ANALYSIS OF WATER DEMANDS

ON ICICLE CREEK

AND

RESULTS OF PROPOSED SOLUTIONS

The Icicle Working Group (IWG) was formed by Chelan County and the Department of Ecology to address Icicle Creek water resources including recent requests for additional water. Icicle Creek water has been over-appropriated for many years stopping all requests for additional water.

In addition to out-of-stream uses, water has been requested to improve flow in Icicle Creek for fish habitat between the USGS Gage Station 12458000 RM 5.8 and / RM 2.8. Studies prepared for the Leavenworth National Fish Hatchery (LNFH) show that 250 cfs is needed to allow for fish passage past Dam 5 and covers 100% of steelhead spawning habitat. The IWG decided that, if 250 cfs is not manageable, then the goal is to increase flows to 100 cfs which does allow fish passage at Dam 5 if some of the bays are closed and covers 79% of steelhead spawning habitat. If 100 cfs is not achievable, the goal is to provide 60 cfs which covers 61% of steelhead spawning habitat and allows fish past Dam 5 if additional bays are closed. The 60 cfs has been selected by the IWG to be the target flow in drought years.

Steelhead trout are native to Icicle Creek and are listed as endangered under the Endangered Species Act (ESA) along with two other fish species, Spring Chinook listed as endangered under the ESA and Bull trout listed as threatened under the ESA.

With respect to out-of-stream uses, another request for water is from the Town of Leavenworth to provide potable water for future growth. Their request is for an additional 3 to 4 cfs.

The Icicle Peshastin Irrigation District (IPID) has water rights in Snow Lakes, (Upper and Lower), Colchuck Lake, Eight Mile Lake, Klonaqua Lake and Square Lake. The Leavenworth National Fish Hatchery (LNFH) also has a water right to Snow-Lakes. All five lakes are in the Alpine Lakes Wilderness and are located within the Icicle Creek watershed. The five lakes are the only source of stored water within the Icicle watershed.

WATER AVAILABILITY

Icicle Creek

Icicle Creek has produced an annual average of 450,000 ac-ft. since 1938. The icicle Creek watershed is a snow/rain watershed. Flows in late summer and early fall have decreased and continue to decrease while flows in winter and early spring months have increased since 1983[1].

Snow Lakes

The LNFH has a water right to 16,000 ac-ft. from Snow Lake for the purpose of fish propagation with no cfs limitation[2]. However, the LNFH can draw only a maximum of 12,450 ac-ft. from the Lake because of the position of the intake in the bottom of the upper lake. Also, because of the size of the Lake and its geographical location east of the Cascade Range crest, the USFWS Region 1 Div. of Engineering / Water Resources Branch cautioned managers to draw no more than 7,000 ac-ft. from the Lake to retain a 60% probability

[1] Stevens pass and Fish Lake Snotel sites.
[2] Recorded Water Rights of the Department of Ecology region 2 page three.

of recharge.[3] As a result, LNFH leaves at least 5,450 ac-ft. in the Lakes each year. Also, IPID has a water right of 1000 ac-ft. from Snow Lakes and which is contained within and senior in priority to the LNFH 12,450 ac-ft. right. The LNFH usually discharges Snow-Lakes water at the rate of between 50 and 55 cfs. IPID has a right to discharge its' 1000 ac-ft. at a rate of up to 25 cfs.

When Snow-Lakes water is released it discharges from the bottom of the lake, through a granite ridge via a ½ mile long tunnel to a large boulder field traveling about 400 yards downhill into Nada Lake. A dam at Nada Lake controls water via an unnamed tributary of Snow Creek. IPID uses a flume to transfer its water right from Snow Creek to the IPID irrigation canal.

Colchuck Lake

IPID has a water right to 2,500 ac-ft. from Colchuck Lake for the purpose of irrigation. The water right allows a discharge rate of up to 50 cubic feet per second (cfs).

Eight Mile Lake

The IPID has a water right to 2,500 ac-ft. from Eight Mile Lake for the purpose of irrigation. The water right allows a discharge rate of up to 25 cfs. (Eight Mile Lake dam is currently in disrepair leaving about 1,300 ac-ft. available to IPID).

