70	65.0	0.40	40.0	$85,000	$1,308	$2,125
10/14/2009	Taneum Creek	Columbia River	4/1 to 10/31	100 (Permanent)	1.36	309.4	0.56	115.3	$166,445	$538	$1,443
9/10/2009	Touchet River	Walla Walla River	4/1 to 4/1	4	0.40	73.5	0.40	73.5	$9,555	$130 $33/yr	$130 $33/yr
8/18/2009	Methow River	Columbia River	4/1 to 10/31	10	1.23	521.2	0	0	$45,000	$86 $9/yr	-
6/15/2009	Teanaway River	Yakima River	8/13 to 9/15	1	0.37	29.6	0	23.3	$1,330	$45 $45/yr	$57 $57/yr
3/6/2009	North Fork Teanaway River	Yakima River	5/1 to 9/15	3	0.05	13.4	0.02	5.8	$1,403	$105 $35/yr	$242 $81/yr
3/5/2009	Methow River	Columbia River	5/1 to 10/15	100 (Permanent)	0.50	168.0	0	0	$131,220	$781	-
3/5/2009	Teanaway River	Yakima River	5/1 to 9/15	1	5.80	1,527.0	2.18	470.0	$42,865	$28 $28/yr	$91 $91/yr
3/3/2009	Poorman Creek	Twisp River	4/15 to 10/31	1	10.50	571.8	0	0	$86,490	$151 $151/yr	-
2/6/2009	Touchet River	Walla Walla River	4/1 to 4/1	100 (Permanent)	3.00	455.6	2.80	387.3	$232,380	$510	$600
11/12/2008	Chewuch River	Methow River	7/15 to 10/1	1	22.40	3,113.8	0	0	$140,621	$45 $45/yr	-
11/12/2008	Chewuch River	Methow River	7/15 to 10/1	100 (Permanent)	0.50	153.0	0	0	$193,063	$1,262	-
11/11/2008	Wolf Creek	Methow River, Columbia River	3/15 to 10/31	100 (Permanent)	1.00	200.0	0	0	$131,994	$660	-
11/10/2008	Methow River	Columbia River	5/1 to 10/15	100 (Permanent)	0.69	342.0	0	0	$95,000	$278	-
11/10/2008	North Fork Teanaway River	Yakima River	5/1 to 9/15	3	0.04	9.5	0.02	4.2	$1,000	$105 $35/yr	$240 $80/yr
8/25/2008	Mill Creek	Walla Walla River	4/1 to 10/15	5	0.40	50.0	0.30	40.0	$0 (Donation)	-	-
8/12/2008	South Fork Cowiche Creek	Cowiche Creek	4/1 to 10/31	5	0.48	96.0	0.33	74.0	$0 (Donation)	-	-
8/7/2008	Manastash Creek	Yakima River	4/1 to 10/31	100 (Permanent)	1.70	254.8	0	0	$364,192	$1,429	-

Date of Transaction Submission	Primary Benefited Stream	River Tributary	Instream Use Time Period	Length of Term (yrs)	Primary Instream Flow Increase (cfs)	Primary Instream Flow Volume Increase (ac-ft/yr)	Secondary Instream Flow Increase (cfs)	Secondary Instream Flow Volume Increase (ac-ft/yr)	Water Cost	Cost per Primary ac-ft Increase	Cost per Secondary ac-ft Increase
8/6/2008	Entiat River	Columbia River	4/15 to 10/31	3	0.3	60	0.17	31.56	$0 (Donation)	-	-
8/5/2008	North Fork Walla Walla River	Walla Walla River	7/10 to 8/31	5	0.57	59.0	0.17	15.2	$8,500	$144 $29/yr	$561 $112/yr
8/4/2008	Salmon Creek	Okanogan River	4/1 to 9/30	1	29.9	700	0	0	$50,400	$72 $72/yr	-
3/14/2008	North Fork Teanaway River	Yakima River	5/1 to 9/15	7	1.22	244.0	0.62	95.5	$53,282	$218 $31/yr	$558 $80/yr
3/10/2008	McCartney Creek	Rattlesnake Creek	4/1 to 10/31	10	0.28	110	0.28	110	$0 (Donation)	-	-
3/4/2008	Hancock Springs	Methow River	4/1 to 10/15	5	0.50	88.1	0.30	34.7	$0 (Donation)	-	-
11/1/2007	Teanaway	Yakima	8/1 to 9/15	15	0.56	36.6	0.26	28.0	$43,110	$1,177 $78/yr	$1,539 $103/yr
10/31/2007	Salmon Creek	Okanogan River	4/1 to 9/30	1	25	693	0	0	$48,896	$71 $71/yr	-
10/28/2007	Manastash Creek	Yakima River	4/1 to 10/31	100 (Permanent)	0.04	15.0	0	0	$20,505	$1,367	-
10/28/2007	Manastash Creek	Yakima River	4/1 to 10/31	100 (Permanent)	0.09	32.0	0	0	$43,744	$1,367	-
10/28/2007	Manastash Creek	Yakima River	4/1 to 10/31	100 (Permanent)	0.08	26.0	0	0	$35,542	$1,367	-
10/28/2007	Manastash Creek	Yakima River	4/1 to 10/31	100 (Permanent)	0.06	20.0	0	0	$27,340	$1,367	-
10/28/2007	Manastash Creek	Yakima River	4/1 to 10/31	100 (Permanent)	2.80	844.2	0	0	$844,230	$1,000	-
10/27/2007	Chewuch River	Methow River	7/15 to 10/1	1	24.00	2,504.7	0	0	$114,762	$46 $46/yr	-
5/15/2007	Twisp River	Methow River	5/15 to 10/1	3	0.19	25.3	0.19	17.7	$2,250	$89 $30/yr	$127 $42/yr
3/1/2007	Salmon Creek	Okanogan River	4/1 to 9/30	1	25	700	0	0	$25,200	$36 $36/year	-
2/27/2007	Okanogan River	Columbia River	4/1 to 10/1	100 (Permanent)	0.2	30	0.12	22.4	$45,000	$1,500	$2,009
2/27/2007	Methow River	Columbia River	4/15 to 11/1	3	0.37	51.3	0	0	$8,090	$158 $53/yr	-
2/20/2007	Touchet River	Walla Walla River	4/1 to 4/1	2	1.89	189.0	1.12	143.0	$9,475	$50 $25/yr	$66 $33/yr
2/20/2007	Mill Creek	Walla Walla River	4/1 to 10/31	100 (Permanent)	0.40	119.6	0.30	83.9	$59,800	$500	$713
10/31/2006	Walla Walla River	Columbia River	7/10 to 10/31	3	0.19	46.4	0	0	$1,734	$37 $12/yr	-
5/10/2006	Methow River	Columbia River	5/1 to 10/15	100 (Permanent)	4.01	1,098.0	0	0	$327,126	$298	-
5/8/2006	Beaver Creek	Methow River	1/5 to 9/15	1	0.50	76.0	0.13	36.6	$3,800	$50 $50/yr	$104 $104/yr
5/8/2006	Touchet River	Walla Walla River	1/1 to 12/31	1	1.89	149.0	1.56	100.6	$3,521	$24 $24/yr	$35 $35/yr
4/26/2006	Teanaway	Yakima	5/1 to 9/15	15	0.37	115.2	0.19	32.0	$65,356	$567 $38/yr	$2,041 $136/yr

Date of Transaction Submission	Primary Benefited Stream	River Tributary	Instream Use Time Period	Length of Term (yrs)	Primary Instream Flow Increase (cfs)	Primary Instream Flow Volume Increase (ac-ft/yr)	Secondary Instream Flow Increase (cfs)	Secondary Instream Flow Volume Increase (ac-ft/yr)	Water Cost	Cost per Primary ac-ft Increase	Cost per Secondary ac-ft Increase
3/3/2006	Frazer Creek	Beaver Creek	5/1 to 9/15	3	0.10	28.6	0.10	19.9	$2,520	$88 $29/yr	$127 $42/yr
2/26/2006	South Fork Cowiche Creek	Cowiche Creek	4/1 to 7/10	100 (Permanent)	0.82	164.0	0.54	61.6	$61,600	$376	$1,000
2/17/2006			5/1 to 9/15	2	0.18	36.0	0.09	13.0	$1,994	$55 $28/yr	$153 $77/yr
2/17/2006	Entiat River	Columbia River	4/15 to 10/31	3	0.3	60	0.17	31.56	$0 (Donation)	-	-
12/9/2005	Teanaway River	Yakima River	8/1 to 9/15	5	0.51	45.0	0.38	31.4	$9,000	$200 $40/yr	$287 $57/yr
12/9/2005	North Fork Teanaway River	Teanaway River	5/1 to 9/15	4	0.53	106.9	0.28	42.8	$14,963	$140 $35/yr	$350 $88/yr
12/8/2005	Walla Walla River	Columbia River	1/1 to 12/31	100 (Permanent)	0.33	-	0	0	$45,000	-	-
6/26/2005	Middle Fork Gold Creek	Gold Creek	4/15 to 9/15	1	0.50	20.0	0	0	$0 (Donation)	-	-
6/16/2005	Methow River	Columbia River	4/1 to 10/1	1	2.53	683.1	0	0	$0 (Donation)	-	-
6/15/2005	Methow River	Columbia River	4/15 to 9/15	1	1.29	166.8	0.69	0	$3,942	$24 $24/yr	-
4/22/2005	NF Teanaway River	Teanaway River	5/1 to 9/15	5	1.33	264.4	0.36	99.2	$46,270	$175 $35/yr	$467 $93/yr
4/20/2005	Beaver Creek	Methow River	5/1 to 8/15	1	0.50	76.0	0.13	36.6	$0 (Donation)	-	-
4/20/2005	Teanaway	Yakima	7/8 to 9/15	1	1.53	193.2	0	53.2	$6,762	$35 $35/yr	$127 $127/yr
1/26/2005	Libby creek	Mehtow river	4/1 to 11/1	7	0.63	97.0	0	0	$49,351	$509 $73/yr	-
1/26/2005	Touchet River	Walla Walla River	4/1 to 9/15	1	1.12	145.2	0	0	$5,075	$35 $35/yr	-
1/23/2005	Taneum Creek	Yakima River	11/16 to Feb 19	100 (Permanent)	28.80	5,427.0	0	0	$830,316	$153	-
1/16/2005	Teanaway River	Yakima River	7/27 to 9/15	30	1.80	356.1	0	38.6	$46,750	$131 $4/yr	$1,211 $40/yr
4/2/2004	North Fork Walla Walla River	Walla Walla River	7/10 to 8/31	5	0.57	59.8	0	0	$7,650	$128 $26/yr	-
1/20/2004	Touchet River	Walla Walla River	4/5 to Jun 30	100 (Permanent)	0.89	153.9	0.77	130.8	$64,405	$419	$492
1/20/2004	South Naches Channel	Naches River	4/1 to 10/31	100 (Permanent)	0.38	112.0	0.24	55.9	$30,000	$268	$536
1/5/2004	Teanaway River	Yakima River	5/1 to 9/15	5	1.10	346.0	0.48	80.0	$38,710	$112 $22/yr	$484 $97/yr
10/27/2003	Gold Creek	Methow River	4/15 to 11/15	1	1.29	211.7	0.69	137.7	$4,554	$22 $22/yr	$33 $33/yr
10/27/2003	Libby Creek	Methow River	4/1 to 11/1	2	1.01	97.0	0.41	64.9	$14,099	$145 $73/yr	$217 $109/yr

