Leavenworth National Fish Hatchery
Proposed Flow Management Operations
for
2009 -2014

U.S. Fish and Wildlife Service
Leavenworth National Fish Hatchery
12790 Fish Hatchery Road
Leavenworth, WA 98826

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Introduction

In January 2008, the U.S. Fish and Wildlife Service (Service) requested a 401 Certification from the Washington State Department of Ecology (Ecology) for a National Pollution Discharge Elimination System (NPDES) permit for the Leavenworth National Fish Hatchery (Leavenworth NFH). Ecology requested Leavenworth NFH develop a flow management plan in order to adequately conduct a 401 certification. This flow management plan describes how Leavenworth NFH will be operated for the next five years and influences flow in Icicle Creek. The five year time period is consistent with the term of the NPDES permit and Ecology's 401 certification of that permit.

This plan describes Leavenworth NFH's water control facilities which influence Icicle Creek, and when and how those facilities are used. The description of the operations is consistent with that described in the Service's Biological Assessment and Biological Opinion for the operation and maintenance of the Leavenworth National Fish Hatchery (USFWS 2006 and 2008) and includes updated information based on changes to the operations in the last two years. Also identified are proposed studies to help Leavenworth NFH manage the current facilities in achieving resource needs. In conjunction with continually refining how the current facilities are operated, the Service is working with partners to achieve long term and sustainable modifications to operations and facilities to achieve the multiple objectives regarding fish production, tribal and sport fishing, native fish passage and rearing, riparian habitat, water quality, flood control and ground water recharge.

Features and Operation of the Water Supply System

The hatchery's water delivery system consists of five major components and conveyance systems: (1) intake and pipeline; (2) the Snow/Nada Lake Basin supplementation water supply reservoirs; (3) the well system on hatchery property; 4) water discharge facilities; and 5) structures 2 and 5. Leavenworth NFH's water rights for each component, as relevant, are shown in Table 1. Each of these five major components and conveyance systems are described individually below.

Intake and Pipeline

Leavenworth NFH shares a point of diversion with Cascade Orchard Irrigation District (Cascade) on Icicle Creek at river mile (RM) 4.5 (Figure 1). Leavenworth NFH maintains and operates the intake diversion dam and its associated intake structures as part of a 1939 contract between the United States and Cascade. Cascade has a 1905 water right for 12.4 cubic feet per second (cfs) during the irrigation season (approximately May 1st through October 1st) and Leavenworth NFH holds a 1942 water right to divert 42 cfs all year long.

Leavenworth NFH's intake facilities contain several components. The current intake system relies on gravity flow to convey water from the intake to the hatchery. Primary to the Leavenworth NFH water intake system is a low rubble masonry diversion dam with concrete spillway crest across Icicle Creek. The dam raises water elevations several feet allowing a portion of the flow to be diverted through a grizzly rack (bars spaced at about

6 inches) and into a concrete water conveyance channel. In the late 1980's, the diversion dam was rehabilitated and a pool and weir fish ladder was constructed. Water which enters the conveyance channel is transported a short distance from the coarse grizzly rack to a small building which houses a fine rack (1 ½ inch bar spacing), an overflow spill section, and a sediment sluicing section. The coarse and fine racks serve to limit the size of the debris which enters the pipeline.

Table 1. Leavenworth National Fish Hatchery's Water Rights

WATER RIGHT #	PRIORITY DATE	SOURCE	INSTANTANEOUS QUANTITY*	ANNUAL QUANTITY
Certificate No. 1824	03/26/1942	Icicle Creek	42 cfs (18,851 gpm)	
Certificate No. 1825	03/26/1942	Snow & Nada Lakes		16,000 acre-feet of storage
Claim No. 12008	08/01/1939	Groundwater (1 Well)	1.56 cfs (700 gpm)	570 acre-feet
Claim No. 12009	06/01/1940	Groundwater (1 Well)	2.01 cfs (900 gpm)	730 acre-feet
Certificate No. 3103-A	10/16/1957	Groundwater (1 Well)	2.67 cfs (1200 gpm)	1,120 acre-feet Nov 1 – June 1
Certificate No. G4-27115C	10/20/1980	Groundwater (4 Wells)	8.69 cfs (3900 gpm)	5257 acre-feet