Klonaqua Lake

IPID has a water right to 2,500 ac-ft. from Klonaqua Lake for the purpose of irrigation. The water right allows a discharge rate of up to 25 cfs.

[3] Management Recommendations for Reservoir Releases from Upper Snow Lake: Leavenworth National Fish Hatchery.

Square Lake

IPID has a water right of 2,000 ac-ft. from Square Lake for the purpose of irrigation. The water right allows a discharge rate of up to 10 cfs.[4]

Table 1, below, outlines the volumes in cubic feet per second (cfs) permitted from Icicle Creek by the five users of Icicle water. Table 1 shows the total cfs when supplying 250 cfs for fish habitat in pink, the total cfs when supplying 100 cfs for fish habitat in green and total cfs when supplying 60 cfs for fish habitat in yellow.

Table 1

TOTAL ASSUMED DEMANDS FOR ICICLE CREEK FOR OUT-OF-STREAM AND INSTREAM USES[5]

(Assuming all projects proposed by the IWG have been completed)

Entity	June	July	August	September	October
IPID	93	99	99	78	0
LNFH	16	20	0	0	20
COIC	5	5	5	5	5
CITY	6	6	6	6	4
FISH	100	100	100	100	100
TOTAL	220	230	210	189	129

ASSUMED DEMANDS OF 60 CFS FOR INSTREAM RESOURCES

TOTAL	180	190	170	149	89

ASSUMED DEMANDS OF 250 CFS FOR INSTREAM RESOURCES

Total	370	380	360	339	279

[4] Recorded Water Rights of the Department of Ecology Region 2 pages 2, 3, 12, 13, 25 February 28, 1989.
[5] Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion NMFS Consultation Number: WCR-2015-00969.

The zeros in August and September for the LNFH are correct because at this time of year the LNFH relies entirely on Snow-Lakes instead of Icicle Creek to rear young salmon. Snow-Lakes water enters Icicle Creek below the USGS gage that is the control point for this analysis.

What follows is a series of assumptions that were applied to a spreadsheet to analyze the impacts on lake levels of the wilderness lakes, on a daily basis using 100 cfs and 60 cfs as a demand for fish habitat. Two hundred and fifty cfs was not analyzed because it is obvious this amount of water is beyond the capability of Icicle Creek to produce when commercial demands are added.

ASSUMPTIONS

1. The LNFH installs circular tanks resulting in a lowered demand from 41 cfs to 24 cfs.
2. If Icicle Creek has a deficit in June and July, the LNFH uses Snow-Lakes water to address the deficit. Deficit, in this context, refers to water that needs to be added to meet demand due to Icicle Creek shortage as measured at the Icicle Creek USGS Gage Station.
3. The LNFH no longer diverts water into their canal to recharge the aquifer for their wells.
4. The LNFH begins to withdraw water from Snow-Lakes in August when Icicle Creek is flowing at a deficit.
5. When the LNFH withdraws water from Snow-Lakes, they draw only enough to supply their new circular tank rearing technology with 24 cfs.
6. Stream flows measured at the USGS Gage were reduced by 35% to account for climate change.[6], [7], [8]

[6] Steelhead Vulnerability to Climate Change in the Pacific Northwest.
[7] 7. Water Resources Climate Impacts Group College of the Environment, University of Washington
[8] Section 6: Water Climate Impacts Group College of the Environment, University of Washington page 6-3

