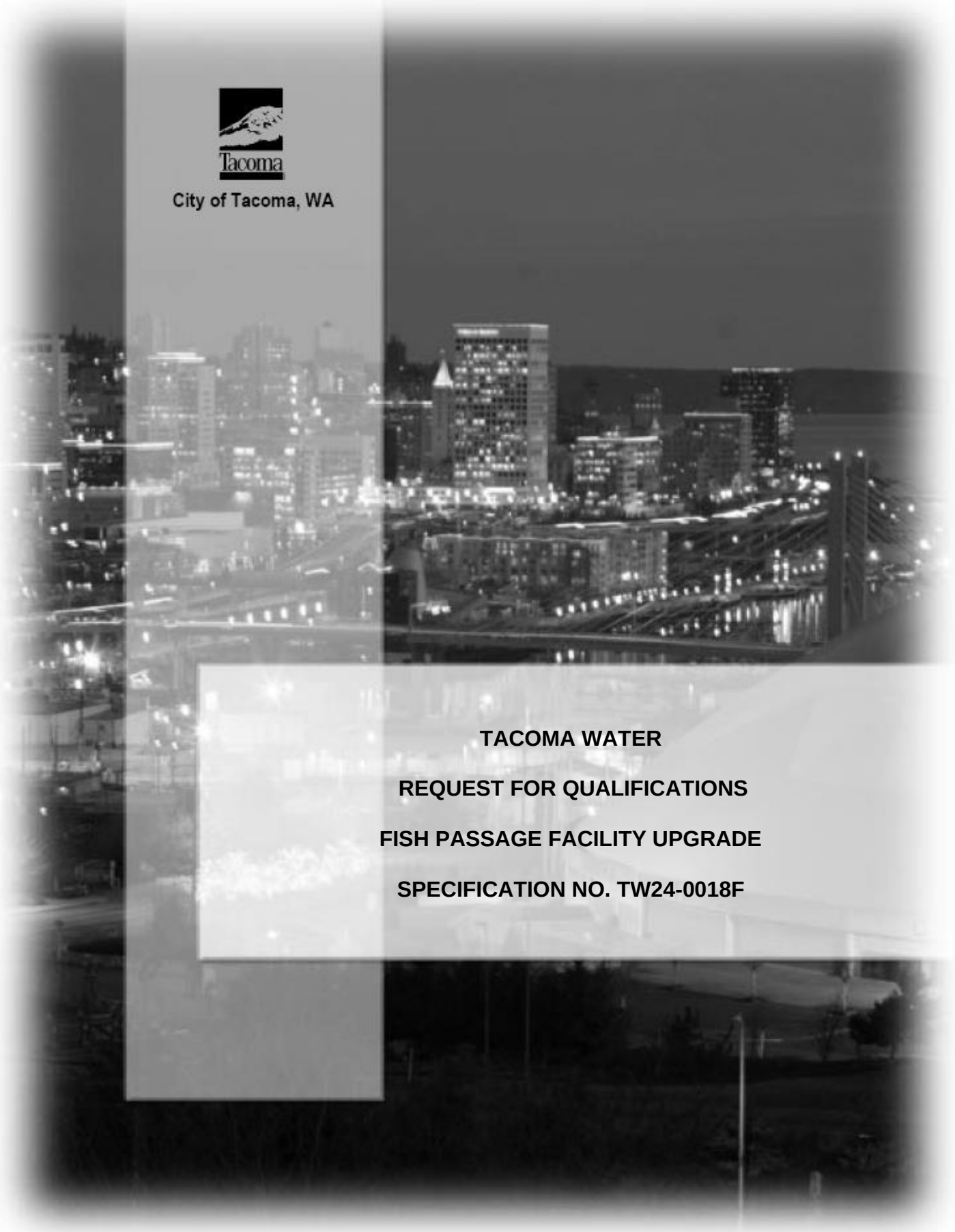

City of Tacoma, WA

TACOMA WATER

REQUEST FOR QUALIFICATIONS

FISH PASSAGE FACILITY UPGRADE

SPECIFICATION NO. TW24-0018F

City of Tacoma
Tacoma Water

REQUEST FOR QUALIFICATIONS TW24-0018F
Fish Passage Facility Upgrade

Submittal Deadline: 11:00 a.m., Pacific Time, Tuesday, March 19, 2024

Submittals must be received by the City's Procurement and Payables Division prior to 11:00 a.m. Pacific Time.

For electronic submittals, the City of Tacoma will designate the time of receipt recorded by our email, sendbid@cityoftacoma.org, as the official time of receipt. This clock will be used as the official time of receipt of all parts of electronic bid submittals. For in person submittals, the City of Tacoma will designate the time of receipt recorded by the timestamp located at the lobby security desk, as the official time of receipt. Late submittals will be returned unopened and rejected as non-responsive.

Submittal Delivery: Sealed submittals will be received as follows:

By Email:
sendbid@cityoftacoma.org
Maximum file size: 35 MB. Multiple emails may be sent for each submittal

Bid Opening: Submittals must be received by the City's Procurement and Payables Division prior to 11:00 a.m. Pacific Time. Sealed submittals in response to a RFB will be opened Tuesday's at 11:15 a.m. by a purchasing representative and read aloud during a public bid opening held at the Tacoma Public Utilities Administrative Building North, 3628 S. 35th Street, Tacoma, WA 98409, conference room M-1, located on the main floor. They will also be held virtually Tuesday's at 11:15 a.m. Attend via this link or call 1 (253) 215 8782. Submittals in response to an RFP, RFQ or RFI will be recorded as received. As soon as possible, after 1:00 PM, on the day of submittal deadline, preliminary results will be posted to www.TacomaPurchasing.org.

Solicitation Documents: An electronic copy of the complete solicitation documents may be viewed and obtained by accessing the City of Tacoma Purchasing website at www.TacomaPurchasing.org.

- Register for the Bid Holders List to receive notices of addenda, questions and answers and related updates.
- Click here to see a list of vendors registered for this solicitation.