Date of Transaction Submission	Primary Benefited Stream	River Tributary	Instream Use Time Period	Length of Term (yrs)	Primary Instream Flow Increase (cfs)	Primary Instream Flow Volume Increase (ac-ft/yr)	Secondary Instream Flow Increase (cfs)	Secondary Instream Flow Volume Increase (ac-ft/yr)	Water Cost	Cost per Primary ac-ft Increase	Cost per Secondary ac-ft Increase
10/27/2003	Teanaway River	Yakima River	5/1 to 9/1	1	0.52	172.5	0	0	$0 (Donation)	-	-
10/27/2003	Teanaway River	Yakima River	5/1 to 9/15	1	0.20	39.2	0.06	14.7	$1,215	$31 $31/yr	$83 $83/yr
10/27/2003	Teanaway River	Yakima River	5/1 to 9/15	1	1.80	575.0	0	0	$8,000	$14 $14/yr	-
10/27/2003	Teanaway River	Yakima River	5/1 to 9/15	3	0.18	36.0	0.10	12.9	$2,916	$81 $27/yr	$226 $75/yr
10/27/2003	Teanaway River	Yakima River	5/1 to 9/15	3	0.53	106.9	0.28	42.8	$9,940	$93 $31/yr	$232 $77/yr
7/15/2003	Walla Walla River	Columbia River	1/1 to 12/31	1	0.20	25.1	0	0	$0 (Donation)	-	-
6/30/2003	North Fork Teanaway River	Yakima River	5/1 to 9/15	1	1.00	200.0	0.26	71.6	$5,400	$27 $27/yr	$75 $75/yr
6/30/2003	North Fork Teanaway River	Yakima River	5/1 to 9/15	3	0.22	44.0	0.10	17.6	$3,564	$81 $27/yr	$203 $68/yr
5/30/2003	South Fork Walla Walla River	Walla Walla River	7/10 to 8/31	1	7.98	930.0	0	0	$16,586	$18 $18/yr	-
5/30/2003	Teanaway River	Yakima River	5/1 to 9/15	5	0.37	8.6	0	24.2	$2,269	$263 $53/yr	$94 $19/yr
5/30/2003	Teanaway River	Yakima River	5/1 to 9/15	1	0.20	40.0	0	15.0	$1,240	$31 $31/yr	$83 $83/yr
5/30/2003	Teanaway River	Yakima River	5/1 to 9/15	1	0.36	72.0	0	27.0	$2,232	$31 $31/yr	$83 $83/yr
5/30/2003	Teanaway River	Yakima River	5/1 to 9/15	1	0.20	40.0	0	15.0	$1,240	$31 $31/yr	$83 $83/yr
5/20/2003	Mill Creek	Walla Walla River	1/1 to 12/31	20	0.13	30.9	0.11	26.2	$12,000	$389 $19/yr	$457 $23/yr
5/4/2003	Methow River	Columbia River	4/15 to 10/15	3	0.43	64.8	0.12	45.5	$13,600	$210 $70/yr	$299 $100/yr
5/4/2003	Frazer Creek	Methow River	5/1 to 9/15	2	0.17	28.6	0.09	18.6	$1,680	$59 $30/yr	$91 $46/yr

Washington Water Trust and Trout Unlimited are listed as partners with the CBWTP on the transactions. A review of the water right transactions since 2007 was performed, and the data indicates that permanent water right transactions completed since 2007 in Washington State with CBWTP total 3,035 acre-feet. The median cost per acre-foot of these transactions was $816 with the maximum price paid $1,500. For leases, about 34,000 acre-feet have been leased since 2007 at a median cost of $46 per acre-foot per year and a maximum cost of $151. Additional water right transactions in the Columbia River Basin outside of Washington State are listed on the CBWTP website and are included in Appendix C. The median cost per acre-foot for permanent transactions since 2007 outside Washington State is $655 and the median cost for leases is $21 per acre-foot per year.

The value or cost of water leasing will depend on the demand for water and the supply in the geographic area where water right transactions occur. In areas where water supply is limited and few water rights exist to satisfy demand, costs will be higher than indicated in Table 5-2. The transactions listed in Table 5-2 may not be representative of potential costs of acquiring water rights within the Wenatchee Watershed.

Several approaches could be used to acquire water rights in the Wenatchee Watershed: one is to directly contact water right holders and negotiate the purchase or lease of water rights; leases could be for a full season or a partial season if cropping patterns allow an interruption of irrigation. Another approach is to hold an auction to attempt to purchase water. A third is to form a water bank. All three approaches have been used successfully in Washington State.

The success of a water acquisition program will depend on certain requirements, which include valid and enforceable Water Rights such as:

- Willing buyers and sellers
- Reasonable Transaction Costs
- Consideration of third party impacts
- Trust between seller and buyer

Discussion of these requirements are found in *Technical Report on Market-Based Reallocation of Water Resources Alternative* (Cascadia Law Group and ECO Northwest,

2007) and other publications such as *Analysis of Water Banks in the Western States* (Ecology and WestWater Research 2004). The Ecology website http://www.ecy.wa.gov/programs/wr/market/market.html) describes water markets in Washington State.

In the Wenatchee Watershed, most of the surface water rights and the largest water rights are held by irrigation districts. The diversions for the irrigation districts are located on the mainstem Wenatchee River and major tributaries such as the Chiwawa River, Icicle Creek, and Peshastin Creek. The surface water permits and certificates for irrigation in the Wenatchee Watershed allow for 567 cfs of instantaneous use and 39,000 acre-feet per year of annual use to irrigate over 31,000 acres. Approximately 70 percent of all the surface water rights held in the Wenatchee Watershed are for irrigation (MWG et al. 2003).

A barrier to acquiring water from irrigation districts will be the reluctance of farmers to transfer water, the time and expense required for managing the water transfer and the authority of an irrigation district board to deny water transfers out of a district. Transfers of non-consumptively used water (seepage from irrigation ditches) has been accomplished for instream flow purposes in some districts however sales or leases of water used for irrigation have not to our knowledge. For those reasons, smaller water acquisitions will need to be the target in the Wenatchee Watershed.

A likely target will be surface and groundwater used for irrigation outside of irrigation districts. While the smaller acquisitions may not affect streamflow and habitat conditions in the Wenatchee River they may have a relatively large benefit in smaller tributaries such as Chumstick Creek and Mission Creek. For example in the Mission Creek subwatershed, surface and groundwater permits and certificates exist for instantaneous use of 8.8 cfs and annual use of 1,581 acre-feet for the irrigation of about 500 acres (MWG et al. 2003). The low flow in Mission Creek measured at the Ecology gage No. 45E070 in late summer is often less than 1 cfs (Ecology 2010). An acquisition or lease of water rights for 100 acres of irrigated land in the Mission Creek subwatershed could improve instream flow by about one cfs in late summer, demonstrating the potential beneficial effect of acquiring water along small streams.

6 SUMMARY AND RECOMMENDATIONS

This report provides a preliminary summary of potential water storage projects and other water resource management strategies intended to improve the availability of water in the Wenatchee River Basin for both instream and out of stream water needs. The primary water needs in the Wenatchee River Basin include irrigation and domestic water supply and instream flows for fish passage and instream rearing and spawning habitat. This section includes a brief summary of the projects and strategies that were evaluated in this report.

6.1 Snow Lakes

A preliminary evaluation was completed of the potential for increasing storage at Snow Lakes, which are located in the Alpine Lakes Wilderness area on land managed by USFWS for the LNFH. Existing rock masonry dams at the site, along with an outlet tunnel and valve from Upper Snow Lake allow USFWS to store water and control discharges from the Upper Snow Creek watershed to Icicle Creek. The preliminary evaluation determined that raising the existing dams or constructing new dams to raise the water levels in Upper and Lower Snow Lakes by 5 feet and drawing down Lower Snow Lake by 3 feet would increase the total storage capacity of the two lakes by approximately 1,079 acre-feet. The additional storage, combined with improvements designed to provide remote control of the outlet valve, would allow for the release of an additional 18 cfs for 30 days or 9 cfs for 60 days to Icicle Creek via Snow Creek to support LFNH operations and increase instream flows in Icicle Creek and the Lower Wenatchee River. The overall cost of the project was estimated to be $1,228,000, approximately $1,138 per acre-foot of additional storage.

Additional considerations beyond just the cost and water supply benefit will determine if the project is feasible and can be implemented. Additional evaluation will need to be completed to identify potential fatal flaws or other issues that might impact the feasibility of the potential improvements to the Snow Lakes facilities. Issues that should be addressed through additional study include:

- **Land ownership –** Additional work is needed to determine the exact boundaries of the parcels owned by USFWS to determine whether the project can proceed without encroaching on the Alpine Lakes Wilderness Area.

- **Permitting –** The permitting requirements will need to be determined through discussions with USFWS, LNFH, U.S. Forest Service, Chelan County and fish agencies.
- **Downstream hazard evaluation –** Modification of the dams at the site will require additional study to determine changes to the current hazard classification. An increased hazard classification could potentially increase operational requirements and risk exposure.
- **Telemetry –** Additional analysis is needed to determine what would be required to automate operation of the existing outlet valve from Upper Snow Lake and the proposed outlet gate at Lower Snow Lake.
- **Operations and Maintenance –** Additional discussion and coordination between Chelan County, LNFH, and the irrigation districts is needed to identify who will be responsible for construction, operations, and maintenance of the new dam(s).
- **Water Rights –** Additional work is needed to determine whether the project would impact existing storage water rights.
- **Funding –** Additional work is needed to identify possible funding sources for construction, operations, and maintenance of the proposed project.
- **Technical and Constructability Issues –** A more detailed evaluation is needed to develop design details and understand construction related challenges. Ground and bathymetric surveys are required, as well as geotechnical investigations of foundation conditions along the dam alignments.

Additional evaluation of the project and further development of the design should be completed with input from stakeholders that would be impacted by the project, including Chelan County, LNFH, Icicle Irrigation District, Peshastin Irrigation District, the U.S. Forest Service, and Ecology. The stakeholders will need to be well informed and engaged in project planning and implementation.

6.2 Wenatchee River Water Quality

Model simulations were completed to estimate the impact to water quality in the Wenatchee River that would result from increasing flows by 50 to 100 cfs during low flow periods. The results indicate that for flow increments of up to 50 cfs improvement in water quality in the lower Wenatchee River was negligible. For 100 cfs flow increment, model results suggested that lower Wenatchee River could assimilate Waste Water Treatment Plant discharges of up to 120 μg/L of total phosphorus without violating the 0.1-unit measurable change (over natural conditions) criterion for pH and 0.2 mg/L-maximal decline criterion for dissolved oxygen. However, the likelihood of increasing flows in the Wenatchee River during low-flow periods to that extent is very low; none of the projects reviewed could provide that amount of flow.

6.3 Potential Irrigation Improvements

The costs and benefits of water conservation improvements to the larger irrigation systems in the Wenatchee Watershed were reviewed. Potential improvements for six irrigation systems were identified and opinions of cost for the improvements were summarized, where available. Potential improvements include piping and lining open ditches to reduce water losses, and relocating diversions to increase instream flow in critical reaches of the Wenatchee River Basin. The estimated cost of the least expensive project identified would be just over $1,000 per acre-foot of water returned to the Wenatchee River. The estimated cost of the most expensive project would be as much as $5,500 per acre-foot. The average cost of the irrigation improvements is estimated to be approximately $825,000 per cfs or $2,600 per acre-foot. Improvements to the Wenatchee Reclamation District were not included in these estimates because no costs have been developed for potential improvements and the district has not expressed interest in potential improvements that have been identified.

Additional evaluation is needed to identify and prioritize water conservation improvements to ensure that water savings are achieved in a cost effective way and stream reaches with the greatest instream flow need are prioritized.

6.4 Water Right Acquisition

Another water resource management strategy described in this report is acquisition of water rights. As part of this strategy, water rights would be acquired by purchasing or leasing existing rights from willing sellers in the Wenatchee River Basin. The water rights would be used to increase instream flows. An evaluation of water right transactions in the Washington State portion of the Columbia River Basin indicates that the median cost of

purchasing a water right was $816 with the maximum price paid $1,500. For leases, about the median cost was $46 per acre-foot per year with a maximum cost of $151.
The elements of a successful program to acquire water rights were described along with barriers to a successful water market. Most of the water rights in the Wenatchee Watershed are held by irrigation districts and a barrier to large water acquisitions will be the reluctance of farmers to transfer water, the time and expense required for managing the water transfer and the authority of an irrigation district to deny water transfers out of a district. For those reasons smaller water acquisitions will need to be the target in the Wenatchee Watershed. While the smaller acquisitions may not affect streamflow and habitat conditions in the Wenatchee River they may have a relatively large benefit in smaller tributaries such as Chumstick Creek and Mission Creek.

