MEMORANDUM

Project No.: 150200

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To: Steve Croci, Leavenworth National Fish Hatchery

From:

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Re: **Leavenworth National Fish Hatchery Water Supply Action Plan**

Summary and Recommendations

Leavenworth National Fish Hatchery (LNFH), located in Chelan County, Washington, relies on a combination of groundwater and surface water sources to supply fresh water for fish propagation purposes. The hatchery was constructed in 1940 to compensate for anadromous fish losses resulting from construction and operation of the Bureau of Reclamation's (Reclamation) Grand Coulee Dam, and is currently operated by the U.S. Fish and Wildlife Service (USFWS). Active water supply sources include seven groundwater supply wells and a surface water diversion from Icicle Creek. The USFWS holds water rights authorizing use of 42 cubic feet per second (cfs), 27,482 acre-feet per year (afy) of water from Icicle Creek and an additional 6,700 gallons per minute (gpm), 7,677 afy of water from the wells.

The hatchery has a recent history of not being able to fully exercise the groundwater rights due to a combination of poor well performance, well drawdown interference, limited available drawdown, and changes in operations of the Hatchery Channel implemented to comply with a National Marine Fisheries Service (NMFS) Biological Opinion (BiOp) for the LNFH facility. Recent groundwater production is about 3,200 gpm (peak instantaneous) and 2,600 afy, leaving a shortfall of about 3,500 gpm (equivalent to about 7.8 cfs) and 5,100 afy relative to the permitted quantities. As a further constraint on water supply, under the BiOp USFWS has targeted a 20 cfs reduction in surface water diversions from Icicle Creek.

In order to maintain hatchery operations and fulfill LNFH's mission of fish propagation, both the existing shortfall in groundwater supply capacity and the planned reduction in surface water diversion will need to be addressed through a combination of new groundwater supply sources and

changes in hatchery operations. This memorandum, prepared by Aspect Consulting, LLC (Aspect), presents the Water Supply Action Plan (Action Plan) for LNFH summarizing recent water supply improvement studies, providing recommendations for groundwater supply improvements and how they integrate into other water system improvements, and providing appraisal level costs for implementing improvements.

Memorandum Organization

The remainder of this summary presents:

- Background on water supply challenges and potential improvement options;
- Recommended improvements to groundwater source capacity;
- Recommended changes to Hatchery Channel operations; and
- Recommended expansion of water reuse.

Following the summary are sections providing:

- Background on the project, including guiding principles of the Icicle Work Group (IWG) and LNFH's water supply improvement objectives;
- Brief summaries of relevant studies and evaluations on which the above recommendations were based; and
- Additional details on the water supply improvements options, including data gaps, feasibility, and permitting considerations.

Water Supply Constraints and Improvement Options

In addition to LNFH's operations, there are multiple competing demands for water in the Icicle Creek Sub-basin. In addition to operation of the LNFH, these demands include out-of-stream water supply needed for irrigation by Icicle-Peshastin Irrigation District, Cascade Orchards Irrigating Company (COIC), and private irrigators, water right permit-exempt wells in rural Chelan County, and municipal use by the City of Leavenworth. Instream flows are needed to support habitat and passage needs for fish species listed under the Endangered Species Act (ESA). Instream flows also support returns of hatchery fish, which support important Treaty harvest by the Yakama Nation and the Colville Confederated Tribes and non-Treaty (i.e., recreational) harvest opportunities. During the late summer and early fall, when natural flows in Icicle Creek are lowest, it is a challenge to supply water for out-of-stream uses while meeting instream flow targets needed to maintain adequate passage and habitat conditions for ESA-listed fish species and their critical habitat.

Chelan County and the Washington State Department of Ecology (Ecology) Office of Columbia River (OCR) formed the IWG in December 2012 to find collaborative solutions for water management within the Icicle Creek Watershed. The USFWS is one of multiple stakeholder members of the IWG. The IWG has established a set of guiding principles to assist in identifying and prioritizing water resource projects within the Icicle Creek drainage.

Efforts on behalf of LNFH to improve hatchery operations, support stakeholder group objectives for habitat and instream flows, and comply with State and Federal regulations have focused on investigation and evaluation of water supply projects and operational changes to increase groundwater source capacity and reduce surface water diversions. Water supply improvements under consideration include:

- Developing a new groundwater source tapping shallow gravel deposits on Hatchery Island by constructing a groundwater collector system;
- Developing new groundwater source(s) at other locations through vertical wells;
- Implementing an effluent pump back system to reroute hatchery effluent that is currently discharged to Icicle Creek to Hatchery Channel, with the purpose of recharging the adjacent aquifer tapped by the hatchery's supply wells; and
- Expanding the existing internal water reuse system to recirculate hatchery water prior to discharge into Icicle Creek.

The first three options are focused on recovering lost groundwater supply capacity and increasing groundwater production up to the permitted quantities. The fourth option is focused on directly reducing surface water diversions from Icicle Creek by reducing hatchery demands. In order to achieve the targeted 7.8 cfs increase in groundwater supply capacity and the 20 cfs reduction in surface water diversions, we recommend a phased development of all of the above water supply improvement options. The recommended phasing and implementation of groundwater source improvements, aquifer recharge improvements, and water reuse improvements, respectively, are provided in the following sections.

Recommended Groundwater Source Improvements

We recommend first proceeding with design, permitting, and construction of a groundwater collection system on Hatchery Island as the primary action to improve groundwater supplies. Additional improvements will also be required to ensure sufficient groundwater source capacity, including activating an existing well that has not been put into service, construction of additional vertical wells to supplement supply, and implementation of the effluent pump back option (discussed in the following section) to recharge the aquifer tapped by LNFH's wells.