Pre-Proposal Meeting: A pre-proposal meeting will not be held.

Project Scope: Tacoma Water intends to award a contract for a fish passage engineering consultant to support and prepare the fish passage facility for full-scale operation. Objectives of the project are prioritized to (1) improve worker safety, (2) reduce fish injury and mortality, and (3) increase the facility's efficiency with the expectation of a fully-functional fish passage facility.

Estimate: $625,000.00 (For budgetary purposes only)

Paid Sick Leave: The City of Tacoma requires all employers to provide paid sick leave in accordance with State of Washington law.

Americans with Disabilities Act (ADA Information: The City of Tacoma, in accordance with Section 504 of the Rehabilitation Act (Section 504) and the Americans with Disabilities Act (ADA), commits to nondiscrimination on the basis of disability, in all of its programs and activities. Specification materials can be made available in an alternate format by emailing the contact listed below in the *Additional Information* section.

Title VI Information:
"The City of Tacoma" in accordance with provisions of Title VI of the Civil Rights Act of 1964, (78 Stat. 252, 42 U.S.C. sections 2000d to 2000d-4) and the Regulations, hereby notifies all bidders that it will affirmatively ensure that in any contract entered into pursuant to this advertisement, disadvantaged business enterprises will be afforded full and fair opportunity to submit bids in response to this invitation and will not be discriminated against on the grounds of race, color, national origin in consideration of award.

Additional Information: Requests for information regarding the specifications may be obtained by contacting Brandon Snow, Senior Buyer, by email bsnow@cityoftacoma.org.

Protest Policy: City of Tacoma protest policy, located at www.tacomapurchasing.org, specifies procedures for protests submitted prior to and after submittal deadline.

Meeting sites are accessible to persons with disabilities. Reasonable accommodations for persons with disabilities can be arranged with 48 hours advance notice by calling 253-502-8468.

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SUBMITTAL CHECK LIST

This checklist identifies items to be included with your submittal. Any submittal received without these required items may be deemed non-responsive and not be considered for award.

Submittals must be received by the City of Tacoma Purchasing Division by the date and time specified in the Request for Qualifications page.

The following items make up your complete electronic submittal package (include all the items below):	
Signature Page (Appendix B)	
Statement of Qualifications (Section 10)	
After award, the following documents will be executed:	
City of Tacoma Contract (Appendix C)	
Certificate of Insurance and related endorsements (Appendix D)	

1. BACKGROUND

The Tacoma Water fish passage facility (FPF) is an integrated component of Tacoma's Headworks Diversion Dam and water intake, located on the Green River in King County, Washington. These facilities are the City of Tacoma's primary source of water, serving more than 300,000 people throughout Pierce and southern King Counties. Upstream and downstream fish passage is a requirement of Tacoma Water's Endangered Species Act Incidental Take Permits and Additional Water Storage Project with the U.S. Army Corps of Engineers[1]. The FPF at the Headworks Diversion Dam was constructed in 2006. The FPF was designed to capture adult salmon at Tacoma Water's dam, transport them upstream above the U.S. Army Corps of Engineer's Howard Hanson Dam (HHD), and allow their offspring safe passage downstream (Figure 1).

