Icicle Irrigation District
Instream Flow Improvement
Options Analysis Study

July 22, 2014

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Abbreviations

Ac..............................acres

Ac Ft..........................acre-feet

CIR............................Crop Irrigation Requirement

CFS............................cubic feet per second

Elev............................Elevation (measured in feet)

Ft...............................feet

GPM..........................gallons per minute

GID............................Gibbs Irrigation Ditch

ID...............................Irrigation District

IID ....Icicle Irrigation District

IPID...........................Icicle/Peshastin Irrigation District

PID ....Peshastin Irrigation District

P-C Interface............Point where pump discharge line connects to the canal

PDL ....Pump Discharge Line

PLC ....Programmable Logic Controller

PWUA.......................Pioneer Water Users Association

TU..............................Trout Unlimited—Washington Water Project

WSU ....Washington State University

Executive Summary

Forsgren Associates, Inc., was contracted by Trout Unlimited—Washington Water Project (TU) to assist in evaluating various means of enhancing instream flow within Icicle Creek, Chelan County, Washington. There are times when the stream flow is sufficiently low that salmon migration is jeopardized. Icicle Irrigation District (IID) has a diversion dam and intake structure off of Icicle Creek approximately 5.8 miles upstream of its confluence with the Wenatchee River at the City of Leavenworth. The occurrence of high irrigation demands occurring simultaneously with naturally occurring lower flow conditions in Icicle Creek later in the irrigation season exasperate the problem.

Without reducing the amount of irrigation water used by individual IID members, there are a number of ways Icicle Creek flow can be enhanced.

- Increase water available to Icicle Creek from the lakes used by IID for water storage;
- Supply some or all of IID irrigation water from the Wenatchee River by means of pump facilities;
- Convert the IID canals to an entirely, or partially, closed system using a pipeline under open flow (gravity) pressure;
- A combination of these methodologies.

In the first case, late season Icicle Creek flows are enhanced from lake storage captured from rainfall and the spring runoff; in the second case, less irrigation water would be diverted from Icicle Creek, thus improving instream flows during the irrigation season. The gravity pipeline approach would eliminate most or all of the spills (used to regulate flow in the canal) and most loses associated with evaporation and infiltration. The water saved by this approach could remain in the creek during the irrigation season.

In this study, TU, Forsgren, and Gravity Environmental evaluated the feasibility and associated costs for a number of potential flow enhancement options. Eightmile Lake was the one storage-lake, managed by Icicle Peshastin Irrigation District (IPID), evaluated as an option for increasing stream flow. The results of it's analysis are presented in Appendix A.

Six different pump sites along the Wenatchee River were also considered. Each option was evaluated according to the amount of water needed to serve the irrigated land within the canal reach (known as a "beat"), the cost of the required infrastructure, and the associated operations and maintenance costs. Section *3.2.2. Optional Pump Stations and System Configuration / Results* summarizes each option and associated key results. See also Table 4-1. Appendix B contains more detailed findings.

For this phase of the study, the replacement of the canal system with enclosed gravity pressure lines was not investigated.

Specific recommendations were intentionally excluded from this phase of the study. The intent is to provide stakeholders associated with the project appropriate data by which each can make an informed assessment regarding the best way to approach Icicle Creek instream flow enhancement. Recommendations can then be developed as appropriate from a consensus of the key stakeholders.

1. Introduction

Icicle Creek, located in Chelan County, Washington, has its source near the crest of the Cascade Mountains and flows eastward until it joins the Wenatchee River at the City of Leavenworth. Salmonids utilize Icicle Creek during numerous life stages. This project is focused on alternative water supply to aid the fisheries while continuing the agricultural heritage of the Icicle Irrigation District users. Most anadromous salmonids begin running in the creek in May, typically continuing through early fall. Fall is also when bull trout migrate and spawn in Icicle Creek. Sufficient creek flow is a critical component to their successful migration and spawning. It is also recognized that rearing during most times of the year is important for all species residing in the basin.

Icicle Irrigation District (IID) has a diversion dam and intake structure off of Icicle Creek approximately 5.8 miles upstream of its confluence with the Wenatchee River (the confluence being at approximately Wenatchee River Mile 25.62). Stream flow below the IID intake tends to become critically low during the later part of the irrigation season, thus jeopardizing fish migration. This is due to two simultaneously occurring events: the creek is at a naturally occurring diminished flow rate and significant amounts of water are diverted from the creek for irrigation purposes.

IID serves approximately 4,300 acres of orchards, primarily apple and pear, and some pasture and lawn, and provides irrigation water on both sides of the Wenatchee River. On the west side of the Wenatchee, it serves parcels from the Town of Leavenworth to the Town of Monitor. On the east side of the river, it extends from North Leavenworth to just south of the Dryden Reclamation Diversion Dam, near the Town of Dryden and Williams Canyon (See Figure 1-1).

Based upon data received from IID covering a period from 2003 to 2013, IID diverted flow from Icicle Creek varied from a low of 29 cfs (May 19, 2008) to a maximum of 118 cfs (Aug 27-30, 2005; this is slightly above the official allocation of 117 cfs). The irrigation season typically runs from April through September. Summary diversion flow data can be found in Appendix B.

Within the Icicle Creek watershed are a number of mountain lakes used by IID to enhance Icicle Creek stream flow. These lakes have low profile dams that allow control of lake out flow. During months of high irrigation demand and reduced Icicle Creek flows downstream of the IID irrigation diversion, extra water from the lakes can be released to increase stream flow.

There are a total of five lakes that are used to this end: Colechuck, Square, Eightmile, Klonaque, and Snow. Present storage capacity in the lakes is not sufficient to increase Icicle Creek flows to an adequate level during high irrigation demand and concurrent low stream flow.

Trout Unlimited (TU) is interested in the feasibility of increasing Icicle Creek stream flow by either reducing the district's irrigation water diversion from Icicle Creek or increasing supplemental flow from the storage lakes. The former would occur by supplying a portion of the system demand from water pumped out of the Wenatchee River directly to the canal system. The latter would occur by making physical changes to at least one of the lakes to increase storage capacity. TU obtained funding and assembled an analysis team to conduct a study to this end.

1.1 The Icicle Irrigation District

The IID was formed as an official irrigation district in 1917. A private company had originally built the irrigation canal and sold the improvements and water rights to the property owners located in what became the IID. One of the primary funders of the original irrigation system was Charles H. Black. At the time the canal was sold, he retained some of the water rights for future sale. Black had a contract with IID in which purchasers of his shares would be supplied water at the same fee as the rest of the district's users. These shares are referred to as *"Black shares."* At its formation, the district had additional shares above those required to irrigate the land within its boundary. The district sold those shares, each being assessed at the same fee as those of the rest of the district. Those shares are referred to as *"Contract shares."* Since they are equal in all other respects, IID is in the process of standardizing its terminology and will in the future delete the distinction between

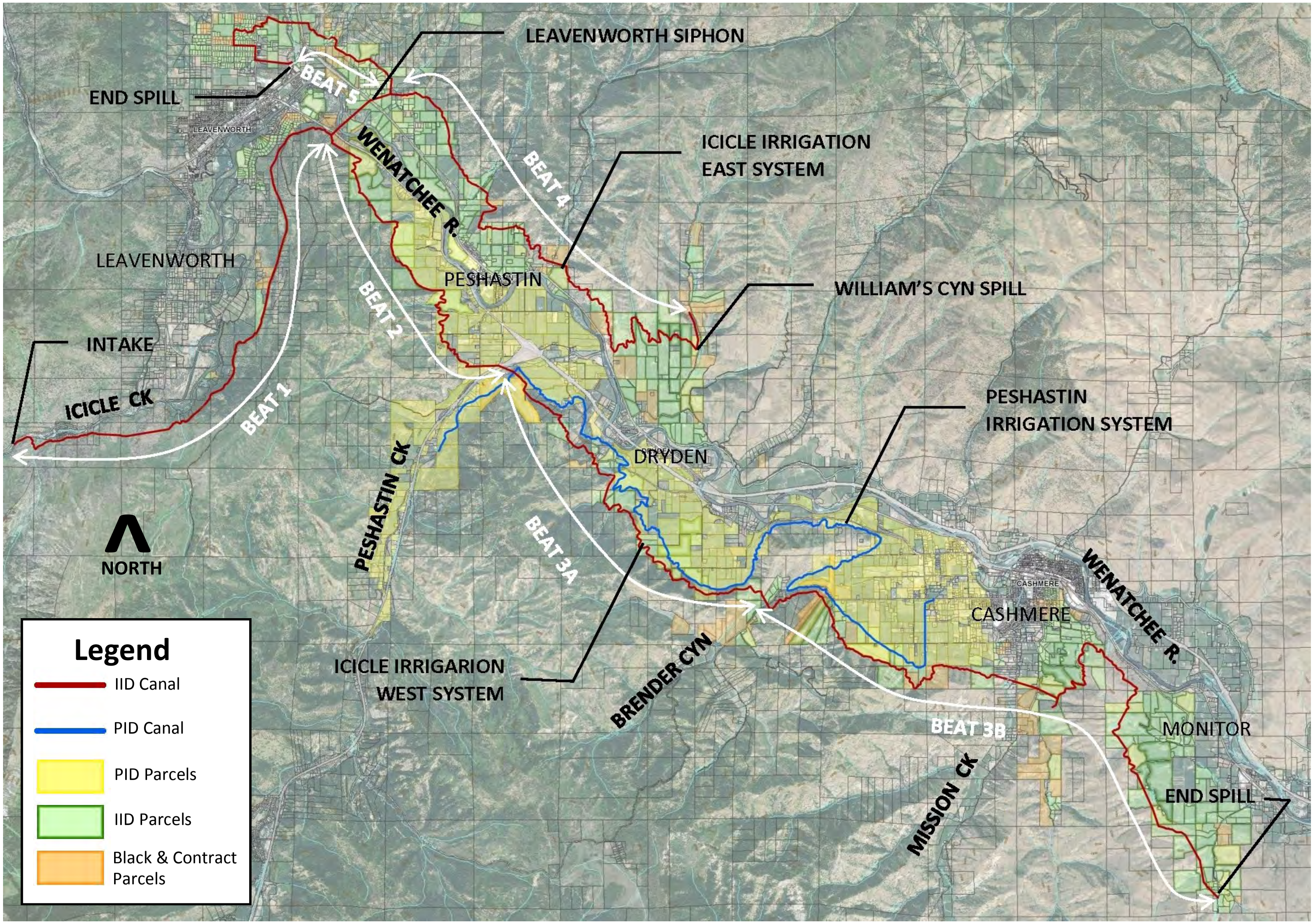


Figure 1-1

General Layout of the Icicle and Peshastin Irrigation Districts

Table 1-1

Summary of Icicle Irrigation District Canal System Distances—West (in miles from intake)

Beat 1						Beat 2		Beat 3A		Beat 3B		
Intake	Snow Ck Spill	Mtn Home Spill	Van Brocklin Spill	Leaven-worth Spill	Leaven-worth Siphon	To Gibbs & Tandy	Peshastin Spill	Brender Spill*	Mission Ck Spill	Weed Screen Spill	Fairview Cyn Spill	End of Box Spill
0.0	0.3	2.1	5.1	6.4	6.5	10.8	10.8	16.5 & 17.1	20.4	23.1	23.2	26.24

*There are 2 Brender Spills, No. 1 and No. 2. / Distances are in miles measured from the intake and based upon data generated from survey grade handheld GPS units.

Table 1-2

Summary of Icicle Irrigation District Canal System Distances—East (in miles from West Canal)

Leaven-worth Siphon (West End)	Beat 4				Leaven-worth Siphon (West End)	Beat 5				Total Length*
	Posey Weir	Derby Cyn Spill	Williams Cyn Spill	End of Line		Parsons Weir	Foxes Spill	Chumstick Spill	End Spill	
0.0	0.9	4.5	8.2	8.6	0.0	1.0	1.4	2.6	4.3	12.65

Total East and West IID System
38.9 miles

*There is an assumed 1,340-ft (0.25 miles) portion of the siphon that is common to both the Beat 4 and Beat 5 calculations; therefore it must be subtracted once from the total length of the combined beats to arrive at the total length of the system on the east side of the Wenatchee River. / Distances are in miles measured from the west side of the Leavenworth Siphon across the Wenatchee River and they are based upon data generated from survey grade handheld GPS units.

shares; Black and Contract Shares will just be called *shares*.

The IID is made up of approximately 39 miles of canals, pipelines, flumes, and tunnels. The system is administratively broken into six sections which IID refers to as *beats*. Beat 1 extends from the intake on Icicle Creek to where the system tees to the Leavenworth Siphon (extends to the east side of the Wenatchee River); Beat 2 extends from the end of Beat 1 to the siphon crossing Peshastin Creek; Beat 3A extends from Peshastin Creek to Brender Canyon; Beat 3B extends from Brender Canyon to the end of the canal (west valley system). See Figure 1-1 and Table 1-1.

IID also serves the east side of the Wenatchee River. A 0.25 mile long siphon, beginning at 6.5 miles from the IID inlet, crosses the Wenatchee River and connects to a canal system on the east side of the valley. Just prior to connection to the canals, the siphon wyes, one line extending to a canal to the north (Parsons Weir), the other to a canal to the south (Posey Weir). Beat 4 corresponds to the canal from Posey Weir to the south were it ends at Williams Canyon. Beat 5 corresponds to the canal from Parsons Weir to the north to its end. See Table 1-2 and Figure 1-1.

1.2 Joint-Use Facilities

The Peshastin Irrigation District (PID) serves about 3,700 acres along the west side of the Wenatchee River, from just south of the IID Leavenworth siphon to just west of the City of Cashmere. A portion of its canal operates in conjunction with IID. The two districts are under the same management and are collectively known as the Icicle/Peshastin Irrigation District (IPID). In order to avoid confusion as to which irrigation system is being referenced, we will refer to them as separate districts.

The main channel of Beats 1 and 2 of the IID canal system is shared jointly with PID. PID has sub-ordinate water rights to some of the water from Icicle Creek. PID owns 40% of the Beat 1 improvements and 50% of the Beat 2 improvements. IID personnel maintain the joint-use improvements and PID reimburses IID for its share of the costs associated with those maintenance efforts.

IID has a legal diversion allocation of 117 cfs that is distributed as follows:

- 45 cfs belongs to Icicle Irrigation District (IID)
- 30 cfs belongs to Peshastin Irrigation District (PID); up to 8 cfs of this amount belongs to Gibbs Irrigation Ditch (GID), a private ditch company
- 42 cfs is split evenly between IID and PID
- Based upon this allocation, maximum flow amounts are: 66 cfs for IID; 51 cfs for PID/GID

A significant portion of PID users are located adjacent to the IID Beat 2 canal and per the IID/PID joint use agreement are serviced from IID Beat 2.

A bifurcation structure at the end of Beat 2 has four outlets:

- A siphon across Peshastin Creek that serves the IID Beats 3A and 3B.
- A pipeline to the Gibbs system.
- A siphon to the PID main canal on the bank of Peshastin Creek.
- Spill to Peshastin Creek.

During the first part of the irrigation season, water is not normally diverted to the PID canal but is spilled to Peshastin Creek. Beginning about mid-July, the PID allocation is diverted to the PID canal with little to no flow spilled to Peshastin Creek.

1.3 Orientation Convention

The IID canal and the Wenatchee River sometimes run north and south, sometimes east and west, and generally somewhere in between. Stating directions thus can become confusing. Therefore, for the purposes of this study we have assumed that up river and up-canal is north, down river and down canal is south. East and west are than relative to these north and south directions.

2. Purpose of this Study

As indicated above, inadequate stream flow for migrating fish occurs during high irrigation demand late in the irrigation season concurrent with naturally occurring lower Icicle Creek flows. Approaches considered to mitigate this situation include:

- Increase flow from reservoir lakes into Icicle Creek during periods of low stream flow;
- Reduce irrigation water diverted from the creek.

The purpose of this study is to provide data and information to pertinent stakeholders who in turn can make informed decisions regarding Icicle Creek stream flow enhancement while simultaneously maintaining irrigation flow to IID members.

2.1 Storage Lakes

This study considered Eightmile Lake for providing increased stream flow during critical low flow periods within Icicle Creek. Since the study of any given lake can be costly, one lake was isolated as the best candidate for providing this instream benefit. Selection was based upon the IID manager’s knowledge of operations at each lake, the size of the watershed supporting that lake, and the likelihood of increasing the lake’s storage by raising the dam, lowering the lake’s drawdown elevation, or a combination of the two.

2.2 Irrigation Pump Back from the Wenatchee River

Another alternative is to provide irrigation water from another source that will allow reduction of the amount of water diverted from Icicle Creek. This can be done by constructing an irrigation water pump station along the Wenatchee River, where there is a greater abundance of instream flow, and pumping up to the irrigation system.

This study considered a number of possible pump station locations along the Wenatchee River. It assessed how much irrigation water could be reallocated from the Wenatchee River at a given location and what would be the capital and operations costs associated with the amount of water pumped.

3. Study Approach / Results

3.1 Lake Appraisal—Eightmile Lake

Eightmile Lake was selected for evaluation as a means of increasing stream flow in Icicle Creek during low flow conditions. It had one of the largest watersheds of the lakes in the system and was believed to be the least cost option in terms of raising the dam at the lake's outlet.

Eightmile Lake is located within the Okanagan-Wenatchee National Forest and is under US Forest Service management. IID has permitted use of the lake for increasing available water within Icicle Creek for irrigation purposes. The lake has a small dam at its east end. There is an underwater gate structure and pipe system that passes under the dam. The gate can be adjusted to regulate flow out of the lake. There is also an overflow weir within the dam that will allow water to flow over it should the lake surface reach that elevation. Water flows out of the lake into Eightmile Creek which then flows into Icicle Creek. The confluence of the two creeks is upstream of the IID intake structure.

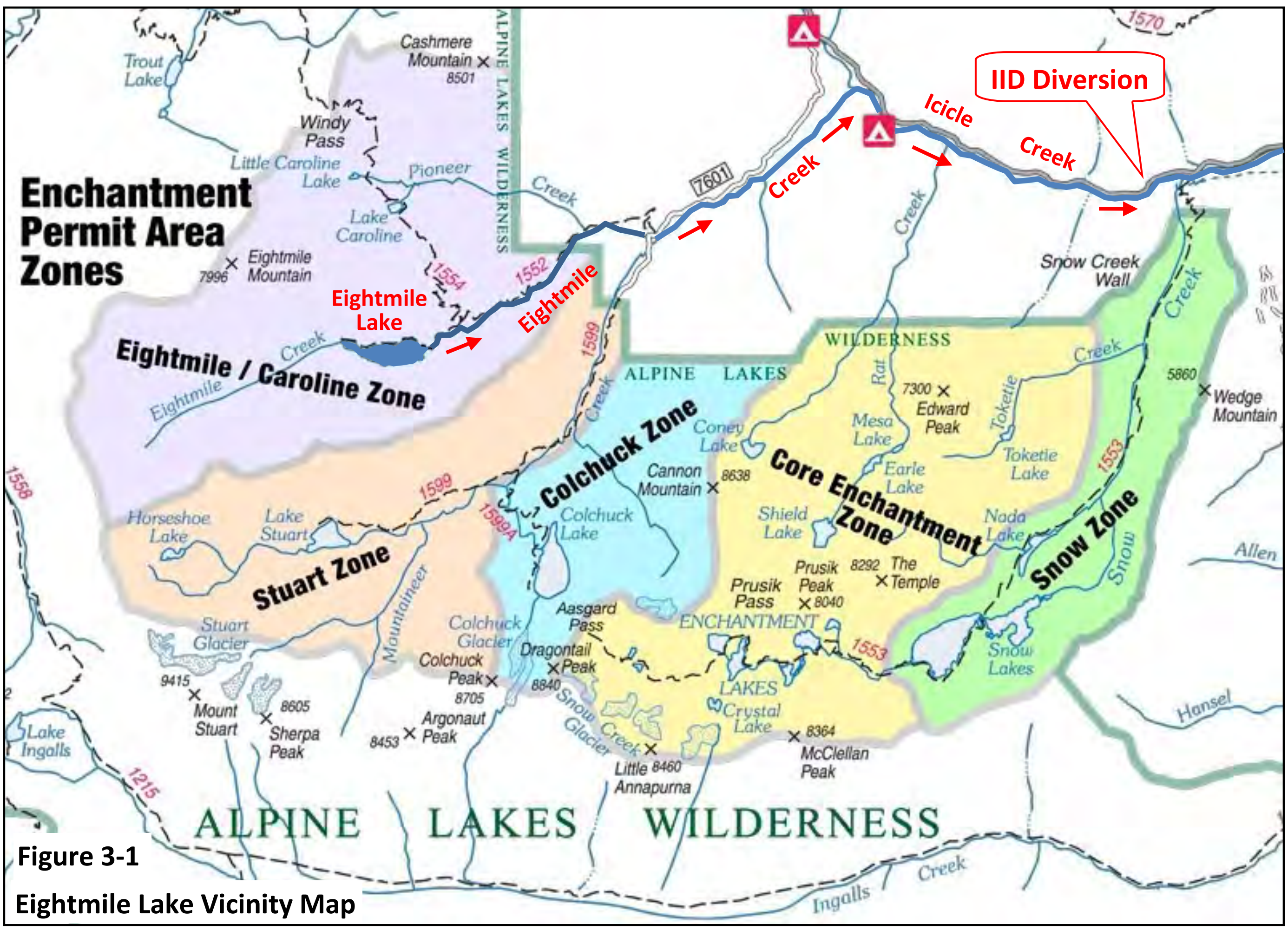


Figure 3-1

Eightmile Lake Vicinity Map

Eightmile Lake is located within the Alpine Lakes Wilderness area and there are activity related restrictions associated with the area. The lake is located within the Eightmile/Caroline Enchantment Permit Area Zone. See Figure 3-1.