Increasing groundwater capacity is a high priority that is expected to be implemented regardless of the outcome of other water supply alternatives currently under study. Pathogen-free groundwater is the preferred source for incubation, early rearing, and adult holding aspects of hatchery operations. At present, groundwater source capacity limits withdrawals to about one half the quantities authorized by the LNFH groundwater rights portfolio and is not adequate to support the hatchery's needs.

The groundwater collector system considered for Hatchery Island has the greatest potential for large improvements in groundwater source capacity, with estimated yields of about 2 to 5.5 cfs (Aspect, 2016). Yields are expected to vary seasonally, depending on Icicle Creek stage and whether the Hatchery Channel is hydrated and recharging the adjacent shallow aquifer on Hatchery Island.

Historically, Hatchery Channel was hydrated most of the year. Starting in 2006, operation of Hatchery Channel was modified to improve fish passage and habitat in the natural (historical) Icicle Creek channel. Currently, the Hatchery Channel is largely dry with only limited, periodic diversions from Icicle Creek allowed to help recharge the adjacent aquifer; implementation of the pump back option would likely further improve groundwater source development, as discussed below.

Options for constructing new, vertical groundwater supply wells were evaluated through review of existing well construction and performance information and a geophysical survey of the LNFH property and an adjacent County-owned parcel (Aspect, 2015a). The value of equipping existing well PW-10 with a pump and bringing it online was also considered.

Suitable locations for new wells on USFWS property are limited, either by potential drawdown interference from LNFH's existing wells west of Hatchery Channel or unfavorable soil conditions. Potential feasible locations for new, vertical wells include the northern end of Hatchery Island where moderately coarse-grained soils were inferred at depth from the geophysical survey, and, if access can be arranged, a private property north of the hatchery facility. Expected yield from new vertical wells is uncertain, but is assumed to be about 300 gpm per well, based on sustained yields from other wells completed at the facility. The evaluation of well PW-10 indicated a maximum of about 200 gpm could be produced if this well is equipped with a pump and tied-in to the distribution system; however, limited available drawdown and pumping interference with other active hatchery wells would likely reduce the long-term yield from this well and/or reduce yields from existing wells. Given these concerns, activating well PW-10 was not retained as an option.

Table 1 shows estimated yields, appraisal-level costs of the groundwater source options, and the resulting cost per cfs of improved yield. Although the groundwater collector has potentially the highest cost per cfs of yield, it is also the only groundwater source improvement option with the potential to fill a significant portion of the groundwater supply shortfall. We recommend that this option be retained as the highest priority groundwater improvement option.

Table 1 — Estimated Yields and Costs for Groundwater Source Improvements

Groundwater Improvement	Estimated Yield Improvements	Estimated Cost[1, 2]	Cost per cfs of Additional Yield
Groundwater Collector	2 to 5.5 cfs	$1,700,000	$309,000 to $850,000
New Well (each)	0.67 cfs (300 gpm)	$200,000	$300,000

[1] Estimated cost is appraisal-level, and includes design, permitting (except water rights), and construction
[2] Appraisal-level cost estimates are based on general experience with projects similar in scope and design

The approximately 7.8 cfs shortfall in groundwater source capacity will likely not be met by construction of the groundwater collector alone, and it is expected that additional well capacity will be needed. Estimated cost per cfs of improved yield is about $300,000 for new wells. To minimize

pumping interference and impacting yields from existing hatchery wells, the most suitable location for new wells would be private property north of the hatchery facility, if access and easements could be arranged. Although access and ownership issues lead to uncertainty in the ability to site new wells at suitable locations, any remaining shortfalls in groundwater source capacity would need to be made up with construction of new vertical wells, and these are retained as a groundwater improvement option.

The estimates of yield and cost were used to develop an approximate total cost for groundwater improvements to meet the 7.8 cfs shortfall in groundwater source capacity. Assuming the collector produces about 4 cfs (approximately the mid-range of the estimated yields), then five to six additional vertical wells each producing 0.7 cfs would be required to meet the current groundwater supply shortfall. This may not be achievable, given access and space limitations for developing new vertical wells, and points to the importance of successful development of the groundwater collector system. Under these assumptions, and assuming sufficient vertical wells could be sited and constructed, total cost to recover 7.8 cfs of groundwater supply capacity would be about $2.7 million.

A generalized, recommended timeline for implementing the above groundwater source improvements, including permitting, design, and construction is provided below. Table 2 summarizes key elements of this timeline, with similar timelines for the effluent pump back and water reuse options.

Spring 2016

- Reconvene the IWG Groundwater Technical Committee to get stakeholder concurrence on the recommended approaches for improving groundwater supply;
- Initiate National Environmental Policy Act (NEPA) and Joint Aquatic Resource Permit Application (JARPA) permitting and consultation; and
- Submit water right change applications to Chelan County Water Conservancy Board (Conservancy Board) to permit changes to the water rights, as recommended in the *Leavenworth National Fish Hatchery Water Rights Permitting Strategy* memorandum (Aspect, 2016).

Summer 2016

- Topographic survey of Hatchery Island to support design;
- 30 percent groundwater collector design; and
- Site selection for additional wells at north end of Hatchery Island and/or on private property north of the LNFH facility.

Fall 2016

- 60 percent groundwater collector design; and

- Drill test well at north end of Hatchery Island or on private property north of the LNFH facility and complete aquifer testing to assess yield and required well spacing to minimize drawdown interference.

Winter 2016/2017

- Complete water right change permitting through the Conservancy Board;
- 90 percent design of groundwater collector; and
- Size and design conveyance from planned new wells to the hatchery. Depending on where new wells are sited, conveyance may be shared with the groundwater collector.