6.5 Comparison of Water Storage Projects to Other Strategies

Table 6-1 provides a summary of the projects that were reviewed in this report, their potential for improving instream flows in the Wenatchee River Basin, and their relative costs. In general, the storage projects would provide the largest opportunity for supplementing flows in the watershed during periods of low flow. Storage can be held and released to meet the needs of downstream users and instream flow needs. The Snow Lakes project would provide additional storage volume at a relatively low cost ($1,132 per acre-foot), as would the Lake Wenatchee Storage Improvement project ($1,170 per acre-foot). However, the Lake Wenatchee project would be extremely difficult to implement because of landowner opposition. The estimated cost for other storage reservoirs studied is much higher, greater than $4,900 per acre-foot because of site constraints and high costs for constructing lined reservoirs.

Irrigation improvements provide an opportunity to improve instream flows without major environmental impacts, permitting issues or landowner opposition. The cost of the projects average $2,600 per acre-foot, less than most small surface water reservoirs. Additional evaluation is needed to identify and prioritize water conservation improvements to ensure that water savings are achieved in a cost effective way and maximum benefit is provided to reaches with the greatest instream flow needs.

Water right acquisitions may be the least expensive strategy for improving instream flows as water rights in other Washington State basins have been acquired for a median price of $816 per acre-foot. However there will be a limited amount of water available for acquisition and this strategy should be directed towards tributaries, where small acquisitions could provide relatively large instream flow and habitat benefits.

Table 6-1
Comparison of Watershed Storage Projects and Other Strategies

Project	Volume of Storage or Annual Water Savings (ac-ft)	Estimated Cost (dollars)	Estimated Cost (dollars/ ac-ft)	Instream Flow Benefit
Storage Projects				
Snow Lakes Improvements	1,079	$1,222,000	$1,132	18 cfs for 30 Days
Lake Wenatchee Storage Improvements [1]	6,750	$7,900,000	$1,170	75 cfs for 30 Days
Campbell Creek Storage Project [2]	1,000	$18,400,000	$18,400	16 cfs for 30 Days
Other Storage Projects [3]	Varies	Varies	$4,900 to $176,200	0.1 cfs to 18.9 cfs for 30 Days
Irrigation Improvements				
Wenatchee Reclamation District	NA	NA	NA	NA
Pioneer Water Users Association	4,797	$5,000,000	$1,042	15 cfs for 161 Days
Jones-Shotwell Ditch Company	800	$1,907,000	$2,384	1.9 cfs for 209 Days
Wenatchee-Chiwawa Irrigation District	885	$2,242,000	$2,533	3 cfs for 149 Days
Icicle-Peshastin Irrigation District	2,000	$8,636,000	$4,318	6 cfs for 168 Days
Peshastin Irrigation District	2,093	$9,344,000	$4,464	7 cfs for 151 Days
Water Right Acquisition				
None defined	NA	NA	$800-$1,500	Varies depending on volume acquired

Notes:

1 Source: *Lake Wenatchee Water Storage Feasibility Study* (Montgomery Watson Harza 2003). Costs are in 2003 dollars.

2 Source: *Campbell Creek Reservoir Feasibility Study* (Anchor QEA 2010)

3 Source: *Multi-Purpose Water Storage Assessment in the Wenatchee River Watershed* (MWG 2006). Costs are in 2006 dollars.

7 REFERENCES

Anchor (Anchor Environmental, LLC), 2007. Peshastin Subbasin Needs and Alternatives Study. Prepared for Chelan County Natural Resources Department. January 2007.

Anchor QEA, LLC (Anchor QEA), 2010. Campbell Creek Reservoir Feasibility Study. Prepared for Washington State Department of Ecology and Chelan County Natural Resources Department. October 2010.

Anchor QEA, 2011. Pending. Draft Wenatchee-Chiwawa Irrigation District Preliminary Needs Assessment. Prepared for Chelan County Natural Resources Department. March 2011.

Caroll et al. (Carroll, J., S. O'Neal, and S. Golding), 2006. Wenatchee River Basin Dissolved Oxygen, pH, and Phosphorus Total Maximum Daily Load Study. Publication No. 06-03-018, Watershed Ecology Section, Environmental Assessment Program, Washington State Department of Ecology, Olympia, Washington 98504-7710.

Carroll, J. and R. Anderson, 2009. Wenatchee River Watershed Dissolved Oxygen and pH Total Maximum Daily Load, Water Quality Improvement Report. Publication No. 08-10-062, Water Quality Program, Central Regional Office, Washington Department of Ecology, Yakima, WA.

Cascadia Law Group PLLC, and ECO Northwest, 2007. Technical Report on Market-Based Reallocation of Water Resources Alternative — A Component of the Yakima River Basin Storage Feasibility Study. Ecology Publication No. 07-11-004. December 2007.

Christensen, Kent, 2010. Personal Communication with Kent Christensen, Icicle Irrigation District Board of Directors. November 2010.

CBWTP (Columbia Basin Water Transactions Program), 2010. Website. http://www.cbwtp.org/. Last accessed December 2010.

Ecology (Washington State Department of Ecology), 2010. Water measurement website. https://fortress.wa.gov/ecy/wrx/wrx/flows/regions/state.asp. Last accessed December 2010.

Ecology and WestWater Research, 2004. Analysis of Water Banks in the Western States. Ecology Publication No. 04-11-011. July 2004.

Klohn Leonoff, 1993. Icicle Irrigation District Comprehensive Conservation Plan.

MWG et al. (MWG [Montgomery Water Group, Inc.], Economic and Engineering Services, Inc., Pacific Groundwater Group, Inc.), 2003. Wenatchee River Basin Watershed Assessment. Prepared for Wenatchee Watershed Planning Unit and Chelan County Natural Resource Program. August 2003.

MWG, 2006. Multi-Purpose Water Storage Assessment in the Wenatchee River Watershed. Prepared for Chelan County Natural Resources Department. June 2006.

Montgomery Watson Harza, 2003. Lake Wenatchee Water Storage Feasibility Study. Prepared for Chelan County Natural Resources Department. June 2003.

Reclamation (U.S. Bureau of Reclamation), 2010. Upper and Lower Snow Dams Screening Level Risk Assessment. Prepared for the U.S. Department of Interior, Fish and Wildlife Service, Safety of Dams Program. July 2010.

USDA (U.S. Department of Agriculture), 2007. Washington Irrigation Guide. Last Revised September 2007.

WW Wheeler and Associates, 2009a. Lower Snow Dam Intermediate SEED Inspection Report. Prepared for the U.S. Department of Interior, Fish and Wildlife Service, Leavenworth National Fish Hatchery. February 25, 2009.

WW Wheeler and Associates, 2009b. Nada Dam: Reconstructing a Concrete Dam in the Wilderness. Prepared in conjunction with Future Engineering and Technology Group, U.S. Fish and Wildlife Service, and Leavenworth National Fish Hatchery.

Wurster, 2006. Management Recommendations for Reservoir Releases from Upper Snow Lake: Leavenworth National Fish Hatchery. Prepared for the United States Fish and Wildlife Service, Leavenworth National Fish Hatchery. 2006.

PHOTOS

PHOTOS

Photo 1. Outlet from Upper Snow Lake

Photo 2. Masonry Dam between Upper Snow Lake (on left) and Lower Snow Lake (on right)

Photo 3. Masonry Dam between Upper and Lower Snow Lake

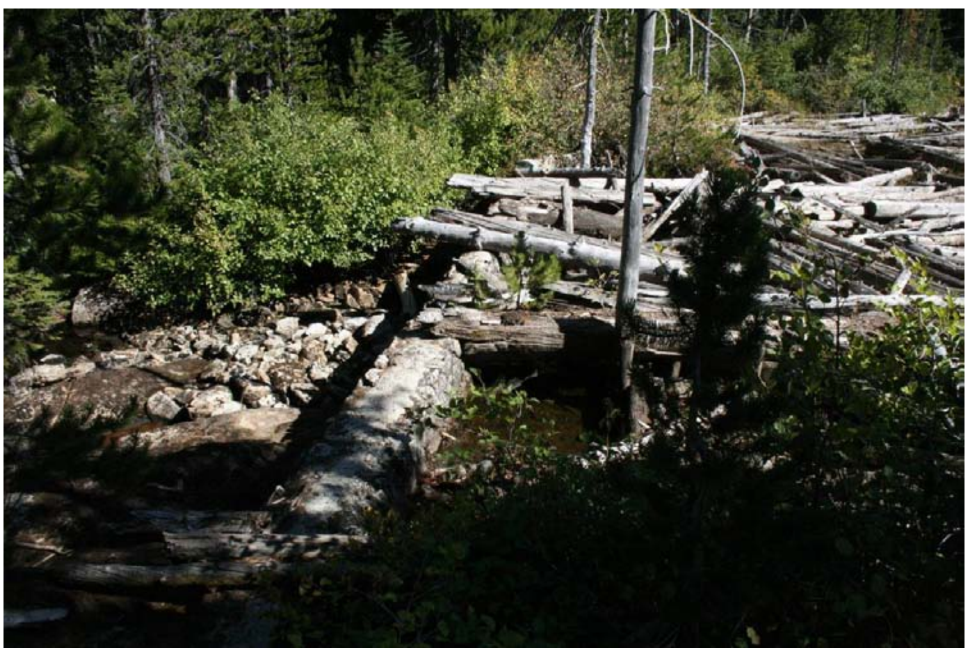

Photo 4. Masonry Dam at North End of Lower Snow Lake

Photo 5. Channel below Lower Snow Lake Dam

Photo 6. Typical Shoreline of Lower Snow Lake

(Maximum water level can be seen in discoloration of rocks, approximately 2 to 3 feet above the low level, on September 25, 2009)

Photo 7. Shoreline of Upper Snow Lake

APPENDIX A
COST ESTIMATES

Opinion of Probable Costs D. Rice
Snow Lakes Storage Improvements 28-Dec-10

ITEM	UNIT	QUANTITY	UNIT COST	COST
Site Work				
Removal of Logs and Debris at Existing Dams	LS	1	$7,000	$7,000
Clearing and Tree Removal	AC	20	$1,500	$30,000
Stripping and Stockpiling of Organic Material	CY	148	$5	$740
Diversion and Care of Water	LS	1	$20,000	$20,000
Erosion and Sediment Control	LS	1	$20,000	$20,000
Demolition/Removal of Existing Dams	LS	1	$15,000	$15,000
Subtotal - Site Work				**$92,740**
Replace/Raise Upper Snow Lake Dam				
Rock Removal for Dam Construction	CY	33	$40	$1,320
Waste of Excavated Material On Site	CY	107	$10	$1,070
Installation of Drilled Rock Anchors	LF	100	$100	$10,000
Place Reinforced Concrete for Dam	CY	86	$750	$64,500
Place Rock/Masonry Facing on Dam	SF	2,084	$45	$93,780
Install Wood Walkway On Dam Crest	SF	450	$20	$9,000
24-inch low level outlet pipe	LF	20	$175	$3,500
Flap Gate	EA	1	$4,000	$4,000
Subtotal - Replace/Raise Upper Snow Lake Dam				**$187,170**
Automation of Existing Upper Snow Lake Outlet Valve				
Motorized Valve Actuator	EA	1	$20,000	$20,000
Power Supply (Solar Panels and Battery Pack)	LS	1	$10,000	$10,000
Weatherproof Control Panel	LS	1	$5,000	$5,000
Subtotal - Automation of Existing Upper Snow Lake Outlet Valve				**$35,000**
Replace/Raise Lower Snow Lake Dam and Install Controlled Outlet				
Rock Removal for Dam Construction	CY	31	$40	$1,240
Waste of Excavated Material On Site	CY	105	$10	$1,050
Installation of Drilled Rock Anchors	LF	80	$100	$8,000
Place Reinforced Concrete for Dam	CY	78	$750	$58,500
Place Rock/Masonry Facing on Dam	SF	1,559	$45	$70,155
Install Wood Walkway On Dam Crest	SF	420	$20	$8,400
24-inch low level outlet pipe	LF	18	$175	$3,150
Sluice Gate	EA	1	$4,000	$4,000
Motorized Gate Actuator	EA	1	$15,000	$15,000
Weatherproof Control Panel	LS	1	$5,000	$5,000
Subtotal - Raise Lower Snow Lake Dam and Install Controlled Outlet				**$174,495**
Telemetry				
Telemetry - Upper Snow Lakes Outlet Valve	LS	1	$15,000	$15,000
Telemetry - Lower Snow Lakes Outlet Gate	LS	1	$15,000	$15,000
Two New Repeater Stations	LS	1	$40,000	$35,000
Subtotal - Raise Lower Snow Lake Dam and Install Controlled Outlet				**$65,000**
Subtotal				**$554,000**
Mobilization Costs (Assumes Use of Helicopter)				
Miscellaneous Mobilization/Demobilization	7.5%			$41,550
Helicopter Mobilization/Demoblization/Rental				$162,000
Construction Subtotal				**$758,000**
Contingency	30.0%			$227,400
Engineering, Permitting and Administration	20.0%			$151,600
Sales Tax	8.0%			$90,960
Total Project Cost				**$1,228,000**
Additional Storage Provided				1,079
Total Project Cost ($/Acre-foot of Additional Storage)				**$1,138**