In order to accurately assess the lake's capacity, a topographic representation of the ground around the lake and below water level was required. TU retained Gravity Environmental to perform the topographic survey. A bathymetric survey was conducted for mapping the lake bottom and GPS was used for determining the topography surrounding the lake. Gravity also was able to obtain LIDAR survey data for the area and incorporated that into the topographic model.

The survey data was placed within a CAD/GIS computer environment and the lake elevation necessary to obtain a specific volume of usable lake water was determined. Multiple volumes and corresponding elevations were evaluated. The area of inundation for the various elevations considered was added to an aerial image of the lake. Each elevation was given a different color to help facilitate the evaluation of the various options. Recreational features, including trails and campsites, were added to the image. Any impact of a given elevation upon those recreational features was thus immediately evident. Forsgren was able to estimate how high the existing dam would have to be raised for various lake capacities considered. Also evaluated was the option of lowering the maximum drawdown elevation of the lake to increase reserve water available for enhancing Icicle Creek stream flow.

The watershed surrounding the lake was also evaluated. Rain and snow melt run-off for a typical year was calculated to determine the maximum usable storage possible for the lake.

Together, Forsgren and Gravity Environmental determined how high and wide the dam would have to be to accommodate a given usable storage capacity. Estimating the cost of constructing the dam was not part of either consultant's scope of work.

Appendix A contains the findings associated with the Eightmile Lake assessment. Forsgren and Gravity Environmental were only involved in collecting data and performing calculations relating to the raising of the dam at Eightmile Lake and/or lowering the maximum lake drawdown in order to achieve various usable volumes. How or if the lake will be used as a means of supplementing Icicle Creek stream flow will be determined by others.

3.2 Pump Station Options

A total of six pump station sites were analyzed. These sites were selected as being the best candidates based upon the following criteria:

- Proximity to the IID canal;
- Geology and general terrain;
- Adequate pool of water within the river where a fish screen and the pump intake could be located.
- Adequacy of the site:
  - To physically locate a pump station on it;
  - To obtain readily availability electrical power;
  - To obtain right-of-way and acquisition of the land;
  - For ready operations and maintenance access by IID personnel.

3.2.1 Pump Station Option System Layout Considerations

Each option has one of the following scenarios for conveying water to the IID.

- Pump and open discharge to a new inlet structure within the existing canal. This will allow for gravity flow below the structure. Canal flows above the outlet structure will be reduced by the volume pumped from the Wenatchee River. Flows below the outlet structure will essentially match current canal flows for that section of canal. This discharge scenario does not need to occur at an existing canal spill as long as the current canal capacity is not exceeded.
- Pump to a pressure main that typically follows the existing canal alignment. End users would connect to the pressure main. The extent of the mainline will be limited by system pressures. For the purposes of this study, a maximum pressure at the pump station of 350 psi was selected. A

maximum mainline pressure at user points of connection was selected to be approximately 60 psi (based upon input from IID). It was assumed that any portion of the canal remaining in operation upstream of the pressure pipe would end at a spillway. In this scenario, flow in the canal upstream of the pipe could be reduced by the corresponding volume of irrigation water pumped from the Wenatchee River.

- A combination of pumping to an open canal and a pressure main. In this scenario, water would be pumped to the existing canal with a portion directed to a pressure mainline as described above and another portion discharging to the existing gravity canal. The upstream termination of the pressure mainline would typically occur at a spill as described above. This would allow the irrigated acreage up-canal of the pressure main to be adequately served by the existing canal and provide a path back to the river for any unused water still in the canal at the terminus of the pressure main.

3.2.2 Optional Pump Stations and System Configuration / Results

Following are the pump sites selected for evaluation. Each is identified by an option number. In some cases, sub-options were also assessed. After each option is a summary of the flow benefit to both the Wenatchee River and Icicle Creek. Capital costs include pump station, pipe, and related construction elements. See Tables 4-1 and B-3 for more detailed summary information for all the options. Note that the "pump discharge line (PDL)" is the pump pressure line from the pumps to the canal. The "pressure main" refers to a pressure pipe extended from the end of the PDL up-canal to serve some IID users.

Option 1: Fairview Canyon Site • Pump & Pressure Main System

This option would serve Beat 3B. The pump station would be located at the Department of Fish and Wildlife parcel at the Monitor Bridge in the Town of Monitor. There are two sub-options:

Option 1A: The pump discharge line would be routed through the Town of Monitor and up Fairview Canyon to the existing terminus of the IID canal's west valley system. A pressure main would replace the existing pipe and open ditch on the lower portion of the canal system. The pipe would terminate at Weed Screen Spill. See Figure B-1.

Results:
- Benefiting peak flow: 13.91 cfs
- Wenatchee River Miles benefiting: 19.70
- Icicle Creek Miles benefiting: 5.76
- Capital construction cost: $4,633,396

Option 1B: The pump discharge line would be routed through the town and up Fairview Canyon to a point just beyond the Jones-Shotwell Irrigation Ditch on Fairview Canyon Road. From there it would become a pressure main and continue along Fairview Canyon Road with a tee occurring at Zager Road. One branch of the tee would extend in a generally north and easterly alignment along Zager Road, branching out from there along other County roadways and remaining within County right-of-way throughout (See Figure B-2 for the layout). The other branch of the tee will continue south along Fairview Canyon Road to the present terminus of the IID canal system. This latter line would include a booster pump. The entire pressure main would have a minimum 40 psi residual pressure and would serve the IID users presently supplied by the existing canal south of Weed Screen Spill. The canal south of the Weed Screen Spill can be eliminated. See Figure B-2.

Results:
- Benefiting peak flow: 13.91 cfs
- Wenatchee River Miles benefiting: 19.70
- Icicle Creek Miles benefiting: 5.76
- Capital construction cost: $4,021,613

Key considerations
Options 1A:
- The pump discharge line is long, has a significant elevation gain, and runs within existing roadways with the associated pavement removal and replacement costs.
- Has the longest pressure line and head per acre served.
- Has the longest River Benefit of all the options.

Option 1B:

- The same pavement replacement requirements as under Option 1A will apply.
- Has less elevation gain than Option 1A and the pipe is closer to the end users, in most cases, making it more efficient.
- Some additional easements will be needed to reach some of the users now served from the canal.
- Along with Option 1A, has the longest River Benefit of all the options.

Option 2: Cashmere Treatment Plant Site • Pump & Pressure Main / Gravity System

This option would serve Beat 3B. The pump station would be located at south end of the existing City of Cashmere Wastewater Treatment Plant site, on the west side of the Wenatchee River. The pump discharge line would run under an adjacent railroad track, up a hill, and connect to the existing IID canal. Two sub-options were considered:

Option 2A: The pump discharge line would discharge into the existing canal and provide gravity flow to the south. See Figure B-3.

Results:

- Benefiting peak flow: 13.91 cfs
- Wenatchee River Miles benefiting: 17.07
- Icicle Creek Miles benefiting: 5.76
- Capital construction cost: $2,311,128

Option 2B: The pump discharge line would discharge into the existing canal and provide gravity flow to the south; additionally, a pressure main would extend to the north to a point south of Mission Creek Spill. See Figure B-3.

Results:

- Benefiting peak flow: 22.39 cfs
- Wenatchee River Miles benefiting: 17.07
- Icicle Creek Miles benefiting: 5.76
- Capital construction cost: $4,102,017

Key considerations (Options 2A & 2B):

- Will need to negotiate with the City of Cashmere to place pump station on its land.
- Must obtain an easement under railroad and with land owner between railroad and canal.
- Has one of the shortest pump discharge lines and very direct route to the canal.
- Option 2B has a relatively short pressure main since distance to first spill is short but to the next spill would result in excessive pressures..
- There would be no pavement replacement.

Option 3: Cashmere Mill Site (Port of Chelan) • Pump & Pressure Main / Gravity System

This option would serve Beats 3A and 3B. The pump station would be located west of BNSF railroad tracks, the tracks being west of the Wenatchee River. The pump station intake would have to pass under the railroad tracks to the river. The pump discharge line would be routed through the City of Cashmere, up Mission Creek to the IID canal. From this point, there were two sub-options considered:

Option 3A: The pump discharge line would discharge into the canal and provide gravity flow to the south. See Figure B-4.

Results:

- Benefiting peak flow: 22.39 cfs
- Wenatchee River Miles benefiting: 15.03
- Icicle Creek Miles benefiting: 5.76
- Capital construction cost: $4,243,464

Option 3B: The pump discharge line would discharge into the existing canal and provide gravity flow to the south; additionally, a pressure main would extend to the north to a point approximately 0.7 miles north of the Option 4 connection point to the canal. There are no users between the end of the pipe and the next spill to the north (Peshastin Spill). Since there are no IID services to the north between the end of the pressure main and the Peshastin Spill, that portion of the canal can be eliminated as part of Option 3B. See Figure B-4.

Results:

- Benefiting peak flow: 29.53 cfs
- Wenatchee River Miles benefiting: 15.03
- Icicle Creek Miles benefiting: 5.76
- Capital construction cost: $8,534,105

Key considerations (Options 3A & 3B):

- Will need to negotiate with the City of Cashmere for siting the pump station.
- The railroad tracks would be between the river and the pump station; suction line would have to pass under the tracks and an easement obtained.
- The pump discharge line is relatively long and must run through portions of the City of Cashmere and would require pavement removal and replacement.
- Option 3B has the longest pressure main which results in the second highest capital cost and third largest pump station.

Option 4: Dryden South Site • Pump & Gravity System

This option would serve Beats 3A and 3B. The pump station would be located just west of the Wenatchee River bridge, about 1/4 mile north of Dryden Avenue on Highway 2. A pressure main would run up hill to the west where it would connect to the IID canal. See Figure B-5.

Results:

- Benefiting peak flow: 28.99 cfs
- Wenatchee River Miles benefiting: 8.98
- Icicle Creek Miles benefiting: 5.76
- Capital construction cost: $4,487,780

Key considerations:

- The pump station would need to acquire property or a long term easement from private land owner.
- The pump discharge line would need to acquire an easement/right-of-way from existing land owners; some of the line would run in public right-of-way.
- The pump discharge line is relatively short among the various options considered.
- The pump discharge line would have to cross under the PID canal.

Option 5-West: Dryden Reclamation Diversion Dam Site—West Side • Pump & Gravity System

This option would serve Beats 3A and 3B. The pump station would be located on the west side of the Wenatchee River, just upstream of the existing Dryden Reclamation Diversion Dam. The pump discharge line would run to the west along various streets in the Town of Dryden, across Highway 2, through an orchard, up an embankment, and to the IID canal. Water would flow by gravity in the IID canal to the south, serving almost all of Beats 3A and 3B. See Figure B-6.

Results:

- Benefiting peak flow: 29.52
- Wenatchee River Miles benefiting: 7.75
- Icicle Creek Miles benefiting: 5.76
- Capital construction cost: $4,992,060

Key considerations:

- Would need to negotiate pump station land use with reclamation district.
- The pump discharge line is relatively long and would need to run within public right-of-way for most of it's alignment to the IID canal; will require pavement removal and replacement.
- A portion of the alignment will require an easement or right-of-way on private property.
- The pump discharge line would run under Highway 2 and would require a WSDOT permit.
- The pump discharge line would cross under the PID canal just before reaching the IID canal.

Option 5-East: Dryden Reclamation Diversion Dam Site—East Side • Pump & Gravity System

This option would serve Beat 4. The pump station would be located on the east side of the Wenatchee River, opposite the existing Dryden Reclamation Diversion Dam Site. Once the pump discharge line reached the southeast canal, the water would flow by gravity from there to the end of the canal. See Figure B-6.

Results:

- Benefiting peak flow: 10.40
- Wenatchee River Miles benefiting: 7.68
- Icicle Creek Miles benefiting: 5.76
- Capital construction cost: $5,327,400
- Maximum pump horsepower required: 510
- Pump discharge line size: 24”
- Pump discharge line elevation gain: 337’

Key considerations:
- The site for the pump station is the most challenging of all the options and is the reason for its high relative cost per acre served.
- Working in the river will be more challenging than other options due to the presence of the railroad track so close to the shore and the power lines adjacent to it.
- Connecting to the pipe on the side of the rock face will be challenging.
- Thorough geological assessment is needed as pump station excavation could undermine the adjacent embankment.
- Cost to flow benefit is the highest of the options.

Option 6: Leavenworth Siphon Site • Pump to Gravity System

The pump station for this option would be located on the east side of the Wenatchee River adjacent to the siphon that crosses the river to feed the irrigation system on the east side of the valley. Three options were investigated for this site.

Option 6A would pump to the East canal, Beats 4 and 5. It would pump to the existing Posey Weir which supplies flow to the southeast and corresponds to Beat 4. It also would pump to Parson's Weir which supplies flow to the northeast and corresponds to Beat 5. For purposes of this study, it was assumed that the existing siphon would be replaced with a new line from the pump station to the East Canal system. The existing siphon would be removed/abandoned as the portion between the West Canal and the pump station would no longer be needed. See Figure B-7.

Results:
- Benefiting peak flow: 30.41 cfs
- Wenatchee River Miles benefiting: 2.83
- Icicle Creek Miles benefiting: 5.76
- Capital construction cost: $4,672,443

Option 6B would replace the existing siphon with a new pipe and the pump station would pump through it to both the East Canal system as outlined in Option 6A and to the West Canal. Water would be introduced into both canal systems and flow by gravity to their respective terminus points. See Figure B-7.

Results:
- Benefiting peak flow: 62.04 cfs
- Wenatchee River Miles benefiting: 2.83
- Icicle Creek Miles benefiting: 5.76
- Capital construction cost: $7,195,880

Option 6C eliminates the need for any diversion from Icicle Creek; the entire diversion allocation is pumped from the Wenatchee River. Since there are a few users along Beat 1 that would still require service, a relatively small pump house would be placed at the existing Leavenworth siphon diversion point along the existing IID canal and a small pressure main would run along the existing canal and service those users. The Beat 1 canal itself could be filled in and the intake at Icicle Creek removed. The rest of the IID irrigation flow required for the west valley system would be delivered to the existing canal and allowed to flow by gravity—just as in Option 6B but with a much larger flow contributed from the pump station as no flow will be coming from Beat 1. The flow to the west canal would also include PID's Icicle Creek diversion allocation. The east valley allocation would be supplied as in Options 6A and 6B. See Figure B-7.

Results:
- Benefiting peak flow: 117.00 cfs
- Wenatchee River Miles benefiting: 2.83
- Icicle Creek Miles benefiting: 5.76
- Capital construction cost: $12,966,738

Key considerations (Options 6A, 6B, & 6C):
- The actual Wenatchee River Miles benefit is the lowest of all the options.
- Option 6C is the only option that allows elimination of the IID diversion structure and the district's diversion of Icicle Creek water.

3.2.3 Additional Option Functionality

Gravity Flow Only Systems: These systems can either function throughout the irrigation season, or just during periods of peak demand when Icicle Creek is at a critical low flow volume. In the later case, flow from the existing IID Icicle Creek diversion structure would continue to supply the system as it currently does for most of the season. During times of low flow in Icicle Creek, the pump station would be started and supply water to the canal. The amount of flow diverted from Icicle Creek at the system diversion structure would then be reduced by the equivalent amount provided to the system by the pump station.

Combined Gravity Flow and Pressure Main Systems: For all combined gravity flow and pressure main options, the pump discharge line extends from the pump station to the canal, that connection point being referred to as the pump-canal interface (P-C Interface). Down-canal from the P-C Interface, water supplied by the pump station will flow by gravity within the existing canal. Up-canal of the P-C Interface, a pressure main will replace a portion of the canal. Since the pressure main replaces a portion of the canal, the pump station must operate throughout the irrigation season—not just during critical low flow periods within Icicle Creek.

Pressure Main Only Systems: Options 1A and 1B are the only *pressure main only systems* and replace the lower end of the existing canal. These options require that the pump station be operated throughout the irrigation season—not just during critical low flow periods within Icicle Creek.

3.2.4 IID System Management Changes

Following are some of the system management changes that would occur if one of the proposed pump station options were implemented.

Gravity Flow Only Systems (Options 2A, 3A, 4, 5-West, and 5-East): Diverted flow from Icicle Creek can be reduced by the equivalent volume pumped from the Wenatchee River. The amount of diverted water from Icicle Creek should be adjusted so that the water in the canal is at a minimum as it reaches the P-C Interface. Sensors at key locations down-canal of the P-C Interface will be able to control the pumps so that water level in the canal is properly maintained. This will provide the most efficient water management within the canal.

Combined Gravity Flow and Pressure Main Systems (Options 2B, 3B): As in the gravity flow only options, the amount of water diverted from Icicle Creek can, in general, be reduced by the amount of water conveyed to the canal by the pump station. The spill just above the end of a pressure main should be monitored and the amount of water diverted from Icicle Creek adjusted so that the volume of water overflowing to the spill is minimized. Pressure sensors will automatically turn on and off the pumps according to the amount of water users are drawing from the pressure main. Depth of flow sensors down canal can control a valve that releases the water from the pump discharge line into the canal, thus maintaining an appropriate level of water. In principal, the system from the pressure main south (down canal) should be relatively automatic, but flow in the canal system north of the pressure main will need to be controlled largely as it currently is unless additional automation is employed (see end of this section).

Pressure Main Only Systems (Options 1A & 1B): Options 1A and 1B are pressure main only systems. The portion of the IID canal south of the Weed Screen Spill can be abandoned. Flows diverted from Icicle Creek can be reduced by the volume pumped from the Wenatchee River. The amount of water diverted from Icicle Creek should be adjusted so that the amount of water flowing in the canal that reaches the Weed Screen Spill, and overflowing to it, is minimized.

Special Case—Option 6: As in the other options, diversion from Icicle Creek can be reduced by the volume pumped from the Wenatchee River. Option 6A pumps to Beats 4 and 5 only. For this option, the Leavenworth siphon gate can be closed and the diverted water from Icicle Creek should be adjusted so that the water in the canal reaching the spills south of Leavenworth siphon are reduced to a minimum. A programmable logic controller (PLC) tied to sensitive float switches in the Beat 4 and 5 canals may be able to control the pumps. For Option 6B, water will be pumped to the East valley canals (Beats 4 and 5) and up to the West valley canal; the Leavenworth siphon will no longer be needed. Water diverted from Icicle Creek should be adjusted so that the water in the canal reaching the Leavenworth spill, just up-canal of the Leavenworth siphon, is reduced to a minimum. For Option 6C, the Beat 1 canal can be eliminated. It is anticipated that various sensors will supply data to a PLC which will in turn be able to control pumps and valves so that water can be properly supplied to Beats 2, 3A, 3B, 4, and 5. There will be a small pump station near the west canal at the present Leavenworth siphon.