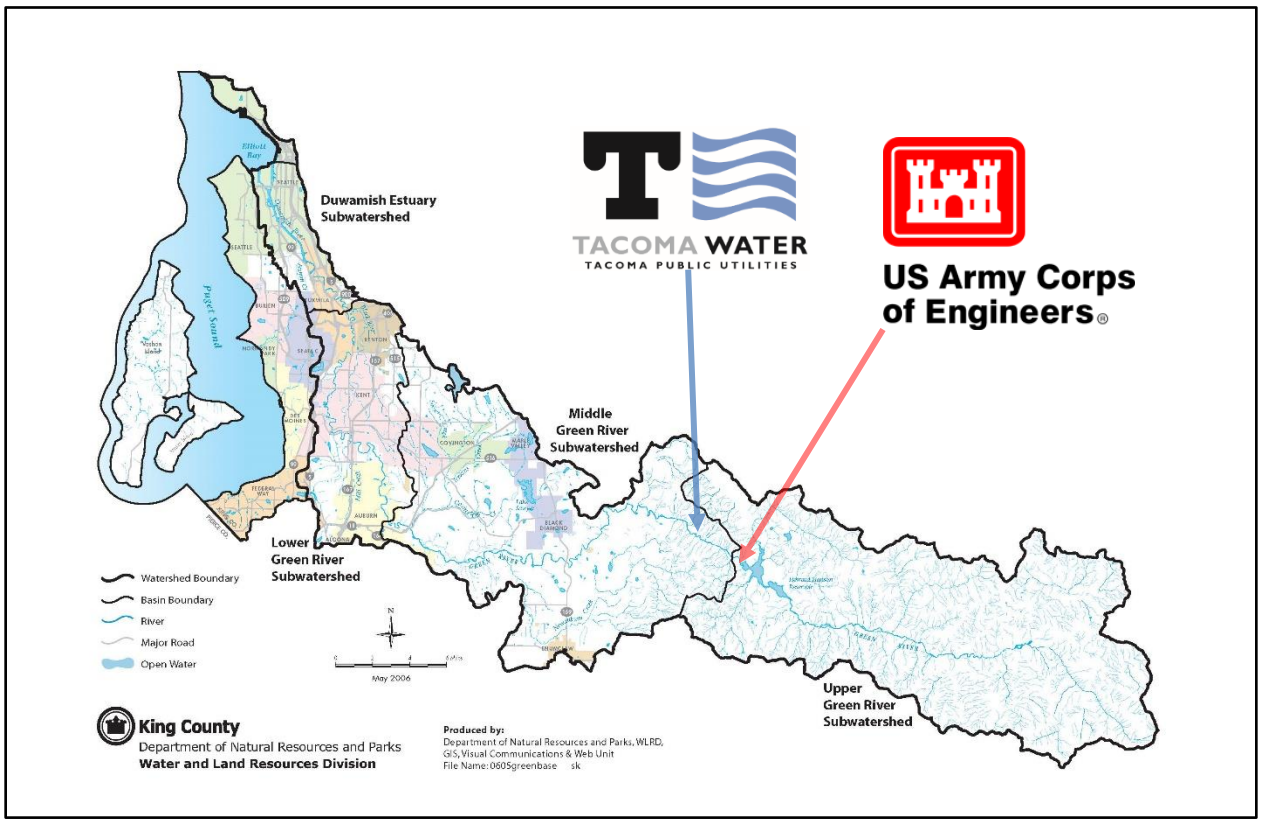

Figure 1. The Green River watershed, located in King County, WA and the location of the two dams owned and operated by Tacoma Water or the U.S. Army Corps of Engineers. Tacoma Water provides upstream fish passage above both dams. Downstream fish passage will be provided at both.

[1] Additional Water Storage Project Draft Feasibility Report & EIS (USACE, 1998)

The FPF became operational in 2007, and since that time, it has become apparent that upgrades are required prior to full-scale operation.

Moreover, some components and maintenance requirements were never installed or initiated, limiting the FPF's operational capacity and longevity. However, in 2011, downstream fish passage construction at HHD was suspended, likewise postponing Tacoma Water's fish passage requirements.

Between 2007 and 2019 the upstream portion of the FPF, known as the trap and haul or trap and sort facility, was used in a limited capacity for ecological benefits and training purposes or to supplement hatchery genetics with wild broodstock. While these operations demonstrate the facility's functionality, they were limited compared to what full-scale, year-round operations will be. Then in 2020, safety concerns and failures of critical components rendered the facility inoperable.

Based on the 2019 Biological Opinion (BiOp) on HHD[2], full-scale operations are expected to occur the fall before completion of the downstream fish passage system at HHD (February 2031). This may occur, in a limited capacity, sooner if reintroduction is required for evaluation or as part of interim measures. While the FPF is currently not operated, once fish reintroduction occurs, operating the facility and transporting fish will occur on a nearly year-round basis.

To learn more about the City of Tacoma, visit www.cityoftacoma.org. To learn more about Tacoma Water, visit www.mytpu.org.

2. PROJECT OBJECTIVES

Tacoma Water intends to award a contract for fish passage engineering consultant support to prepare the FPF for full-scale operation as envisioned in Tacoma Water's Habitat Conservation Plan[3]. Objectives of the project are prioritized to (1) improve worker safety, (2) reduce fish injury and mortality, and (3) increase the facility's efficiency with the overall goal to have a vetted and fully functional fish passage facility coinciding with HHD downstream fish passage. This will be achieved by hiring a consultant to assess the existing facility and suggest a suite of improvements and alternatives for Tacoma and stakeholders to consider and approve for design.

3. SUMMARY OF SCOPE OF SERVICES AND DELIVERABLES

Tacoma Water intends to select a consultant based on qualifications and abilities of the firm and key project individuals.

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[2] HHD Operations and Maintenance Biological Opinion (NMFS, 2019)
[3] Tacoma Water Habitat Conservation Plan (TPU, 2001)

The contract will be limited to the pre-design phase but may be amended, as described below. The selected consultant will perform the following primary services:

1) Support Tacoma Water staff during initial stakeholder engagement meeting(s) for consultations and decision prompts regarding fish passage obligations
2) Contract with Tacoma Water's systems integrator (S&B Inc.) and assist Tacoma Water in making the existing facility operational for a facility and operations assessment
3) Develop facility assessment plan to identify safety issues, identify fish health/injury concerns, determine operational capacity, evaluate operations, and describe how the facility is not meeting latest standards
4) Present assessment plan to stakeholders for feedback and permissions
5) Observe Tacoma Water staff operate the FPF and take any measurements necessary to meet the assessment plan's objectives
6) Write facility assessment report including recommendations to meet project's objectives
7) Develop conceptual/preliminary designs and cost estimates
8) Write combined facility assessment and recommended alternatives report including conceptual design drawings, estimated cost of each alternative, and comparison analyses of alternatives
9) Support Tacoma Water staff during stakeholder consultation meeting(s)

Consultant deliverables include proposal presentations, meeting minutes, recommendation reports, facility assessment plan, facility assessment report, conceptual design drawings, cost estimates, alternatives analyses, and recommended alternatives.

These services are budgeted at approximately $625,000.00. However, the final scope, deliverables, budget, and schedule will be negotiated with the selected consultant.

Additional services include facility integration with intake/diversion and SCADA system, engineering designs, construction permitting, construction support services, and operations and maintenance manual development. Construction is anticipated to start December 2026 but will be procured using a traditional design-bid-build approach. These additional services will be in an amended or separate contract and occur concurrently with downstream passage construction at HHD.

Additional details including a project charter, facility information, and past studies/reports are provided in Appendix A.

4. ANTICIPATED CONTRACT TERM

The contract is anticipated to have a three-year duration to carry the project to the design and permitting phase, with the intent to execute an amendment. The amendment will extend the contract for the additional services cited above prior to bidding for construction.

5. CALENDAR OF EVENTS

The following schedule has been established for the submission and evaluation of the Statement of Qualifications (SOQs) and selection of the consultant. These are tentative dates only and the City reserves the right to adjust these dates at its sole discretion.

Contract may be issued after Public Utility Board and/or City Council approval.

The anticipated schedule of events concerning this Solicitation is as follows:

Publish and issue Solicitation:	**2/20/2024**
Pre-Submittal Questions:	**2/28/2024**
Response to Questions:	**3/5/2024**
Submittal Due Date:	**3/19/2024**
Submittal Evaluated, on or about:	**4/3/2024**
Interviews/presentations, on or about:	**4/10/2024**
Award Recommendation, on or about:	**4/15/2024**
Public Utility Board/City Council Approval, on or about:	**May 2024**

6. INQUIRIES

6.1 Questions should be submitted to Brandon Snow, via email to bsnow@cityoftacoma.org. Subject line to read:

TW24-0018F – Fish Passage Facility Upgrade – *VENDOR NAME*

6.2 Questions are due by 3 pm on the date included in the Calendar of Events section.

6.3 Questions marked confidential will not be answered or included.

6.4 The City reserves the discretion to group similar questions to provide a single answer or not to respond when the requested information is confidential.