APPENDIX B
WATER QUALITY MODEL RESULTS

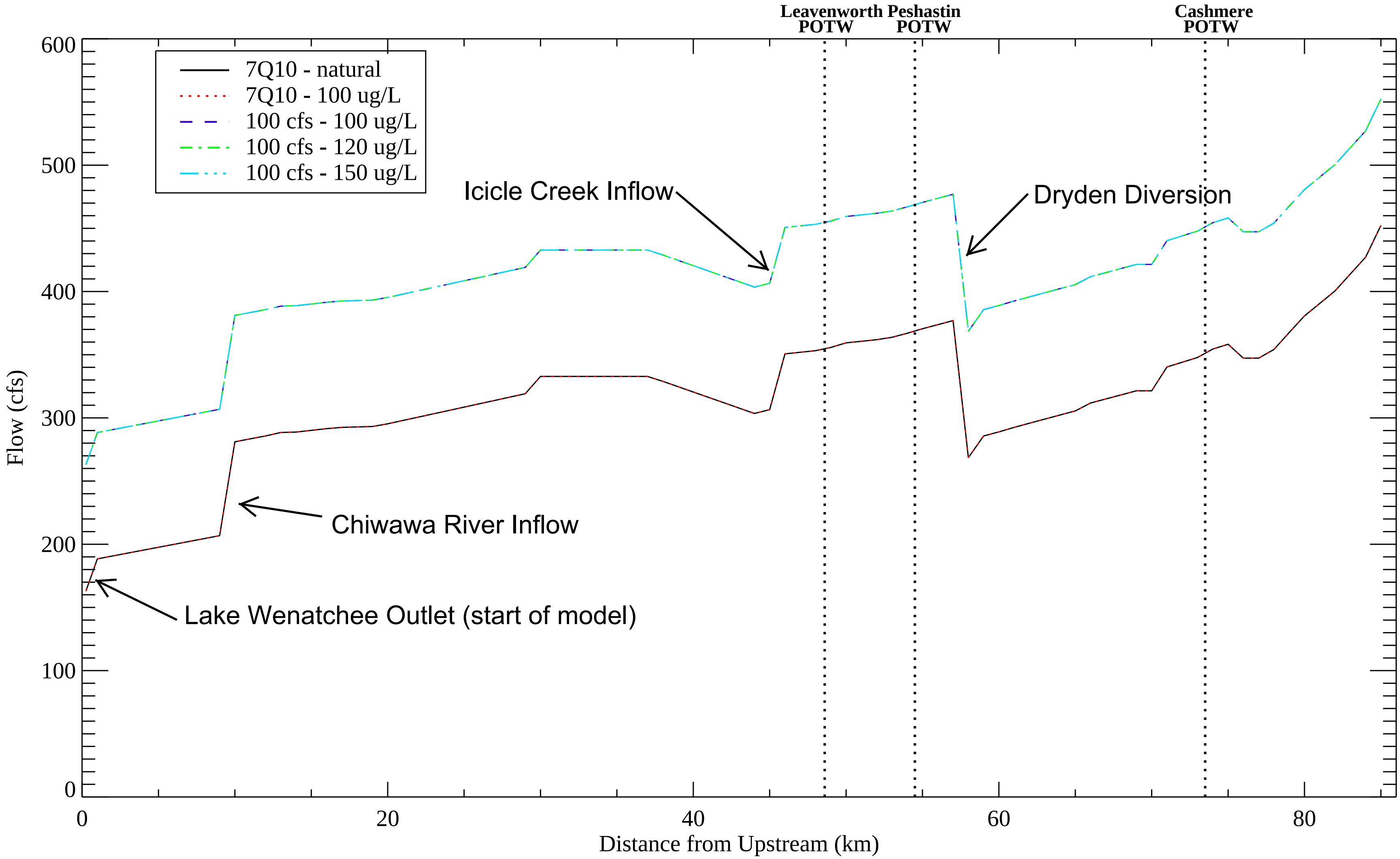

Figure B-1

Flows simulated by QUAL-2K model at different flow increments at the headwater (Lake Wenatchee outlet) shown compared to the 7Q10 low-flow simulation with maximum natural loadings in the DOE TMDL.

Phosphorus discharges from Leavenworth, Peshastin and Cashmere POTWs occured at design flow and concentrations of 100 ug/L, 120 ug/L and 150 ug/L for cases with 100 cfs flow increase.

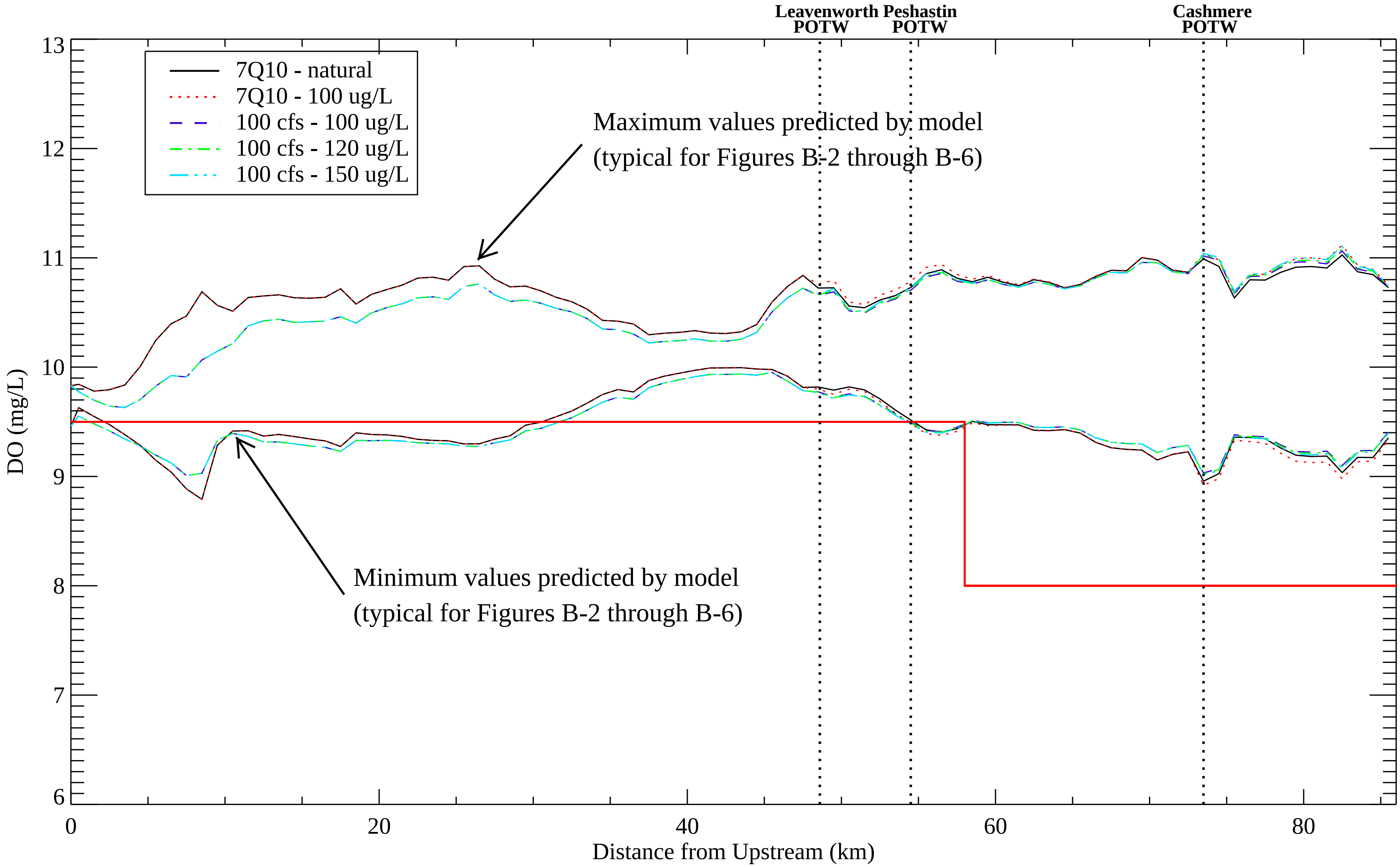

Figure B-2

Dissolved oxygen concentrations simulated by QUAL-2K model at different flow increments at the headwater (Lake Wenatchee outlet) shown compared to the 7Q10 low-flow simulation with maximum natural loadings in the DOE TMDL.

Phosphorus discharges from Leavenworth, Peshastin and Cashmere POTWs occured at design flow and concentrations of 100 ug/L, 120 ug/L and 150 ug/L for cases with 100 cfs flow increase.
Minimum and maximum values simulated by the model are shown for each flow condition.
Solid redline shows the minimum DO criterion.

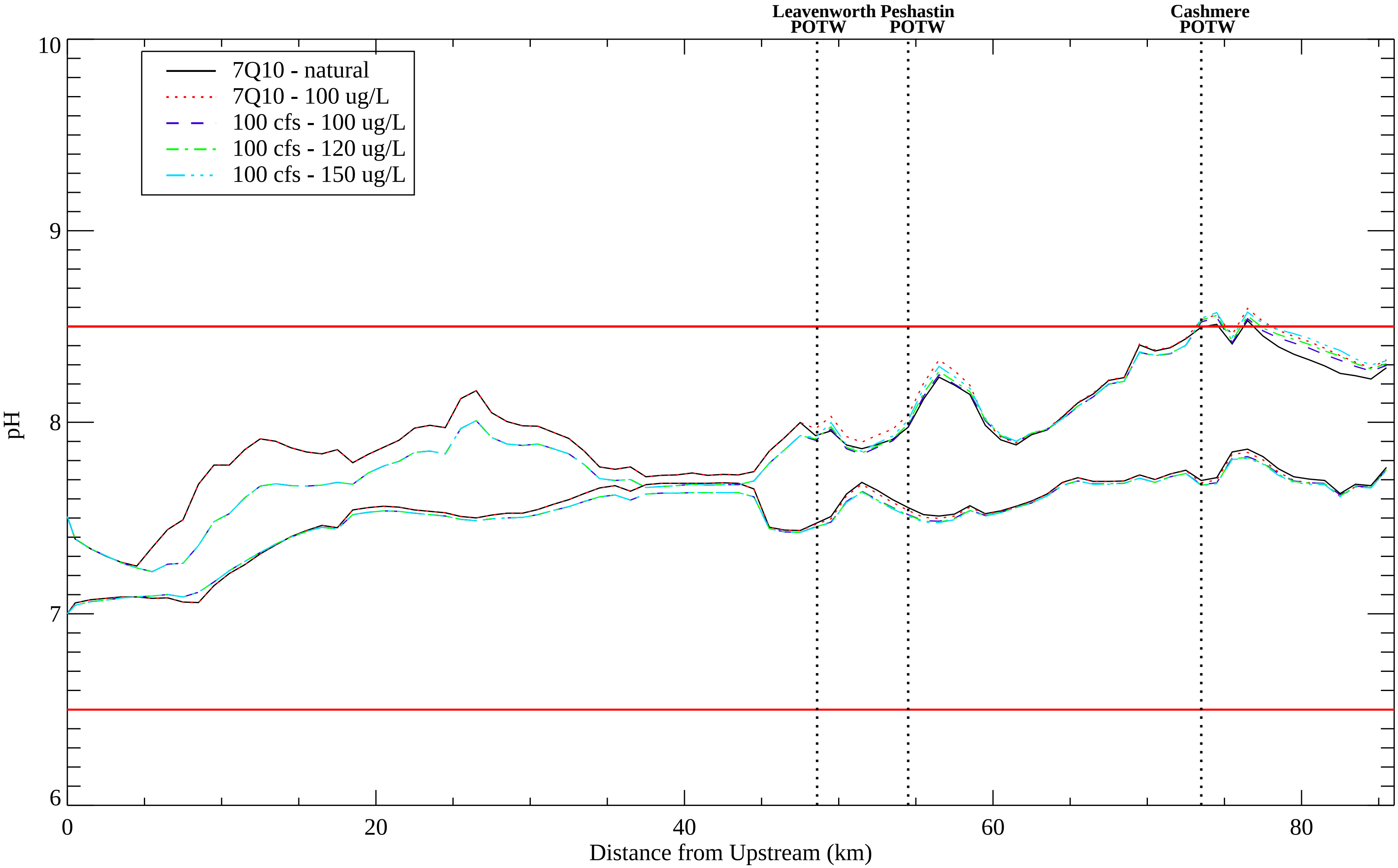

Figure B-3

pHs simulated by QUAL-2K model at different flow increments at the headwater (Lake Wenatchee outlet) shown compared to the 7Q10 low-flow simulation with maximum natural loadings in the DOE TMDL.