Spring 2017

- Final design and specifications for groundwater collector;
- Prepare bid documents, solicit bids, and award contract for groundwater collector construction;
- Submit applications for construction-related permits (e.g., Construction General Stormwater Permit); and
- Complete NEPA and JARPA processes.

Summer/Fall 2017

- Construction of groundwater collector system and conveyance to hatchery; and
- Assess yields and performance of groundwater collector and reevaluate number of and required yields from new wells to meet any remaining shortfall in capacity.

Winter 2017/2018

- Prepare bid documents, solicit bids, and award contracts for drilling and testing new well(s) and constructing conveyance to tie-into the LNFH distribution system.

Spring/Summer 2018

- Complete construction of additional wells and conveyance, equip with pumps, and bring online.

Recommended Groundwater Recharge Improvements

Severely reduced diversions since 2006 from Icicle Creek to Hatchery Channel have reduced groundwater recharge to the adjacent aquifer tapped by the LNFH wells, resulting in lower groundwater elevations and reduced well yield compared to historical operations of the Hatchery Channel. One option under consideration for keeping Hatchery Channel hydrated and improving groundwater levels and well yields is to divert treated hatchery effluent to Hatchery Channel rather than to Icicle Creek.

Benefits of this pump back option have not been quantified, but results of a pilot study completed in 2015 indicate that the pump back is a promising option for improving and maintaining groundwater elevations and associated well yields compared to the current operation of Hatchery Channel. For the pilot study, the head of Hatchery Channel was blocked with a rubber bladder dam and approximately 20 cfs of effluent was pumped into the channel. This pumping rate resulted in water in the hatchery overflowing through the spillway dam. Results indicate that water levels in the hatchery production wells rose by about 3 feet in response to channel hydration. Although field monitoring data indicated groundwater temperatures may have increased during the pump back study, the recharged groundwater was pathogen-free.

Based on the pilot study results, we recommend that the pump back option continue to be developed, with the goal of recharging the aquifer tapped by the LNFH wells and supporting higher groundwater levels and well yields. Additional evaluation and study is required to quantify potential benefits to groundwater supply, assess potential impacts to groundwater quality and fate of recharged water, and complete design.

Estimated costs for assessing the 2015 pilot study results and planning a second pilot study are about $40,000. Detailed costs for implementing a second pilot study are not available; however, the 2015 pilot study cost about $200,000, and costs for a second study with additional monitoring and analysis are expected to be on the order of $200,000 to $300,000. Preliminary estimated costs for construction of the pump back option are about $720,000 for construction of a 28.5 cfs system, with annual operating costs of about $25,000. These costs may be conservative, given that during the 2015 pump back pilot study a flow rate of 20 cfs was more than sufficient to hydrate the channel. Required system capacity and estimated costs will be refined through further evaluation of the 2015 pump back pilot study and implementation of additional pilot study and design.

A generalized timeline for implementing the above groundwater recharge improvements, including permitting, design, and construction is provided below. Table 2 summarizes key elements of this timeline, with similar timelines for the effluent pump back and water reuse options.

Spring 2016

- Evaluate results of 2015 pilot study and assess the potential for impacts to water quality and benefits to well yields;
- Reconvene the IWG Groundwater Technical Committee to get stakeholder concurrence on the pump back concept; and
- Develop plan for additional pilot study of the pump back option to support design and permitting.

Summer/Fall 2016

- Secure regulatory approvals and complete additional pilot study; and
- Complete geotechnical investigation of proposed pump station and pipeline alignment.

Winter 2016/2017

- Quantify benefits of pump back to groundwater supply (including planned groundwater collector), and account for effects in determining number of additional vertical wells needed for groundwater source improvements;
- Revise estimated construction and operation costs; and
- Complete pump back pump station and pipeline design.

Spring 2017

- Prepare bid documents, solicit bids, and award contracts for construction of pump back system.

Summer/Fall 2017

- Construct pump back system and bring online.

Recommended Water Reuse Improvements

A concept under study is to expand an existing system to recirculate hatchery water prior to discharge into Icicle Creek, with the primary goal of reducing surface water diversions by the 20 cfs target specified in the 2015 BiOp (NMFS, 2015). McMillen Jacobs Associates, Inc. (McMillen) is completing an alternatives analysis for improvements at LNFH, including the water reuse option; however, this report is not currently final. We understand that there is additional detail in the alternatives analysis that will be available for inclusion in the Action Plan, once the alternatives analysis is finalized.

A portion of the surface water right for the hatchery equal to any realized reduction in Icicle Creek diversions would be placed into the State Trust Water Right Program (TWRP). Water in the TWRP is managed by Ecology for instream flow purposes and is considered to be beneficially used and thus protected from relinquishment. Additional details on water right permitting are provided in the *Leavenworth National Fish Hatchery Water Rights Permitting Strategy* memorandum (Aspect, 2016).

LNFH's surface water diversion on Icicle Creek is shared with COIC. Studies are ongoing to develop improvements to fish screens at the intake structure and also to potentially relocate the COIC diversion downstream to the Wenatchee River. Further assessment and development of water reuse should be coordinated with the COIC improvement projects to ensure the intake structure is sized appropriately.

A relative cost and schedule for this option have not been developed, but will be updated once the McMillen alternatives analysis is finalized. We recommend that this option continue to be developed and implemented. We do not expect that the targeted 20 cfs reduction in Icicle Creek diversions can be accomplished by increasing groundwater supplies, and that some form of reuse will be required.