This will supply a pressure main that will serve the users along Beat 1.

General Automation: It should be noted that automation for irrigation canals can sometimes be complicated and can vary in cost depending upon the system envisioned. In addition to the automation suggested above, it may be possible to control the IID inlet gate at the Icicle Creek diversion structure by use of a PLC and accurate water level sensors at strategic locations along the canal. During the design phase of any proposed improvements, a more thorough evaluation of the system dynamics should be undertaken and an assessment made as to the extent that automation will be practical for the new IID system.

3.2.5 Data Collection

IID Supplied Data: IID supplied Forsgren and TU a general understanding of its facilities and their operations, how they interface with other irrigation users along its alignment, flow data from its diversion at Icicle Creek, and a study; *Comprehensive Water Conservation Plan,* March 2, 1993 by Klohn Leonoff, Inc. This study provided a great deal of useful background information for the IID canal system.

Field Data: The horizontal and vertical alignment of the entire IID canal system was identified in the field by TU personnel. Using survey grade hand held GPS units, they took readings along the entire 39 miles of the IID system. They noted changes in canal size and material; location of siphons and their size (when visible); size and location of customer turn-outs; the size and location of spills; and any other pertinent information. Optional pump station sites and associated water levels were also recorded. Special codes were used for each of the data types to make the classifying of the data as practical as possible. After each day in the field, TU personnel downloaded the electronic data saved in the GPS units to Forsgren computers. This data was then input into both GIS and AutoCAD programs. In this way, data could be checked almost immediately and if any important data appeared inconsistent with surrounding data values, TU personnel could be notified and new readings taken in the field.

4. Additional Notes on Study Findings

4.1 Eightmile Lake

Appendix A contains the findings associated with the Eightmile Lake assessment. Forsgren and Gravity Environmental were only involved in collecting data and performing calculations relating to the raising of the dam at Eightmile Lake and/or lowering the maximum lake drawdown in order to achieve various usable volumes. How or if the lake will be used as a means of supplementing Icicle Creek stream flow will be determined by others.

4.2 Pump Station Options

Appendix B contains the results of the Pump Station calculations for the various options and associated piping configurations. As expected, some options are able to provide more flow than others, some required more capital cost to construct, and some will have lower on-going operations and maintenance costs. No attempt was made to rank the options but only to provide stakeholders with pertinent information useful for identifying, for further investigation, the most beneficial alternatives that meet instream flow objectives and addresses IID irrigation needs. See also Table 4-1.

4.2.1 Capital Costs

Capital Costs are probable cost estimates based upon historic data associated with similar sized pump stations and unit costs of installed pipe. The pipe unit cost accounts for fittings, isolation valves, user connection valves, trenching, backfill, and pavement restoration when construction is in a roadway right-of-way. A contingency of 20%, an estimate for legal, administrative, and engineering costs of 25%, and construction sales tax at 8.2% (Cashmere, WA) was included in the estimated costs.

4.2.2 Power Costs

In order to estimate power costs, monthly flow data estimates were first calculated. These were determined based on crop irrigation requirement (CIR) values from local irrigation guides and data from similar recent studies in the region. A conveyance efficiency factor was accounted for in the CIR estimates. These flows were then converted to kilowatt hours based upon pump horsepower ratings. Local power rates for similar irrigation districts were then used to estimate power costs. These results were checked against Pioneer Water Users Association (PWUA) water usage and associated power costs for its pressurized irrigation system. PWUA is located in Wenatchee, Washington. Assumptions related to the irrigated acreage in PWUA and the associated power costs were utilized to validate the power cost estimates.

Tables B-3A and B-3B have power usage costs for the Normal Year and Dry Year respectively. The power costs associated with the Normal Year reflect average irrigation water usage years; the Dry Year data is based upon the water usage during 2005 which was one of the peak water usage seasons during the eleven years for which IID has records.

4.2.3 Maintenance Costs

These costs are associated with the values typically incurred in operating similarly sized pumping stations in terms of pump maintenance, periodic service, building maintenance, and the annual contribution associated with a pump replacement fund. Operation and maintenance costs for a pressure pipeline was also estimated. For the purposes of this study a operations and maintenance costs were estimated to be 0.8% of the pump station capital cost and 0.2% of the pipeline capital cost. These percentages correspond to historic costs associated with similar systems.

4.2.4 Operations and Maintenance Costs

These are the total annual costs associated with combined Power and Maintenance Costs.

4.2.5 Existing System Maintenance Costs

The operations and maintenance cost for the portions of the existing system that would remain for any given option were not included in this study. At present, IID does not have operations and maintenance costs broken out by segment of the system (or beat). This would need to be undertaken if operations and maintenance costs are to be factored in for the portions of the IID system that would remain in place for any given pump station option.

Table 4-1

Pump Station Option Summary—Normal Year

Pump Station Alternative	Peak Flow		Area Served[3] (ac)	Acre-ft[4]	Piping Const. Cost ($)[5]	Pump Station Const. Cost ($)[6]	Pump Station HP[7]	Annual Power Cost ($)[8]	Annual Maint. Cost ($)[9]	Total Annual O&M Cost ($)[10]	Weekly O&M Cost ($) (Peak)[11]	Total Capital Cost ($)[12]
	GPM[1]	CFS[2]										
Option 1A	6,241	13.91	925	1,663	2,442,396	2,191,000	1,312	31,191	22,413	53,604	2,747	4,633,396
Option 1B	6,241	13.91	925	1,663	1,961,613	2,060,000	1,033	24,529	20,403	44,932	2,225	4,021613
Option 2A	6,241	13.91	925	1,663	73,128	2,238,000	1,048	29,587	18,050	47,637	2,428	2,311,128
Option 2B	10,048	22.39	1,489	2,677	724,017	3,378,000	1,744	49,479	28,472	77,951	3,953	4,102,017
Option 3A	10,048	22.39	1,489	2,677	937,464	3,306,000	1,707	49,243	28,323	77,576	3,933	4,243,464
Option 3B	13,256	29.53	1,964	3,532	4,365,105	4,169,000	2,461	87,627	42,082	129,709	6,537	8,534,105
Option 4	13,013	28.99	1,928	3,467	516,780	3,971,000	1,701	49,082	32,802	81,883	4,174	4,487,780
Option 5-West	13,249	29.52	1,963	3,530	1,083,060	3,909,000	1,582	45,633	33,438	79,071	4,044	4,992,060
Option 5-East	4,670	10.40	692	1,244	37,400	5,290,000	510	14,700	42,395	57,094	3,060	5,327,400
Option 6A	13,650	30.41	2,022	3,637	864,443	3,808,000	1,313	37,869	32,193	70,062	3,603	4,672,443
Option 6B	27,845	62.04	4,125	7,419	986,880	6,209,000	2,912	83,982	51,646	135,628	6,894	7,195,880
Option 6C	52,510	117.0	7,779[13]	13,991	2,303,738	10,663,000	5,278	158,379	89,911	248,291	12,585	12,966,738[14]

1 *GPM:* Maximum gallons per minute pumped from Wenatchee River; actual volume will vary from day to day and time of season.

2 *CFS:* Maximum cubic feet per second pumped from Wenatchee River; actual volume will vary from day to day and time of season.

3 *Area Served in acres:* These are the estimated acres of land that would be served by this option.

4 *Acre-ft:* Acre-feet of water conveyed over the season. This value is based upon the CIR (crop irrigation requirement; see definition and application in *Flow Data*, under *Pump Station Option Calculations*, Appendix B) calculated on a month by month bases.

5 *Piping Construction Cost:* This is the cost of all piping related costs including excavation, installation, backfill, pavement replacement (when applicable) fittings, and services. Also includes booster pump cost for Options 1B and 6C.

6 *Pump Station Construction Cost:* Cost of the pumping station structure, pumps, controls, miscellaneous equipment, piping, intake line, fish screen, etc.

7 *Pump Station HP:* The total pump horsepower to convey maximum peak flow. Actual horsepower used will correspond to actual flow.

8 *Annual Power Cost:* This is calculated based upon the CIR usage numbers (see footnote 4), converted to horsepower usage and then to power used, then to a cost based upon local power costs. This covers the entire irrigation season assuming that the option is in operation throughout the season (Options that are gravity flow only can be operated just during specific times of the season to lower peak diversion flows from Icicle Creek.

9 *Annual Maintenance Cost:* assumes 0.8% of pump station construction costs plus 0.2% pipeline construction cost.

10 *Total of Annual Power and Maintenance Costs.*

11 *Weekly O&M Cost (Peak):* Average of power cost of last two weeks of August plus month of September plus 1/3 of total O&M spread over 6 weeks.

12 *Total Capital Cost:* Summation of piping and pump station construction costs.

13 Option 6C *Acres Served* include about half of PID's acreage which is associated with it's diversion right from Icicle Creek.

14 Does not include removal of the diversion structure or any of Beat 1 canal.

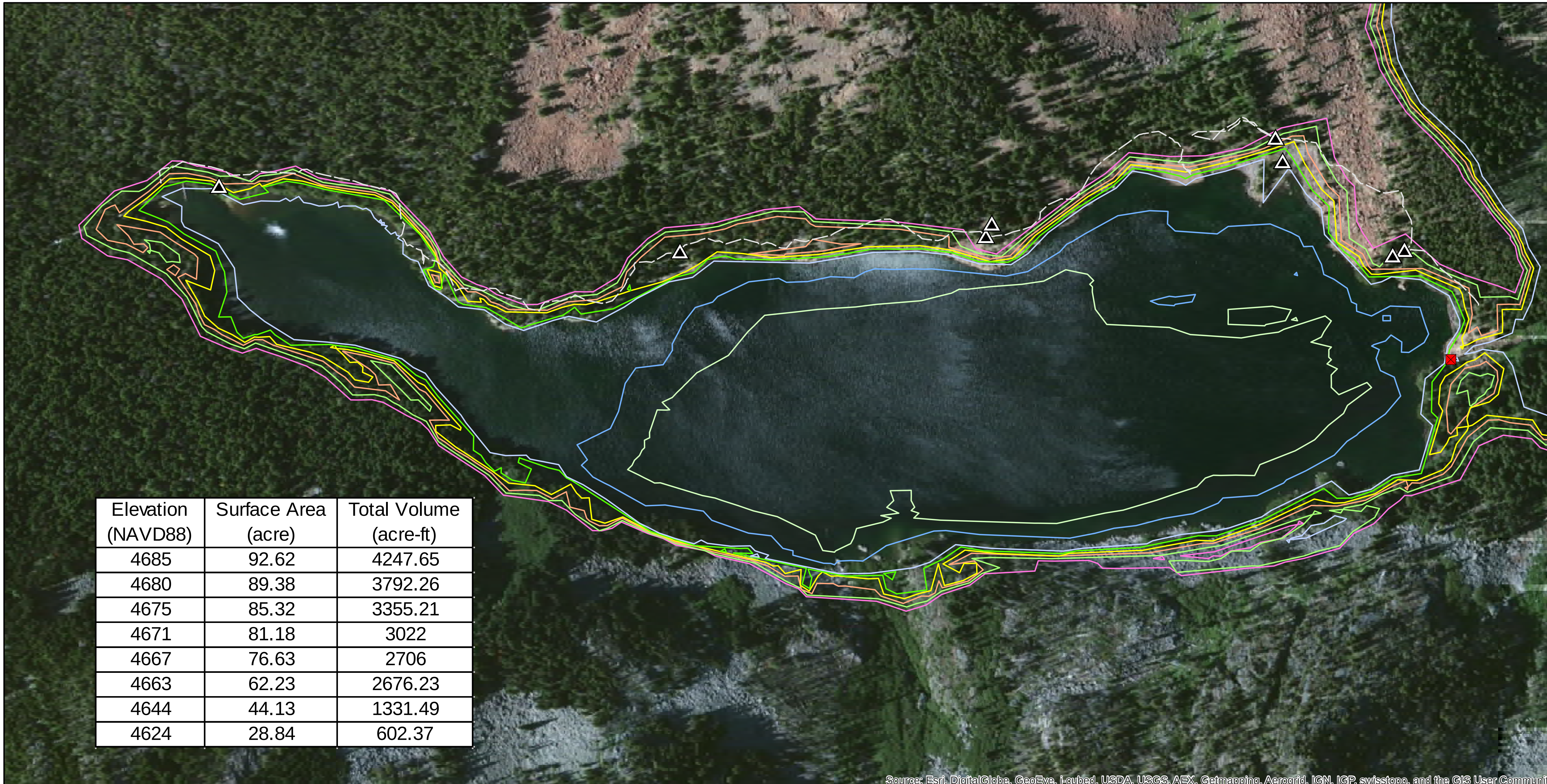
See Table B-3A for more summary information and Table B-3B for Dry Year data
See Tables B-4 through B-15 for detailed information on pump station cost estimates

APPENDIX A

Eightmile Lake Study Findings

The following are included in this appendix:

- Image of Eightmile Lake with contour elevations (from Gravity Environmental Consultants).
- Associated calculations.
- Note:
  - Calculations associated with the cost of improvements to the dam and related infrastructure was not part of this study.
  - Recommendations for including the lake as a means of increasing stream flow in Icicle Creek was not part of this study.



Elevation (NAVD88)	Surface Area (acre)	Total Volume (acre-ft)
4685	92.62	4247.65
4680	89.38	3792.26
4675	85.32	3355.21
4671	81.18	3022
4667	76.63	2706
4663	62.23	2676.23
4644	44.13	1331.49
4624	28.84	602.37

Elevation - NAVD88

- 4685
- 4680
- 4675
- 4671 (Top of Dam)
- 4667 (High Water)
- 4663 (No Rec. Impact)
- 4644 (Max Draw Down)
- 4624 (Proposed Draw Down)

- Campsites
- Dam
- Trail

Feet: 0 100 200 400 600 800

N

Figure A1
Lake Elevation and Storage

GRAVITY Consulting LLC

TROUT UNLIMITED

SCALE: See Scale Bar
SIZE: 11 x 17
PROJECT:
DATE: 10/30/2013

VERSION: A01
DRAWN: JW
CHECKED:
APPROVED:

PROJECTION: GRS 1980 Lambert Conformal Conic

SOURCE: (c) 2010 Microsoft Corporation and its data suppliers. WBCAS

Path: C:\Users\Shawn Hinz\Desktop\Projects\EightMile\GIS\MXD\additional_scenarrios_figure_11x17.mxd

FORSGREN Associates Inc.

Executive Summary of Calculations

Volume Summary Based upon *Gravity Consulting* Survey Data

Water Elev.	Surf Area (ac)	Total Vol. (ac-ft)	Δ H_2O (ft)[1]	Δ Dam (ft)[2]	
4624	28.8	602	-43	-47	← Proposed Lowest Drawdown
4644	**44.1**	**1,331**	**-23**	**-27**	**← Current Lowest Drawdown**
4663	62.2	2,676	-4	-8	← No Recreational Impact
4667	**76.6**	**2,706**	**0**	**-4**	**← Current Normal High Water Elevation**
4671	80.8	2,998	4	0	← Current Top of Dam Overflow Elevation

Present Usable Storage (ac-ft): 1,375 (Elev. 4644 to 4667)

At Assumed New Maximum Drawdown Elevation 4624

Following is a combination of existing and potential new water elevations and associated dam dimensions.

Present System Capacity (ac-ft): ***2,104*** (at assumed drawdown to 4624)

Water Elev.	Surface Area (ac)	Total Vol. (ac-ft)	Useable Vol. (ac-ft)	Δ Pres. H_2O Elev (ft)[3]	Δ Pres. Dam Elev (ft)[4]	Approx. Dam Lgth (ft)[5]	
4667	76.6	2,706	2,104	0.0	-4.0	Exist	← Current High Water
4671	80.8	2,998	2,395	4.0	0.0	Exist	← Current Dam Overflow
4672	82.3	3,102	2,500	5.0	1.0	81*	← To Achieve 2,500 ac-ft
4675	85.3	3,355	2,753	8.0	4.0	169*	← Additional Options
4680	89.4	3,792	3,190	13.0	9.0	337*	←

FOOTNOTES:

1. "Δ H_20" is elevation difference measured from Current Top of Dam Overflow.
2. "Δ Pres. Dam" is elevation difference measured from Current High Water Elevation.
3. "Δ Pres. H_20 Elev" is height measured from the approximate existing high water elevation.
4. "Δ Pres. Dam Elev" refers to the height of new dam overflow above the current dam overflow.
5. "Approx. Dam Lgth" refers to length of new dam. This refers to total new dam structure; in some cases there will be an "island" of land with dam extending on either side of it to fill in the opening (marked with *). In some cases, the structure can be a reinforced earthen berm.

Lake Depth at Drawdown to Elev. 4624

Lowest H_2O Lvl	Deepest Contour	Depth (ft)
4624	4580	44

Watershed Runoff Less Evaporation

We performed calculations for water shed runoff based upon Town of Leavenworth rainfall data (approximately 25-in per year) as it was the nearest historic rainfall data available. We also looked at evaporation rates using NOAA evaporation maps for the area. The evaporation rate is 25-in per year. The rainfall is distributed over the entire watershed (approximately 3,783 acres) whereas the evaporation rate only applies to the lake itself (assumed elevation of 4680). The summary of the calculations are shown below. There are also losses associated with lake water seeping into the ground which is not addressed here as we do not currently have the means to estimate that value. The data below assumes the worst case scenario for the soil type within the watershed based upon USDA website data.

Runoff (ac-ft)	Evap. (ac-ft)	Net (ac-ft)
7,749	-186	7,563

More Detailed Calculations

This is an Executive Summary of calculations for Eightmile Lake. A much more detailed version of these calculations is available.

Elevations of Pt. 'A' and Pt. 'B' below are survey data from Gravity Consulting. The "Current Normal High Water" elevation is based upon Tony Jantzer's estimation that it was roughly half-way between the "Top of Weir at Dam Opening" (Pt. 'B') and the Historic Top of Dam Overflow" (Pt. 'A'). Jantzer also indicated that the lowest current drawdown elevation is approx. 27' below PT. 'A'.

Estimating Run-off and Its Affect on Lake Storage

Method Used: Modified SCS

SCS is the method used in Chelan County, WA for determining stormwater runoff. The method is primarily used to calculate run-off associated with a particular storm of a particular strom frequency. In this case, we are using it to estimate run-off associated with an entire year's worth of rainfall. By reverting to the basic equations, this should result a reasonable estimate of run off. In this case, we are looking at average rainfall (some years will be more, some less). Since we are looking at total run-off, the intensity of a particular storm event is not at issue. Therefore, the design type of storm (Type 1A, Type 2, etc.) isn't relevant. Rainfall for an average year was used.

Soil Type

See the *Soil Data* Tab for how the soil type was determined. It is summarized below:

3,783 Acres (Total Water Shed Area)

Soil Type	%	Acres	CN		
			Poor	Fair	Good
A	1%	38	45	36	30
C	10%	378	77	73	70
D	89%	3,367	83	79	77
	Composite:	3,783	82.02	77.97	75.83

"Composite" is the averaging of CN's for the various soil types.

CN (Curve No.) values were taken from TR-55 manual, 2nd Ed, June 1986. The category chosen was "Woods" and the corresponding soil descriptions of "Poor," "Fair," and "Good," are as follows:

Poor: Forest litter, small trees, and brush are destroyed by heavy grazing or regular burning.
Fair: Woods are grazed but not burned, and some forest litter covers the soil.
Good: Woods are protected from grazing, and litter and brush adequately cover the soil.

The higher the CN value, the more run-off will occur. "Poor" soils don't apply so the appropriate numbers to use will be either "Fair" or "Good." Both conditions were evaluated.

Rainfall

The Town of Leavenworth was used for total rainfall since this is the nearest documented rainfall that has historic averages. This should be a conservative number since Eightmile Lake is at a higher elevation and is located closer to the Cascade Range peaks and therefore would be expected to have a higher rainfall.

The Rainfall values include the snow liquid equivalent (see Rainfall Data).