* cfs = cubic feet per second, gpm = gallons per minute

A discharge channel guides the spilled/excess water and sluiced material back to the creek downstream of the building. Water retained in the system is transported from the fine rack into a 33-inch-diameter buried pipeline. A gate valve is located at the pipe entrance to regulate flow into the pipe. Normally this gate is left fully open. Approximately 1,260 feet down gradient from the beginning of the pipe system is a gate valve that controls flow into Cascade's delivery system.

A maximum of 42 cfs of river water that does not enter Cascade's water delivery system is transported through a 31-inch-diameter buried pipeline approximately 5,200 feet to a sand settling basin, through fish screens and then to the rearing units. Water leaving the rearing units is discharged at RM 2.8. When rearing ponds are cleaned effluent is discharged through the pollution abatement pond (RM 2.7). The sand settling basin has an overflow bypass pipe which also empties into the pollution abatement pond.

Evaluations of the Leavenworth NFH's water delivery system (diversion dam, intake building, pipeline and fish screens) indicate it needs to be rehabilitated. Over the last several years the Service has worked to rehabilitate the Leavenworth NFH's water delivery system to meet the needs of the hatchery, instream flow, fish passage, and habitat restoration.

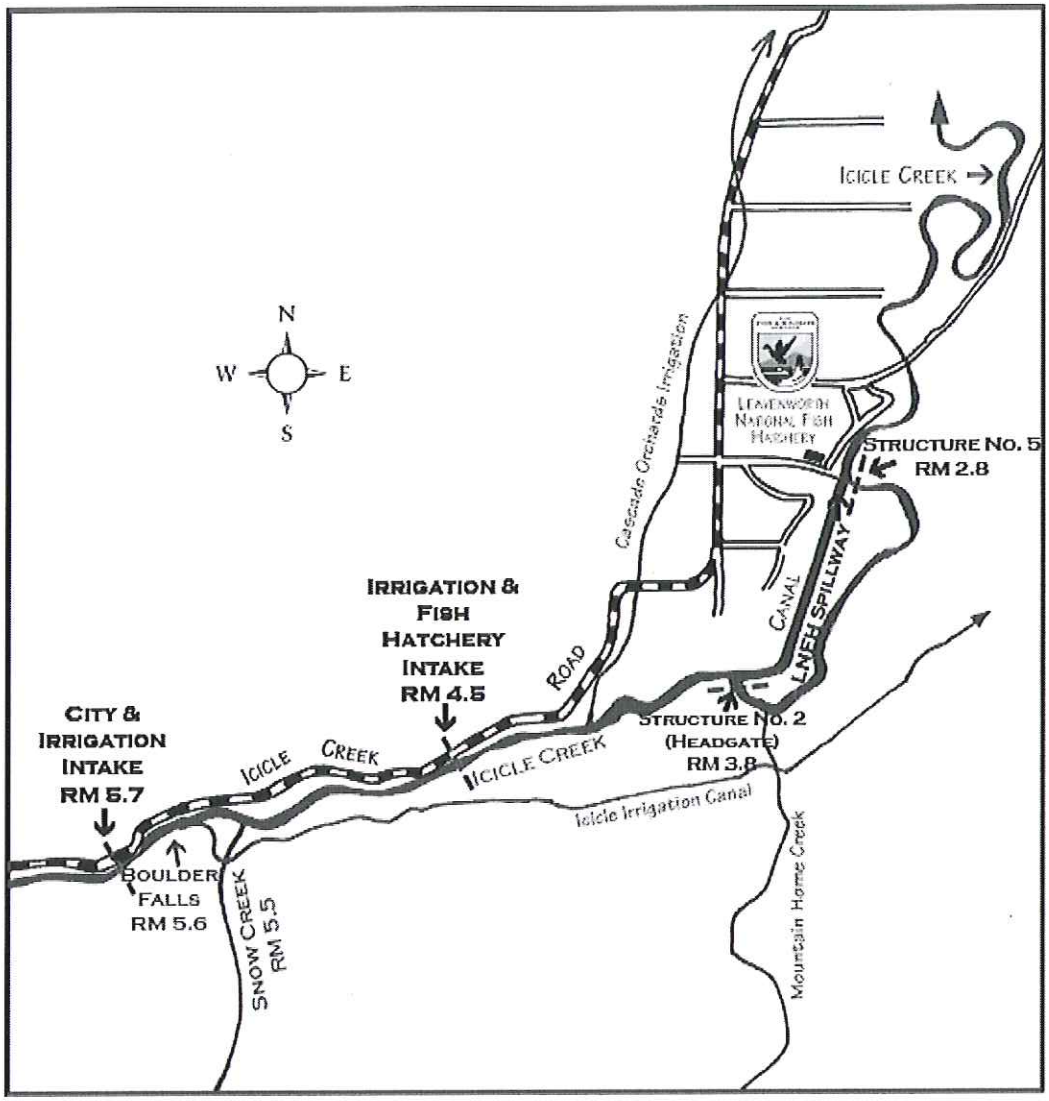

Figure 1. Leavenworth National Fish Hatchery and Vicinity

Since the fall of 2006, the PASS (Project Alternatives Solution Study) Process was initiated to address Icicle Creek Restoration and LNFH Water Intake improvements. The cross-functional PASS process is structured to generate and evaluate creative alternatives within defined objectives. The Group Objectives and Logistics (GOAL) Team met on September 8, 2006 to outline these objectives. The PASS Technical Team met on October 15-18 and also November 6-8 of 2006 to develop viable alternatives to address those objectives. They had teleconference progress updates during the winter and spring of 2007 to review cost estimates and rank the alternatives. The PASS team continued to meet in 2008 and recently met on November 20th, 2008 in Leavenworth. At the meeting