Project Background

This section provides background information on the IWG, charged with finding collaborative solutions for water management within the Icicle Creek Watershed, followed by our understanding of LNFH's objectives for water supply improvements. Recommendations in this Action Plan were developed to meet both the IWG guiding principle and LNFH's water supply objectives.

Icicle Working Group Guiding Principles

The IWG was co-convened as by Chelan County Department of Natural Resources and Ecology's Office of Columbia River as a coalition of local water users, federal, state, and local government biologists, and other interested parties.

The IWG stakeholder coalition works together to improve efficiency of water use and instream flows in Icicle Creek. It has adopted Guiding Principles intended to guide the identification of water management solutions that lead to implementation of high-priority water resource projects within the Icicle Creek drainage. The nine Guiding Principles include:

1. Streamflow that:
    a. Provides passage
    b. Provides healthy habitat
    c. Serves channel formation function
    d. Meets aesthetic and water quality objectives
    e. Is resilient to climate change
2. Sustainable hatchery that:
    a. Provides healthy fish in adequate numbers
    b. Is resource efficient
    c. Significantly reduces phosphorus loading
    d. Has appropriately screened diversion(s)
    e. Does not impede fish passage
3. Tribal Treaty and federally-protected fishing/harvest rights are met at all times
4. Provide additional water to meet municipal and domestic demand
5. Improved agricultural reliability that:
    a. Is operational
    b. Is flexible
    c. Decreases risk of drought impacts
    d. Is economically sustainable

6. Improves ecosystem health including protection and enhancement of aquatic and terrestrial habitat
7. Comply with state and federal law
8. Protect Non-Treaty Harvest
9. Compliance with wilderness acts and management plans

The IWG, working to develop an integrated water management plan for Icicle Creek, established a collective instream flow management goal of 100 cfs in Icicle Creek calculated as monthly average flow. The collective instream flow goal of 100 cfs includes the LNFH and all water users in Icicle Creek.

LNFH Water Supply Objectives

As a stakeholder in the IWG, LNFH seeks to align its objectives with the guiding principles of the IWG wherever feasible. In developing this memorandum, Aspect made the following assumptions based on our understanding of LNFH operations and needs:

- Protect water rights and restore full use of permitted water;
- Provide cleaner (filtration) and colder water than currently available;
- Consolidate groundwater rights to increase operational flexibility; and
- Focus primarily on developing groundwater sources in light of desire for cleaner, colder water.

Groundwater is an important water source supporting LNFH operations because it is generally pathogen-free and is cooler in summer and warmer in winter than surface water. It is the preferred source for incubation, early rearing, and adult holding aspects of hatchery operations. From a hatchery operations standpoint, the hatchery would use the full 6,700 gpm (14.9 cfs) quantity authorized in its groundwater right portfolio if well source capacity could produce it. The importance of groundwater as a pathogen-free hatchery water source was highlighted in 2015 when disease from surface water resulted in the euthanasia of 160,000 juveniles and movement of 250,000 more to avoid their loss.

Despite a clear need to use groundwater as much as possible, production records indicate the LNFH groundwater sources can only produce about 6 to 8 cfs, which falls short of desired groundwater supply in spring months and provides only about half the quantity authorized by the water right (Aspect, 2016a).

Recent reductions in groundwater capacity are primarily due to operational changes at the hatchery. Recharge to production wells diminished substantially beginning in about 2006 when changes were made to the operation of Structure 2, the diversion controlling flow to the artificial Hatchery Channel. With more flow now diverted to the historical Icicle Creek channel, the Hatchery Channel is dewatered for all but up to 75 days each year, severely reducing the amount of water recharging

the shallow aquifer adjacent to the channel tapped by the LNFH wells. Groundwater levels and well yields have declined in response to the change in operations.

Summary of Relevant LNFH Water Supply Evaluations

Below are summaries of recent evaluations of potential projects to improve water supplies and reduce demands at the LNFH.

Groundwater Conditions at the Leavenworth National Fish Hatchery (Reclamation, 2010)

This memo summarized results of revisions to groundwater flow modeling at LNFH that was originally developed in the mid-1990s. Reclamation updated a MODFLOW numerical groundwater flow model using results from a two-week test period in October 2009 when water was diverted to hydrate Hatchery Channel and promote groundwater recharge. Model results indicated that hydration of Hatchery Channel is of critical importance to recharge the aquifer and maintain pumping rates from the LNFH wells.

Groundwater Conditions at the Leavenworth National Fish Hatchery, 2014 Model Update (Reclamation, 2014)

Reclamation used an expanded data set to update groundwater flow modeling from the 2010 modeling effort. The 2014 study reevaluated the previous groundwater model using a larger data set. The 2014 study showed that, in addition to surface water flow through the Hatchery Channel contributing to recharge, recharge from the historic channel is equally important.

Leavenworth National Fish Hatchery Water Source Assessment (Aspect, 2014)

This memorandum presented an assessment of groundwater supplies at LNFH based on data provided by the USFWS and a June 2014 site visit. The memo summarized groundwater sources (including condition of infrastructure and capacities), identified known existing water system constraints, and provided recommendations. Pumps in active wells appeared to be in reasonable operating condition but the wells appeared to be experiencing declining efficiency over time, contributing to reduced pumping capacity. Recommendations included a geophysical survey to identify potential targets for groundwater supply development, additional investigation of well PW-10 (a well that was drilled in 1995 and never tested), and water right permitting changes to create a well field[1]. It was recommended that the geophysical survey focus on Hatchery Island and a County-owned property northwest of the LNFH facility.