6.5 The answers are not typically considered an addendum.

6.6 The City will not be responsible for unsuccessful submittal of questions.

6.7 Written answers to questions will be posted alongside the specifications at www.tacomapurchasing.org

7. DISCLAIMER

The City is not liable for any costs incurred by the Respondent for the preparation of materials, or a submittal submitted in response to this Solicitation, for conducting any presentations to the City, or any other activities related to responding to this Solicitation or related to the contract negotiation process.

8. EVALUATION CRITERIA

A Selection Advisory Committee (SAC) consisting of City staff and other stakeholders, as appropriate, shall independently evaluate the SOQs. The relative weight of each scoring criteria is indicated in the table below.

Criteria	Max Score
Firm Qualifications & Team Technical Knowledge (Section 10.1)	30
Project Approach & Understanding (Section 10.2)	25
Experience in Related Projects (Section 10.3)	35
Client References (Section 10.4)	5
Equity in Contracting (Section 10.5)	5
Total	**100**

After the evaluation, the SAC may conduct interviews of the most qualified Respondents before final selection.

8.1 The SAC may select one or more Respondents to provide the services required.

8.2 The SAC may use references to clarify information in the submittals and/or interviews, if conducted, which may affect the final scoring. The City reserves the right to contact references other than those included in the submittal.

8.3 Part 1 of the evaluation process shall consist of the evaluation of the written SOQ package submitted by each Proposer and as a result, a short list of Proposers may be invited to interview with the SAC.

8.4 Part 2 of the evaluation process will evaluate the interviews, if conducted, to produce a final rating. The City reserves the right to select a consultant directly from the SOQs (Part 1 evaluation) without conducting an interview.

9. SOQ SUBMITTAL AND GENERAL GUIDELINES

The SOQ should be submitted in PDF format. The City recommends that the Proposer's SOQ submittals be limited to 16 double-sided pages or 32 pages total (not including City of Tacoma required forms, front and back covers, and appendices specifically referenced).

10. CONTENT TO BE SUBMITTED

A full and complete response to each of the "CONTENT TO BE SUBMITTED" items is expected in a single location; do not cross reference to another section in your submittal.

Information that is confidential must be clearly marked and provide an index identifying the affected page number(s) and locations(s) of such identified materials. See Section 1 of the Standard Terms and Conditions – Solicitation 1.06 for Public Disclosure: Proprietary or Confidential Information.

Respondents are to provide complete and detailed responses to all items below. Submittals that are incomplete or conditioned in any way that contain alternatives or items not called for in this RFQ, or not in conformity with law, may be rejected as being non-responsive. The City will not accept any submittal containing a substantial deviation from the requirements outlined in this RFQ.

Submittals should present information in a straightforward and concise manner, while ensuring complete and detailed descriptions of the respondent's/team's abilities to meet the requirement of this RFQ. Emphasis will be on completeness of content.

The City reserves the right to request clarification of any aspect of a firm's submittal or request additional information that might be required to properly evaluate the submittal. A firm's failure to respond to such a request may result in rejection of the firm's submittal. Firms are required to provide responses to any request clarification within three business days.

Requests for clarification or additional information shall be made at the sole discretion of the City. The City's retention of this right shall no way diminish a Proposer's responsibility to submit a submittal that is current, clear, complete, and accurate.

10.1 Firm Qualifications & Team Technical Knowledge – 30 points

Please describe the consulting team to be assigned to this project, including names with titles, technical qualifications, and general project responsibilities. Include the following:

- Project manager background and experience relevant to this project
- Key team members expected to make contributions to this project
- Provide an org chart for the team including all subconsultants
- Identify which office(s) the project will be delivered from and its location
- Provide a statement that conveys the firm's commitment to actively perform the proposed work (additional services included) and the ability of all project personnel for completing the project in view of the firm's current and projected workload
- Individual résumés for all team members as an appendix

10.2 Project Approach & Understanding – 25 points

Please summarize the firm's understanding of the project, including primary and additional services that will need to be completed to meet Tacoma Water's objectives and fish passage requirements. Describe the following:

- Respondent's understanding of the key issues to be addressed in this project and potential approaches to address them including any proposed activities, methodologies, tools, or tasks the Respondent would like Tacoma to be aware of
- Availability of the firm and sufficient resources to perform all the services
- Availability of the project manager and key team members

10.3 Experience in Related Projects – 35 points

Please provide five examples of related projects the firm has successfully completed. At least three of the examples should involve anadromous salmonid passage facility assessments, development of recommended alternatives, and/or stakeholder engagement. At least two of the examples should involve facility designs, permitting, and/or construction support services. For each example, include the following:

- General description
- Name and contact information of the client
- Project location
- Start and completion dates
- Services provided
- Any key similarities to Tacoma Water's Fish Passage Facility Upgrade project
- Involvement of the individuals proposed for this project team and their roles on the example project

10.4 Client References – 5 points

References shall be used to verify the accuracy of the information provided by the Respondent in project experience, which may affect the rating of the Respondent. The City reserves the right to contact references other than those submitted by the Proposer.

10.5 Equity in Contracting – 5 points

Proposed teams with certified Washington State Office of Minority & Women's Business Enterprises will receive five points, these include the following categories:

☐ Disadvantaged Business Enterprise (DBE)

☐ Minority Business Enterprise (MBE)

☐ Minority/Women Business Enterprise (MWBE)

☐ Small Business Enterprise (SBE)

☐ Women Business Enterprise (WBE)

11. INTERVIEWS / ORAL PRESENTATIONS

An invitation to interview may be extended to Respondents based on SAC review of the written submittals. The SAC reserves the right to adjust scoring based on additional information and/or clarifications provided during interviews. The SAC may determine additional scoring criteria for the interviews following evaluation of written submittals.