Bureau of Reclamation engineers presented conceptual designs of potential Icicle Creek intake alternatives and restoration of the historic channel. The team will continue to meet in 2009. The Service will share the alternative from the PASS group with the general public during the NEPA process. Agencies participating in the PASS process include the Service, Bureau of Reclamation, NOAA Fisheries, Washington Department of Fish and Wildlife, Ecology, Wild Fish Conservancy, Yakama Nation, and Colville Confederated Tribes.

Snow/Nada Lakes

During construction of the hatchery, it was recognized that surface flow and temperatures in Icicle Creek might at times be insufficient to meet fish production demands. A supplementary water supply project in Upper and Lower Snow and Nada Lakes was therefore developed and a water right to store up to16,000 acre feet was obtained (Table 1). These lakes are located approximately seven miles from the hatchery and about one mile above it in elevation. A one-half mile tunnel was drilled through granite to the bottom of Upper Snow Lake and a control valve was installed at the outlet end of the tunnel. Water drains from Upper Snow Lake to Nada Lake which drains into Snow Creek, a tributary to Icicle Creek that enters at RM 5.5. Thus, supplemental flows from Snow Creek enter Icicle Creek one mile above Leavenworth NFH's intake system. Icicle Peshastin Irrigation District has a right to 600 acre feet of natural flow from Snow Creek.

The lakes are accessed by helicopter or foot at least twice a year to open and close the control valve. More trips may occur to adjust releases from the lakes and to perform maintenance. In the mid-1990s the USFWS installed water monitoring sites at four different locations to help manage the reservoirs: 1) the mouth of Snow Creek near Icicle Creek; 2) the outlet of Nada Lake; 3) the outlet valve for Upper Snow Lake, and; 4) the mouth of main tributary entering Upper Snow Lake. Data from the recorders is managed by the Service's Region 1 Water Rights Division in Portland, OR.

Recent reports by Wurster (2006) and Montgomery Water Group (2004) describe water use from the reservoirs. Both reports indicate that in most years the reservoirs are capable of providing the hatchery's full water right (42 cfs) from approximately early July to October with a reasonable expectation of refilling the withdrawn amount by July of the following year.