Leavenworth National Fish Hatchery Pump Back – Preliminary Assessment (Anchor QEA, 2014)

This report presented a preliminary assessment of rerouting the discharge of hatchery effluent from Icicle Creek to Hatchery Channel in order to keep the channel hydrated and recharge groundwater. The report provided background on how the pump back project would fit into the IWG Guiding Principles and presented details for a potential project concept. The report also discussed

[1] In other words, to add all existing groundwater wells as points of withdrawal to all existing groundwater rights.

considerations for project development and operations, and preliminary estimates for capital, operations, and maintenance costs.

Effluent Pump Back Pilot Study (USFWS, 2015)

In the fall of 2015, the USFWS worked with the US Army Corps of Engineers and Ecology to perform a pilot study to evaluate the feasibility of an effluent pump back system. A temporary rubber bladder dam was installed to enclose a portion of the north end of the Hatchery Channel. Two pumps powered by generators were used to convey 20 cfs into the Hatchery Channel to hydrate much of the length of the channel with water impounded behind the bladder dam. Water levels in nearby supply wells increased by about 3 feet and groundwater from wells appeared to be free of pathogens. Field monitoring data indicated groundwater temperatures may have increased during the pump back study due to the presence of effluent entering the shallow groundwater regime.

LNFH Geophysical Survey Results and Recommendations (Aspect, 2015a)

This memorandum provides results of a geophysical survey completed in late 2014 to identify potential areas for groundwater development. Survey lines were completed in three areas:

- Hatchery Island;
- A County-owned parcel north of the LNFH; and
- An area south of LNFH between wells PW-1 and PW-2.

The survey indicated that coarse-grained deposits extend beneath Hatchery Island to a depth of approximately 60 feet, overlying finer-grained deposits. On the County-owned parcel, the survey indicated approximately 30 feet of relatively fine-grained deposits overlying moderately coarse-grained materials, although the reliability of results at this location were limited by difficult access and metallic surface features at the parcel. Survey results indicate subsurface conditions near wells PW-1 and PW-2 were similar to those beneath Hatchery Island. Based on these results, a horizontal groundwater collector system (as opposed to a vertical well) constructed in shallow coarse grained deposits underlying Hatchery Island was selected as the most promising target for groundwater development.

It is anticipated that the use of vertical wells on Hatchery Island or near wells PW-1 and PW-2 would require deeper completion into the finer-grained materials, similar to the depth of well PW-9. Well yields would be expected to be similar to existing wells, on the order of 300 to 500 gpm.

Recommendations from this report included completing a field investigation to confirm shallow soil conditions, assessing the feasibility of a groundwater collector on Hatchery Island, and assessing the yield and condition of well PW-10. Other recommendations included consulting the IWG Groundwater Technical Committee to obtain stakeholder concurrence and developing this Action Plan for implementing new water supply improvements.

Leavenworth National Fish Hatchery Groundwater Supply Investigations (Aspect, 2015b)

This memorandum summarized analyses and results of groundwater supply investigations recommended in the *Leavenworth National Fish Hatchery Water Source Assessment* (Aspect, 2014) and the *LNFH Geophysical Survey Results and Recommendations* (Aspect, 2015a). The investigation consisted of test pit exploration and pump testing of the shallow aquifer on Hatchery Island and a downhole video inspection and hydraulic testing of existing well PW-10.

Nine test pits were excavated on Hatchery Island along potential groundwater collector alignments to confirm locations where the geophysical survey suggested shallow, coarse-grained soils conditions favorable for a groundwater collector. A short pumping test was conducted in two test pits to assess groundwater inflow. A shallow observation well fitted with a water level data logger was also constructed near this location to monitor seasonal changes to groundwater. The MODFLOW groundwater model for the hatchery area (Reclamation, 2010 and 2014) was acquired and configured to assess potential groundwater collector yields at this location. Model results for a groundwater collector constructed to a depth of about 18 feet and completed with three 200-foot-long laterals range from a low of about 2 cfs during the low surface water flow season to 5.5 cfs during peaks flows (spring freshet).

This report also included an assessment of well PW-10 to evaluate feasibility of equipping it with a pump and bringing it online. Testing and analyses included step and constant rate pump tests to predict long term production. Results indicated that well PW-10 would likely sustain only about 200 gpm; it was recommended that this well not be tied into the distribution system.

Leavenworth National Fish Hatchery Spring Chinook Salmon Program Biological Opinion (NMFS, 2015)

The NMFS BiOp evaluated impacts to ESA-listed fish species resulting from the proposed continuation of the LNFH Chinook salmon program and concluded that adverse effects are likely. The BiOp acknowledged USFWS participation in the IWG and IWG's efforts to decrease impacts to ESA-listed species through a collective instream management goal of maintaining 100 cfs in Icicle Creek. The BiOp acknowledged LNFH's planned short- and long-term actions for meeting water supply and instream flow obligations including increasing groundwater capacity, a potential effluent pump back project, and internal water reuse. The BiOp viewed as favorable, the LNFH planned action to help meet the collective 100 cfs goal including an internal water reuse project that could reduce surface water diversions by 20 cfs or more.

Water Right Permitting Strategy Memorandum (Aspect, 2016)

This memorandum outlines a recommended approach to permit new groundwater sources and provides strategies to protect existing groundwater rights from relinquishment for nonuse. Groundwater source pumping records were evaluated for 2011 and 2012. Estimates for beneficial use during these years confirm a production shortfall of about 3,500 gpm (7.8 cfs) and 5,100 afy. This shortfall in water use could be subject to relinquishment; however, it is likely that the unavailability of water exemption to relinquishment in RCW 90.14.140(a) applies. Applicability of this exemption is predicated on the unavailability of water being outside of the water right holder's reasonable control and demonstrating reasonable diligence in improving supplies. Both of these criteria appear to be met. Additional water right permitting recommendations included adding all

existing or planned groundwater wells and the groundwater collector as points of withdrawal to all existing groundwater rights to increase flexibility in well field operations and changing the place of use for three groundwater rights to cover the entire hatchery facility.