The City reserves all rights to begin contract negotiations without conducting interviews.

Respondents must be available to interview within five business days' notice.

If interviews are conducted, the SAC will schedule the interviews using the email address for communications provided on the signature page. Additional interview information will be provided at the time of invitation.

At this time, it is anticipated that the main objective of the interview will be for the SAC to meet the project manager and key personnel that will have direct involvement with the project and hear about their relevant experience and expertise. The City does not intend to meet with firm officials unless they are to be directly involved with the project.

12. RESPONSIVENESS

12.1 Respondents agree their submittal is valid until a contract(s) has been executed.

12.2 All submittals will be reviewed by the City to determine compliance with the requirements and instructions specified in this Solicitation. The Respondent is specifically notified that failure to comply with any part of this Solicitation may result in rejection of the submittal as non-responsive. The City reserves the right, in its sole discretion, to waive irregularities deemed immaterial.

12.3 The final selection, if any, will be that submittal which, after review of submissions and potential interviews, in the sole judgement of the City, best meets the requirements set forth in this Solicitation.

13. CONTRACT OBLIGATION

The selected Respondent(s) will be expected to execute a Contract with the City. At a minimum, any contract will incorporate the contents of this specification, including all stated services or deliverables and other requirements and the City of Tacoma Standard Terms and Conditions, together with the contents of Respondent's submittal. The submittal contents of the successful Respondent will become contractual obligations.

14. FORM OF CONTRACT

In event the City's Services Contract or other City Contract template is attached to this RFQ as a sample form of Contract, the City expects to utilize the Terms and Conditions contained in the sample form of Contract. Post award negotiation may occur at the discretion of the City.

Respondents should clearly state exceptions to City's Standard Terms and Conditions as well as to the Terms and Conditions contained in any attached sample form of Contract and to any other portions of this RFQ, including the stated Insurance Requirements. Respondents may also propose to utilize their own form of Contract and in such instances.

Respondent must provide its form of Contract as part of its submittal. City, at its sole option, will decide whether to engage in negation on any or all proposed exceptions. City reserves sole discretion to determine the final form of Contract that will be used.

15. STANDARD TERMS AND CONDITIONS

City of Tacoma Standard Terms and Conditions apply.

16. INSURANCE REQUIREMENTS

Successful Respondent will provide proof of and maintain the insurance coverage in the amounts and in the manner specified in the City of Tacoma Insurance Requirements contained in this solicitation – Appendix D.

17. PARTNERSHIPS

The City will allow Respondents to partner in order to respond to this Solicitation.

Respondents may team under a Prime Respondent's submittal in order to provide responses to all sections in a single submission; however, each Respondent's participation must be clearly delineated by section. The Prime Respondent will be considered the responding vendor and the responsible party at contract award. Any contract negotiations will be conducted only with the Prime Respondent. All contract payments will be made only to the Prime Respondent.

Any agreements between the Prime Respondent and other companies will not be a part of the agreement between the City and the Prime Respondent. The City reserves the right to select more than one Prime Respondent.

18. COMMITMENT OF FIRM KEY PERSONNEL

The Respondent agrees that key personnel identified in its submittal or during contract negotiations as committed to this project will, in fact, be the key personnel to perform during the life of this contract. Should key personnel become unavailable for any reason, the selected Respondent shall provide suitable replacement personnel, subject to the approval of the City. Substantial organizational or personnel changes within the agency are expected to be communicated immediately. Failure to do so could result in cancellation of the Contract.

19. AWARD

Awardee shall be required to comply with 2 CFR Part 25 and obtain a unique entity identifier and/or be registered in the System for Award Management as appropriate.

After the Respondent(s) is selected by the SAC and prior to award, all other Respondents will be notified via email by the Purchasing Division.

Once a finalist (or finalists) has been selected by the SAC, contract negotiations with that finalist will begin, and if a contract is successfully negotiated, it will, if required, be submitted for final approval by the Public Utility Board and/or City Council.

20. SCOPE, BUDGET, AND SCHEDULE

The selected Proposer will meet with the City to review the project scope and timeline. Based on the meeting, the selected Proposer shall submit a draft scope, budget, and project schedule to the City within five (5) business days or as directed by the City's Project Manager.

The scope and budget shall include an itemized list of tasks and include estimated hours for the proposed work. The budget shall be supported by a list of hourly rates for personnel to be utilized under this contract.

21. ENVIRONMENTALLY PREFERABLE PROCUREMENT

In accordance with the City's Sustainable Procurement Policy and Climate Action Plan, it is the policy of the City of Tacoma to encourage the use of products or services that help to minimize the environmental and human health impacts of City Operations. Respondents are encouraged to incorporate environmentally preferable products or services that have a lesser or reduced effect on human health and the environment when compared with competing products or services that serve the same purpose. This comparison may consider raw materials acquisition, products, manufacturing, packaging, distribution reuse, operation, maintenance or disposal of the product or service.

The City of Tacoma encourages the use of sustainability practices and desires any awarded contractor(s) to assist in efforts to address such factors when feasible for the following:

- Durability, reusability, or refillable
- Pollutant releases, especially persistent bioaccumulative toxins (PBTs), low volatile organic compounds (VOCs), and air quality and stormwater impacts
- Toxicity of products used
- Greenhouse gas emissions, including transportation of products and services, and embodied carbon
- Recycled content
- Energy and water resource efficiency

22. PROPRIETARY OR CONFIDENTIAL INFORMATION

The Washington State Public Disclosure Act (RCW 42.56 et seq.) requires public agencies in Washington make public records available for inspection and copying unless they fall within the specified exemptions contained in the Act, or are otherwise privileged. Documents submitted under this RFQ shall be considered public records and, with limited exceptions, will be made available for inspection and copying by the public.