Since 2006, Leavenworth NFH operates the Snow/Nada Lake Supplementation Water Supply Reservoirs to fully account for its 42 cfs water right from approximately late July to early October (a usual period of operation). This commitment equates to a release of nearly 7,000 acre feet of storage, a volume recommended by Wurster (2006; 70 days at 50 cfs) with an estimated 60% probability that inflows to Upper Snow Lake will meet or exceed the released volume (Figure 2). Events such as equipment malfunction or consecutive years of drought (two or more years) would alter the release operations. Water in excess of 42 cfs is typically released to account for transport loss, natural flow into the Snow/Nada Lakes Basin during the time of drawdown, decreasing head pressure and water released as the reservoir level drops and ensuring flow for the fish ladder at the intake diversion dam.

Table 2: A) Volume of water (ac-ft) removed from Upper Snow Lake for different flow scenarios. B) Estimated probability that inflows to Upper Snow Lake will meet or exceed the released volumes from 5A. The row corresponding to average hatchery diversions from Icicle Creek is shaded (40 cfs). Total lake volume is about 12,450 ac-ft Wurster (2006).

A

Days Upper Snow Lake Valve is Open

Average Release from Upper Lake (cfs)	40	50	60	70	80	90	100	110	120
20	1580	1980	2380	2770	3170	3560	3960	4360	4750
30	2380	2970	3560	4160	4750	5350	5940	6530	7130
40	3170	3960	4750	5540	6340	7130	7920	8710	9500
50	3960	4950	5940	6930	7920	8910	9900	10890	11880
60	4750	5940	7130	8320	9500	10690	11880		
70	5540	6930	8320	9700	11090	12470			
80	6340	7920	9500	11090	12670				
90	7130	8910	10690	12470					
100	7920	9900	11880			Exceeds Total Volume of Lake			
110	8710	10890							
120	9500	11880							

B

Days Upper Snow Lake Valve is Open

Average Release from Upper Lake (cfs)	40	50	60	70	80	90	100	110	120
20	> 92	> 92	> 92	> 92	> 92	> 92	> 92	91	86
30	> 92	> 92	> 92	93	86	79	72	65	58
40	> 92	> 92	86	76	67	58	48	39	29
50	> 92	83	72	60	48	36	25	13	< 8
60	86	72	58	43	29	15	< 8		
70	76	60	43	27	10	< 8			
80	67	48	29	10	< 8				
90	58	36	15	< 8					
100	48	25	< 8			Exceeds Total Volume of Lake			
110	39	13							
120	29	< 8							

Well System

Groundwater provides the third major component of Leavenworth NFH's water delivery system. The Leavenworth NFH operates seven wells, which produce the quality of water needed to sustain the current fish production program. The wells are located on the west bank of the hatchery channel. These wells draw water from two aquifers, one deep and one shallow. Well 5 draws from the deeper aquifer, which is not influenced locally by surface water. Wells 1-4 and 7 draw water from the shallow aquifer. Well 6 draws water from both aquifers. Recharge of the shallow aquifer is affected by how much water is present, and thus percolates into groundwater, in the historic and hatchery channels. The water levels in wells 1- 4 and 7 rise when water is in the hatchery channel and fall when water is not present in the hatchery channel. Well water is used to supplement and temper surface water to meet fish production targets. Fish production could not be sustained year-around or for long periods of time on either river water or well water alone.

Water Discharge

All of the surface water and groundwater used at the hatchery, minus any leakage or evaporation, is returned to Icicle Creek immediately downstream of the hatchery. This water is discharged into Icicle Creek at two locations, at the base of the fish ladder (RM 2.8) or through the pollution abatement pond (RM 2.7). The majority (>98%, approximate range 42-50 cfs average daily discharge which changes seasonally) of the water is returned to Icicle Creek at the base of the fish ladder except when the rearing units are cleaned. Cleaning effluent is routed through the pollution abatement pond. A portion of the rearing units are cleaned nearly every day and about 4 cfs is discharged during the 2-hour cleaning period. The pollution abatement pond discharges approximately 1 cfs (daily average) or less than two percent of the total effluent discharge for the hatchery.