7. IPID transfers excess wilderness lake water to Leavenworth and to maintain Icicle Creek at a minimum of 100 or 60 cfs but only after their customers are satisfied.
8. Eight Mile Lake dam has been raised so the historic quantity of 2500 ac-ft. can be accessed.
9. All five wilderness lakes (Snow, Colchuck, Eight Mile, Klonaqua and Square) are controlled remotely to manage water on a daily basis.
10. Instruments are installed in each of the five lakes to measure water volume removed.
11. It is assumed that no water is lost on its way downstream to the USGS Gage Station or, in the case of Snow-Lakes, when Snow Creek is either diverted by IPID into their canal or when it joins Icicle Creek.
12. Because of Snow-Lakes limitations, no more than 7,000 ac-ft. of water will be drawn from the Lakes leaving a minimum of 5,450 ac-ft. left in the Lakes.
13. The total amount of water that can be discharged from Colchuck, Eight Mile, Klonaqua and Square lakes all at once is 110 cfs.
14. The total amount of water accessible to IPID is 2000 ac-ft. from Square Lake, 2500 ac-ft. from Klonaqua Lake, 2500 ac-ft. from Eight Mile Lake, 2500 ac-ft. from Colchuck Lake and 1000 ac-ft. from Snow-Lakes for a total of 10,500 ac-ft.
15. It is assumed that the City of Leavenworth will increase its water consumption from 3 cfs (the City's water right) to 6 cfs from June to the end of October.
16. It is assumed that COIC will consume 5 cfs from April to mid-October
17. It is assumed that IPID will consume 93 cfs in June, 99 cfs in July, 99 cfs in August, 78 cfs in September and 0 cfs in October.

18. It is assumed that IPID will address Icicle Creek water deficits beginning on August 1st and ending September 30th.

Using these numbers and assumptions, **(Table 2)** was constructed using a spreadsheet to see if it would have been possible in the years from 1994 to 2015 to accommodate 100 cfs for fish plus other demands listed above with the IWG projects in place and functioning. The spreadsheet used daily flows from June 1st to October 31st for each year from 1994 to 2015 measured at the Icicle Creek USGS Gage Station. If 100 cfs was not achievable, another table **(Table 3)** was constructed to see if it would have been possible to accommodate 60 cfs for fish from 1994 to 2015. Tables 2 and 3 are printed below on 8 and page 10.

When the goal is to achieve 100 cfs flow in Icicle Creek for fish we conclude the following (Table 2):

- Seven out of the 22 years demand exceeded the Snow Lakes limit of retaining 5450 ac-ft. in the lakes.
- Nine out of the 22 years demand exceeded the total annual quantity of IPID 10500 ac-ft. water rights to the wilderness lakes.
- Sixteen out of the 22 years demand exceeded the combined instantaneous quantity (cfs) limits named in the water right permits for Square, Klonaqua, Eightmile and Colchuck lakes, all of which are located upstream of the Icicle Creek USGS Gage Station.

TABLE 2

100 cfs for fish

Year	Acre feet remaining in Snow-Lakes Limit is no less than 5450 ac-ft.	Acre feet drawn from Snow-Lakes Limit is no larger than 7000 ac-ft.	Acre feet drawn from Wilderness Lakes Limit is no larger than 10500	Number of days CFS limit exceeded Limit 110 cfs	Date when Wilderness lakes fully drawn down	
1994	3711	7175	15381	55	9/12/1994	*
1995	9510	2940	8633	5		
1996	8091	4359	8758	2		
1997	10593	1857	4445	0		
1998	4695	7755	13150	32	9/20/1998	*
1999	9542	2908	4010	0		
2000	8882	3658	9822	4		
2001	4448	7002	14819	35	9/18/2001	*
2002	5049	7401	9960	17		
2003	5615	6835	14014	32	9/17/2003	*
2004	8944	3506	5812	0		
2005	1915	10535	16267	60	9/08/2005	*
2006	4576	7874	13224	33	9/18/2006	*
2007	8156	4294	12824	22	9/20/2007	x
2008	8054	4396	9367	11		
2009	6970	548	11588	0	9/25/2009	x
2010	10070	2380	5281	0		
2011	10711	1735	3720	0		
2012	8313	4137	7982	12		
2013	9177	3273	8866	4		
2014	8282	4168	8390	2		
2015	-2421	14871	15512	82	9/10/2015	*

Note: There are years like 1994 when the amount of water withdrawn from the four wilderness lakes exceeds the water right. In cases like this it is possible that Snow Lakes could have extra water to place the short-fall from the four wilderness lakes. The red * indicates failure of Snow-Lakes to satisfy the short-fall. However the blue x indicates Snow-Lakes are capable of addressing the short-fall.

When the goal is set to achieve 60 cfs for fish (Table 3), we conclude the following:

- One year out of the 22 years analyzed, demand exceeded the limit of retaining 5450 ac-ft. in the Snow Lakes; and
- Three out of the 22 years water demand exceeded wilderness lakes annual (ac-ft.) water right capacity.