Phosphorus discharges from Leavenworth, Peshastin and Cashmere POTWs occured at design flow and concentrations of 100 ug/L, 120 ug/L and 150 ug/L for cases with 100 cfs flow increase.
Minimum and maximum values simulated by the model are shown for each flow condition.
Solid redlines show the minimum and maximum pH criteria.

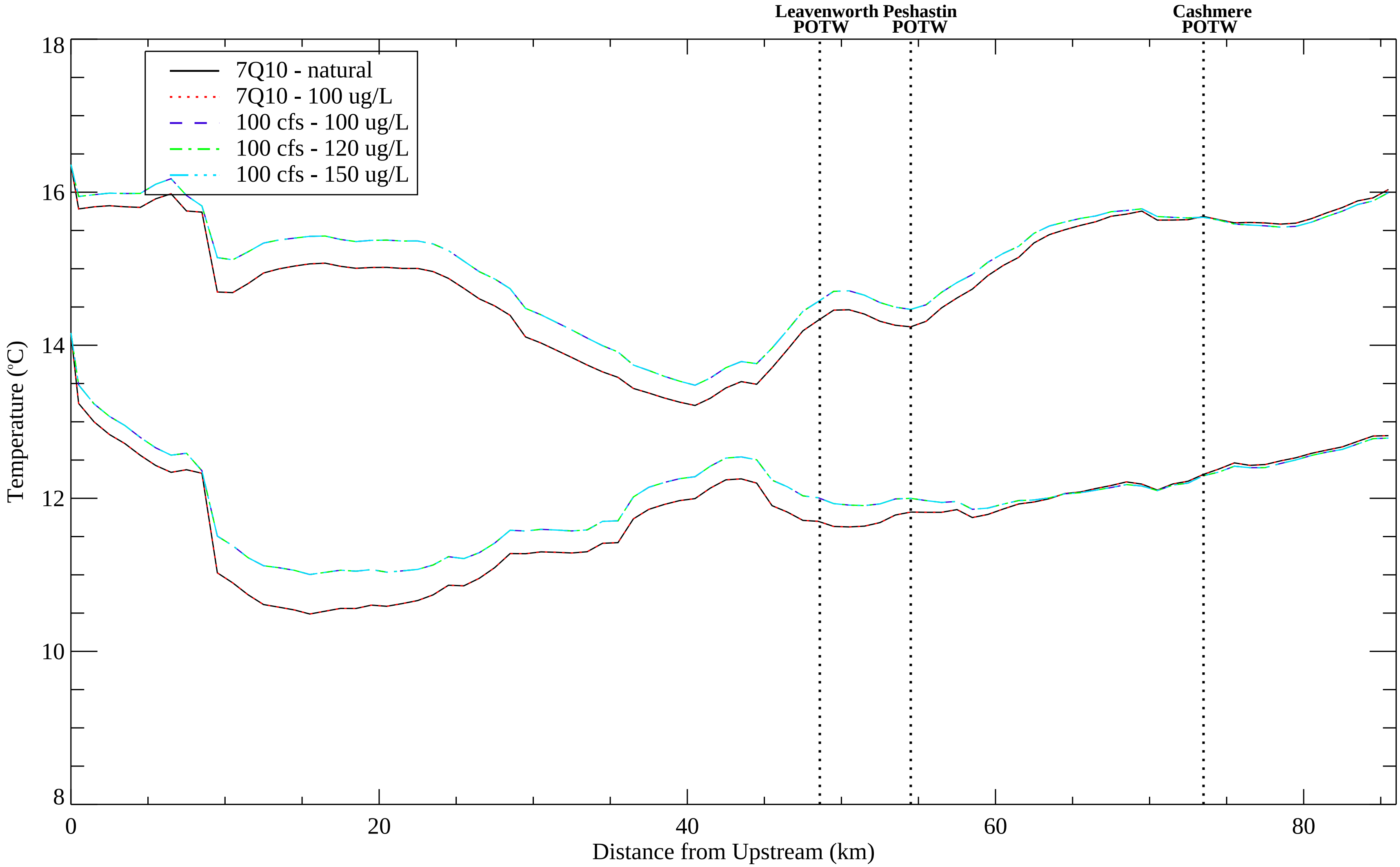

Figure B-4

Temperatures simulated by QUAL-2K model at different flow increments at the headwater (Lake Wenatchee outlet) shown compared to the 7Q10 low-flow simulation with maximum natural loadings in the DOE TMDL.

Phosphorus discharges from Leavenworth, Peshastin and Cashmere POTWs occured at design flow and concentrations of 100 ug/L, 120 ug/L and 150 ug/L for cases with 100 cfs flow increase.
Minimum and maximum values simulated by the model are shown for each flow condition.

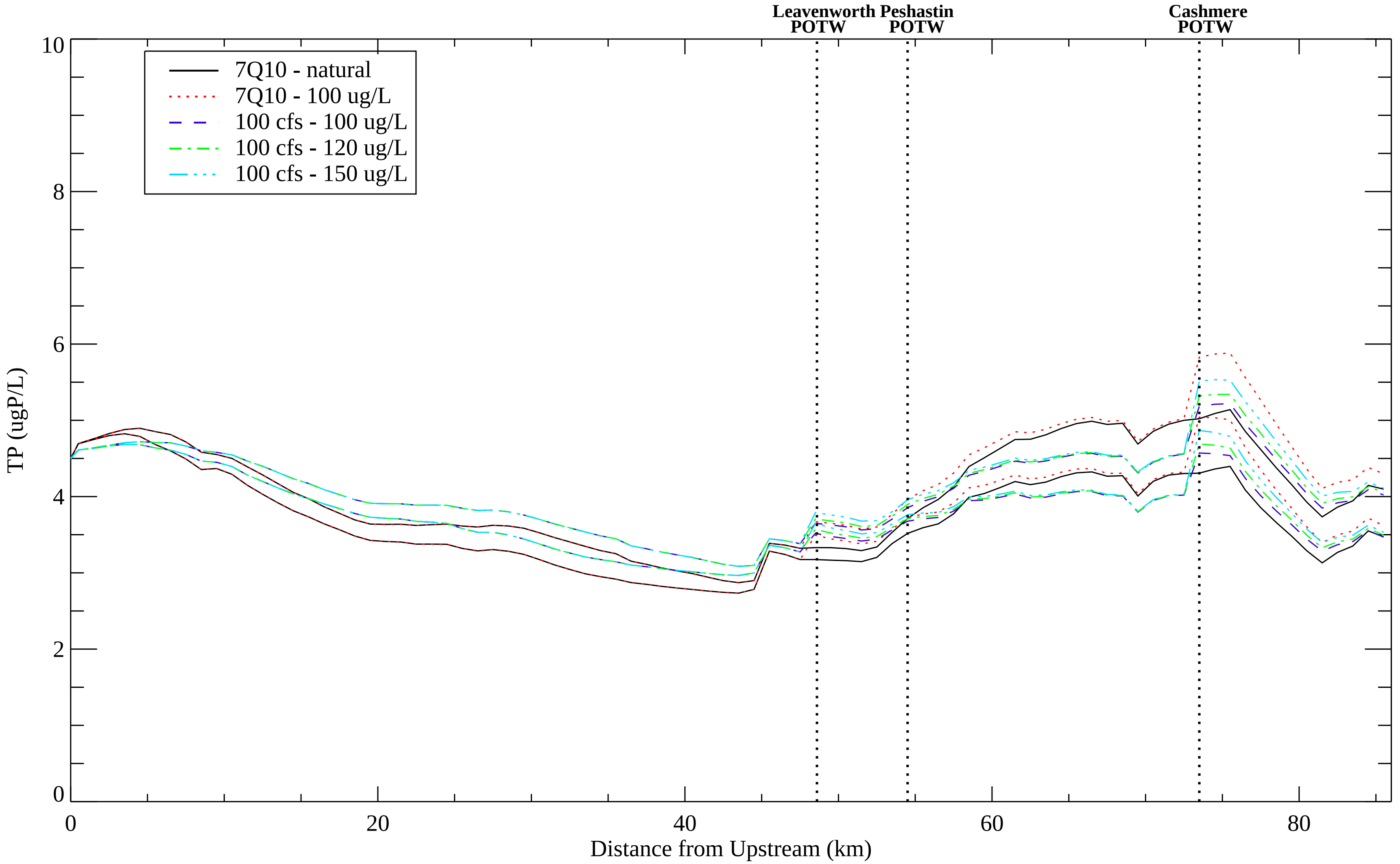

Figure B-5

Total phosphorus concentrations simulated by QUAL-2K model at different flow increments at the headwater (Lake Wenatchee outlet) shown compared to the 7Q10 low-flow simulation with maximum natural loadings in the DOE TMDL.

Phosphorus discharges from Leavenworth, Peshastin and Cashmere POTWs occured at design flow and concentrations of 100 ug/L, 120 ug/L and 150 ug/L for cases with 100 cfs flow increase.
Minimum and maximum values simulated by the model are shown for each flow condition.

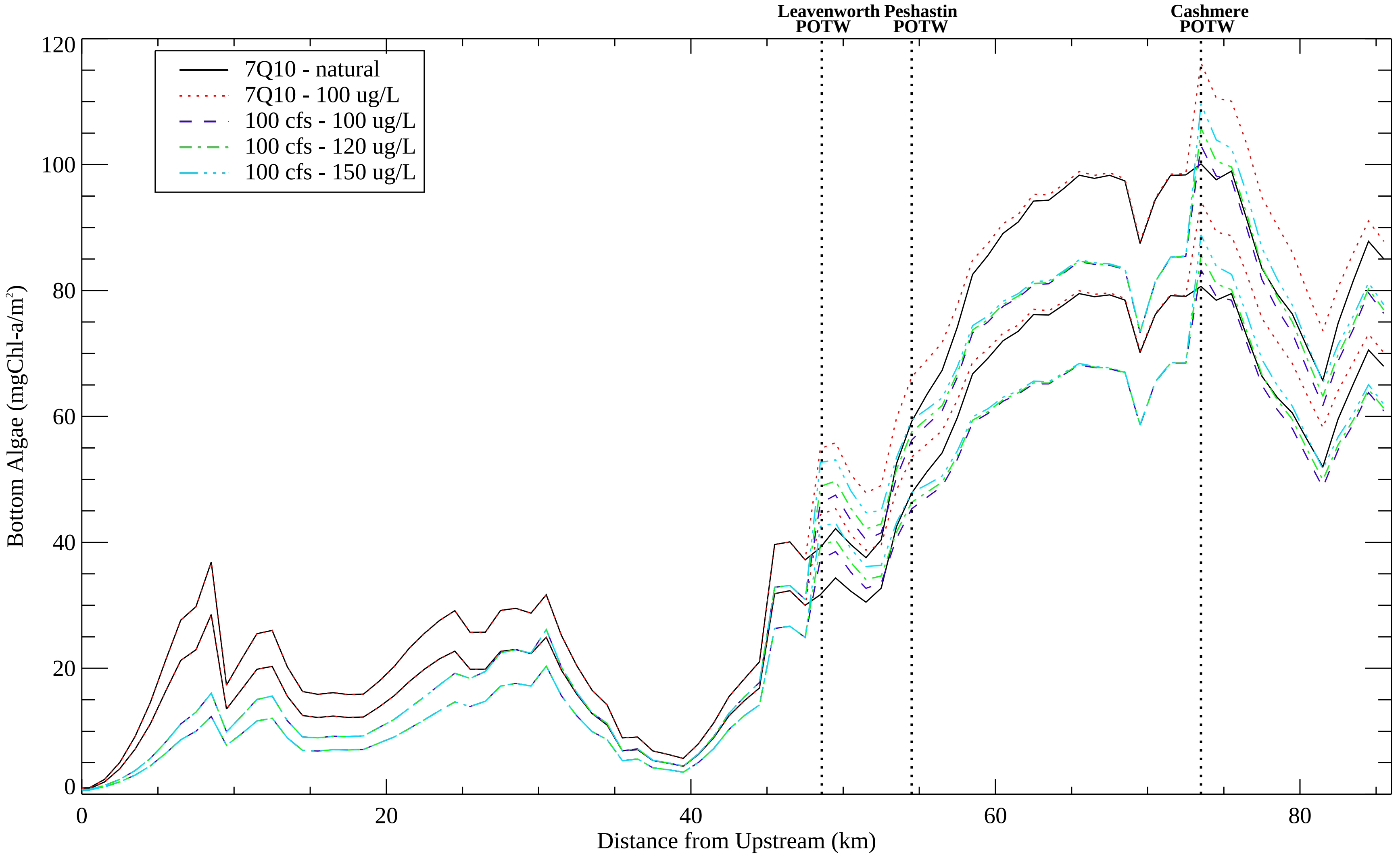

Figure B-6

Bottom algae densities simulated by QUAL-2K model at different flow increments at the headwater (Lake Wenatchee outlet) shown compared to the 7Q10 low-flow simulation with maximum natural loadings in the DOE TMDL.