Month	Rainfall (in)	Non-Irrigation	Irrigation
Jan	6.38	6.38	
Feb	3.73	3.73	
Mar	2.50	2.50	
Apr	1.03		1.03
May	0.85		0.85
Jun	0.85		0.85
Jul	0.34		0.34
Aug	0.44		0.44
Sep	0.71		0.71
Oct	2.04	1.02	1.02
Nov	4.79	4.79	
Dec	6.91	6.91	
Total	30.56	25.32	5.24

Formulas

$Q = (P-I)^2 / [(P-I) + S]$

Q = runoff (in); P = rainfall (in)
S = potential max. retention after runoff begins (in)
I = initial abstraction (in) = 0.2· S (experimentally obtained)

$S = (1000/CN) - 10$

$Q = [P - 0.2 \cdot S]^2 / [P + 0.8 \cdot S]$

CN	S
77.97	2.825
75.83	3.187

CN	Q1 (in)	Q2 (in)	QT (in)
"Fair"	22.22	2.92	25.14
"Good"	21.86	2.72	24.58

Q1 = Runoff Rainfall for non-irrigation months (in)
Q2 = Runoff Rainfall for irrigation months (in)
QT = Total Annual Runoff Rainfall (in)

Note: Values are less than the annual values stated above due to evapotranspiration and soil absorption losses.

Actual Run-Off Based Upon Tributary Area

Area: 3,783 Acres

CN	Q1' (ac-ft)	Q2' (ac-ft)	QT' (ac-ft)
"Fair"	7,005	919	7,924
"Good"	6,892	858	7,749

Q1' = Runoff Rainfall for non-irrigation months (ac-ft)
Q2' = Runoff Rainfall for irrigation months (ac-ft)
QT' = Total Annual Runoff Rainfall (ac-ft)

Note: These values reflect the rainfall in the table above spread out over the entire watershed and collected in the lake.

Losses

In addition to the release of water through the dam, there are also losses due to evaporation and percolation into the lake bed. Evaporation can be calculated but percolation losses are not easily estimated without monitoring water flow from all sources into the lake, flow out through the dam, and accounting for evaporation. Therefore, no attempt has been made to estimate percolation losses.

Evaporation Losses:

According to NOAA's Evaporation Maps for Shallow Lakes (See *Evaporation Data* Tab), the annual evaporation rate for the Eightmile Lake area is 25 inches.

Lake Area (acres)*:	89.4
Evaporation Rate (in/yr):	25
Net Loss (ac-ft):	186.3

*Area is based upon the highest assumed elevation of 4680.

Net Annual Lake Inflow (Without Percolation Losses)

CN	QT' (ac-ft)	Evap (ac-ft)	Net (ac-ft)
"Fair"	7,924	-186	7,738
"Good"	7,749	-186	7,563

Rainfall Data (from Office of the Washington State Climatologist)

LEAVENWORTH 3 S, WASHINGTON (454572)

Period of Record Monthly Climate Summary

Period of Record : 5/ 1/1914 to 3/31/2013

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Max. Temperature (F)	33.4	41.9	52.5	62.9	72.1	78.8	87.8	87.2	78.0	63.1	44.2	33.9	61.3
Average Min. Temperature (F)	17.3	21.4	27.8	33.9	40.3	46.3	50.8	50.0	42.7	34.6	28.0	20.4	34.5
Average Total Precipitation (in.)	4.35	2.77	2.07	1.01	0.85	0.85	0.34	0.44	0.71	2.01	4.01	4.82	24.22
Average Total SnowFall (in.)	30.4	14.4	6.4	0.3	0.0	0.0	0.0	0.0	0.0	0.5	11.7	31.3	94.9
Average Snow Depth (in.)	18	18	7	0	0	0	0	0	0	0	2	10	5

Percent of possible observations for period of record.
Max. Temp.: 84.6% Min. Temp.: 84.5% Precipitation: 88.5% Snowfall: 86.5% Snow Depth: 84.9%
Check Station Metadata or Metadata graphics for more detail about data completeness.

Western Regional Climate Center, wrcc@dri.edu

http://www.climate.washington.edu/

Rainfall Data • Total Monthly Run-Off and Distribution by Irrigation/Non-Irrigation Months

Snow Equivalent Factor: 15 ← See NOAA Table Below (Assumed Avg. Temp. 27 to 20 degrees)

Month	Rainfall (in)	Snow (in)	Snow Eqv. (in)	Total (in)	Non-Irrigation	Irrigation
Jan	4.35	30.40	2.03	6.38	6.38	
Feb	2.77	14.40	0.96	3.73	3.73	
Mar	2.07	6.40	0.43	2.50	2.50	
Apr	1.01	0.30	0.02	1.03		1.03
May	0.85	0.00	0.00	0.85		0.85
Jun	0.85	0.00	0.00	0.85		0.85
Jul	0.34	0.00	0.00	0.34		0.34
Aug	0.44	0.00	0.00	0.44		0.44
Sep	0.71	0.00	0.00	0.71		0.71
Oct	2.01	0.50	0.03	2.04	1.02	1.02
Nov	4.01	11.70	0.78	4.79	4.79	
Dec	4.82	31.30	2.09	6.91	6.91	
Total	24.23	95.00	6.33	30.56	25.32	5.24

Approximate Snowfall Liquid Equivalent (NOAA) • Assume 27 to 20 for Average Temperature

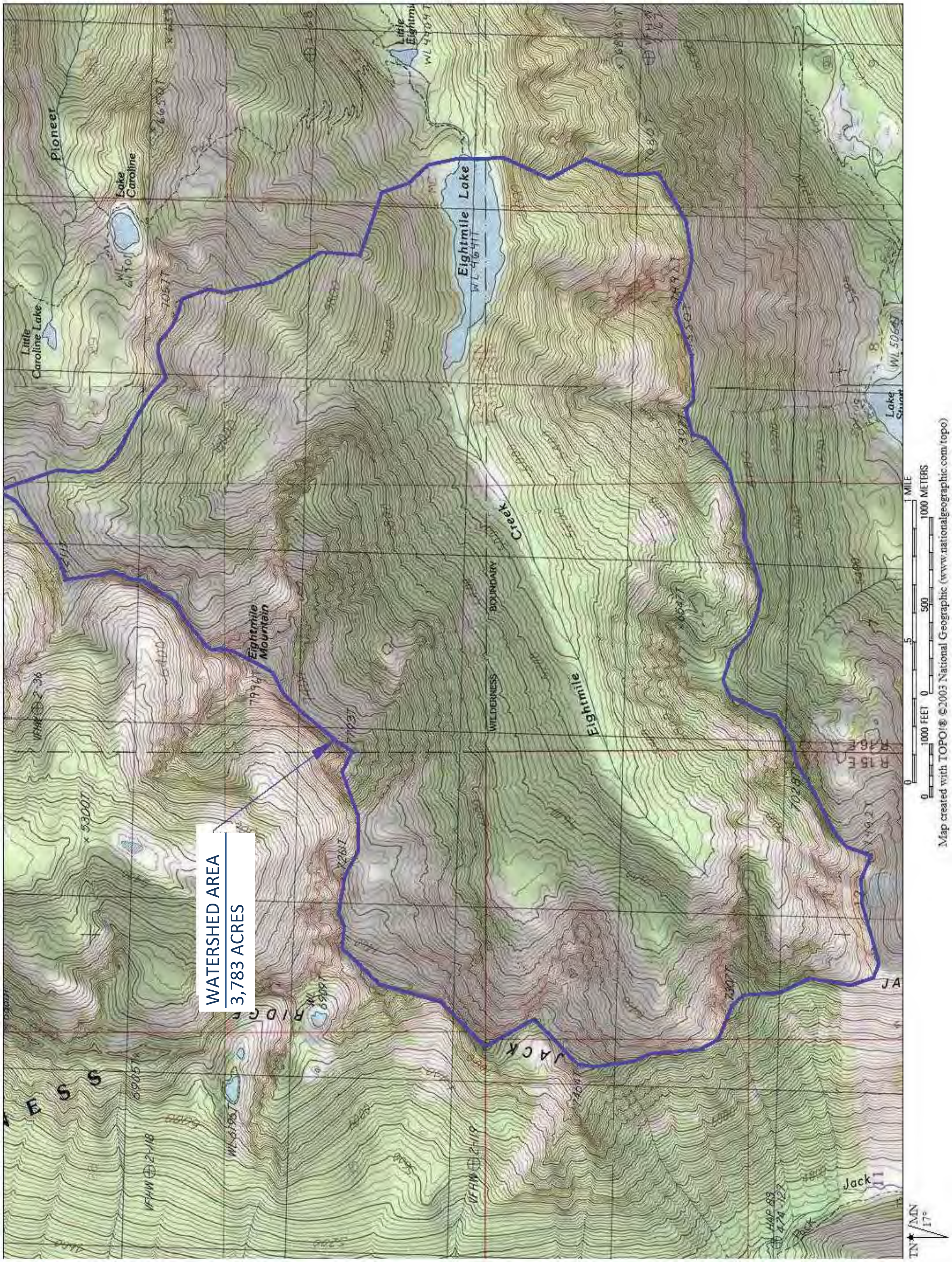
Approximate snowfall amounts at specified temperature ranges

Melt Water Equivalent (inches)	Temperature (degrees F) 34 to 28	27 to 20	19 to 15	14 to 10	9 to 0	-1 to -20	-21 to -40
Trace	trace	0.1	0.2	0.3	0.4	0.5	1.0
.01	0.1	0.2	0.2	0.3	0.4	0.5	1.0
.02	0.2	0.3	0.4	0.6	0.8	1.0	2.0
.03	0.3	0.5	0.6	0.9	1.2	1.5	3.0
.04	0.4	0.6	0.8	1.2	1.6	2.0	4.0
.05	0.5	0.8	1.0	1.5	2.0	2.5	5.0
.50	5.0	7.5	10.0	15.0	20.0	25.0	50.0
.60	6.0	9.0	12.0	18.0	24.0	30.0	60.0
.70	7.0	10.5	14.0	21.0	28.0	35.0	70.0
.80	8.0	12.0	16.0	24.0	32.0	40.0	80.0
.90	9.0	13.5	18.0	27.0	36.0	45.0	90.0
1.00	10.0	15.0	20.0	30.0	40.0	50.0	100.0
2.00	20.0	30.0	40.0	60.0	80.0	100.0	200.0
3.00	30.0	45.0	60.0	90.0	120.0	150.0	300.0

This table gives a statistical relationship between amounts of snow that fall and the corresponding water equivalent at specified temperature ranges. The water equivalent and snow fall amounts are listed in inches. Temperature ranges are listed in degrees Farenheit. These values are only approximate. The Actual values for a specific storm can vary significantly from this table.

http://www.erh.noaa.gov/box/tables/snowfall-meltwater.html

Watershed • USGS Mapping

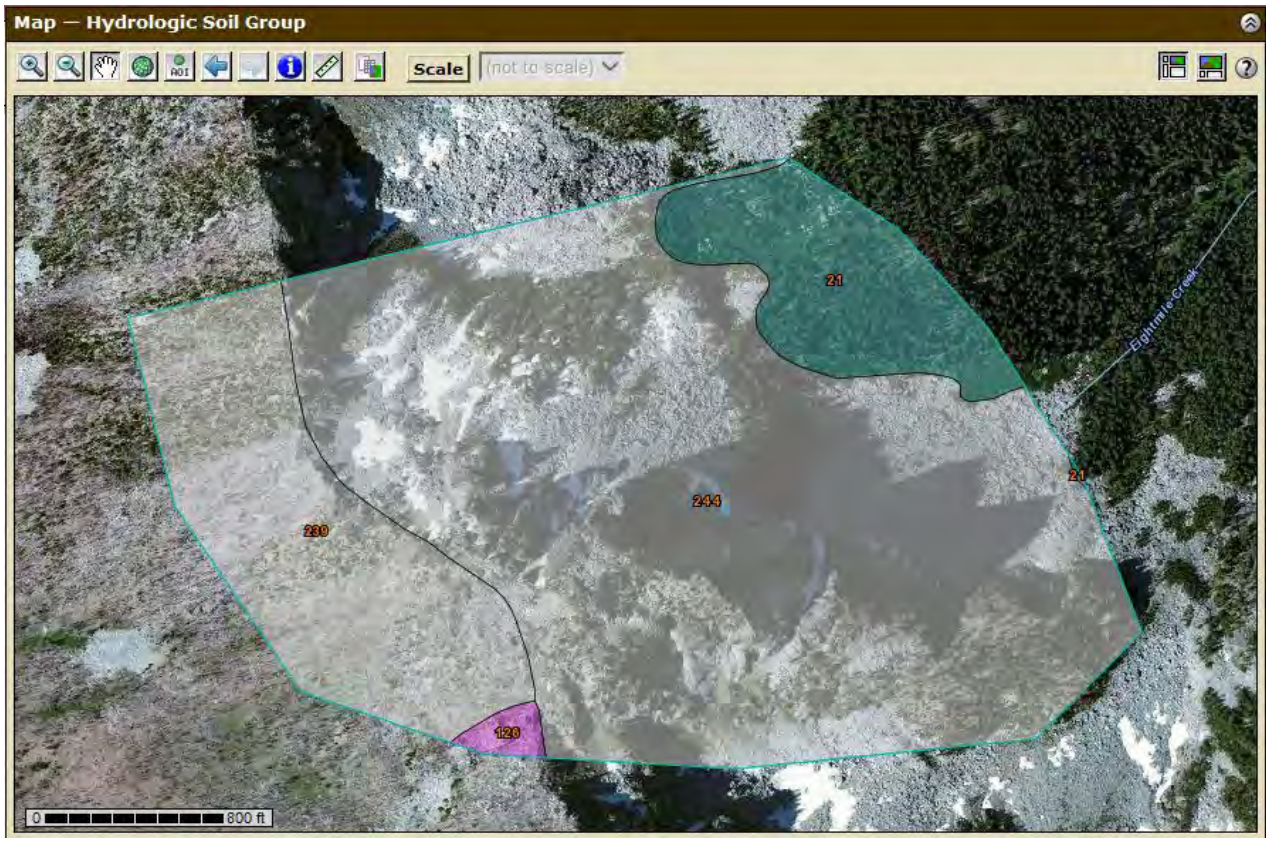


Soil Data from USDA Website (See Note Below):

Tables — Hydrologic Soil Group — Summary By Map Unit

Summary by Map Unit — Cashmere Mountain Area, Washington, Parts of Chelan and Okanogan Counties (WA608)

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
21	Andic Cryumbrepts-Haplocryods-Rock outcrop complex, steep and very steep*	C	21.3	9.9%
126	Haplocryods-Andic Cryochrepts-Rock outcrop complex, steep and very steep*	A	1.6	0.8%
239	Rock outcrop		40.9	19.0%
244	Rock outcrop-Rubble land-Glaciers, snowfields complex		151.4	70.4%
Totals for Area of Interest			**215.2**	**100.0%**



Notes:

1) It was difficult to view the lake accurately on the USDA Web Map since the lake was in shadow. It's also difficult to estimate the watershed boundary on the image. The area shown here was a rough approximation but should give an appropriate ratio of soil types in the immediate area.

2) In comparing the scale of this map with USGS maps of the area, the scale in acres seems to be inaccurate. However, for the purposes of this exercise, we care more for the ratio of land types rather than the accuracy of the area calculation as we can obtain that number more accurately using the USGS maps.

Description — Hydrologic Soil Group

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

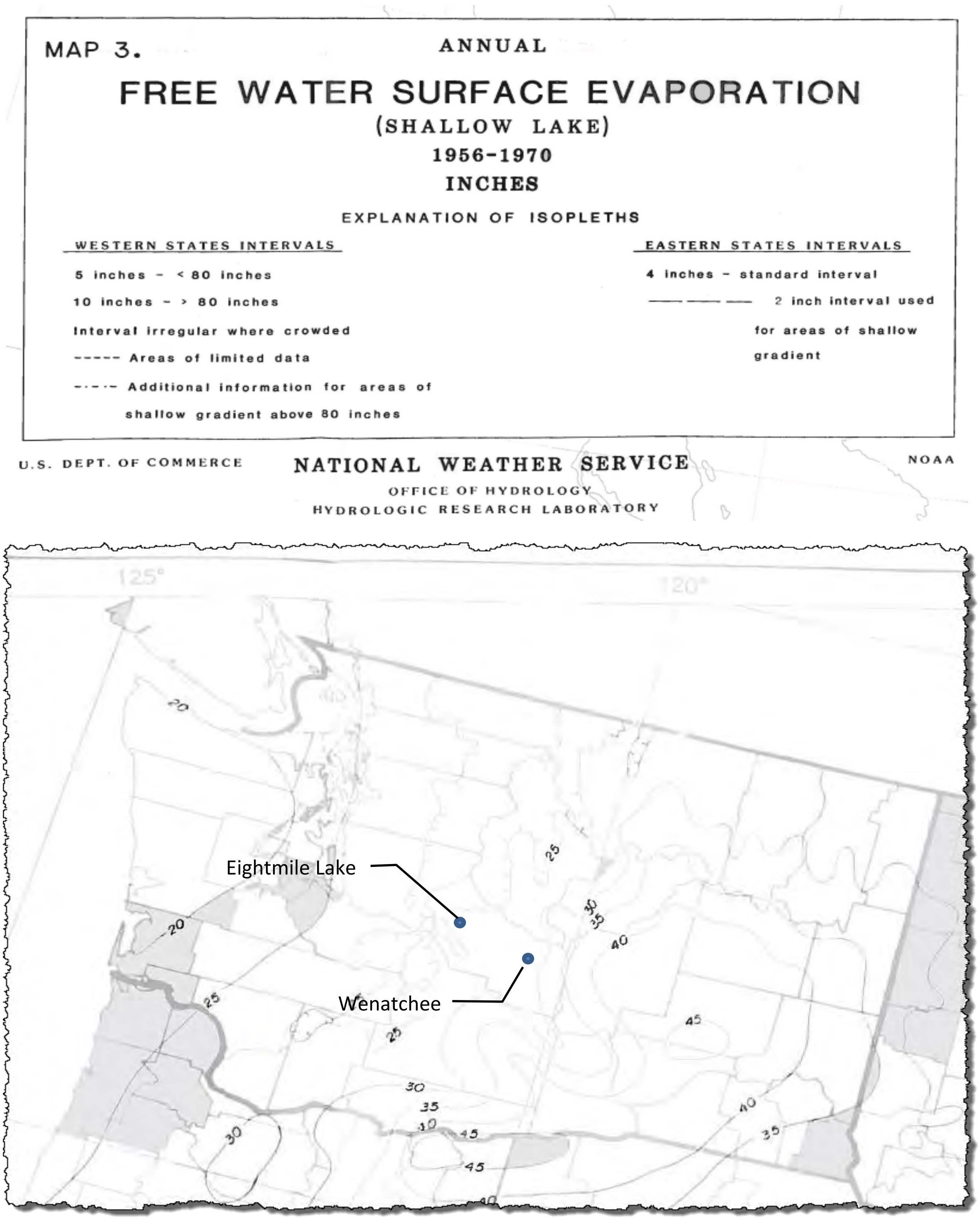
Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

Area per USGS Map Delineation
3,783 Acres

Soil Type	%	Acres	CN
A	1%	38	36
C	10%	378	70
D	89%	3367	77

Below is a annual *Shallow Lake Evaporation* map from NOAA. Annual evaporation rate for Eightmile Lake is approximately 25 inches. Note that the only NOAA evaporation resources available are rates for evaporation pans and what is shown here for "Shallow Lakes." The latter is the most appropriate application for Eightmile Lake. Evaporation pans generate higher evaporation rates than are experienced for lakes and must be adjusted when applied to lakes. This appears to be the most recent data available from NOAA.