TABLE 3
60 cfs for fish

Year	Acre feet remaining in Snow-Lakes Limit is no less than 5450 ac-ft.	Acre feet drawn from Snow-Lakes Limit is no larger than 7000 ac-ft.	Acre feet drawn from Wilderness Lakes Limit is no larger than 10150	Number of days CFS limit exceeded Limit 110 cfs	Date when Wilderness lakes fully drawn down
1994	6731	5719	10542	0	9/28/1994
1995	10308	2142	4460	0	n/a
1996	9907	2543	4924	0	n/a
1997	10975	1475	1561	0	n/a
1998	7784	1666	8310	0	n/a
1999	11069	1381	1883	0	n/a
2000	9950	2500	5593	0	n/a
2001	7151	5299	9987	0	n/a
2002	7841	4609	2380	0	n/a
2003	7868	4582	3568	0	n/a
2004	10644	1806	2778	0	n/a
2005	6290	6160	11507	0	9/22/2005
2006	7378	5072	8385	0	n/a
2007	9379	3071	7984	0	n/a
2008	9949	2501	4912	0	n/a
2009	8783	3667	6905	0	n/a
2010	10879	1571	4455	0	n/a
2011	11260	1190	1406	0	n/a
2012	9804	2646	4510	0	n/a
2013	9792	2658	4529	0	n/a
2014	9868	2580	4214	0	n/a
2015	3839	9611	10672	0	9/28/2015 *

In addition to water supply deficits, there will be physical impacts to the wilderness lakes and streams. There will be riparian damage to the lake shores of all five lakes used to supply water for the lower Icicle using this management scheme. In addition, there will be potential damage to the riparian zones of the tributary streams of Icicle Creek due to release of unnatural volumes.

There is a need to study this situation closely, in particular, the quantifying of how much of the shore line of each lake will be annually exposed, for how long, and how wilderness visitors will react to the artificial scale imposed on the wilderness lakes and streams associated with this project.

Finally, IWG and IPID will need to address changing the beneficial use to include water for municipal use and water for instream uses as a beneficial use. The ramifications could establish a precedent that would affect wilderness systems throughout the Nation

The assumption that there is no loss of water between the outlets of some of the wilderness lakes and their destinations should be analyzed. The use of a Variable Infiltration Capacity (VIC) model would help clarify this assumption.

This study did not take into account "lag time" when remotely adjusting water valves at the various wilderness lakes. The best that can be done at the moment is to respond on a "day after" schedule. The spread sheet did not take this account. Instead, it adjusted on the same day as the reading was recorded.

IWG members and Wilderness supervisors need to know the working value of 60 cfs as it reaches lower Icicle Creek. We know it can cover 61% of steelhead spawning habitat. We do not know how well 60 cfs flowing in a 120 foot wide channel, as in lower Icicle Creek, cushions prolonged warming air temperatures or if it significantly dilutes phosphorus discharged into Icicle Creek by the LNFH.

We know that 100 cfs is the goal identified by the IWG and that 60 cfs is identified by the IWG to be accepted only during drought years. However, it appears that using the wilderness lakes as a storage supply for all uses means

100 cfs is beyond reach most of the time, that 60 cfs is the best that can be attained, and that flows will be much lower in drought years

An additional 60 cfs should help address ESA issues but this issue has not been fully vetted.

One major wilderness question is, “Is the wilderness paying too high a price for what it is receiving”? The trade is more water in lower Icicle Creek, but at levels that fall short of what the IWG has indicated is desirable on a normal year. In exchange, the public will experience five, less natural and less pristine alpine lake shorelines located in a wilderness that emphasizes pristine, natural and healthy alpine lakes.

Is more water in lower Icicle Creek, but at levels that fall short of what the IWG has indicated is desirable in a normal year. In exchange, the public will experience five, less natural and less pristine alpine lake shorelines located in a wilderness that emphasizes pristine, natural and healthy alpine lakes.