Information that is confidential or proprietary must be clearly marked. Further, an index must be provided indicating the affected page number(s) and location(s) of all such identified material. Information not included in said index will not be reviewed for confidentiality or as proprietary before release.

23. ADDENDUMS

In the event it becomes necessary to revise any part of this RFQ, an addendum will be posted alongside specifications at www.tacomapurchasing.org. Failure to acknowledge addendum(s) on the required Signature Page may result in a submittal being deemed non-responsive by the City.

APPENDIX A

Supplemental Project Information

Fish Passage Facility Upgrade Project

PROJECT SUMMARY

Problem Statement

The Tacoma Water fish passage facilities (FPF) at the Headworks Diversion Dam were constructed in 2006. The FPF was designed to capture adult salmon, transport them upstream above Howard Hanson Dam (HHD), and allow their offspring safe passage downstream. Upstream and downstream fish passage is a requirement of Tacoma's Endangered Species Act Incidental Take Permit and Additional Water Storage Project with the U.S. Army Corps of Engineers. Failure to meet these requirements would put Tacoma's water diversion and water storage at HHD in jeopardy.

The FPF became operational in 2007, and since that time, it has become apparent upgrades are required prior to full-scale operation. Moreover, some components and maintenance requirements were never installed or initiated, limiting the FPF's operational capacity and longevity. Between 2007 and 2019 the upstream portion of the FPF, known as the trap and haul or trap and sort facility, was used in a limited capacity for ecological benefits and training purposes or to supplement local hatchery genetics with wild broodstock. While these operations demonstrate the facilities functionality, they were limited compared to what full-scale, year-round operations will be. Then in 2020, safety concerns and failures of critical components rendered the facility inoperable.

Based on the 2019 Biological Opinion (BiOp) on HHD, full-scale FPF operations are expected to begin the fall before completion of the downstream fish passage system at HHD (February 2031). This may occur, in a limited capacity, sooner if reintroduction is required for evaluation or as part of interim measures. While the FPF is currently not operated, once fish reintroduction occurs, operating the facility and transporting fish will occur on a nearly year-round basis.

Project Description

The Fish Passage Facility Upgrade project would prepare the FPF for full-scale operation as envisioned in Tacoma Water's Habitat Conservation Plan. Objectives of the project are prioritized to (1) improve worker safety, (2) reduce fish injury and mortality, and (3) improve the facility's efficiency. This will be achieved by hiring a consultant to assess the facility and suggest a suite of improvements and alternatives for Tacoma and stakeholders to consider and approve for design. Actual construction will occur incrementally and concurrently with downstream passage construction at HHD. Project success will be measured by the FPF's ability to return salmon safely and efficiently to the upper Green River watershed in conformance with the latest standards[1] [2], Tacoma Water's legal requirements, and through consultation with regulators and fisheries co-managers.

SCHEDULE & BUDGET

Phases & Milestones

- **Phase I:** Project Kickoff includes project planning, solicitation, award, and stakeholder engagement
- **Phase II:** Make Existing Facility Operational for evaluation
- **Phase III:** Perform Facility Assessment to determine needs
- **Phase IV:** Consultant to Design and Permit Upgrades for FPF
- **Phase V:** Construction to occur concurrently with downstream passage at HHD
- **Phase VI:** Upgraded Facility Operational and ready for full-scale operation
- **Phase VII:** Project Closeout

[1] Anadromous Salmonid Passage Facility Design Manual
[2] Water Crossing Design Guidelines

Project Schedule

This project's schedule is based on the anticipated salmon reintroduction date and on the availability of fish for facility assessments. Pink salmon (*Oncorhynchus gorbuscha*) will be the test fish used for facility assessments, but they are only available in odd years (e.g., 2025, 2027, 2029). If HHD downstream fish passage is completed per the BiOp requirement, then our facility needs to be fully operational by September 1, 2030 (Phase VI). Thus, construction must be completed by April 2, 2029 (Phase V), allowing five months of commissioning, testing, and training before the fall salmon run of 2029. This is the final year test fish will be available before the anticipated reintroduction date and the last opportunity to guarantee an upgraded facility is ready.

After the project is initiated on January 4, 2024 (Phase I) a consultant should be onboarded as the project management plan is finalized and stakeholder engagement begins. Stakeholders who must be consulted throughout this project include the Muckleshoot Indian Tribe, Washington Department of Fish and Wildlife, National Marine Fisheries Service, WRIA 9, U.S. Army Corps of Engineers, and U.S. Fish and Wildlife Service. They will need to be prompted in this first phase to decide on the number, species, and origin of fish to be transported upstream. Then in October 2024, the existing facility can be made operational (Phase II) for the assessment scheduled during the pink salmon run of 2025. What is consider an operational facility will be based on advice gathered during a walkthrough with the consultant and project resources. This walkthrough will also allow the consultant to develop an evaluation plan to follow during the assessment.

The facility assessment will occur between September and November 2025 (Phase III) and will involve passing pink salmon through the facility and upstream of HHD, using the consultant's evaluation plan and existing operations manual. The purpose of this phase is for the consultant to evaluate the facilities' operational capacity and to identify upgrades, improvements, retrofits, or replacements to satisfy this project's objectives. Following the facility assessment, the consultant can suggest their suite of improvements for Tacoma and stakeholders to consider and approve for design (Phase IV).