The Leavenworth NFH operates and monitors its water discharge in compliance with the original (1974) NPDES permit (Permit WA-000190-2; Leavenworth NFH submitted an application for a new NPDES discharge permit on November 15, 2005.). The permit contains discharge limits, and monitoring and reporting requirements for settable and suspended solids, and flow.

Structures 2 and 5

Structure 2 is located at RM 3.8 in Icicle Creek and was designed to control flow into the hatchery channel (RM 2.8 to RM 3.8). The hatchery channel was built to bypass flow so a portion of Icicle Creek could be used to accommodate hatchery fish production. That portion of Icicle Creek (RM 2.8 to 3.8) is now called the historic channel and once included a few instream structures to aid in fish production. Today only structures 2 and 5 remain. Structure 5 is at the downstream end of the historic channel (RM 2.8) and is a bridge with a foundation to support racks, dam boards and/or fish traps. The hatchery channel parallels the historic channel with the upper end bifurcating at structure 2 (RM 3.8) and, after spilling over a dam, rejoins the historic channel just downstream of structure 5 at RM 2.8.

From approximately 1940 to 2005, hatchery operations focused on keeping water in the hatchery channel, which blocked fish passage year round and limited flow into the historic channel (USFWS 2002a). Since 2006, Leavenworth NFH operations changed at structures 2 and 5 to improve fish passage and habitat. Now all dam boards, racks and traps are removed from structure 5 and the gates at structure 2 are in the fully opened position most of the year (Table 3; Appendix 1). The Service considered numerous aspects such tribal and sport fishing, native fish passage and rearing, riparian habitat, water quality, flood control and ground water recharge in developing an operational plan. The Service uses the most applicable data available to develop a suitable operations plan which is modified when new and relevant information becomes available. Additional aspects of this operation are addressed as part of the Service's 2008 Biological Opinion addressing impacts of operations on listed bull trout (USFWS 2008).

The relatively new management strategy impacts the Service's ability to meet operational needs of the hatchery like broodstock collection and smolt emigration. Additionally, large flood events on Icicle Creek demand that water passes through the hatchery channel to prevent flooding of properties adjacent to the historic channel and protection of infrastructure on the hatchery. Lastly, reducing flow in the hatchery channel reduces the ground water recharge to the shallow alluvial floodplain aquifer adjacent to Icicle Creek. The hatchery infrastructure has been built based on expectations that we will continue to have access to both surface and well water. The Service's experience during the last three years suggests managing the two channels needs to be consistent with past flow management practices at certain times of the year to meet hatchery operations and maintain shallow aquifer recharge.

The following section describes how the Service manages flow between the historic and hatchery channels to meet the needs for:

1) Broodstock collection/tribal fishing
2) Smolt emigration
3) Aquifer recharge
4) Flood control

Broodstock collection/tribal fishing is a scheduled operation which occurs annually. The other three occur only when environmental conditions warrant (*i.e.*, high or low Icicle Creek flow; Table 3). Any time structure 2 or 5 is adjusted, it is done slowly and incrementally to avoid rapid water level reductions. Flow reductions are managed to occur at a rate of approximately one inch per hour (USFWS 2008). After adjustments are complete the channel with reduced flow is surveyed and stranded fish are returned to Icicle Creek. Please note that exact flow values are not available so all references to flow in the following sections is relative. The "Informational Needs" section suggests studies to acquire flow data that could be used to improve flow management by the Service at Leavenworth NFH.

Broodstock Collection/Tribal Fishing
Scheduled adjustments to structures 2 and 5 occur mid-May through early July when hatchery origin spring Chinook salmon return to Icicle Creek. At this time, most flow (actual amount in volume or percentage is unknown) is directed into the hatchery channel, and racks, dam boards and a fish trap are installed at structure 5 to manage upstream fish passage. Sufficient spring time flows through the hatchery channel and over the spillway dam provide the attraction flow to collect spring Chinook salmon broodstock at the hatchery. With the gates open at structure 2, increased flows through the historic channel decrease attraction capabilities of the fish ladder and attract the spring Chinook salmon up the historic channel. Maintaining sufficient flow in the hatchery channel during the broodstock collection time period also provides fishing opportunities to members of the Yakama Nation and Wenatchi Band of the Colville Confederated Tribes. Tribal members fish in the spillway pool adjacent to the hatchery's fish ladder.