Potential Water Supply Improvement Projects

Three types of potential projects are being evaluated to meet water supply demands and reduce surface water diversions at the hatchery, including developing additional groundwater source capacity, constructing an effluent pump back system to hydrate Hatchery Channel and recharge the aquifer tapped by LNFH's wells, and increased internal reuse of water to reduce surface water diversions. As discussed above under LNFH's Water Supply Objectives, the preference to meet demands is to increase groundwater supply capacity. Developing new groundwater sources to address the 7.8 cfs groundwater capacity shortfall will likely need to include a combination of constructing a groundwater collector and one or more new vertical wells.

In addition to developing new groundwater sources expanding the internal water reuse system and using hatchery effluent to hydrate Hatchery Channel and recharge groundwater are under consideration and development.

Additional details on the three water supply improvement options, including data gaps, feasibility, and permitting considerations, are summarized below.

New Groundwater Sources

Groundwater Collector

A groundwater collector completed in shallow coarse-grained gravels at Hatchery Island is anticipated to yield significant quantities of water compared to one or more vertical wells. This is the highest priority among potential projects for new groundwater sources.

Initial investigation and evaluation of a groundwater collector on Hatchery Island has been completed, but still requires engineering design. A conceptual design includes three 200-foot long collector laterals leading to a central sump equipped with a pump from which water would be withdrawn for hatchery use. A pipeline would be required to convey water from the sump to the hatchery, with a preliminary alignment assuming the pipeline would be installed in an excavation beneath Hatchery Channel. Electrical supply for the pump and controls would be extended from the hatchery facility.

The sump and laterals would be installed to the maximum depth practicable (approximately 20 feet) during late summer when water elevations are expected to be lowest. This will maximize groundwater yield from the collector and help ensure that the laterals remain fully submerged throughout the year.

Groundwater Well(s)

Groundwater supply shortfalls not addressed by a groundwater collector would need to be addressed through constructing one or more new vertical. Vertical wells at the hatchery sustain yields of about 300 to 600 gpm. Higher yields from the existing wells are limited by the small available drawdown in the wells (i.e., the water column above the pump inlet), drawdown interference between pumping wells, and changes in operations of Hatchery Channel.

The key to constructing a new vertical well is selecting a location where aquifer conditions will permit a yield adequate to meet LNFH demands. A new well would need to be located sufficient distance from existing wells so as not to cause well interference. In consideration of these factors, opportunities to locate a new well are limited, either due to potential drawdown interference from existing wells or unfavorable aquifer conditions.

The geophysical survey (Aspect, 2015a) examined hydrogeologic conditions in three areas as potential locations for new wells: a County-owned parcel northwest of well PW-5, the area south of LNFH between wells PW-1 and PW-2, and on Hatchery Island.

The geophysical survey north of PW-5 indicated about 100 feet of fine-grained media overlying bedrock with a possible thin, coarse-grained layer immediately on top of the bedrock. Of the three areas investigated, geologic conditions at this location represent the least-favorable area for a new well.

The area near wells PW-1 and PW-2 hosts several existing LNFH production wells. Well logs for wells PW-2 and PW-7 located in this area describe alternating layers of clay and cobbles above bedrock. These wells yield 300 to 600 gpm and a new well is expected to yield similar quantities (Aspect, 2015a). However, increased production in this area from operation of a new well would likely reduce production from other active wells due to increased drawdown interference during pumping. Therefore, installation of a new well near existing wells PW-1 and PW-2 is not recommended.

The area beneath Hatchery Island is the most suitable location for a new well, with coarse-grained deposits extending to a depth of approximately 60 feet, Finer-grained deposits were identified from depths of about 60 feet to the top of bedrock at a depth of about 180 to 200 feet. In order to have sufficient available drawdown to support pumping, a vertical well on Hatchery Island or near PW-2 and PW-7 west of Hatchery Channel, would require a completion interval extending through the coarser, shallow deposits and into the finer-grained materials, similar to well PW-9 located on Hatchery Island. Well PW-9 is screened between 80 and 200 feet below ground surface and was tested at a rate of 400 gpm before collapsing. Yields at a Hatchery Island well are expected to be of a similar magnitude, and for this Action Plan are conservatively assumed to be on the order of 300 gpm. Because there are no other active supply wells on Hatchery Island, Aspect expects there is a lower likelihood of well interference should more than one well be drilled there.

Data Gaps

The Groundwater Supply Investigations memo (Aspect, 2015b) addressed much of what is required to design, permit and construct a groundwater collector, including test pit soil exploration, test pit pumping tests, and groundwater modeling. Remaining data gaps for the siting and design of the groundwater collector and new, vertical wells are described below.

Groundwater Collector

- Topographic survey: a topographic survey of Hatchery Island will be required to support design of the groundwater collector and conveyance pipeline.

New Wells

Additional study required to site and construct new wells include:

- Property Access: determine if potential well locations will be limited to LNFH property (i.e., north part of Hatchery Island), or if other, off-property locations could be accessed.
- Well Interference: complete analysis of interference between existing and proposed new wells, including proposed groundwater collector.
- Complete Well Siting: determine final location for a potential new well including locations for utilities.
- Construct Test Well: asses yield, refine well interference analysis, and finalize well spacing and target depths based on test well.

Feasibility

Groundwater Collector

The subsurface investigation, hydraulic testing, water quality analyses, and groundwater modeling documented in the Groundwater Supply Investigations memo (Aspect, 2015b) determined that a groundwater collector constructed on Hatchery Island is a feasible option for significantly increasing groundwater supply.