Using 60 cfs for instream resources, (Table 4) was constructed to give a general idea of how far the water level of each of the five wilderness lakes would have dropped if the IWG proposed project had been in operation between 1994 and 2015. Table 4 does not account for the shape or depth of the lake topography under water. The acreage of each lake was found using a dot counter which is old technology. The results listed in Table 4 are biased toward the least amount of drop. The amount of exposed shoreline is left to the imagination.

TABLE 4
Estimate of vertical feet drawdown from each of the five wilderness lakes
between 1994 - 2015 using 60 cfs for fish habitat

Year	Acre feet drawn from Snow-Lakes Limit is no larger than 7000 ac-ft.	Estimated acres Snow Lakes 164 acres	Estimated Snow Lakes drawdown in vertical feet 2000 acre feet 21%	Acre feet drawn from Square, Klonaqua Eightmile, Colchuck Limit is no larger than 10150 - 650 = 9500 ac-ft.	Estimated acres Square 70 acres	Estimated Square drawdown in vertical feet 2000 acre feet 21%	Estimated acres Klonaqua 66 acres	Estimated Klonaqua drawdown in vertical feet 2500 acre feet 26%	Estimated acres Eightmile 63 acres	Estimated Eightmile drawdown in vertical feet 2500 acre feet 26%	Estimated acres Colchuck 77 acres	Estimated Colchuck drawdown in vertical feet 2500 acre feet 26%
1994	5719	164	35	9500	70	29	66	37	63	39	77	32
1995	2142	164	13	4460	70	13	66	18	63	18	77	15
1996	2543	164	16	4924	70	15	66	19	63	20	77	17
1997	1475	164	9	1561	70	5	66	6	63	6	77	5
1998	1666	164	10	8310	70	25	66	33	63	34	77	28
1999	1381	164	8	1883	70	6	66	7	63	8	77	6
2000	2500	164	15	5593	70	17	66	22	63	23	77	19
2001	5299	164	32	9500	70	29	66	37	63	39	77	32
2002	4609	164	28	2380	70	7	66	9	63	10	77	8
2003	4582	164	28	3568	70	11	66	14	63	15	77	12
2004	1806	164	11	2778	70	8	66	11	63	11	77	9
2005	6160	164	38	9500	70	29	66	37	63	39	77	32
2006	5072	164	31	8385	70	25	66	33	63	35	77	28
2007	3071	164	19	7984	70	24	66	31	63	33	77	27
2008	2501	164	15	4912	70	15	66	19	63	20	77	17
2009	3667	164	22	6905	70	21	66	27	63	28	77	23
2010	1571	164	10	4455	70	13	66	18	63	18	77	15
2011	1190	164	7	1406	70	4	66	6	63	6	77	5
2012	2646	164	16	4510	70	14	66	18	63	19	77	15
2013	2658	164	16	4529	70	14	66	18	63	19	77	15
2014	2580	164	16	4214	70	13	66	17	63	17	77	14
2015	7000	164	43	9500	70	29	66	37	63	39	77	32

TABLE 4 Note: This table was created to give an estimate of how many vertical feet each wilderness lake would have been drawn down each year starting in 1994 and ending in 2015 if 60 cfs had been supplied to Icicle Creek between RM 5.7 and 2.8 assuming completion of all IWG projects considered in 2016. The columns in blue show the vertical feet the drawdown of each year from 1994 to 2015. The estimated acreage of each lake was found using a dot counter with each dot equaling 1.4 acres

We are many years away from completing the proposed projects and realizing assumptions outlined in this paper. The current situation is truly destructive of some natural systems associated with Icicle Creek. If nothing is done to change this trend, collapses, such as collapsed fish species like steelhead and Dace or collapsed river otter populations and amphibians or collapsed critical insect species like benthic macroinvertebrates that make up the food chain of fish, all of which are dependent on critical Icicle flows at specific times of the year with water temperatures and dissolved oxygen a major goal.

This analysis may stimulate evaluation of other solutions than what the IWG is currently exploring. Icicle Creek water availability is an unusually difficult problem, in part, because of the magnitude of over appropriated Icicle Creek water. Add to that, a warming globe and the problem intensifies. But this does not mean there are no solutions. We have other sources of water that have yet to be considered and we have new technologies springing up constantly.

This analysis is an attempt to expose details that will help people understand the pros and cons associated with this project.

Dick Rieman