Annually, the Service coordinates with the Washington Department of Fish and Wildlife, NOAA Fisheries, the Yakama Nation, and the Colville Confederated Tribes on the timing of the adjustments to structures 2 and 5 for broodstock collection and tribal fishing. These agencies use an adaptive management approach to limit, to the extent practical, the broodstock collection period through consideration of annual run timing of spring Chinook salmon at Columbia River dams (*e.g.* Priest Rapids, Rock Island), number of adult spring Chinook salmon in Icicle Creek, number of bull trout captured in the fish traps and any other pertinent and available fish data. For example, early run timing may require installing racks slightly earlier while later run-timing may allow for a slightly later installation. The Service is continually evaluating options to improved passage for native fish species and it using the adaptive management process discussed in the Service's Biological Opinion (USFWS 2008).

Smolt Emigration
Leavenworth NFH typically releases juvenile spring Chinook and coho salmon in late April. A term and condition of the NOAA Fisheries Biological Opinion requires that hatchery Chinook salmon juveniles be ready to actively migrate to the ocean (NMFS 2003). Salmon smolts use physiological and environmental cues to initiate their migration downstream. High spring time flows facilitate the migration.

Prior to 2006, when Icicle Creek water was directed down the hatchery channel, the released fish emigrated quickly from Icicle Creek. Since 2006, during the mid to late April fish release period, all Icicle Creek flow has gone through the historic channel and fish released from Leavenworth NFH did not quickly emigrate. To assist emigration of these fish some flow is directed through the hatchery channel. This is effective in stimulating emigration and only lasts for a few days in late April or early May. Adjustments to structure 2 always result in flowing water in the historic channel, although at a reduced rate.

Biologically and physiologically the fish could be released as late as mid-May. At that time, even with the current structures still in place, the amount of flow in Icicle Creek

would normally be high enough that some water would flow down both the historic and hatchery channels. The Service has been actively working towards building more flexibility into the release date so fish can be released when Icicle Creek is naturally flowing down the hatchery channel, thus not relying on closure of the gates at structure 2.

Aquifer Recharge

In order for Leavenworth NFH to reach its program target of releasing 1.2 million smolts at an average size of 5.5 inches, ground water is required. Surface water temperatures fluctuate from 32° F to 68° F causing stress associated with a reduction in oxygen and the activity of other organisms detrimental to fish health when temperatures rise above 50° F. At water temperatures below 50° F, fish growth is reduced, feeding rates decline, and fat reserves diminish (Piper et. al.1982). Ground water (well water) provides water at a constant temperature especially during incubation and early rearing when surface water temperatures are declining towards 32° F. At 50° F optimum growth is achieved and early rearing survival rates are maintained.

Structure 2 controls flow between the historic and hatchery channels. When the gates are open at structure 2 during high flows, the flow splits into the both the historic and hatchery channels, but at low flows (due to an elevation difference between channels) most of the water flows into the historic channel. Water in the hatchery channel affects the recharge of the shallow aquifer in hydraulic continuity with it. Observations by hatchery staff and others over last 20 years suggest the hatchery channel recharges the shallow alluvial aquifer of the Icicle Creek floodplain in and around the hatchery property (GeoEngineers 1995). Six of the hatchery's seven wells are located in this aquifer (see "Well System" above.) De-watering of the hatchery channel reduces this recharge, causes water levels in production wells to drop, and reduces the pumping capacity of the wells.

Currently, Leavenworth NFH needs between 1,060 gallons per minute (gpm) and 6,590 gpm of ground water during its fish production cycle (Sverdrup 2000). The most demand begins in December (6,110 gpm), when young salmon fry begin to feed. Ground water use continues throughout the winter months in order to temper cold surface water used on yearling salmon in outdoor ponds. Conversely, the ground water is used to cool surface water in the summer months as surface water temperatures begin to rise.