APPENDIX B

Pump Station Option Findings

The following are included in this appendix:

- Exhibits showing locations of the pump sites evaluated
- Criteria used for probable cost estimates
- Summary calculations for the pump station options
- Flow Data from Diversion at Icicle Creek

Pump Option Exhibits: Figures B-1 through B-7

Definitions for Figures

Creek Mile .... Distance from Icicle Creek's confluence with the Wenatchee River*

Elev .... Elevation (measured in feet)

ft .... feet (linear feet)

Gravity flow to the End ..... Refers to the portion of a pump station's flow that will be released into the existing canal and allowed to flow by gravity to the end of the canal

Mile .... Refers to the distance in miles from the IID Inlet at Icicle Creek to the point under consideration

Pressure Main .... A pressurized irrigation pipe that replaces a corresponding section of canal

Pump Discharge Line .... Pump discharge line that transmits water from pump station to canal; from there water either flows in a pressure main or by gravity or both

PS Option .... Pump Station Option number

River Mile .... Distance from Wenatchee River's confluence with the Columbia River*

*Scaled from USGS Maps

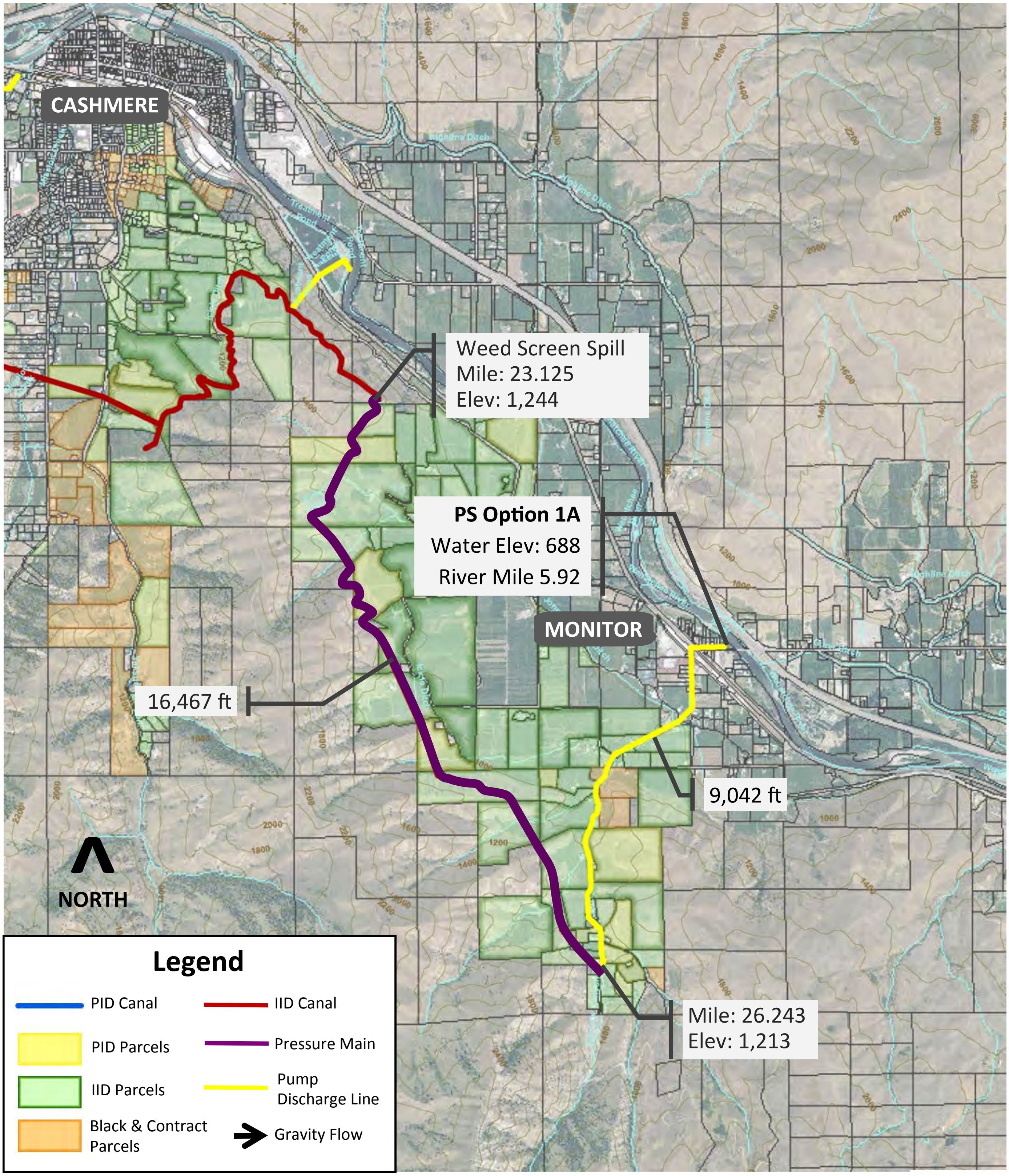


Figure B-1: Pump Station Option 1A

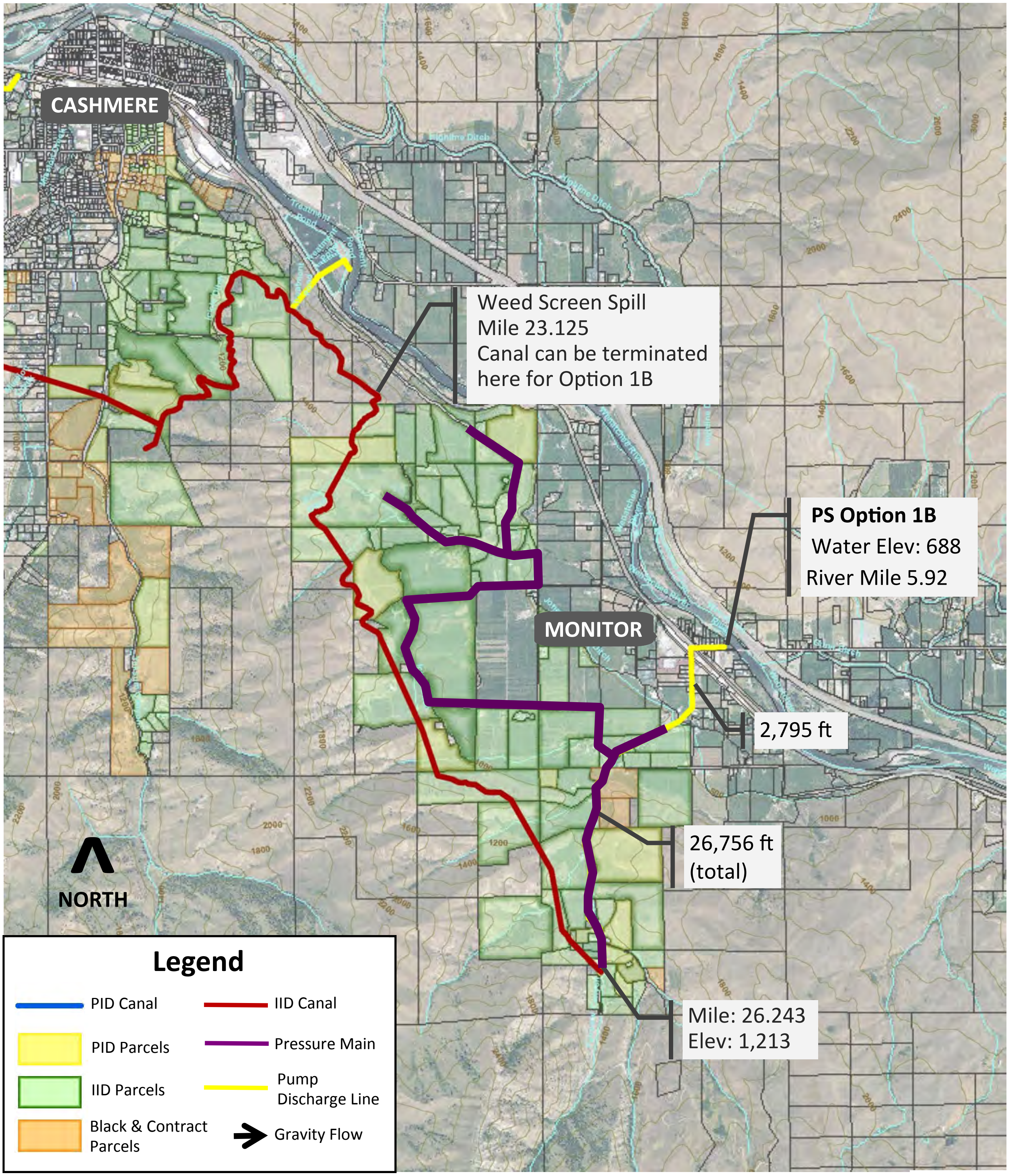


Figure B-2: Pump Station Option 1B

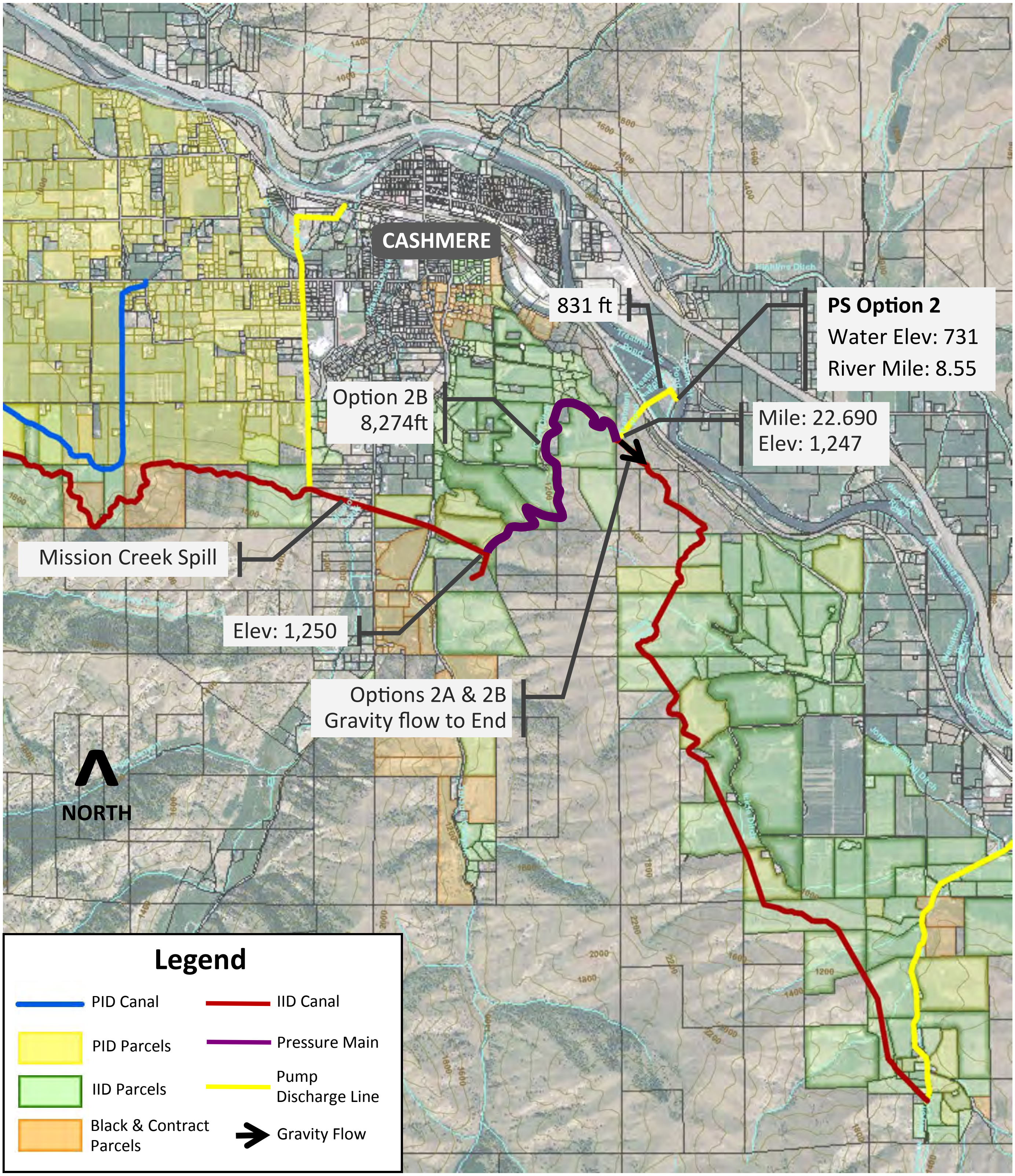


Figure B-3: Pump Station Option 2

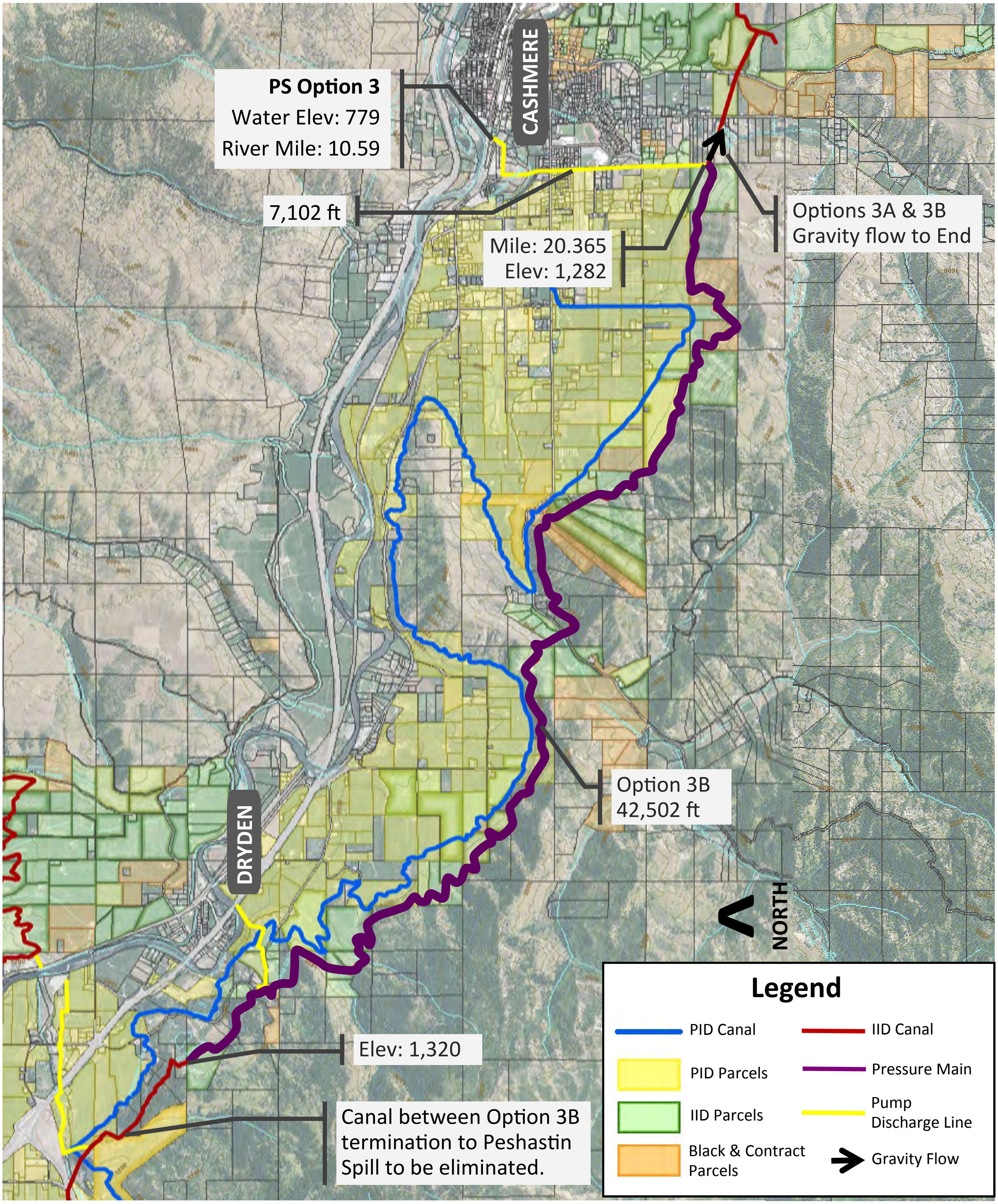


Figure B-4: Pump Station Option 3

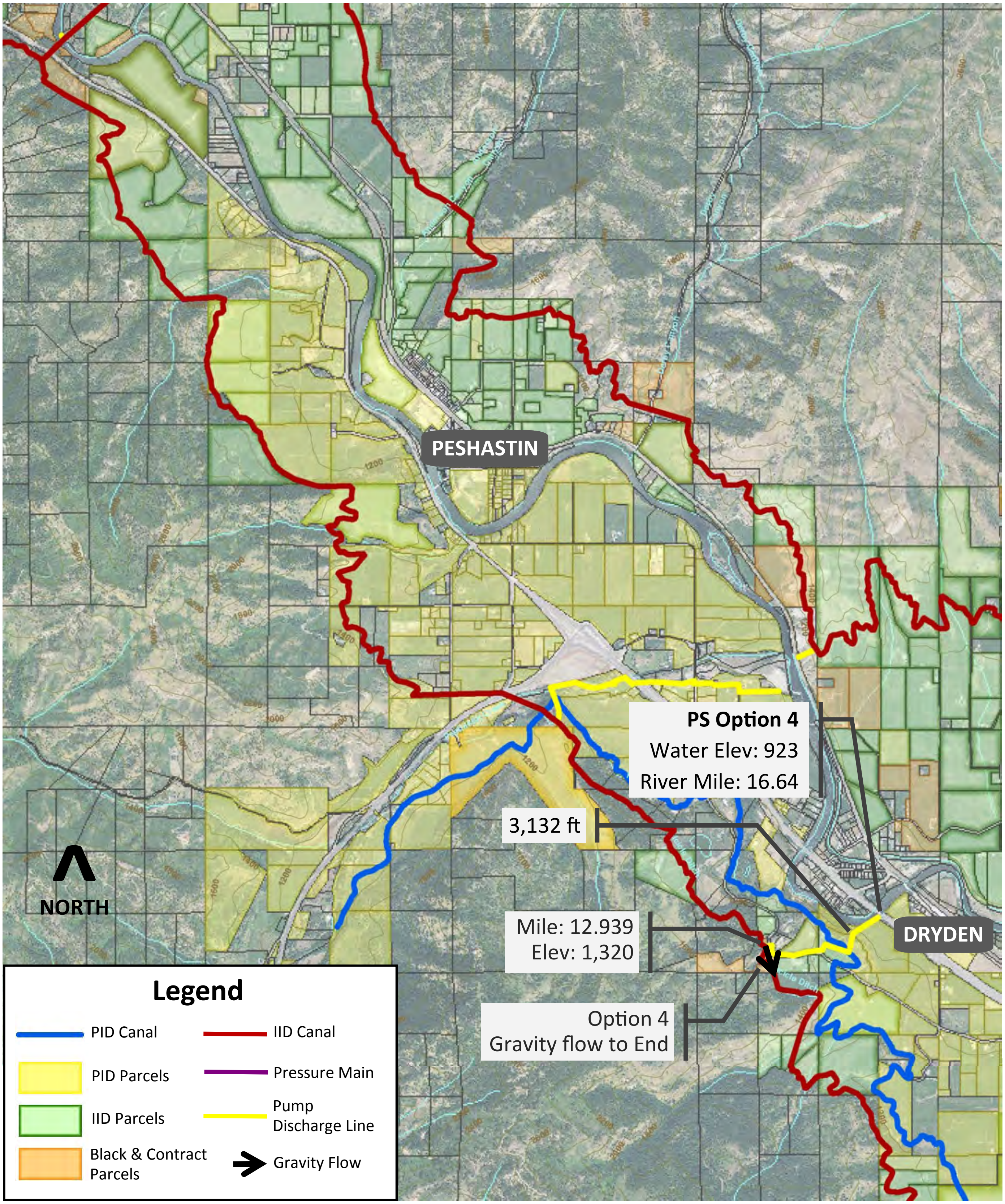


Figure B-5: Pump Station Option 4

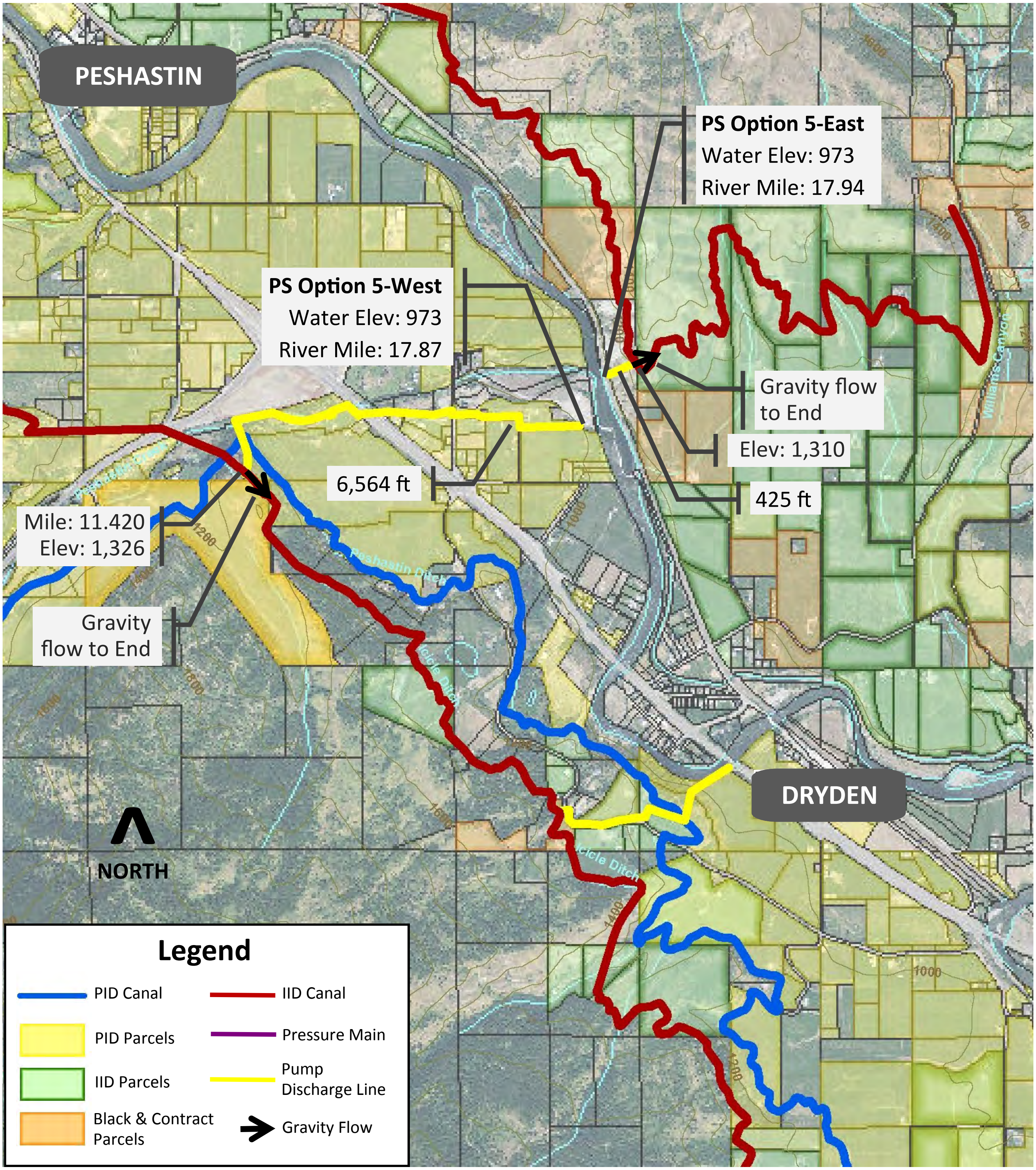


Figure B-6: Pump Station Options 5-East and 5-West

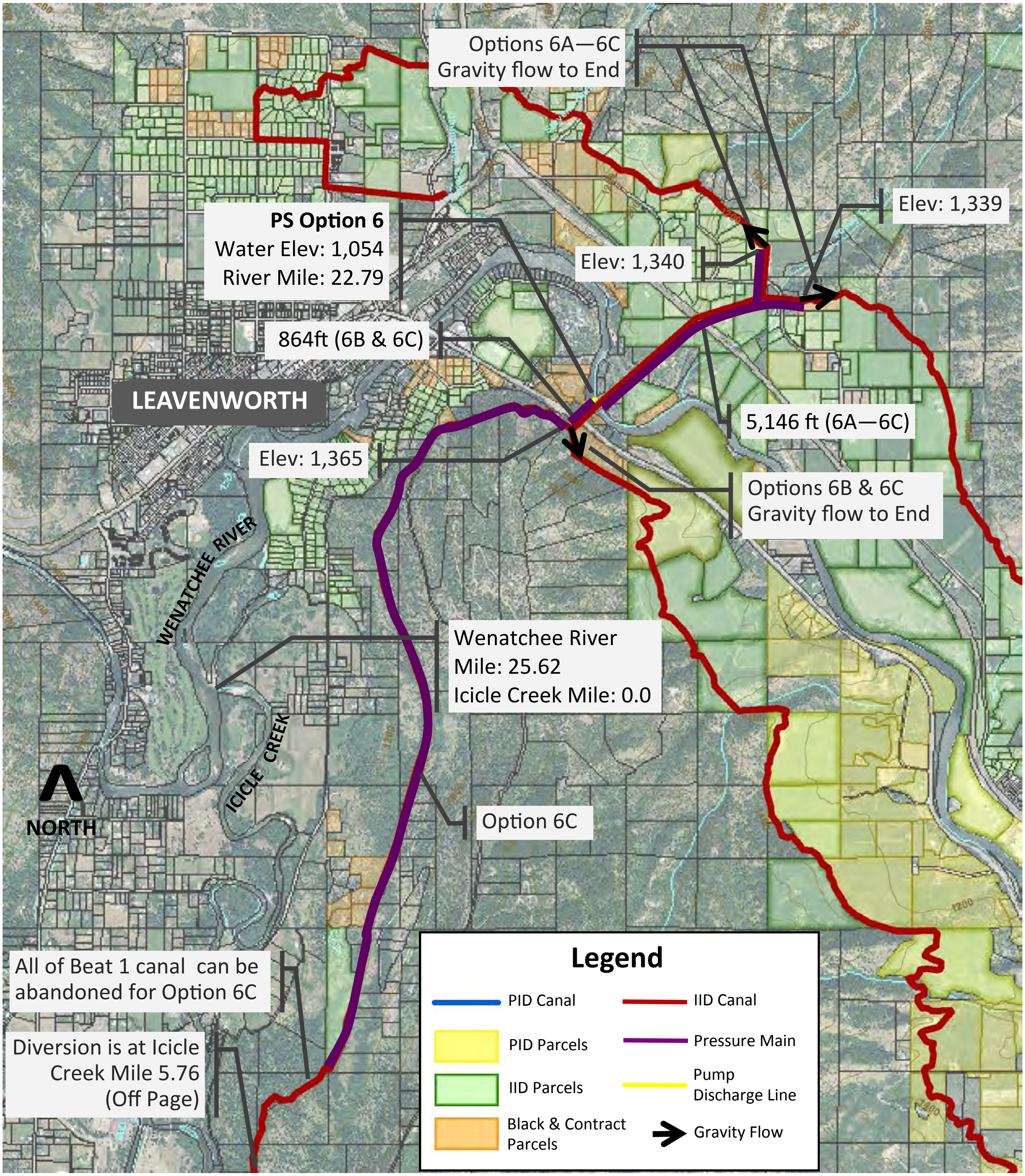


Figure B-7: Pump Station Option 6

Pump Station Option Calculations

Approach/Assumptions

The calculations developed in this study were based upon field measurements, information from the IID manager, previous IID reports, and data obtained from local and federal government agencies. Operational data from the newly constructed Pioneer Water Users Association (PWUA) pump station and pipeline was also used to verify costs and operational assumptions.

Data used for this project was based upon the following.

IID System Physical Data: Elevation and horizontal alignment data of the IID canal, tunnels, flumes, pipes, user turnouts, and spillways were recorded in the field using survey grade hand held GPS units. Results should be accurate within a few feet, often with even greater accuracy. This work was performed by Trout Unlimited personnel and provided to Forsgren for inclusion in the computer model.

Flow Data: IID indicated that the maximum allowable flow rate to each of its members is 0.015 cfs (6.75 gpm) per acre at the delivery point. The calculations accounted for delivery and application efficiencies estimated for the system. Additional water is conveyed to the Peshastin Irrigation District (PID) as well as several small irrigation districts by means of IID's canal. All of these add to a total diversion flow from Icicle Creek that exceeds just the needs of IID's users. Actual delivery rates vary from month to month during the irrigation season relative to actual irrigation demands by the district users.

Each option considered in this study is a subset of the total system. Since there is no specific historic flow data for each of these subsets, calculation of the monthly flow for each of them was determined using *crop irrigation requirement* (CIR) values.

CIR values from the Klohn Leonoff report previously completed for IID, were used as a basis for estimating CIR values for this study. Adjustments were made based on recent experience with the PWUA and current CIR values available from the Washington Irrigation Guide and Washington State Cooperative Extension Service.

Following is the description given by the Klohn Leonoff report for how the CIR values were developed.

"Crop irrigation requirements (CIR's) are the water required to satisfy evapotranspiration, leaching, and miscellaneous water requirements that are not provided by water stored in the soil, and precipitation that enters the soil. Average monthly CIR's were obtained from the State of Washington Irrigation Guide [USDA SCS, Washington State Cooperative Extension Service] for crops in Wenatchee and Leavenworth. The CIR's are averages, based upon mean temperatures, average precipitation for each month and average soil conditions. The CIR's can vary from year to year based upon temperatures, precipitation and soil moisture conditions at the start of the irrigation season. The CIR's will also vary within the District depending on the soil type within each orchard.

"The average CIR's from the State of Washington Irrigation Guide are listed in Table 5-1. Data was also available from the WSU Tree Fruit Research Center in Wenatchee for tree water use for the period of 1972 to 1991. The monthly averages are listed in Table 5-1 below the CIR's obtained from the State of Washington Irrigation Guide. The total CIR from the WSU data (34.92 inches) corresponds closely to the CIR listed in the State of

Washington Irrigation Guide for apples with cover (35.14 inches)." *(Klohn Leonoff, page 63)*.

The values used for this study agree substantially with operational observations of the PWUA 2013 irrigation season and are believed to be appropriate for the purposes of this study.

Forsgren was able to acquire the power bills for PWUA's 2013 irrigation season (the only season for which the new pump back irrigation system was in operation) along with the total acreage within the PWUA boundary and the water used for the season. With that data, the gallons/acre used for PWUA was estimated. This information was utilized to calibrate power costs calculations and estimates for this study.

Land Use and System Efficiency: The exercise above indicates there are two primary variables that affect the calculations' accuracy:

- Amount of land actually being irrigated compared to land within the district's boundary, and;
- The efficiency of the irrigation system in conveying water.

Comparing the PWUA with the IID calculations shows how the percentage of land actually being irrigated can affect the water demand calculations. Just as important is the efficiency of the system. The CIR calculations are the empirical values determined at the actual point of crop uptake. Because there is leakage and evaporation losses in the conveyance system, more water must be diverted than is needed by the crops per se. For the IID system, the exact values associated with the percent of district land actually being irrigated and the efficiency of the system very yearly and do not remain static. Therefore, assumptions have been made regarding both.

Table B-1

Crop Irrigation Requirements (CIR)

Crop Irrigation Requirements (Inches)

(Taken from Klohn Leonoff, Table 5-1)

Crops at Leavenworth	Month						Total
	May	Jun	Jul	Aug	Sep	Oct	
Pasture	0	3.58	6.78	5.05	2.77	0	18.18
Apples w/cover	0	4.52	8.54	6.44	3.60	0	23.10
Pears w/ cover	0.47	4.53	7.83	5.89	3.19	0	21.91

Crops at Wenatchee	Month						Total
	May	Jun	Jul	Aug	Sep	Oct	
Pasture	4.04	7.09	8.41	5.91	4.12	0.51	30.08
Apples w/cover	3.37	8.23	10.55	7.52	5.00	0.47	35.14
Pears w/ cover	3.97	7.47	9.69	6.88	4.56	0.40	32.97
WSU Tree Fruit	4.53	7.37	9.41	7.66	4.15	N/A	34.92

CIR Averages (Inches)

(Based on Klohn Leonoff, Table 5-2)

Month	Orchard	Pasture	Weighted Avg.*
May	1.69	2.02	1.71
June	5.45	4.46	5.40
July	9.05	7.19	8.95
Aug	9.05	7.19	8.95
Sept	3.95	3.11	3.91
Oct	0.24	0.26	0.24
Season	29.42	24.23	29.20

*Irrigated land is 95% orchards, 5% pasture. These are values used in this present study.

The Klohn Leonoff report provided efficiency values for the existing system (1993). With the exception of two beats and a portion of a third, the values were based upon actual tests carried out in the field. The others were estimated by the District. These values are summarized in Table B-2. The average of the values was 70%.

Calculations suggest an average canal efficiency of 70% applies to the present system. For the new pressure mains, 95% efficiency was assumed.