Phosphorus discharges from Leavenworth, Peshastin and Cashmere POTWs occured at design flow and concentrations of 100 ug/L, 120 ug/L and 150 ug/L for cases with 100 cfs flow increase.
Minimum and maximum values simulated by the model are shown for each flow condition.

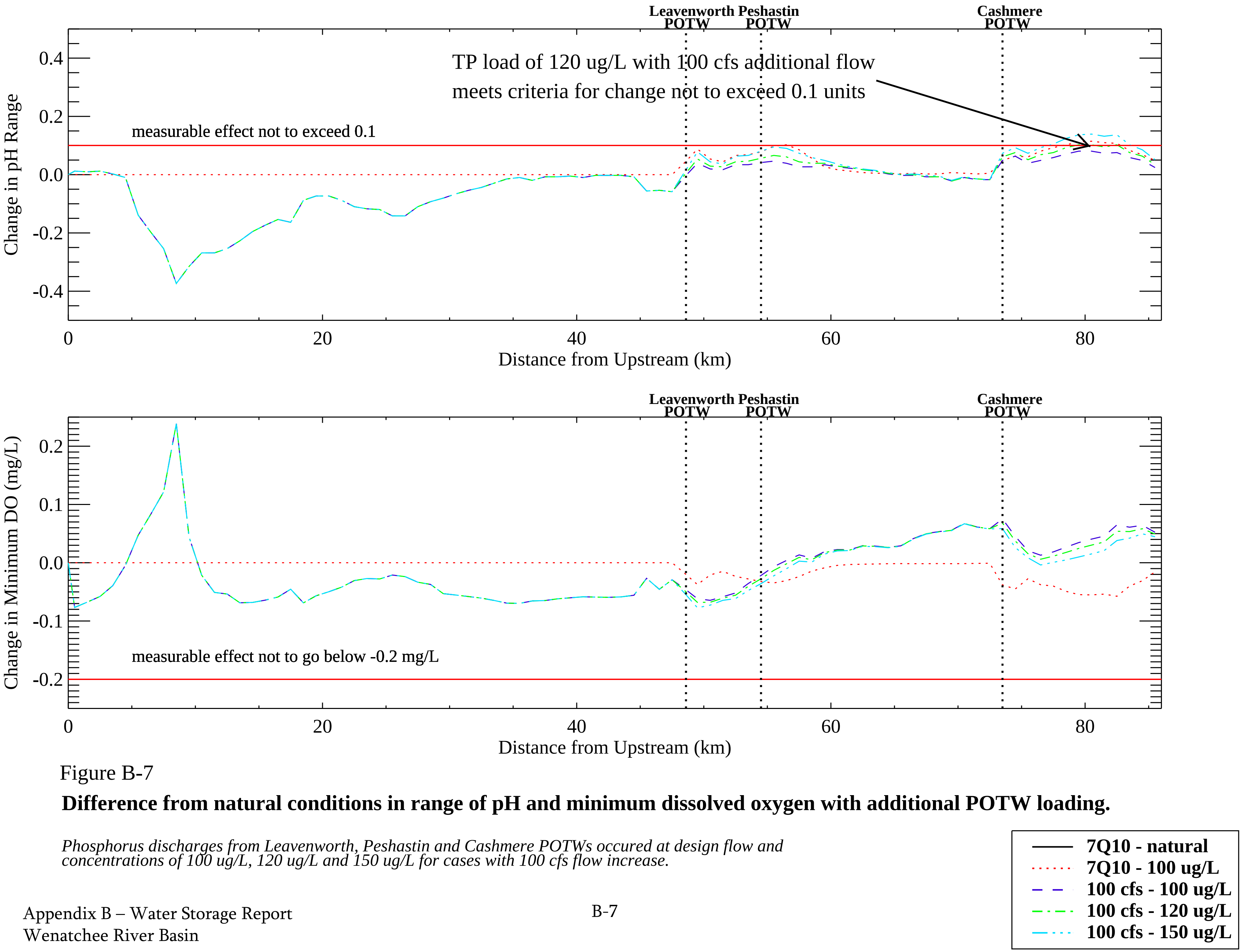

Figure B-7

Difference from natural conditions in range of pH and minimum dissolved oxygen with additional POTW loading.

Phosphorus discharges from Leavenworth, Peshastin and Cashmere POTWs occured at design flow and concentrations of 100 ug/L, 120 ug/L and 150 ug/L for cases with 100 cfs flow increase.

APPENDIX C
WATER RIGHT ACQUISITIONS OUTSIDE OF COLUMBIA RIVER BASIN

Table C-1
Summary of Water Right Acquisitions Outside of Columbia River Basin

Date of Transaction Submission	Primary Benefited Stream	River Tributary	Instream Use Time Period	Length of Term (yrs)	Primary Instream Flow Increase (cfs)	Primary Instream Flow Volume Increase (ac-ft/yr)	Secondary Instream Flow Increase (cfs)	Secondary Instream Flow Volume Increase (ac-ft/yr)	Water Cost	Cost per Primary ac-ft Increase	Cost per Secondary ac-ft Increase
2/22/2010	Placid Creek	Placid Lake	7/1 to 9/15	5	0.95	142.9	0	0	$10,000	$70 $14/yr	-
2/11/2010	Clark Fork River (upper)	Columbia River	7/15 to 10/15	1	11	0	0	0	$73,825	-	-
2/9/2010	John Day River	Columbia	7/15 to 9/30	1	0.72	110.87	0	0	$3,843	$35 $35/yr	-
1/25/2010	Big Hat Creek	Hat Creek	4/1 to 10/31	5	1.23	152.6	0.88	109	$4,360	$29 $6/yr	$40 $8/yr
1/25/2010	Lemhi River	Salmon River	3/15 to 11/15	1	17.47	173.2	0	0	$7,041	$41 $41/yr	-
12/4/2009	Hawkins Creek	Middle Fork John Day River	4/1 to 9/30	5	0.43	170.5	0	0	$8,170	$48 $10/yr	-
10/19/2009	Deschutes River	Columbia River	11/1 to 4/1	1	10	2000	0	0	$165,000	$83 $83/yr	-
10/19/2009	Standard Creek	John Day River	7/4 to 9/30	1	4.93	200	4.93	0	$11,750	$59 $59/yr	-
10/19/2009	Lemhi River	Salmon River	3/15 to 11/15	12	1.14	132.65	0	0	$3,600	$27 $2/yr	-
10/15/2009	Deschutes River (middle, lower)	Columbia River	4/1 to 11/1	1	39.74	15517.33	0	0	$269,101	$17 $17/yr	-
10/14/2009	Roberts Creek	Mainstem John Day River	7/6 to 9/30	3	7.14	816	0	0	$117,810	$144 $48/yr	-
10/14/2009	Pine Creek	John Day River	4/1 to 9/30	100 (Permanent)	1.92	506	0	0	$101,760	$201	-
10/13/2009	Big Timber Creek	Lemhi River	3/15 to 11/15	20	4.5	1707.3	4.5	1707.3	$626,672	$367 $18/yr	$367 $18/yr
10/9/2009	Rattlesnake Creek	White Salmon River	4/1 to 9/30	3	0.8	166	0.22	80	$17,430	$105 $35/yr	$218 $73/yr
6/9/2009	Big Hat Creek	Hat Creek	4/1 to 10/31	1	1.23	152.6	0.88	109	$872	$6 $6/yr	$8 $8/yr
4/15/2009	Deschutes River (middle, lower)	Columbia River	4/1 to 11/1	1	15.3	5026.6	0	0	$157,664	$31 $31/yr	-
3/6/2009	Lostine River	Wallowa River	8/22 to 9/30	3	15	1188	15	1188	$492,000	$414 $138/yr	$414 $138/yr
3/5/2009	Roberts Creek	Mainstem John Day River	7/6 to 9/30	1	7.14	816	0	0	$34,986	$43 $43/yr	-

Date of Transaction Submission	Primary Benefited Stream	River Tributary	Instream Use Time Period	Length of Term (yrs)	Primary Instream Flow Increase (cfs)	Primary Instream Flow Volume Increase (ac-ft/yr)	Secondary Instream Flow Increase (cfs)	Secondary Instream Flow Volume Increase (ac-ft/yr)	Water Cost	Cost per Primary ac-ft Increase	Cost per Secondary ac-ft Increase
3/5/2009	Morgan Creek	Salmon River	4/1 to 10/31	5	2	591	0	0	$34,613	$59 $12/yr	-
3/4/2009	Dairy Creek	Tualatin River	5/1 to 9/30	5	0.13	21	0	0	$1,575	$75 $15/yr	-
2/25/2009	Lemhi River	Salmon River	3/15 to 11/15	100 (Permanent)	0.96	121.45	0	0	$82,560	$680	-
1/29/2009	Murphy Spring Creek	North Fork Blackfoot River	7/1 to 10/15	1	2.2	556.8	0	0	$8,120	$15 $15/yr	-
1/26/2009	Lemhi River	Salmon River	3/15 to 11/15	1	17.47	173.16	0	0	$7,041	$41 $41/yr	-
11/26/2008	Lemhi River	Salmon River	3/15 to 11/15	100 (Permanent)	1.33	155.4	0	0	$114,380	$736	-
11/10/2008	Deschutes	Columbia	4/1 to 10/31	100 (Permanent)	5.95	2029.15	0	0	$1,786,089	$880	-
10/21/2008	Lemhi River	Salmon River	3/15 to 11/15	100 (Permanent)	0.73	85.05	0	0	$62,780	$738	-
10/21/2008	Lemhi River	Salmon River	3/15 to 11/15	100 (Permanent)	2.52	299.95	0	0	$216,720	$723	-
9/3/2008	Lemhi River	Salmon River	3/15 to 11/15	100 (Permanent)	1.81	211.05	0	0	$155,660	$738	-
9/3/2008	Lemhi River	Salmon River	3/15 to 11/15	100 (Permanent)	0.33	38.5	0	0	$28,380	$737	-
8/8/2008	Mud Springs Creek	Trout Creek	4/1 to 11/1	5	2.28	913.2	2.28	913.2	$139,517	$153 $31/yr	$153 $31/yr
8/8/2008	Deschutes River	Columbia River	4/1 to 9/26	100 (Permanent)	1.34	458.95	0.35	142	$207,629	$452	$1,462
8/5/2008	Deschutes	Columbia	4/1 to 10/31	100 (Permanent)	0.88	286.81	0	0	$210,049	$732	-
8/5/2008	Birch Creek	Umatilla River	5/1 to 10/29	5	0.81	292	0	0	$24,000	$82 $16/yr	-
7/30/2008	Tin Cup Creek	Bitterroot River	8/1 to 9/30	99	3.33	400	0	0	$400,000	$1,000 $10/yr	-
7/27/2008	Lemhi River	Salmon River	3/15 to 11/15	100 (Permanent)	2.25	280	0	0	$193,500	$691	-
7/16/2008	Fourth of July Creek	Salmon River	5/1 to 10/31	20	2.97	129.3	0.24	86.2	$23,705	$183 $9/yr	$275 $14/yr
3/14/2008	Fifteenmile Creek	Columbia River	7/1 to 10/29	5	0.41	99.9	0	0	$2,712	$27 $5/yr	-
11/1/2007	Deschutes River	Columbia River	4/1 to 11/1	1	72.6	23592.2	7.76	2776.2	$432,487	$18 $18/yr	$156 $156/yr
11/1/2007	Rudio Creek	North Fork John Day River	4/1 to 9/30	100 (Permanent)	2	356.4	0	0	$140,000	$393	-
10/31/2007	Pahsimeroi River	Salmon River	4/1 to 10/31	20	9.87	1169	0	0	$431,297	$369 $18/yr	-
10/8/2007	Deschutes River	Columbia River	4/1 to 11/1	100 (Permanent)	0.14	44.44	0.03	14.65	$23,882	$537	$1,630
5/15/2007	Lostine River	Wallowa River	5/1 to 9/30	100 (Permanent)	2.22	495	0	0	$137,520	$278	-
5/15/2007	Duck Springs	Pahsimeroi River	4/1 to 10/31	20	3.14	633.9	0	0	$439,612	$694 $35/yr	-