	Phase	Scheduled Start	Estimated Duration (Months)	Deadline
I	Project Kickoff	January 4, 2024	9	
II	Existing Facility Operational	October 2024	11	September 2025
III	Facility Assessment	September 2025	3	
IV	Design and Permit Upgrades	December 2025	12	
V	Construction	December 2026	28	April 2, 2029
VI	Upgrade Facility Operational	April 2, 2029	17	September 1, 2030
VII	Project Closeout	September 1, 2030	NA	
	Total	Jan. 2024 – Sep. 2030	80	

PROJECT SCOPE

Targeted Outcomes	1) Conditions for workers within facility improved 2) Risk of fish injury and mortality decreased 3) Facility efficiency increased 4) Tacoma Water's fish passage facility prepared for full-scale operation 5) Regulators and fisheries co-managers approve of facility designs and operations
In-Scope	• Facility and operation evaluations • Facility/equipment upgrades, improvements, retrofits, or replacements • Facility integration with intake/diversion and SCADA • Operations and maintenance manual

	• Stakeholder consultations and decision prompts • May include downstream fish passage facility assessment and improvement • May include infrastructure, easements, and other needs related to delivering fish upstream
Out-of-Scope	• While modifications of the existing facility are anticipated, major demolition or reconstruction are beyond what is considered necessary
Risks & Constraints	-Accessory equipment (e.g., trucks, tanks, hoppers) must be compatible with Tacoma Power's fish passage facility equipment. -S&B shall be the System Integrator (sub)contractor, future contracts will make this distinction. -A great unknown is the number, species, and origin of fish to be transported upstream. This is a fish management decision beyond the responsibility of Tacoma, but the resource agencies have yet to provide that information. Those decisions will greatly affect designs for our facility. -Don't know our facilities' designed capacity. If the facility is incapable of transporting the requested volume of fish, fulfilling Tacoma's commitments are at risk. -Downstream fish passage operations expected at HHD to begin in February 2031, so the facility will need to be ready for full-scale fulltime operations in 2030, or sooner. If HHD advances or delays their expected completion date, this would affect this project greatly. -Operational and emergency procedures will need to be updated prior to full-scale operations but a consultant may need them to complete their design. -Seasonal constraints such as water availability for testing, fish windows confining in-river construction, variable weather at the Headworks, etc. -Must avoid repairing or replacing a component (Phase II) we expect to upgrade later (Phase IV), but our facility must be brought to a state of functionality for evaluation (Phase III). -Abundantly available test fish (e.g., *Oncorhynchus gorbuscha*) for upstream FPF assessments only available in 2025, 2027, and 2029.

PROJECT RESOURCES

Resources

Position/Department	Role
Tacoma Power Natural Resources	Internal fish passage consultants to advise and guide. Review proposals, designs, etc. Ensures our accessory equipment is compatible with their equipment.
Tacoma Power Fish Passage Engineer	Manufacturing oversight. Review proposals, designs, etc. Ensures our accessory equipment is compatible with their equipment.
Treatment Plant Maintenance	Facility expert to advise and guide. Review proposals, designs, etc.
Electrical & Control Systems Manager	Systems integration expert to advise and guide. Review proposals, designs, etc.
Construction Management	Manage the overall construction project to uphold the requirements of the contract and design specifications.
Procurement Coordinator	Facilitates financing and purchasing process.

Internal Stakeholders

Position/Department	Interest/Concern
Treatment Plant Supervisor	Facility or operational changes at headworks impacting treatment operations.
Water Treatment Plant Maintenance Supervisor	Facility or operational changes at headworks impacting maintenance activities.
M&C Operations Manager	Changes to headworks maintenance activities impacting labor needs.
Safety Office	Facility safety concerns being resolved prior to use.
System Planning	Changes impacting the intake system, especially hydraulic impacts.
Asset Planning	Asset and maintenance plan changes (i.e., upgrades, retrofits, and/or replacements).
Water Treatment & Quality Planning	Facility or operational changes at headworks impacting treatment or water quality.
Watershed Operations	Contractor presence at headworks, use of roads, and protection of water supply.
Financial Stewardship	RWSS budget impacts and future O&M costs for facility.

External Stakeholders

Organization	Interest/Concern
Muckleshoot Indian Tribe	- Co-manager of fisheries resources in Green River - Determine number, species, and origin of fish to be transported - Proposals and designs developed in close coordination with MIT
Washington Department of Fish & Wildlife	- Co-manager of fisheries resources in Green River - Determine number, species, and origin of fish to be transported - Proposals and designs developed in close coordination with WDFW
National Marine Fisheries Service	- Responsible for marine and anadromous species under the Endangered Species Act - Produced fish passage design criteria guidelines - Regulating authority of Tacoma Water's Incidental Take Permit
U.S. Fish & Wildlife Service	- Responsible for species within the interior of the U.S. under the Endangered Species Act - Regulating authority of Tacoma Water's Incidental Take Permit
U.S. Army Corps of Engineers	- Vested interest in the success of this facility - Extensive fish passage experience
WRIA 9	- Water Resource Inventory Area 9 (WRIA 9 – Green/Duwamish Watershed) salmon restoration forum
RWSS	- Vested interest in the success and cost of this facility

Additional Information

Other Information or Previous Work

- Maintenance Planning Project for FPF inventoried and established maintenance plans for all components of existing facility.
- Updated design Fish Transfer Hoppers available.

Link(s) to additional project information

- AWSP, Draft Feasibility Report & EIS
- AWSP Draft Feasibility Report Appendix F1 - Fish Mitigation and Restoration.pdf
    - Section 2.A.3.3 Fish Passage Facility Evaluation (pg. 42)
- Habitat Conservation Plan Vol 1.pdf
    - Habitat Conservation Measure, HCM 1-03
    - Habitat Conservation Measure, HCM 1-04
    - Habitat Conservation Measure, HCM 2-05
    - Compliance Monitoring Measure, CMM-04
    - Compliance Monitoring Measure, CMM-05
    - Compliance Monitoring Measure, CMM-06
- NMFS Biological Opinion on HDD, Operations, and Maintenance, Green River, Washington.pdf
    - Reasonable and Prudent Alternative, RPA Action Item 1
    - Appendix A, Project Development Milestones
- Anadromous Salmonid Passage Facility Design Manual
- Water Crossing Design Guidelines

Preliminary Draft

Operations and Maintenance Manual

Green River Headworks

Adult Trap and Sorting Facility

for

City of Tacoma
Department of Public Utilities
Water Division

by

FishPro
A Division of HDR Engineering, Inc.
3780 S.E. Mile Hill Drive
Port Orchard, Washington 98366

Under contract through

R.W. Beck, Inc.
1001 Fourth Avenue, Suite 2500
Seattle, WA 98154-1004

August 2004

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Chapter 1. Introduction

The Adult Trap and Sorting Facility is a segment of the Green River Headworks Project (GRHP) that diverts water from the Upper Green River as a part of the City of Tacoma's water supply. See Figures 1-1 and 1-2 for Location Map and Site Plan, respectively. The Headworks Diversion contains the following major fisheries related components that are used to provide both upstream and downstream fish passage:

- Diversion Intake
- Settling Basin and Fish Ladder Entrance
- Downstream Fish Passage Facility
- Adult Trap and Sorting Facility (ATSF)

This manual covers the operation and maintenance of the Adult Trap and Sorting Facility only.