It is known that a portion of the land served by IID is not actually under irrigation. In discussions with the IID manager, it is assumed that approximately 25% of the land technically within the IID is not being irrigated. This value is reflected in the power costs summarized in this appendix.

Table B-2
Existing Canal Beat Efficiencies

The Klohn Leonoff study contained estimated efficiencies for the various Beats of the IID canal system. There have been numerous system upgrades since then. Additionally, the IID manager believes that Beat 1's efficiency is significantly lower than what is stated in the report. Since no definitive studies have been undertaken since the Klohn Leonoff study, there are only subjective estimates available. Below are the IID managers estimates for system efficiency.

Condition	Estimated Efficiency
At Start up and early in Irrigation Season	60%
During peak flow	80%
Average System Efficiency	70%

The largest system spills back to the Wenatchee River system occur during start-up and early in the season. Spills are lowest during peak demands. An average 70% efficiency corresponds favorably with the comparison of CIR values and actual flow data.

Hydraulic, Power, and Cost Calculations

A hydraulic analysis was performed for each alternative considered in this study. The hydraulic analysis provides the basis for determining preliminary pipeline and pump sizing. The analysis also provides a basis for development of preliminary pump station and intake screen sizing and configuration.

Pipeline hydraulics was analyzed with a spreadsheet model based on the Hazen-Williams formula. A Hazen-Williams coefficient of 130 was used for calculating friction losses through piping. Minor losses due to pipe bends, valves, transitions, and other fittings were accounted for with a minor loss factor in the calculations. This factor varied with each alternative based on the preliminary pumping and piping configuration.

Pump horse power was calculated using standard equations based on flow and Total Dynamic Head (TDH). An overall pump system efficiency of 78% was assumed for horsepower calculations (different from the canal system efficiency). The TDH for each alternative is based on a combination of pipeline friction losses, minor losses, and the pumping elevation required for each alternative. The horse power calculations provide the basis for calculating power costs for each alternative. Power costs were based on current user rates charged by Chelan County Public Works District for irrigation users.

Estimated power and maintenance costs were calculated separately and then combined together and referred to as Operations and Maintenance (O&M) costs. Annual maintenance costs were estimated by assuming a 0.8% of pump station capital costs and a 0.2% for new pipeline capital costs. This is based upon actual equipment replacement costs (pumps, valves, etc.) determined for each option and typical miscellaneous expenses and labor costs that have been observed historically for similar installations.

Calculation Summary Description

Following are the calculations for the pump station options. They are based upon the following:

- **Peak Flow (GPM & CFS):** The peak flow based upon 0.015 cfs per acre of land within the district. An 80% efficiency factor was assumed.
- **Area Served:** the estimated acres within the district boundary associated with the service limits of any particular option. Actual irrigated acres may be less than this amount.
- **Annual Volume (ac ft):** This is the calculated volume used based upon month by month CIR values. This includes 70% efficiency for gravity systems utilizing the existing canals and 95% for pressure mains.
- **Annual Power Costs:** Power costs are based upon the annual volume. They were calculated on a month by month basis and added together for this value.
- **Annual Maintenance Cost:** This is based upon the assumption that the annual costs will be approximately 1% of the capital costs for the new pump stations and the pressure mains. Maintenance costs associated with the existing canals that will remain are not included in this amount.
- **Annual O & M Cost:** This is the total of the Annual Power Costs and the Annual Maintenance Costs.
- **Weekly O&M Cost (Peak):** This is the O&M costs for half of the month of August and all of the month of September divided by six (weeks). This number can be used to calculate the O&M costs if the pump station only runs on a week by week basis during the critical Icicle Creek low flow periods.
- **Total Capital Costs:** these are the costs associated with the construction and installation of the pump station and the new pressure pipe and associated appurtenances.

Table B-3A | Cost Summary Table—Normal Year

	Peak Flow						Pump Supply Line[7]		Pressure Main[8]									
Pump Station Alternative	GPM[1]	CFS[2]	Area Served (ac)[3]	Wen. River Benefit (miles)[4]	Icicle Creek Benefit (miles)[5]	Acre-ft[6]	Length (ft)	Dia. (in)	Length (ft)	Dia. (in)	Piping Const. Cost[9]	Pump HP[10]	Pump Station Const. Cost[11]	Annual Power Cost[12]	Annual Maint. Cost[13]	Total Annual O&M Cost[14]	Weekly O&M Cost (Peak)[15]	Total Capital Cost[16]
Option 1A: Pressure Pipe	6,241	13.91	925	19.70	5.76	1,663	9,042	24	16,467	24	$2,442,396	1,312	$2,191,000	$31,191	$22,413	$53,604	$2,747	$4,633,396
Option 1B: Pressure Pipe (Valley Floor)	6,241	13.91	925	19.70	5.76	1,663	2,795	24	26,756	Var	$1,961,613	1,033	$2,060,000	$24,529	$20,403	$44,932	$2,225	$4,021,613
Option 2A: Gravity Only	6,241	13.91	925	17.07	5.76	1,663	831	24			$73,128	1,048	$2,238,000	$33,814	$18,050	$51,864	$2,631	$2,311,128
Option 2B: Pressure Pipe and Gravity	10,048	22.39	1,489	17.07	5.76	2,677	831	30	8,191	18	$724,017	1,744	$3,378,000	$53,347	$28,472	$81,819	$4,138	$4,102,017
Option 3A: Gravity Only	10,048	22.39	1,489	15.03	5.76	2,677	7,102	30			$937,464	1,707	$3,306,000	$56,277	$28,323	$84,600	$4,270	$4,243,464
Option 3B: Pressure Pipe and Gravity	13,256	29.53	1,964	15.03	5.76	3,532	7,102	36	42,577	18	$4,365,105	2,461	$4,169,000	$96,363	$42,082	$138,445	$6,956	$8,534,105
Option 4: Gravity Only	13,013	28.99	1,928	8.98	5.76	3,467	3,132	36			$516,780	1,701	$3,971,000	$56,093	$32,802	$88,895	$4,510	$4,487,780
Option 5-West: Gravity Only	13,249	29.52	1,963	7.75	5.76	3,530	6,564	36			$1,083,060	1,582	$3,909,000	$52,152	$33,438	$85,590	$4,357	$4,992,060
Option 5-East: Gravity Only	4,670	10.40	692	7.68	5.76	1,244	425	24			$37,400	510	$5,290,000	$16,799	$42,395	$59,194	$3,160	$5,327,400
Option 6A: East Valley Gravity	13,650	30.41	2,022	2.83	5.76	3,637	4,616	36			$864,443	1,313	$3,808,000	$43,279	$32,193	$75,472	$3,862	$4,672,443
Option 6B: East & West Valley Gravity	27,845	62.04	4,125	2.83	5.76	7,419	5,269	36			$986,880	2,912	$6,209,000	$95,980	$51,646	$147,625	$7,469	$7,195,880
Option 6C: Replacement of Icicle Diversion	52,510	117.0	7,779	2.83	5.76	13,991	5,269	36 & 72			$2,303,738	5,278	$10,663,000	$181,005	$89,911	$270,916	$13,669	$12,966,738

1 GPM: Peak gallons per minute pumped by the pump station; actual volume pumped will vary from day to day and time of season.

2 CFS: Peak cubic feet per second pumped by the pump station; actual volume pumped will vary from day to day and time of season

3 Area Served in acres: These are the estimated acres of land that would be served by a given option

4 Wenatchee River Benefit: The distance in miles in which there is additional flow within the Wenatchee River as a result of this option.

5 Icicle Creek Benefit: The distance in miles in which there is additional flow within Icicle Creek as a result of this option.

6 Acre-ft: Volume of water in acre-feet used over the season. Value based on CIR (crop irrigation requirement; see definition and application in *Flow Data* , under *Pump Station Option Calculations* , Appendix B) calculated on a month by month bases.

7 Pump Supply Line is the pressure pipe from the pump station to the canal.

8 Pressure main is the pressure pipe that extends up-canal from the end of the pump supply line at the canal.

9 Piping Construction Cost: This is the cost of all piping related costs including excavation, installation, backfill, pavement replacement (when applicable) fittings, services, etc.