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5/15/2007	Pahsimeroi River	Salmon River	4/1 to 10/31	20	15.99	1331.8	0	0	$348,687	$262 $13/yr	-
5/14/2007	Lolo Creek	Bitterroot River	5/15 to 9/30	10	1.99	542.3	0	0	$10,000	$18 $2/yr	-
5/10/2007	Duck Springs	Pahsimeroi River	4/1 to 10/31	20	0.55	23.1	0	0	$29,098	$1,260 $63/yr	-
4/13/2007	Dayton Creek	Flathead Lake	7/15 to 10/19	1	1.42	267	0	0	$11,000	$41 $41/yr	-
4/13/2007	Ronan Creek	Dayton Creek	6/1 to 10/4	1	1.47	381	0	0	$5,950	$16 $16/yr	-
4/13/2007	Bermeister Creek	Thomas Creek	5/13 to 9/30	5	0.21	58.5	0	0	$6,552	$112 $22/yr	-
4/11/2007	Murphy Spring Creek	North Fork Blackfoot River	5/1 to 10/1	1	2.2	556.5	0	0	$8,120	$15 $15/yr	-
4/10/2007	Dayton Creek	Flathead Lake	6/1 to 9/4	1	4	160	0	0	$5,500	$34 $34/yr	-
3/26/2007	Morgan Creek	Salmon River	4/1 to 10/31	1	9.21	591	0	0	$8,865	$15 $15/yr	-
3/26/2007	Morgan Creek	Salmon River	4/1 to 10/31	1	2	297.5	0	0	$4,463	$15 $15/yr	-
3/1/2007	Keep Cool Creek	Blackfoot River	4/1 to 11/1	10	1.98	100	0	0	$25,000	$250 $25/yr	-
3/1/2007	Stonewall Creek	Keep Cool Creek	4/25 to 10/15	10	4.28	152	0	0	$38,000	$250 $25/yr	-
3/1/2007	Ninemile Creek	Clark Fork	7/1 to 10/15	1	2.58	399	0	0	$12,000	$30 $30/yr	-
2/28/2007	Ninemile Creek	Clark Fork	7/1 to 10/15	4	2.58	488.4	0	0	$60,000	$123 $31/yr	-
2/21/2007	Iron Creek	Salmon River	4/1 to 10/31	20	7.08	572.6	0	0	$364,552	$637 $32/yr	-
2/21/2007	Eighteenmile Creek	Lemhi River	3/15 to 11/15	19	7.54	877	0	0	$262,635	$299 $16/yr	-
2/19/2007	Alturas Lake Creek	Salmon River	5/1 to 9/30	1	5.86	300.8	0.54	200.8	$5,000	$17 $17/yr	$25 $25/yr
2/19/2007	Alturas Lake Creek	Salmon River	5/1 to 9/30	5	2.66	135.4	0.25	90.4	$11,250	$83 $17/yr	$124 $25/yr
2/5/2007	Lemhi River	Salmon River	3/15 to 11/15	1	32.06	1971.3	0	0	$80,154	$41 $41/yr	-
2/5/2007	Lemhi River	Salmon River	3/15 to 11/15	100 (Permanent)	5	574.7	0	0	$430,000	$748	-

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2/5/2007	Lemhi River	Salmon River	3/15 to 11/15	1	31.46	837.2	0	0	$34,039	$41 $41/yr	-
11/2/2006	Deschutes River	Columbia River	4/1 to 10/31	100 (Permanent)	0.68	218.46	0.17	72.14	$88,080	$403	$1,221
11/1/2006	Badger Creek	Little Lost River	4/1 to 9/30	30	2.28	430.5	0	0	$150,000	$348 $12/yr	-
10/31/2006	Lostine River	Wallowa River	8/22 to 9/30	1	20	1814.88	20	1814.88	$148,010	$82 $82/yr	$82 $82/yr
10/31/2006	Joseph Creek	Grande Ronde River	6/7 to 9/30	5	0.81	197.7	0	0	$30,000	$152 $30/yr	-
10/31/2006	Lostine River	Wallowa River	8/22 to 9/30	1	15	1814.88	15	1814.88	$164,000	$90 $90/yr	$90 $90/yr
10/30/2006	Deschutes River	Columbia River	4/1 to 11/1	1	86	27710	0	0	$641,066	$23 $23/yr	-
10/26/2006	Deschutes River	Columbia River	4/1 to 10/31	100 (Permanent)	9	3158	0	0	$3,078,501	$975	-
10/20/2006	Whychus Creek	Deschutes River	6/1 to 9/30	1	3.76	218	0	0	$3,628	$17 $17/yr	-
10/20/2006	Deschutes River	Columbia River	4/1 to 10/1	100 (Permanent)	0.37	158.77	0	0	$73,000	$460	-
10/19/2006	Buck Hollow Creek	Deschutes River	7/1 to 9/19	1	1.23	196.8	0	0	$5,000	$25 $25/yr	-
10/13/2006	Little Blackfoot River	Clark Fork River	6/15 to 9/30	5	1.68	117	0	0	$32,500	$278 $56/yr	-
10/10/2006	Deschutes River	Columbia River	4/1 to 10/31	100 (Permanent)	1.63	551	0	0	$276,753	$502	-
10/4/2006	McKay Creek	Umatilla River	1/1 to 12/31	100 (Permanent)	0.48	130.5	0	0	$32,625	$250	-
8/31/2006	Wasson Creek	Nevada Spring Creek	4/15 to 10/31	10	0.75	295.5	0	0	$75,000	$254 $25/yr	-
5/9/2006	Fifteenmile	Columbia River	4/1 to 9/30	5	2.19	524.52	0	0	$19,683	$38 $8/yr	-
5/9/2006	Dayton Creek	Flathead Lake	6/1 to 9/4	1	4	160	0	0	$5,500	$34 $34/yr	-
5/9/2006	Dayton Creek	Flathead Lake	7/15 to 10/19	1	1.42	111	0	0	$11,000	$99 $99/yr	-
5/9/2006	Ronan Creek	Dayton Creek	6/1 to 10/15	1	1.47	129	0	0	$5,950	$46 $46/yr	-
5/2/2006	Morgan Creek	Salmon River	4/1 to 10/31	1	2	591	9.21	0	$8,865	$15 $15/yr	-
5/2/2006	Iron Creek	Salmon River	4/1 to 10/31	1	4.81	388.5	0	0	$6,000	$15 $15/yr	-
4/28/2006	Eighteenmile Creek	Lemhi River	6/1 to 11/15	10	0.53	63.4	0.14	45.3	$16,000	$252 $25/yr	$353 $35/yr

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4/10/2006	Eighteenmile Creek	Lemhi River	7/1 to 11/15	1	1.8	142.2	0.38	104.6	$4,500	$32 $32/yr	$43 $43/yr
3/29/2006	Alturas Lake Creek	Salmon River	5/1 to 9/30	1	8.52	435	0.79	290	$7,250	$17 $17/yr	$25 $25/yr
3/29/2006	Fourth of July Creek	Salmon River	5/1 to 10/31	2	2.97	129.3	0.24	86.2	$4,310	$33 $17/yr	$50 $25/yr
3/29/2006	Fourth of July Creek	Salmon River	5/1 to 10/31	1	2.97	129.3	0.24	86.2	$0 (Donation)	-	-
3/8/2006	Fire Creek	Ninemile Creek, Middle Clark Fork	7/1 to 10/15	1	1.75	370.75	0	0	$6,000	$16 $16/yr	-
3/3/2006	Fire Creek	Ninemile Creek, Middle Clark Fork	7/1 to 10/15	5	1.75	370.75	0	0	$30,000	$81 $16/yr	-
3/3/2006	Big Hat Creek	Hat Creek	4/1 to 10/31	2	0.52	91	0.37	65	$3,700	$41 $21/yr	$57 $29/yr
3/3/2006	Big Hat Creek	Hat Creek	4/1 to 10/31	1	0.52	91	0.37	65	$1,850	$20 $20/yr	$28 $28/yr
3/2/2006	Murphy Spring Creek	North Fork, Blackfoot	5/1 to 10/1	1	2.2	556.5	0	0	$11,420	$21 $21/yr	-
3/2/2006	Wasson Creek	Spring Creek	4/15 to 10/31	1	0.5	198	0	0	$5,000	$25 $25/yr	-
3/1/2006	Mill Creek	Willamette River	6/1 to 9/30	5	1.44	347.75	0	0	$5,844	$17 $4/yr	-
2/23/2006	Lostine River	Wallowa River	8/1 to 9/30	1	15	1814.88	15	1814.88	$180,000	$99 $99/yr	$99 $99/yr
2/23/2006	Tualatin River	Willamette River	6/22 to 9/30	5	0.62	124.25	0	0	$14,148	$114 $23/yr	-
2/23/2006	Tualatin River	Willamette River	6/22 to 9/30	5	0.49	98.75	0	0	$19,310	$196 $39/yr	-
2/23/2006	Bledsoe Creek	Tualatin River	6/22 to 9/30	5	0.06	12.5	0	0	$750	$60 $12/yr	-
2/6/2006	Lemhi River	Salmon River	3/15 to 11/15	1	34.56	2711	0	0	$110,231	$41 $41/yr	-
2/6/2006	Pole Creek	Salmon River	5/1 to 9/30	5	5	744	0	0	$32,000	$43 $9/yr	-
12/13/2005	Deschutes River	Columbia River	4/1 to 11/1	100 (Permanent)	0.37	156.7	0	0	$73,000	$466	-
12/9/2005	Little Blackfoot River	Blackfoot River	6/15 to 9/30	1	1.68	117	0	0	$6,500	$56 $56/yr	-
12/9/2005	Standard Creek	John Day River	7/4 to 9/30	4	4.93	591.6	4.93	0	$55,000	$93 $23/yr	-