New Well

The feasibility of new wells at the north end of Hatchery Island is supported by results of the geophysical survey, indicating the presence of moderately coarse-grained aquifer materials at depth. Similar results are not available for the private parcel north of the hatchery facility. A test well is needed to confirm aquifer conditions wherever a new well is sited; the test well would be converted to a production well and equipped with a permanent pump after testing. Hydraulic testing will provide analytical information needed to size a production pump, design and site additional production wells, and size and design conveyance to the hatchery.

Permitting

All groundwater improvement projects will require water rights permitting action to authorize new points of withdrawal. A detailed water rights permitting strategy is presented in the *Leavenworth National Fish Hatchery Water Rights Permitting Strategy* memorandum (Aspect, 2016). This memo recommended submitting changes to all four LNFH groundwater rights to add all existing and planned groundwater points of withdrawal (wells and the groundwater collector) to each of the rights. This permitting approach would authorize new groundwater sources, including a collector, while improving operational flexibility of the water rights and sources.

Construction of a groundwater collector is anticipated to require JARPA permitting, NEPA review, a Construction Stormwater General Permit, and potentially Chelan County Grading Permit.

Permitting processes for JAPRA and NEPA generally begin with a consultation between the project proponent and issuing lead agency to outline requirements based on conceptual planning. Permit applications should be submitted with preliminary designs (60 percent design).

Aquifer Recharge – Development of Effluent Pump Back

With more flow now diverted to the historical Icicle Creek channel at Structure #2, the Hatchery Channel is dewatered for all but 75 days each year and well yields have correspondingly declined significantly. An effluent pump back project would increase groundwater recharge to the aquifer tapped by existing and new supply wells by rehydrating the Hatchery Channel.

The effluent pump back project was identified by LNFH managers and studied by Anchor QEA (Anchor, 2014 and USFWS, 2015). This project would change the location where effluent that is not used for hatchery cleaning (known as run-through water) discharges into Icicle Creek from downstream of the Hatchery Channel spillway to the Hatchery Channel. The water pumped into the Hatchery Channel would keep a portion of the channel hydrated to increase recharge to the shallow aquifer, which is the source for most of the hatchery's groundwater supply wells.

The concept evaluated by Anchor QEA (2014) involved full flow (56 cfs) and half flow (28 cfs) pump back alternatives. The full flow alternative matches the total instantaneous quantity of the hatchery's water right even though run-through water is typically less than the total water supplied to the hatchery. We have assumed the half flow alternative would be preferable.

The pump back concept involves diverting the existing run-through drain to a reinforced concrete vault measuring approximately 18 by 18 by 14 feet deep. Turbine pumps in the vault would lift and discharge effluent to a common, buried, 36-inch diameter pipeline. The use of pumps is required because the Hatchery Channel sits at a higher elevation than the existing gravity-flow outfall to Icicle Creek. The buried pipeline would extend approximately 300 feet from the pump station to the discharge point along the west bank of the Hatchery Channel near the upstream end of the ramp that leads to the Hatchery Channel spillway. The outlet would require construction of energy dissipation structures and the pump station would require power extension.

Aquifer Recharge Data Gaps

The pump back pilot study indicated that water levels in LNFH wells increased by about 3 feet due to recharge from the pump back (USFWS, 2015). Additional study is required to estimate the impact increased water levels will have on existing well capacity. The pump back pilot study also indicated water in wells monitored during the pump back was pathogen-free and increased in temperature from 48 F to 55 F (USFWS, 2015). Additional study, including a second round of pilot studies, is required to characterize the impact of pathogens and temperature on groundwater quality and its effects on hatchery operations during extended operation of the pump back.

Other studies recommended by Anchor QEA (2014) to support design and development of an aquifer recharge system include:

- Detailed hydraulic analysis of the proposed project to verify size and configuration of the pump station, discharge pipeline, and delivery to the Hatchery Channel;
- Geotechnical exploration to verify soils to support design of the pump station vault and pipeline facilities;

- An evaluation to determine whether the use of chillers would be required for egg incubators due to increased water temperature, as observed during the pilot test; and

- A more thorough evaluation of the magnitude, timing, and duration of flows in the run-through effluent pipeline and flows required to sustain the hatchery process is needed to verify design flow rates.

Aquifer Recharge Feasibility

The 2015 pilot study indicated that implementing pump back would be beneficial to groundwater levels (and in turn well yields) in the aquifer adjacent to Hatchery Channel. However, additional information is needed to assess the feasibility of this option, as outlined above in the data gaps section. It is recommended that a more detailed assessment of design constraints, flow rates, operations, hydraulic conditions, geotechnical, existing utilities, cultural resources, power supply requirements, and environmental impacts and permitting requirements be completed to determine the feasibility and challenges for design and implementation. Of particular importance for operation of this concept is design of the permanent dam system to accommodate rapid changes in natural Icicle Creek flows and to maximize benefits of the system.

Aquifer Recharge Permitting

The LNFH National Pollution Discharge Elimination System (NPDES) permit would need to be modified to authorize discharge of hatchery effluent in a manner that is different than existing conditions. LNFH is conducting long term water quality testing at the outfall to demonstrate that effluent meets water quality standards to be approved for infiltration. In October 2011, LNFH submitted an updated NPDES permit application to EPA and a new Clean Water Act 401 certification permit application to Ecology to address changes to hatchery operations. The application included an additional discharge location (Outfall #6, located at ~RM 3.3) in the Hatchery Channel to be used as a discharge point for the effluent pump back system. A final decision on this permit application is still pending. JARPA permitting and NEPA review are also anticipated to be required.