Considering the hatchery channel's role of recharge for the shallow aquifer, concerns related to effects of the Icicle Creek Restoration Project on the production wells were raised and studied (USFWS 2002). To assess the effects of a dewatered hatchery channel, a ground water flow model MODFLOW was used to simulate ground water conditions in the shallow aquifer. Information from this data represents the predicted amount of water available from each well in the shallow aquifer given an eight-week modeling scenario.

Three conditions were applied to the model, all with the wells pumping:

1.) Condition I is a wet hatchery channel and normal aquifer recharge.
2.) Condition II is a dry hatchery channel with normal aquifer recharge.
3.) Condition III is a dry hatchery channel with low aquifer recharge.

At the time when the model runs were simulated, Leavenworth NFH generally operated between Conditions I and II with ground water production at or near 5,300 gpm, from wells 1-4, and 6-7. The most critical time was during the late fall and the early winter months when river conditions are typically low and the hatchery channel is dry (Condition III). Based upon the simulated assessment of ground water levels, under Condition II or III, Leavenworth NFH would lose between 510 gpm and 1960 gpm from wells 1-4 and 6-7, a 10% to 37% decrease.

Ground water modeling was compared to actual well pumping conditions during the winter of 2001 when Leavenworth NFH operated under Condition III. Data collected by the Leavenworth NFH fish production supervisor confirmed the predicted decrease of 28% in supply of ground water from Leavenworth NFH's wells. Wells 1 and 5 were near capacity, Wells 4, 6, and 7 were below capacity, and Wells 2 and 3 produced no water by February 28, 2001. (Well 5 draws solely from the deep aquifer.)

As indicated by the surface water/ground water modeling scenarios, the diversion of surface water into the historic channel would affect water levels in the wells. Modeled Conditions II and III would prevail in the late summer and fall when structure 2 remains open. It was estimated a potential 28% reduction in ground water supplies would occur during low recharge conditions when the hatchery channel is dry and wells 2, 3 and 7 would be dewatered during extreme low surface water conditions.

Since 2005, the Leavenworth NFH has operated in situations similar to Condition III, where surface water flow and aquifer recharge is low. At low flows structure 2 gates must be closed to divert water into the hatchery channel to recharge the aquifer. Since 2005, these gates are not closed more than two weeks at one time in order to maintain flows in the historic channel. Hatchery staff found that they need more than two weeks to significantly influence recharge of the aquifer. The Service is currently trying to quantify how much and how long water needs to be in the hatchery channel to recharge the aquifer consistent with the recharge that has occurred since the hatchery channel's construction in the late 1930's. Prior to 2005, wells 2 and 3 were in use during 25% and 34% of the time, respectively. In 2008, when the hatchery channel was dry for most of the summer and early fall, wells 2 and 3 were in use during 12% and 3% of the time, respectively. Each well is monitored at least weekly. These data and reports indicate production from these wells has been substantially reduced in 2008 and since operation of structures 2 and 5 were modified in 2005. Additional data is needed (identified in the section "**Information Needs**") so the available water is best manage for instream flow and hatchery needs.

Flood Control

Flood and/or high flow events usually occur in the spring and fall and can also occur in winter with a rain on snow event. These flood events generally last less than two weeks. To prevent flooding of downstream properties, the Leavenworth NFH begins to lower the gates at Structure 2 when flow approaches one foot below the bottom of the bridge deck at Structure 5 and the weather forecast suggests increasing river flow (*i.e.*, heavy rain or

rapidly increasing temperature with lots of snow on the ground). However, action may occur when other factors known to affect Icicle Creek flow are occurring such as high flows in the Wenatchee River, large amount of ice in Icicle Creek, recent high flow events, personnel limitations, etc. Since 2006 the gates at structure 2 were closed once (November 6-20, 2006) when Icicle Creek flow reached 15,700 cfs (USGS at http://waterdata.usgs.gov/wa/nwis/inventory/?station=124580000). Even when the gates are completely closed the historic channel still has flow, because the gates leak and there is some upwelling of ground water, particularly when the hatchery channel is full.