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12/7/2005	Deschutes River	Columbia River	4/1 to 10/31	1	93	29203	0	0	$650,234	$22 $22/yr	-
12/7/2005	McKay Creek	Umatilla River	3/1 to 7/30	5	2.6	237.7	0	0	$13,102	$55 $11/yr	-
12/6/2005	Ninemile Creek	Clark Fork River	5/1 to 10/4	12	9.9	1885	0	0	$76,452	$41 $3/yr	-
12/6/2005	Deschutes River	Columbia River	4/1 to 11/1	100 (Permanent)	1.48	627.1	0	0	$239,919	$383	-
12/6/2005	Whychus Creek	Deschutes River	6/1 to 10/30	1	3.67	157	0.93	157	$2,502	$16 $16/yr	$16 $16/yr
12/6/2005			4/1 to 11/1	100 (Permanent)	4.4	1864.36	0	0	$227,902	$122	-
12/5/2005	Deschutes River	Columbia River	4/1 to 11/1	100 (Permanent)	0.71	300.84	0	0	$176,000	$585	-
12/5/2005	Deschutes River	Columbia River	11/1 to 4/1	1	6.9	2000	0	0	$35,000	$18 $18/yr	-
11/9/2005	Sixmile Creek	Clark Fork River	4/15 to 10/19	2	0.46	100	0	0	$4,000	$40 $20/yr	-
8/10/2005	Vinegar Creek	Middle Fork John Day River	7/20 to 9/30	100 (Permanent)	10.2	1476.8	0	0	$700,000	$474	-
6/27/2005	Coyote Creek	Long Tom River	7/7 to 10/15	1	7.07	645.21	1.67	0	$9,113	$14 $14/yr	-
6/22/2005	Lemhi River	Salmon River	7/1 to 11/15	1	24.55	4472	0	0	$184,600	$41 $41/yr	-
6/22/2005	Pole Creek	Salmon River	5/1 to 10/31	1	5	384	0	0	$4,992	$13 $13/yr	-
6/16/2005	Ronan Creek	Dayton Creek	7/1 to 10/15	1	1.47	129	0	0	$5,950	$46 $46/yr	-
5/20/2005	Lemhi River	Salmon River	3/15 to 11/15	1	3.36	238	0.57	238	$3,272	$14 $14/yr	$14 $14/yr
5/19/2005	Eighteenmile Creek	Lemhi River	3/15 to 11/15	1	0.51	89.6	0.13	64	$2,000	$22 $22/yr	$31 $31/yr
5/18/2005	Big Hat Creek	Hat Creek	4/1 to 10/31	1	0.52	91	0.15	65	$1,850	$20 $20/yr	$28 $28/yr
4/25/2005	Rock Creek	North Fork Blackfoot River	5/1 to 8/31	25	1.5	365	0	0	$65,860	$180 $7/yr	-
4/22/2005	Lostine River	Wallowa River	8/1 to 9/30	1	15	1814.88	15	1814.88	$184,425	$102 $102/yr	$102 $102/yr
4/21/2005	Spring Creek	North Fork Blackfoot	5/1 to 10/1	1	2.2	1093	0	0	$11,420	$10 $10/yr	-
4/20/2005	Rock Creek	Clark Fork River	4/1 to 10/31	2	55	9941	0	0	$33,333	$3 $2/yr	-

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4/12/2005	Tin Cup Creek	Bitterroot River	4/1 to 10/19	10	4.32	457.5	0	0	$6,263	$14 $1/yr	-
4/7/2005	Lemhi River	Salmon River	3/15 to 6/30	1	35	1695.9	0	0	$68,959	$41 $41/yr	-
4/4/2005	Squaw Creek	Deschutes River	6/1 to 10/31	1	3.6	1071	0	0	$19,630	$18 $18/yr	-
3/31/2005	Middle Fork John Day River	John Day River	7/10 to 9/30	1	5.04	829.55	7.62	1254.4	$19,000	$23 $23/yr	$15 $15/yr
3/30/2005	Tin Cup Creek	Bitterroot River	4/1 to 10/19	10	4.32	457.5	0	0	$62,632	$137 $14/yr	-
3/30/2005	North Spring Creek	Bitterroot River	7/1 to 9/22	1	3	500	0	0	$3,750	$8 $8/yr	-
3/30/2005	Sweeney Creek	Bitterroot River	4/1 to 10/4	100 (Permanent)	0.91	80.46	0	0	$0 (Donation)	-	-
3/30/2005	Beaver Creek	Salmon River	5/1 to 10/31	10	9.38	834.6	1.83	556.4	$55,640	$67 $7/yr	$100 $10/yr
3/28/2005	Ninemile Creek	Clark Fork River	4/15 to 10/19	2	3.67	704.78	0	0	$7,000	$10 $5/yr	-
3/28/2005	Little blackfoot River	Clark Fork River	6/15 to 10/15	1	1.68	117	0	0	$7,000	$60 $60/yr	-
3/27/2005	Wasson Creek	Nevada Spring Creek	4/14 to 10/15	1	0.5	198	0	0	$5,000	$25 $25/yr	-
3/24/2005	Fire Creek	Ninemile Creek	7/1 to 10/15	1	1.75	370.56	1.25	183.05	$6,000	$16 $16/yr	$33 $33/yr
1/26/2005	Buck Hollow Creek	Deschutes River	7/1 to 9/19	1	1.23	196.8	0	0	$5,000	$25 $25/yr	-
1/26/2005	Ronan Creek	Dayton Creek	1/1 to 12/31	6	0.3	216.81	0	0	$25,367	$117 $20/yr	-
1/26/2005	Lostine River	Wallowa River	6/1 to 10/1	3	2.15	360	0	0	$27,000	$75 $25/yr	-
1/26/2005	Big Boulder Creek	Middle Fork John Day River	4/1 to 9/30	25	3.77	127.5	2.45	753.23	$110,000	$863 $35/yr	$146 $6/yr
1/26/2005	Middle Fork John Day River	North Fork John Day River	4/1 to 9/30	100 (Permanent)	0.9	309.1	0	0	$18,900	$61	-
1/26/2005	Kenney Creek	Lemhi River	7/1 to 11/15	1	3.72	221.3	0.81	221.3	$9,613	$43 $43/yr	$43 $43/yr
1/25/2005	Middle Deschutes River	Columbia River	4/1 to 11/1	100 (Permanent)	0.52	168.97	0.13	0	$31,183	$185	-
1/25/2005	Deschutes River	Columbia River	4/1 to 10/31	1	79	22533	0	0	$611,803	$27 $27/yr	-

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1/24/2005	Fifteenmile Creek	Columbia River	7/1 to 10/29	3	1.16	281.7	0.13	0	$1,883	$7 $2/yr	-
1/24/2005	Fifteenmile Creek	Columbia River	7/1 to 10/29	5	1.16	281.7	0.13	0	$8,117	$29 $6/yr	-
6/21/2004	Willow Creek	Bitterroot River	4/1 to 10/1	1	3.55	495	0	0	$12,375	$25 $25/yr	-
6/11/2004	Deschutes River	Columbia River	5/1 to 9/30	1	39	22365	0	0	$61,636	$3 $3/yr	-
6/11/2004	Middle Fork John Day River	John Day River	7/1 to 9/30	1	5.71	903.61	0	0	$19,000	$21 $21/yr	-
6/11/2004	McKay Creek	Umatilla River	Jan 0 to Jan 0	100 (Permanent)	5	300	0	0	$116,400	$388	-
6/10/2004	Lemhi River	Salmon River	5/16 to 6/30	1	35.03	347.32	0	0	$14,130	$41 $41/yr	-
4/5/2004	Paulina Creek	Little Deschutes River	4/1 to 8/14	1	4.69	1213.5	0	0	$13,200	$11 $11/yr	-
4/2/2004	Lolo Creek	Bitterroot River	4/28 to 10/31	100 (Permanent)	2.37	332.5	0	0	$25,000	$75	-
4/2/2004	Wasson Creek	Nevada Spring Creek	5/1 to 9/10	1	0.5	374.22	0	0	$7,500	$20 $20/yr	-
4/2/2004	Deschutes River	Columbia River	7/2 to 10/31	1	0.44	105.3	0	0	$737	$7 $7/yr	-
4/2/2004	Ronan Creek	Dayton Creek	6/1 to 5/31	1	3	1538.46	0	0	$30,000	$20 $20/yr	-
4/2/2004	Lemhi River	Salmon River	7/1 to 11/15	1	3.72	221.3	0.81	221.3	$9,613	$43 $43/yr	$43 $43/yr
3/31/2004	Joseph Creek	Grande Ronde River	6/1 to 9/30	2	0.81	194.4	0	0	$10,272	$53 $27/yr	-
2/1/2004	Fourth of July Creek	Salmon River	5/1 to 10/31	2	2.97	129.3	0.24	86.2	$4,310	$33 $17/yr	$50 $25/yr
1/22/2004	Ochoco Creek	Crooked River	5/6 to 10/15	1	7.74	2552.4	0	0	$43,106	$17 $17/yr	-
1/20/2004	West Fork Bitterroot River	Bitterroot River	7/7 to 9/30	100 (Permanent)	173	10000	0	0	$1,100,000	$110	-
1/20/2004	Burnt Fork Creek	Ninemile Creek	7/14 to 9/14	5	0.5	50	0	0	$6,250	$125 $25/yr	-
1/20/2004	Beaver Creek	Salmon River	5/1 to 10/31	1	9.45	722.7	1.83	560.4	$4,818	$7 $7/yr	$9 $9/yr
1/20/2004	Big Hat Creek	Hat Creek	4/1 to 10/31	1	0.52	91	0.15	65	$1,850	$20 $20/yr	$28 $28/yr
1/20/2004	Calapooia River	Willamette River	1/1 to 12/31	100 (Permanent)	12	8663.8	0	0	$180,000	$21	-

Date of Transaction Submission	Primary Benefited Stream	River Tributary	Instream Use Time Period	Length of Term (yrs)	Primary Instream Flow Increase (cfs)	Primary Instream Flow Volume Increase (ac-ft/yr)	Secondary Instream Flow Increase (cfs)	Secondary Instream Flow Volume Increase (ac-ft/yr)	Water Cost	Cost per Primary ac-ft Increase	Cost per Secondary ac-ft Increase
8/25/2003	ninemile Creek	Clark Fork River	6/1 to 9/30	10	0.2	15	0	0	$3,750	$250 $25/yr	-
8/1/2003	Threemile Creek	Bitterroot River	4/1 to 10/31	20	0.75	96	0	0	$19,200	$200 $10/yr	-
8/1/2003	North Fork Blackfoot River	Blackfoot River	7/12 to 9/30	30	18.45	2468.3	0	0	$55,813	$23 $1/yr	-
6/2/2003	Paulina Creek	Little Deschutes River	7/17 to 11/1	1	5.85	1044	0	0	$16,440	$16 $16/yr	-
5/31/2003	Calapooia River	Willamette River	4/9 to 10/9	2	35	8000	0	0	$20,000	$3 $2/yr	-
5/30/2003	O'Brien Creek	Bitterroot River	5/1 to 9/24	10	3.35	240.8	0	0	$1,000	$4 $1/yr	-
5/30/2003	Middle Deschutes River	Columbia River	4/1 to 11/1	5	0.53	172.7	0	0	$14,451	$84 $17/yr	-
5/30/2003	Deschutes River	Columbia River	4/1 to 11/1	1	3.87	1269.15	0	0	$8,859	$7 $7/yr	-
5/30/2003	Deschutes River	Columbia River	4/1 to 11/1	100 (Permanent)	3.09	1003	0	0	$121,287	$121	-
5/30/2003	Fourth of July Creek	Salmon River	5/1 to 10/31	1	4.15	291.6	0	0	$0 (Donation)	-	-
5/30/2003	Panther Creek	Salmon River	4/1 to 10/31	1	4	297.5	0	0	$6,375	$21 $21/yr	-
5/30/2003	Big Hat Creek	Hat Creek	4/1 to 10/31	1	0.52	91	0.15	65	$2,500	$27 $27/yr	$38 $38/yr
4/29/2003	Rock Creek	North Fork Blackfoot River	5/1 to 8/31	1	4	974	0	0	$2,900	$3 $3/yr	-
4/29/2003	Rock Creek	North Fork Blackfoot River	7/15 to 10/15	1	6.85	1430	0	0	$3,427	$2 $2/yr	-
4/21/2003	Poorman Creek	Blackfoot River	5/1 to 10/1	15	15.1	4577.6	0	0	$107,000	$23 $2/yr	-
4/10/2003	Ochoco Creek	Crooked River	6/1 to 9/15	2	1.23	260	0	0	$4,056	$16 $8/yr	-
4/9/2003	Little Bear Creek	Crooked River	7/1 to 10/31	5	0.78	136.28	0	0	$6,501	$48 $10/yr	-
3/4/2003	Ochoco Creek	Crooked River	5/1 to 9/15	1	2.37	787.6	0	0	$10,492	$13 $13/yr	-

Notes:
ac-ft = acre-feet
cfs = cubic feet per second
yr = year