Recirculating Hatchery Water

A concept under study is to expand an existing system to recirculate hatchery water prior to discharge into Icicle Creek, with the goal of maximizing use of existing water sources and reducing surface water diversions. McMillen Jacobs Associates, Inc. (McMillen) is completing an alternatives analysis for improvements at LNFH, including the water reuse option. We understand that there is additional detail in the alternatives analysis that will be available for inclusion in the Action Plan, once the alternatives analysis is finalized.

According to the 2015 BiOp, the long-term effects of a successful reuse system are likely to be beneficial for ESA-listed fish as it would reduce surface water withdrawals up to 20 cfs and allow LNFH to help meet the 100 cfs instream flow goal nearly all months of the year. Unused portions of the surface water right would be placed into trust, preserving the unused portion from relinquishment, retaining flexibility for future uses of the right, and providing additional instream flow in Icicle Creek past the hatchery. Additional preliminary potential benefits include reduced introduction of pathogens from the surface water source, although the potential for other biological risks from increased water reuse are being considered.

LNFH and COIC share a surface water diversion on Icicle Creek. Studies are ongoing to develop improvements to fish screens at the intake structure and also to assess relocating the entire COIC diversion downstream to the Wenatchee River. Further assessment and development of water reuse should be coordinated with the COIC improvement projects to ensure the resulting intake structure is sized appropriately for expected diversions.

A relative cost and schedule for this option have not been developed, but will be updated once the McMillen alternatives analysis is finalized.

References

Anchor QEA, 2014, Leavenworth National Fish Hatchery Pump Back – Preliminary Assessment. Memorandum to Dave Irving and Steve Croci, USFWS, November 19.

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Aspect Consulting LLC, 2016, Leavenworth National Fish Hatchery Water Rights Permitting Strategy. Memorandum to Steve Croci, LNFH, February 24.

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U.S. Bureau of Reclamation (Reclamation), 2010, Groundwater Conditions at the Leavenworth National Fish Hatchery, Chelan County, Washington, February.

U.S. Bureau of Reclamation (Reclamation), 2014, Groundwater Conditions at the Leavenworth National Fish Hatchery, 2014 Model Update. Chelan County, Washington, March.

U.S. Fish and Wildlife Service (USFWS), 2015, Effluent Pumpback Leavenworth NFH, Undated PowerPoint presentation.

Limitations

Work for this project was performed for the Leavenworth National Fish Hatchery (Client), and this memorandum was prepared in accordance with generally accepted professional practices for the nature and conditions of work completed in the same or similar localities, at the time the work was performed. This memorandum does not represent a legal opinion. No other warranty, expressed or implied, is made.

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Attachment

Table 2. Summary of Recommended Water Supply Improvement Project Timelines

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Table 2 - Summary of Recommended Water Supply Improvement Project Timelines

Project No. 150200, Water Supply Action Plan, Leavenworth National Fish Hatchery, Chelan County, WA

Timeframe	Groundwater Supply Improvements			Pump Back/ Aquifer Recharge	Water Reuse
	Groundwater Collector	Activate Well PW-10	New Wells		
Spring 2016	Reconvene the IWG Groundwater Technical Committee to get stakeholder concurrence on water supply projects				
	Initiate JARPA, NEPA, and water right permitting.			Assess 2015 pilot study, develop plan for additional pump back pilot study.	Remaining schedule for development and implementation of expanded water reuse is to be determined. Project development should be coordinated with potential relocation and fish screen improvements to shared LNFH-Cascade Orchards Irrigation Company diversion to ensure proper sizing of diversion and conveyance.
Summer 2016	Topographic survey of Hatchery Island, complete 30 percent design.	Size pump and design appurtenances to bring well PW-10 online. Complete bidding and contracting.	Site selection for additional wells at north end of Hatchery Island and/or private property north of LNFH facility.	Secure regulatory approvals and complete additional pilot study.	
Fall 2016	60 percent groundwater collector design.	Complete construction to bring well PW-10 online and put into operation.	Drill test well and complete aquifer testing to assess yield and required well spacing.	Complete geotechnical investigation of proposed pump station and pipeline alignment.	
Winter 2016/2017	Complete water right change permitting through the Conservancy Board.			Quantify benefits of pump back to groundwater supply.	
	90 percent design of groundwater collector.	Project Complete.	Size and design conveyance from planned new wells to the hatchery.	Update estimated costs and complete design.	
Spring 2017	Complete JARPA and NEPA processes				
	Final design and specifications for groundwater collector. Prepare bid documents, solicit bids, and contracting.			Prepare bid documents, solicit bids, and contracting for pump back system.	
	Submit applications for construction-related permits.			Submit applications for construction-related permits.	

Table 2 - Summary of Recommended Water Supply Improvement Project Timelines

Project No. 150200, Water Supply Action Plan, Leavenworth National Fish Hatchery, Chelan County, WA

Timeframe	Groundwater Supply Improvements			Pump Back/ Aquifer Recharge	Water Reuse
	Groundwater Collector	Activate Well PW-10	New Wells		
Summer and Fall 2017	Construction of groundwater collector system and conveyance to hatchery. Assess yields and performance of groundwater collector. Project Complete.		Finalize number of and required yields from new wells to meet any remaining shortfall in capacity	Construct pump back system and bring online. Project Complete.	Remaining schedule for development and implementation of expanded water reuse is to be determined.
Winter 2017/2018			Prepare bid documents, solicit bids, and award contracts for drilling and testing new well(s) and constructing conveyance to tie-into the LNFH distribution system.		
Spring and Summer 2018			Complete construction of additional wells and conveyance, equip with pumps, and bring online.		