10 Pump Horsepower: The total horsepower of the various pumps within a given pump station/option.

11 Pump Station Construction Cost: Cost of the pump station structure, pumps, controls, miscellaneous equipment, piping, intake line, fish screen, etc.

12 Annual Power Cost: Total power cost if the option operates for the complete season. Power demand is based upon CIRs (see footnote 6) and calculated on a month to month basis and then added together.

13 Annual Maintenance Cost: assumes 0.8% of pump station construction costs plus 0.2% pipeline construction cost. This is based upon experience from similar facilities.

14 Total Annual O&M Costs: Total of *Annual Power* and *Maintenance Costs*

15 Weekly O&M Cost (Peak): average of power cost of last two weeks of August plus month of September plus 1/3 of total O&M spread over 6 weeks; useful for calculating O&M when system only used during peak flows.

16 Total Capital Cost: Summation of piping and pump station construction costs

Table B-3B | Cost Summary Table—Dry Year

Pump Station Alternative	Peak Flow		Area Served (ac)[3]	Wen. River Benefit (miles)[4]	Icicle Creek Benefit (miles)[5]	Acre-ft[6]	Pump Supply Line[7]		Pressure Main[8]		Piping Const. Cost[9]	Pump HP[10]	Pump Station Const. Cost[11]	Annual Power Cost[12]	Annual Maint. Cost[13]	Total Annual O&M Cost[14]	Weekly O&M Cost (Peak)[15]
	GPM[1]	CFS[2]					Length (ft)	Dia. (in)	Length (ft)	Dia. (in)							
Option 1A: Pressure Pipe	6,241	13.91	925	19.70	5.76	1,838	9,042	24	16,467	24	$2,442,396	1,312	$2,191,000	$34,466	$22,413	$56,879	$2,905
Option 1B: Pressure Pipe (Valley Floor)	6,241	13.91	925	19.70	5.76	1,838	2,795	24	26,756	Var	$1,961,613	1,033	$2,060,000	$27,104	$20,403	$47,508	$2,340
Option 2A: Gravity Only	6,241	13.91	925	17.07	5.76	1,838	831	24			$73,128	1,048	$2,238,000	$39,629	$18,050	$57,679	$2,778
Option 2B: Pressure Pipe and Gravity	10,048	22.39	1,489	17.07	5.76	2,958	831	30	8,191	18	$724,017	1,744	$3,378,000	$59,515	$28,472	$87,987	$4,306
Option 3A: Gravity Only	10,048	22.39	1,489	15.03	5.76	2,958	7,102	30			$937,464	1,707	$3,306,000	$64,507	$28,323	$92,830	$4,680
Option 3B: Pressure Pipe and Gravity	13,256	29.53	1,964	15.03	5.76	3,903	7,102	36	42,577	18	$4,365,105	2,461	$4,169,000	$108,468	$42,082	$150,551	$7,561
Option 4: Gravity Only	13,013	28.99	1,928	8.98	5.76	3,831	3,132	36			$516,780	1,701	$3,971,000	$64,296	$32,802	$97,098	$4,918
Option 5-West: Gravity Only	13,249	29.52	1,963	7.75	5.76	3,901	6,564	36			$1,083,060	1,582	$3,909,000	$59,778	$33,438	$93,216	$4,736
Option 5-East: Gravity Only	4,670	10.40	692	7.68	5.76	1,375	425	24			$37,400	510	$5,290,000	$19,256	$42,395	$61,651	$3,283
Option 6A: East Valley Gravity	13,650	30.41	2,022	2.83	5.76	4,019	4,616	36			$864,443	1,313	$3,808,000	$49,607	$32,193	$81,800	$4,177
Option 6B: East & West Valley Gravity	27,845	62.04	4,125	2.83	5.76	8,198	5,269	36			$986,880	2,912	$6,209,000	$110,015	$51,646	$161,661	$8,167
Option 6C: Replacement of Icicle Diversion	52,510	117.0	7,779	2.83	5.76	15,460	5,269	36 & 72			$2,303,738	5,278	$10,663,000	$207,474	$89,911	$297,385	$14,986

[1] GPM: Peak gallons per minute pumped by the pump station; actual volume pumped will vary from day to day and time of season.

[2] CFS: Peak cubic feet per second pumped by the pump station; actual volume pumped will vary from day to day and time of season

[3] Area Served in acres: These are the estimated acres of land that would be served by a given option

[4] Wenatchee River Benefit: The distance in miles in which there is additional flow within the Wenatchee River as a result of this option.

[5] Icicle Creek Benefit: The distance in miles in which there is additional flow within Icicle Creek as a result of this option.

[6] Acre-ft: Volume of water in acre-feet used over the season. Value based on CIR (crop irrigation requirement; see definition and application in *Flow Data* , under *Pump Station Option Calculations* , Appendix B) calculated on a month by month bases.

[7] Pump Supply Line is the pressure pipe from the pump station to the canal.

[8] Pressure main is the pressure pipe that extends up-canal from the end of the pump supply line at the canal.

[9] Piping Construction Cost: This is the cost of all piping related costs including excavation, installation, backfill, pavement replacement (when applicable) fittings, services, etc.

[10] Pump Horsepower: The total horsepower of the various pumps within a given pump station/option.

[11] Pump Station Construction Cost: Cost of the pump station structure, pumps, controls, miscellaneous equipment, piping, intake line, fish screen, etc.

[12] Annual Power Cost: Total power cost if the option operates for the complete season. Power demand is based upon CIRs (see footnote 6) and calculated on a month to month basis and then added together.

[13] Annual Maintenance Cost: assumes 0.8% of pump station construction costs plus 0.2% pipeline construction cost. This is based upon experience from similar facilities.

[14] Total Annual O&M Costs: Total of *Annual Power* and *Maintenance Costs*

[15] Weekly O&M Cost (Peak): average of power cost of last two weeks of August plus month of September plus 1/3 of total O&M spread over 6 weeks; useful for calculating O&M when system only used during peak flows.

[16] Total Capital Cost: Summation of piping and pump station construction costs

Table B-4 | *Option 1A: Pressure Pipe*

Description	Units	Quanity	Unit Costs	Total Cost
Primary Pumps	EA	5	$68,614	$343,070
Primary Motors	EA	5	$19,470	$97,350
Jocky Pumps	EA	1	$35,000	$35,000
Discharge Header/Piping	LS	1	$60,000	$60,000
CMU Building	SF	700	$100	$70,000
Flow Measurement	LS	1	$20,000	$20,000
Electrical/Pump Controls	LS	1	$400,000	$400,000
Excavation / Earthwork	CY	3,800	$12	$45,600
Site Work	LS	1	$35,000	$35,000
Intake Piping	LS	1	$20,000	$20,000
Screening Structure	LS	1	$80,000	$80,000
Bank Protection	LS	1	$30,000	$30,000
Stream Grade Control	LS	1	$75,000	$75,000
Instream Construction Control	LS	1	$60,000	$60,000
			Total Construction	$1,371,020
			Contingency (20%)	$274,204
			Legal, Administrative, and Engineering	$411,306
			Sales Tax (8.2%)	$134,908
			Total Project Cost	**$2,191,000**

Table B-5 | *Option 1B -Pressure Pipe (Valley Floor)*

Description	Units	Quanity	Unit Costs	Total Cost
Primary Pumps	EA	5	$48,030	$240,149
Primary Motors	EA	5	$13,629	$68,145
Jocky Pumps	EA	1	$35,000	$35,000
Booster Pump Station	LS	1	$130,000	$130,000
Discharge Header/Piping	LS	1	$60,000	$60,000
CMU Building	SF	700	$100	$70,000
Flow Measurement	LS	1	$20,000	$20,000
Electrical/Pump Controls	LS	1	$320,000	$320,000
Excavation / Earthwork	CY	3,800	$12	$45,600
Site Work	LS	1	$35,000	$35,000
Intake Piping	LS	1	$20,000	$20,000
Screening Structure	LS	1	$80,000	$80,000
Bank Protection	LS	1	$30,000	$30,000
Stream Grade Control	LS	1	$75,000	$75,000
Instream Construction Control	LS	1	$60,000	$60,000
			Total Construction	$1,288,894
			Contingency (20%)	$257,779
			Legal, Administrative, and Engineering	$386,668
			Sales Tax (8.2%)	$126,827
			Total Project Cost	**$2,060,000**

Table B-6 | *Option 2A: Gravity Only*

Description	Units	Quanity	Unit Costs	Total Cost
Primary Pumps	EA	5	$60,040	$300,200
Primary Motors	EA	5	$16,784	$83,920
Jocky Pumps	EA	1	$35,000	$35,000
Discharge Header/Piping	LS	1	$60,000	$60,000
CMU Building	SF	700	$100	$70,000
Flow Measurement	LS	1	$20,000	$20,000
Electrical/Pump Controls	LS	1	$380,000	$380,000
Excavation / Earthwork	CY	13,000	$12	$156,000
Site Work	LS	1	$35,000	$35,000
Intake Piping	LS	1	$20,000	$20,000
Screening Structure	LS	1	$80,000	$80,000
Bank Protection	LS	1	$25,000	$25,000
Stream Grade Control	LS	1	$75,000	$75,000
Instream Construction Control	LS	1	$60,000	$60,000
			Total Construction	$1,400,120
			Contingency (20%)	$280,024
			Legal, Administrative, and Engineering	$420,036
			Sales Tax (8.2%)	$137,772
			Total Project Cost	**$2,238,000**

Table B-7 | *Option 2B: Pressure Pipe and Gravity*

Description	Units	Quanity	Unit Costs	Total Cost
Primary Pumps	EA	5	$59,868	$299,340
Primary Motors	EA	5	$24,501	$122,505
Jocky Pumps	EA	2	$35,000	$70,000
Discharge Header/Piping	LS	1	$99,000	$99,000
CMU Building	SF	1,200	$100	$120,000
Flow Measurement	LS	1	$20,000	$20,000
Electrical/Pump Controls	LS	1	$800,000	$800,000
Excavation / Earthwork	CY	15,200	$12	$182,400
Site Work	LS	1	$35,000	$35,000
Intake Piping	LS	1	$25,000	$25,000
Screening Structure	LS	1	$180,000	$180,000
Bank Protection	LS	1	$25,000	$25,000
Stream Grade Control	LS	1	$75,000	$75,000
Instream Construction Control	LS	1	$60,000	$60,000
			Total Construction	$2,113,245
			Contingency (20%)	$422,649
			Legal, Administrative, and Engineering	$633,974
			Sales Tax (8.2%)	$207,943
			Total Project Cost	**$3,378,000**

Table B-8 | *Option 3A: Gravity Only*

Description	Units	Quanity	Unit Costs	Total Cost
Primary Pumps	EA	5	$66,391	$331,955
Primary Motors	EA	5	$26,049	$130,245
Jocky Pumps	EA	2	$35,000	$70,000
Discharge Header/Piping	LS	1	$99,000	$99,000
CMU Building	SF	1,200	$100	$120,000
Flow Measurement	LS	1	$20,000	$20,000
Electrical/Pump Controls	LS	1	$800,000	$800,000
Excavation / Earthwork	CY	6,000	$12	$72,000
Site Work	LS	1	$35,000	$35,000
Intake Piping	LS	1	$50,000	$50,000
Screening Structure	LS	1	$180,000	$180,000
Bank Protection	LS	1	$25,000	$25,000
Stream Grade Control	LS	1	$75,000	$75,000
Instream Construction Control	LS	1	$60,000	$60,000
			Total Construction	$2,068,200
			Contingency (20%)	$413,640
			Legal, Administrative, and Engineering	$620,460
			Sales Tax (8.2%)	$203,511
			Total	**$3,306,000**

Table B-9 | *Option 3B: Pressure Pipe and Gravity*

Description	Units	Quanity	Unit Costs	Total Cost
Primary Pumps	EA	6	$70,677	$424,062
Primary Motors	EA	6	$31,787	$190,722
Jocky Pumps	EA	2	$35,000	$70,000
Discharge Header/Piping	LS	1	$140,000	$140,000
CMU Building	SF	1,500	$100	$150,000
Flow Measurement	LS	1	$25,000	$25,000
Electrical/Pump Controls	LS	1	$1,010,000	$1,010,000
Excavation / Earthwork	CY	7,800	$12	$93,600
Site Work	LS	1	$35,000	$35,000
Intake Piping	LS	1	$50,000	$50,000
Screening Structure	LS	1	$240,000	$240,000
Bank Protection	LS	1	$30,000	$30,000
Stream Grade Control	LS	1	$75,000	$75,000
Instream Construction Control	LS	1	$75,000	$75,000
			Total Construction	$2,608,384
			Contingency (20%)	$521,677
			Legal, Administrative, and Engineering	$782,515
			Sales Tax (8.2%)	$256,665
			Total	**$4,169,000**

Table B-10 | *Option 4: Gravity Only*

Description	Units	Quanity	Unit Costs	Total Cost
Primary Pumps	EA	6	$61,443	$368,658
Primary Motors	EA	6	$21,591	$129,546
Jocky Pumps	EA	2	$35,000	$70,000
Discharge Header/Piping	LS	1	$140,000	$140,000
CMU Building	SF	1,500	$100	$150,000
Flow Measurement	LS	1	$25,000	$25,000
Electrical/Pump Controls	LS	1	$1,010,000	$1,010,000
Excavation / Earthwork	CY	8,000	$12	$96,000
Site Work	LS	1	$35,000	$35,000
Intake Piping	LS	1	$50,000	$50,000
Screening Structure	LS	1	$240,000	$240,000
Bank Protection	LS	1	$35,000	$35,000
Stream Grade Control	LS	1	$75,000	$75,000
Instream Construction Control	LS	1	$60,000	$60,000
			Total Construction	$2,484,204
			Contingency (20%)	$496,841
			Legal, Administrative, and Engineering	$745,261
			Sales Tax (8.2%)	$244,446
			Total	**$3,971,000**

Table B-11 | *Option 5-West: Gravity Only*

Description	Units	Quanity	Unit Costs	Total Cost
Primary Pumps	EA	6	$57,157	$342,942
Primary Motors	EA	6	$19,470	$116,820
Jocky Pumps	EA	2	$35,000	$70,000
Discharge Header/Piping	LS	1	$140,000	$140,000
CMU Building	SF	1,500	$100	$150,000
Flow Measurement	LS	1	$25,000	$25,000
Electrical/Pump Controls	LS	1	$1,010,000	$1,010,000
Excavation / Earthwork	CY	8,000	$12	$96,000
Site Work	LS	1	$35,000	$35,000
Intake Piping	LS	1	$50,000	$50,000
Screening Structure	LS	1	$240,000	$240,000
Bank Protection	LS	1	$35,000	$35,000
Stream Grade Control	LS	1	$75,000	$75,000
Instream Construction Control	LS	1	$60,000	$60,000
			Total Construction	$2,445,762
			Contingency (20%)	$489,152
			Legal, Administrative, and Engineering	$733,729
			Sales Tax (8.2%)	$240,663
			Total	**$3,909,000**

Table B-12 | *Option 5-East: Gravity Only*

Description	Units	Quanity	Unit Costs	Total Cost
Primary Pumps	EA	5	$44,074	$220,370
Primary Motors	EA	5	$10,804	$54,020
Jocky Pumps	EA	1	$35,000	$35,000
Discharge Header/Piping	LS	1	$50,000	$50,000
CMU Building	SF	500	$100	$50,000
Flow Measurement	LS	1	$25,000	$25,000
Electrical/Pump Controls	LS	1	$300,000	$300,000
Excavation / Earthwork	CY	30,750	$40	$1,230,000
Site Work	LS	1	$770,000	$770,000
Intake Piping	LS	1	$170,000	$170,000
Screening Structure	LS	1	$140,000	$140,000
Bank Protection	LS	1	$70,000	$70,000
Stream Grade Control	LS	1	$75,000	$75,000
Instream Construction Control	LS	1	$120,000	$120,000
			Total Construction	$3,309,390
			Contingency (20%)	$661,878
			Legal, Administrative, and Engineering	$992,817
			Sales Tax (8.2%)	$325,644
			Total	**$5,290,000**

Table B-13 | *Option 6A: East Valley Gravity Only*

Description	Units	Quanity	Unit Costs	Total Cost
Primary Pumps	EA	6	$53,406	$320,436
Primary Motors	EA	6	$16,784	$100,704
Jocky Pumps	EA	2	$35,000	$70,000
Discharge Header/Piping	LS	1	$140,000	$140,000
CMU Building	SF	1,500	$100	$150,000
Flow Measurement	LS	1	$25,000	$25,000
Electrical/Pump Controls	LS	1	$1,010,000	$1,010,000
Excavation / Earthwork	CY	8,000	$12	$96,000
Site Work	LS	1	$35,000	$35,000
Intake Piping	LS	1	$25,000	$25,000
Screening Structure	LS	1	$240,000	$240,000
Bank Protection	LS	1	$35,000	$35,000
Stream Grade Control	LS	1	$75,000	$75,000
Instream Construction Control	LS	1	$60,000	$60,000
			Total Construction	$2,382,140
			Contingency (20%)	$476,428
			Legal, Administrative, and Engineering	$714,642
			Sales Tax (8.2%)	$234,403
			Total	**$3,808,000**

Table B-14 | *Option 6B: East and West Valley Gravity Only*

Description	Units	Quanity	Unit Costs	Total Cost
Primary Pumps	EA	7	$70,029	$490,203
Primary Motors	EA	7	$24,017	$168,119
Jocky Pumps	EA	4	$35,000	$140,000
Discharge Header/Piping	LS	1	$280,000	$280,000
CMU Building	SF	3,000	$100	$300,000
Flow Measurement	LS	1	$50,000	$50,000
Electrical/Pump Controls	LS	1	$1,500,000	$1,500,000
Excavation / Earthwork	CY	5,100	$12	$61,200
Site Work	LS	1	$75,000	$75,000
Intake Piping	LS	1	$50,000	$50,000
Screening Structure	LS	1	$500,000	$500,000
Bank Protection	LS	1	$75,000	$75,000
Stream Grade Control	LS	1	$75,000	$75,000
Instream Construction Control	LS	1	$120,000	$120,000
			Total Construction	$3,884,522
			Contingency (20%)	$776,904
			Legal, Administrative, and Engineering	$1,165,357
			Sales Tax (8.2%)	$382,237
			Total	**$6,209,000**

Table B-15 | *Option 6C: Replacement of Icicle Diversion*

Description	Units	Quanity	Unit Costs	Total Cost
Primary Pumps	EA	12	$70,029	$840,348
Primary Motors	EA	12	$24,017	$288,204
Jocky Pumps	EA	6	$35,000	$210,000
Discharge Header/Piping	LS	1	$532,000	$532,000
CMU Building	SF	5,700	$100	$570,000
Flow Measurement	LS	1	$95,000	$95,000
Electrical/Pump Controls	LS	1	$2,400,000	$2,400,000
Excavation / Earthwork	CY	9,690	$12	$116,280
Site Work	LS	1	$142,500	$142,500
Intake Piping	LS	1	$95,000	$95,000
Screening Structure	LS	1	$950,000	$950,000
Bank Protection	LS	1	$120,000	$120,000
Stream Grade Control	LS	1	$120,000	$120,000
Instream Construction Control	LS	1	$192,000	$192,000
			Total Construction	$6,671,332
			Contingency (20%)	$1,334,266
			Legal, Administrative, and Engineering	$2,001,400
			Sales Tax (8.2%)	$656,459
			Total	**$10,663,000**