Information Needs

Addressing the informational needs described below will help the Service's management of the current facilities for fish production, tribal and sport fishing, native fish passage and rearing, riparian habitat, water quality, flood control and ground water recharge. The new information will be used to address future operations and modifications at Leavenworth NFH facilities for the benefit of Icicle Creek and natural resource management needs. Studies are needed to determine:

- Instream flow for aquatic species in the historic channel.
- How to best use water releases from Snow/Nada Lakes.
- What flows, adjustments or modification are needed to optimize fish passage at the intake diversion dam and structures 2 and 5.
- The amount of water needed to maintain recharge to the aquifer beneath Leavenworth NFH for well recharge and to support aquatic resources.
- Instream flow for riparian habitat restoration.

Leavenworth NFH will work with federal and state fisheries management agencies (*i.e.*, USFWS, NOAA, WDFW), the affected tribes (Yakamas and Colville Wenatchis), and the Washington State Department of Ecology to address data needs.

Table 3. Average monthly flow in cubic feet per second above and below the Leavenworth NFH intake diversion and other water flow inputs and diversions in Icicle Creek. Also included are time periods when Leavenworth NFH may conduct activities which would impact flow in Icicle Creek.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
USGS Gage[1]	214	195	237	590	1489	1751	762	227	135	165	235	249
Snow Lake Input[2]								50	50			
IPID Diversion[3]				56	77	93	100	100	78			
Other Diversions[4]	2	2	2	8	8	8	8	8	8	2	2	2
LNFH Diversion[5]	36	40	35	32	30	36	39	35	40	41	38	35
Flow below intake[6]	176	153	200	494	1374	1614	615	134	59	122	195	212
Broodstock collection / Tribal Fishing					■■	■■■■	■					
Smolt emigration				□□	□□							
Aquifer recharge	□□□□	□□□□	□□□□					□□□□	□□□□	□□□□	□□□□	□□□□
Flood control					□□□□	□□						

Superscripts

1. From USGS daily statistic records for Icicle Creek gage.
2. From Leavenworth NFH.
3. Washington Department of Ecology water use reporting records 2004 and 2005 (PROVISIONAL)
4. Estimated diversions for City of Leavenworth and Cascade Orchards Irrigation.
5. Estimated from Leavenworth NFH records (2004 & 2005). Not measured directly.
6. USGS gage and Snow Lake input less IPID Diversion, Other Diversions and LNFH Diversion.

Key to symbols:

Cells with symbols identify data needs as no flow information is available.
Each symbol represents approximately one week.
Solid symbols indicate a time period when an action definitely occurs and affects Icicle Creek flow.
Hollow symbols indicate time periods in which actions are likely to occur if environmental conditions warrant (e.g., high flows; low groundwater levels; pre-smolt emigration).

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Appendix

Appendix 1. The number of days, including starting and end dates, structures 2 and/or 5 were adjusted for smolt emigration, broodstock management, flood control or hatchery channel recharge in 2006, 2007 and 2008.

Year	Start Date	End Date	# Days	Structure	Reason
2006	April 19	April 20	1	2	Smolt Emigration
2006	May 16	July 10	55	2	Broodstock Management (spring Chinook)
2006	May 17	July 10	55	5*	Broodstock Management (spring Chinook)
2006	October 13	November 6	24	5	Broodstock Management (coho)
2006	November 6	December 1	23	2	Flood Control
2007	February 22	March 8	14	2	Hatchery Channel Recharge
2007	April 18	April 20	2	2	Smolt Emigration
2007	May 9	July 10	62	2	Broodstock Management (spring Chinook)
2007	May 14	July 10	57	5*	Broodstock Management (spring Chinook)
2008	March 4	March 28	24	2	Hatchery Channel Recharge
2008	April 21	May 1	10	2	Smolt Emigration
2008	May 14	July 11	58	2	Broodstock Management (spring Chinook)
2008	May 15	July 7	53	5*	Broodstock Management (spring Chinook)
2008	October 7	October 21	14	2	Hatchery Channel Recharge
2008	November 7	November 14	7	2	Flood Control

* Managed in concert with structure 2.