Icicle Irrigation District Diversion Flows from Icicle Creek

Date	Year (Flow in CFS)										
	2013	2012	2011	2010	2009	2008	2007	2006	2005	2004	2003
Apr-7				38.30							
Apr-8				38.30							
Apr-9				38.30					50.00		
Apr-10				38.00					52.00		
Apr-11				37.80					54.00		
Apr-12				37.70					55.00		
Apr-13				37.70					55.00		
Apr-14				40.00					57.00		
Apr-15				43.00	45.00				56.50	51.00	
Apr-16				42.80	45.50				55.50	51.00	
Apr-17				43.00	48.10				55.50	52.00	58.70
Apr-18		49.70		46.50	46.50				55.00	52.00	58.70
Apr-19		49.70		49.40	46.20				60.50	51.00	58.70
Apr-20		51.00		54.70	46.50				59.00	51.00	58.70
Apr-21		51.00		53.00	48.10				62.40	48.10	58.70
Apr-22		51.50		52.00	48.10	33.50			62.40	48.10	58.70
Apr-23	49.70	51.50		48.10	48.10	34.00			67.00	48.10	60.70
Apr-24	53.00	52.00		48.10	48.10	35.00			77.00	49.70	64.30
Apr-25	59.00	52.00	46.50	49.40	49.50	30.50	55.00	58.70	71.00	50.00	58.70
Apr-26	64.00	52.00	51.00	48.10	49.50	30.50	55.00	58.70	74.00	51.50	58.00
Apr-27	61.00	53.00	54.00	48.10	48.40	32.50	55.00	60.00	76.00	58.00	57.50
Apr-28	59.00	53.00	54.00	49.40	49.50	33.50	58.70	54.50	75.00	58.00	58.00
Apr-29	60.70	53.00	54.00	48.00	53.00	37.80	58.70	56.50	75.00	56.50	58.00
Apr-30	58.70	53.00	54.00	46.50	55.00	38.30	58.70	61.50	72.00	60.70	58.70
May-1	58.70	53.00	55.00	46.50	52.00	38.30	56.50	61.50	71.00	61.00	58.70
May-2	58.70	51.00	55.00	45.50	51.50	38.30	58.70	61.50	70.00	61.50	58.70
May-3	58.70	50.50	54.00	46.50	56.00	37.80	58.70	58.00	71.00	61.50	58.70
May-4	64.30	50.50	54.00	48.10	56.00	40.00	58.70	58.00	72.00	65.00	58.70
May-5	64.30	50.50	58.70	46.80	57.80	47.00	58.70	58.70	71.00	70.00	60.00
May-6	64.30	50.50	59.70	49.50	57.50	54.50	58.70	60.70	72.00	73.50	60.00
May-7	66.00	51.00	59.70	49.70	57.00	49.70	58.70	60.70	75.50	73.50	61.00
May-8	68.00	51.50	62.20	49.30	57.00	48.10	61.00	60.00	75.50	76.00	61.00
May-9	67.00	51.50	62.40	49.30	62.80	48.10	63.30	59.50	75.50	77.00	63.00
May-10	66.30	62.40	64.20	49.30	73.20	48.10	64.30	59.50	81.00	77.00	64.00
May-11	66.00	58.70	73.30	49.70	80.50	48.10	68.50	59.50	76.00	78.00	65.50
May-12	66.30	58.70	73.50	51.00	78.50	48.10	68.50	59.50	81.50	78.50	65.50
May-13	66.00	58.70	73.50	54.00	75.00	48.10	68.50	57.50	84.50	76.00	65.00
May-14	65.90	58.70	73.50	57.00	75.00	48.10	69.50	57.00	84.50	78.50	71.00
May-15	65.90	58.70	38.50	58.00	68.50	50.40	86.50	59.50	75.50	78.50	72.00
May-16	64.20	58.70	38.30	58.40	80.00	59.50	86.50	64.00	78.50	78.50	72.00
May-17	64.20	58.70	48.10	58.00	89.00	60.70	86.00	63.50	78.50	80.50	71.00
May-18	64.30	62.00	48.40	61.00	99.00	60.00	85.00	71.00	78.00	80.50	75.00
May-19	64.70	66.70	48.40	58.50	99.50	29.00	84.00	61.00	78.00	81.50	84.50
May-20	64.70	66.30	55.20	55.50	95.00	56.00	83.00	73.00	78.00	86.50	87.50
May-21	64.70	66.30	55.40	55.00	92.00	53.00	82.00	73.50	78.00	87.50	87.50
May-22	64.30	66.30	55.40	56.50	88.00	55.50	81.50	71.00	86.50	87.50	90.50

Date	Year (Flow in CFS)										
	2013	2012	2011	2010	2009	2008	2007	2006	2005	2004	2003
May-23	64.30	66.30	55.40	55.50	92.00	56.00	82.00	71.00	84.50	84.50	93.50
May-24	64.00	66.30	55.40	54.00	97.00	40.00	83.00	71.00	84.50	84.50	104.00
May-25	62.40	71.00	51.00	55.00	97.75	61.00	84.00	71.00	76.00	82.50	93.50
May-26	61.00	70.00	51.00	54.50	98.50	61.50	85.00	68.50	81.50	84.00	99.00
May-27	61.00	71.00	51.00	56.00	98.50	62.00	85.50	68.50	92.00	87.50	98.00
May-28	61.00	71.00	51.00	56.50	98.50	62.40	86.50	72.00	92.00	82.50	99.00
May-29	61.00	71.00	51.00	56.50	98.00	62.40	88.00	75.00	100.00	81.50	99.00
May-30	62.40	71.00	51.00	56.00	88.00	74.00	90.00	73.50	101.50	82.50	99.00
May-31	62.40	76.00	51.00	60.00	87.50	74.00	92.00	76.00	98.50	81.50	101.50
Jun-1	62.40	76.00	51.00	61.00	91.00	73.50	93.50	80.00	93.50	81.50	100.00
Jun-2	62.60	78.00	51.00	62.00	91.00	73.50	93.50	82.50	96.00	90.00	100.00
Jun-3	84.50	76.00	51.00	63.00	91.00	73.50	93.50	82.50	100.00	90.50	103.00
Jun-4	90.00	73.50	52.00	64.00	91.00	73.50	93.50	82.00	100.00	94.50	103.00
Jun-5	91.00	73.50	53.00	64.50	91.00	73.50	93.50	81.50	101.80	101.50	103.00
Jun-6	93.04	73.50	55.00	64.50	92.50	71.00	87.50	81.50	105.50	93.50	103.00
Jun-7	93.79	73.50	55.50	65.00	92.50	73.00	87.50	81.00	105.00	94.50	106.50
Jun-8	94.89	73.50	55.00	65.00	92.00	72.00	90.50	81.00	101.80	93.50	107.00
Jun-9	94.90	75.00	55.00	65.50	91.00	73.50	90.00	80.50	101.00	94.50	108.20
Jun-10	91.03	71.00	55.00	66.00	89.00	73.50	89.50	80.50	110.00	96.50	108.20
Jun-11	94.48	71.00	54.80	66.30	87.00	73.50	89.00	81.00	110.00	96.00	106.50
Jun-12	93.27	75.00	55.20	66.30	85.00	73.50	88.50	84.00	110.00	94.50	106.00
Jun-13	93.69	75.00	76.00	71.00	85.50	74.00	88.00	79.00	110.00	96.50	105.50
Jun-14	91.86	75.00	76.00	71.40	85.50	75.50	87.50	79.00	108.20	96.00	107.50
Jun-15	92.45	75.00	76.00	71.00	86.00	78.00	91.50	79.00	106.00	96.00	108.20
Jun-16	93.28	75.00	76.00	71.00	86.00	78.50	91.50	79.00	106.00	99.00	107.00
Jun-17	94.90	75.00	76.00	71.00	86.50	78.50	91.50	77.00	107.50	99.00	107.00
Jun-18	95.37	87.00	76.00	75.50	86.50	78.50	91.50	75.00	106.00	100.00	107.00
Jun-19	95.37	87.50	76.00	81.00	86.50	78.50	91.50	77.00	104.00	101.50	107.00
Jun-20	93.68	87.50	82.50	81.50	85.00	77.00	91.50	82.00	106.50	103.00	105.50
Jun-21	93.60	90.50	90.30	86.00	84.00	77.00	91.50	85.00	111.00	103.00	106.50
Jun-22	94.26	90.50	91.00	87.50	86.50	78.50	91.50	88.50	112.00	103.00	110.00
Jun-23	93.74	90.50	93.50	88.00	87.00	84.50	91.50	93.00	108.20	104.00	110.00
Jun-24	92.60	90.50	91.00	87.50	87.00	83.00	91.50	97.00	109.00	104.00	110.00
Jun-25	93.57	90.00	87.50	87.50	87.50	78.50	91.50	99.00	108.20	104.00	110.00
Jun-26	92.84	90.00	87.00	88.00	87.50	82.50	91.50	98.50	108.20	105.00	111.50
Jun-27	92.67	90.00	84.70	87.50	87.00	86.50	91.50	98.00	109.00	104.00	113.50
Jun-28	92.45	90.50	84.70	86.50	87.00	89.00	91.50	97.00	110.00	105.00	112.00
Jun-29	93.61	90.50	93.70	85.00	87.50	92.00	91.50	96.50	107.50	105.00	112.00
Jun-30	93.48	90.50	93.70	86.50	99.00	93.50	91.50	96.00	107.50	104.50	112.00
Jul-1	94.68	90.50	93.50	86.50	97.00	94.50	91.50	97.00	111.00	104.50	111.00
Jul-2	94.10	90.70	93.50	87.50	102.00	93.50	93.50	97.50	111.00	104.50	112.00
Jul-3	95.30	93.00	92.00	87.00	101.80	96.00	93.50	97.00	111.00	104.50	112.00
Jul-4	95.30	94.00	92.00	86.00	102.50	97.50	93.50	96.00	111.00	104.50	112.00
Jul-5	95.06	96.00	92.00	84.00	102.50	97.00	94.50	95.00	111.00	104.50	112.00
Jul-6	94.75	96.00	92.00	91.00	102.50	94.50	97.00	94.00	109.00	104.50	112.00
Jul-7	95.60	97.00	92.00	92.00	103.00	94.50	94.50	92.00	110.40	104.50	111.00
Jul-8	95.74	96.50	93.70	93.50	103.50	92.50	94.50	90.50	109.00	104.50	110.00
Jul-9	94.61	96.50	93.70	96.00	103.50	96.00	99.00	96.00	116.00	105.00	110.00

Date	Year (Flow in CFS)										
	2013	2012	2011	2010	2009	2008	2007	2006	2005	2004	2003
Jul-10	94.61	96.00	94.00	65.00	93.50	95.00	98.00	95.50	115.50	106.50	109.00
Jul-11	94.30	96.00	96.70	93.50	93.50	94.50	96.50	94.50	112.00	106.50	110.00
Jul-12	92.08	96.00	96.50	93.50	98.00	94.50	96.00	94.00	112.70	106.50	109.00
Jul-13	97.05	96.00	99.00	93.50	100.00	95.00	96.00	93.00	109.00	106.50	110.00
Jul-14	97.35	95.80	94.00	93.50	97.50	94.50	96.00	92.50	108.50	106.50	110.00
Jul-15	96.56	96.00	96.50	93.50	97.50	94.50	93.50	96.50	112.00	105.50	110.00
Jul-16	95.00	94.80	94.00	92.50	98.00	95.00	95.00	96.00	112.70	105.50	109.00
Jul-17	95.50	96.50	93.50	92.00	98.00	95.00	93.50	93.00	112.70	106.50	110.00
Jul-18	95.50	96.80	93.50	90.00	98.00	103.00	93.50	91.00	112.00	108.20	110.00
Jul-19	93.42	98.00	93.80	94.50	99.00	101.00	92.50	93.00	113.00	110.00	111.00
Jul-20	97.98	102.80	93.80	95.00	99.00	103.00	93.50	96.00	110.40	108.20	112.00
Jul-21	97.68	104.00	93.90	93.50	96.50	105.00	98.00	100.00	110.40	108.20	112.00
Jul-22	95.13	104.00	92.00	95.00	96.50	104.50	99.00	101.00	114.50	109.00	112.00
Jul-23	103.54	101.42	92.00	102.50	96.50	103.50	93.50	101.00	114.50	108.20	112.00
Jul-24	103.96	100.60	92.00	102.00	96.50	103.50	93.50	100.50	115.00	108.20	111.00
Jul-25	103.49	102.00	92.00	102.00	96.50	103.00	96.50	100.00	115.00	108.20	111.00
Jul-26	103.34	101.50	92.00	102.00	96.50	103.00	90.50		115.50	106.50	111.00
Jul-27	101.25	104.00	92.00	102.00	104.80	103.00	91.50		115.50	104.00	111.00
Jul-28	101.25	104.00	91.00	102.00	105.00	103.00	91.50		115.50	101.80	111.00
Jul-29	101.26	104.00	90.80	101.80	104.00	102.50	90.00		116.00	101.50	111.00
Jul-30	100.65	104.00	92.00	101.20	102.00	102.00	90.50		116.00	105.50	111.00
Jul-31	101.28	105.00	90.80		97.00	101.50	91.50		116.50	106.50	111.00
Aug-1	101.54	105.60	94.50		98.00	101.00	92.50		113.50	106.50	111.00
Aug-2	101.54	105.89	93.50		96.00	100.50	97.00		116.00	106.00	111.00
Aug-3	101.01	105.69	92.00	96.50	97.00	100.50	98.00		116.00	106.00	111.00
Aug-4	99.57	105.89	92.50	96.50	98.00	101.00	98.00	98.00	116.50	105.50	110.80
Aug-5	99.57	105.69	90.80	99.50	98.00	100.50	96.50	98.00	116.50	106.50	111.00
Aug-6	99.07	106.14	90.80	96.00	97.00	102.00	96.50	97.00	116.50	106.50	111.00
Aug-7	97.55	107.38	90.50	96.00	96.00	103.00	96.50	107.50	116.50	108.20	111.00
Aug-8	105.61	107.00	87.50	96.00	95.00	104.00	96.50	106.50	117.00	105.50	111.00
Aug-9	105.18	107.00	87.50	98.00	93.50	106.50	98.00	106.00	117.00	105.50	111.00
Aug-10	105.57	108.60	90.50	96.00	90.50	104.00	97.00	106.00	117.00	105.50	111.00
Aug-11	100.68	107.45	91.00	96.00	96.50	103.00	98.00	105.50	116.50	105.50	111.00
Aug-12	103.77	106.73	94.50	96.00	98.00	102.50	99.00	105.00	118.00	106.50	111.00
Aug-13	99.45	107.00	97.00	95.00	100.00	103.00	99.00	104.50	118.00	106.50	112.70
Aug-14	103.26	107.24	95.00	96.50	101.80	104.00	99.00	104.50	118.00	106.00	112.70
Aug-15	105.85	107.00	94.00	96.00	102.80	104.50	99.00	106.50	118.00	105.50	112.70
Aug-16	95.45	107.00	94.00	105.50	99.00	104.00	98.50	105.00	118.00	105.50	111.00
Aug-17	90.25	111.67	94.00	105.50	100.00	104.00	98.50	104.50	115.50	108.20	111.00
Aug-18	89.73	111.01	94.50	104.00	99.50	103.50	98.00	107.00	115.50	107.50	111.00
Aug-19	96.81	110.47	94.50	103.00	99.50	103.50	98.00	106.00	116.50	107.50	111.00
Aug-20	98.00	116.00	94.50	105.50	100.00	103.50	97.50	106.50	116.00	106.50	111.00
Aug-21	98.00	115.47	96.00	103.00	101.00	101.00	97.50	106.50	116.00	105.00	111.00
Aug-22	98.00	112.00	96.00	101.80	101.00	98.50	97.00	106.50	113.50	108.20	111.00
Aug-23	98.00	110.00	96.00	105.50	101.00	96.50	97.00	106.50	110.40	109.00	111.00
Aug-24	100.13	108.65	96.00	103.00	99.00	96.00	97.00	106.00	109.00	107.50	111.00
Aug-25	98.46	108.60	95.00	103.00	99.50	96.50	97.00	106.00	101.80	112.70	111.00
Aug-26	97.88	110.47	94.00	108.00	99.00	96.00		106.00	116.50	93.50	111.00

Date	Year (Flow in CFS)										
	2013	2012	2011	2010	2009	2008	2007	2006	2005	2004	2003
Aug-27	97.06	108.10	97.00	108.00	98.50	94.00		106.00	118.00	90.50	111.00
Aug-28	101.87	107.33	96.00	108.00	98.00	92.00		105.00	118.00	91.00	111.00
Aug-29	93.94	107.33	96.00	109.00	99.00	90.50		109.00	118.00	90.50	110.50
Aug-30	92.85		94.50	105.00	97.50	89.00		109.00	118.00	86.50	111.00
Aug-31	92.47	103.29	94.50	104.50	96.00	89.00		110.40	114.00	86.50	110.50
Sep-1	86.65	100.78	94.30	104.50	96.00	86.00		104.00	111.00	90.50	110.50
Sep-2	85.36	100.63	94.00	101.00	96.00	84.50		101.00	110.40	93.50	108.00
Sep-3	85.14	99.45	93.50	101.00	96.50	84.00		99.00	106.00	88.50	106.50
Sep-4	86.00	98.42	92.50	98.50	96.50	83.50		100.00	107.50	87.50	105.00
Sep-5	96.00	98.00	92.50	98.50	96.50	83.00		99.50	107.00	87.50	104.00
Sep-6	75.50	98.00	92.00	99.00	97.00	86.00		99.50	104.50	87.50	104.00
Sep-7	75.00	98.45	92.00	98.50	97.00	85.00	87.50	100.00	99.00	87.50	104.00
Sep-8	75.00	97.64	93.00	98.50	85.00	84.50		100.00	96.50	87.50	100.00
Sep-9	75.00	98.34	94.00	98.50	76.00	84.00		101.00	99.00	87.50	99.00
Sep-10	77.68	99.11	91.00	98.50	72.00	84.00		100.00	106.50	87.50	92.50
Sep-11	76.74	99.35	89.50	98.00	68.50	80.00		99.50	101.50	87.50	92.50
Sep-12	75.75	98.00	89.00	97.00	68.00	80.00		96.00	101.50	87.50	93.50
Sep-13	78.02	97.00	88.00	88.00	67.50	79.00		98.00	96.50	87.50	90.50
Sep-14	77.48	95.00	88.00	88.00	66.30	71.00	76.00	100.00	88.00	88.50	87.50
Sep-15	77.15	94.00	88.00	87.00	66.00	69.50		103.00	82.00	90.50	89.00
Sep-16	78.42	93.00	88.00	83.00	65.50	68.00		96.00	74.00	90.50	88.50
Sep-17	77.87	91.00	87.50	81.50	65.00	67.50	76.00	97.00	74.00	81.50	90.00
Sep-18	77.28	90.00	66.30	82.00	64.30	67.50	78.50	97.00	73.00	80.50	81.50
Sep-19	77.05	88.15	65.00	82.00	64.30	67.50	76.00	98.00	70.00	76.00	81.50
Sep-20	74.48	87.45	66.30	82.00	64.30	67.00		83.00	71.00	76.00	81.50
Sep-21	74.01	87.00	65.00	82.00	64.30	66.50	76.00	83.00	67.00	75.00	80.00
Sep-22	80.45	87.00	65.00	83.00	64.30	66.00		83.00	63.00	75.00	76.00
Sep-23	77.47	86.00	65.00	83.00		65.80		81.50	58.00	74.00	76.00
Sep-24	77.00	86.00	65.00	83.00				79.50	58.00	74.00	71.00
Sep-25	77.00	86.00	66.30	83.00				78.00	53.50	73.50	68.50
Sep-26	77.00	86.00	66.30	82.50				77.00	51.00	73.50	68.50
Sep-27	77.00	85.00	62.40					77.00	51.00	72.00	71.00
Sep-28		85.00	62.80					77.00	49.70	71.00	71.00
Sep-29			62.40					77.00	49.70	72.00	71.00
Sep-30			62.80						49.70	68.00	71.00
Oct-1										68.50	
Oct-2											
Oct-3											
Oct-4											
MAX	105.85	116.00	99.00	109.00	105.00	106.50	99.00	110.40	118.00	112.70	113.50
MIN	49.70	49.70	38.30	37.70	45.00	29.00	55.00	54.50	49.70	48.10	57.50
AVG	84.71	85.30	77.89	76.89	85.14	78.57	86.99	86.89	94.68	89.59	95.54
Median	92.64	90.50	88.00	83.00	92.00	83.00	91.50	93.00	105.50	92.25	106.50

Highest Use Year: 2003 had the highest average, highest median, and well above average peak.

Lowest Use Year: 2010 had the lowest average, lowest median, and an average peak.

Gaps mid season are days when data wasn't recorded.

Raw data provided by Tony Jantzer from Icicle Irrigation District (5/19/14)