As illustrated in the Flow Diagram, Figure 1-3, downstream migrating juvenile fish are excluded from the XX cfs diverted water flow above the dam and are routed downstream of the dam via the Juvenile Fish Bypass Flume. Upstream migrating adult fish are attracted to a fish ladder at the dam apron and are trapped at the output of the ladder. The adult fish are then sorted to holding tanks and relocated, via a truck transfer system, to off site locations.

1.1 Background

1.1.1 Description

The Adult Trap and Sorting Facility is a collection of water containment structures, pumps, pipes, electrical components, and fish handling and transfer equipments.

1.1.2 Purpose

The purpose of the Adult Trap and Sorting Facility is to receive upstream migrating adult fish from the fish ladder exit in the Fish Passage Facility and sort, hold, and transfer them from this location or return them to the river below the dam.

1.1.3 Basic Function

Figure 1-4 is a basic layout of the Adult Trap and Sorting Facility. Upstream migrating adult fish enter the fish ladder at the base of the dam, travel up the ladder, and are collected in the Fish Trap at the ladder exit. Fish in the trap are sorted and routed to Holding Tanks before transfer to trucks that deliver the fish to desired locations. At the facility manager's discretion, fish in the trap and holding tanks can be returned to the river below the dam.

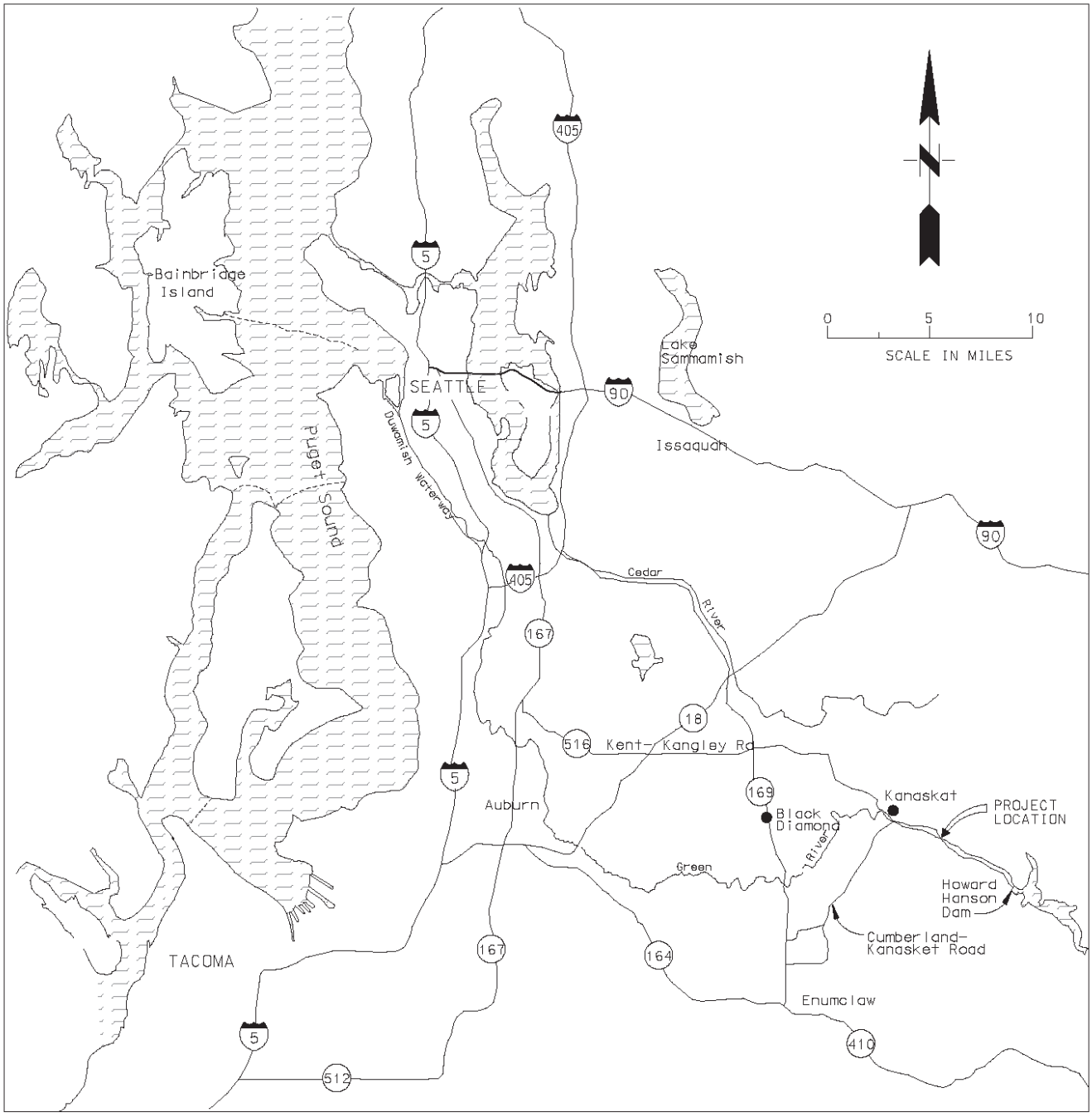

Figure 1-1. Location Map.

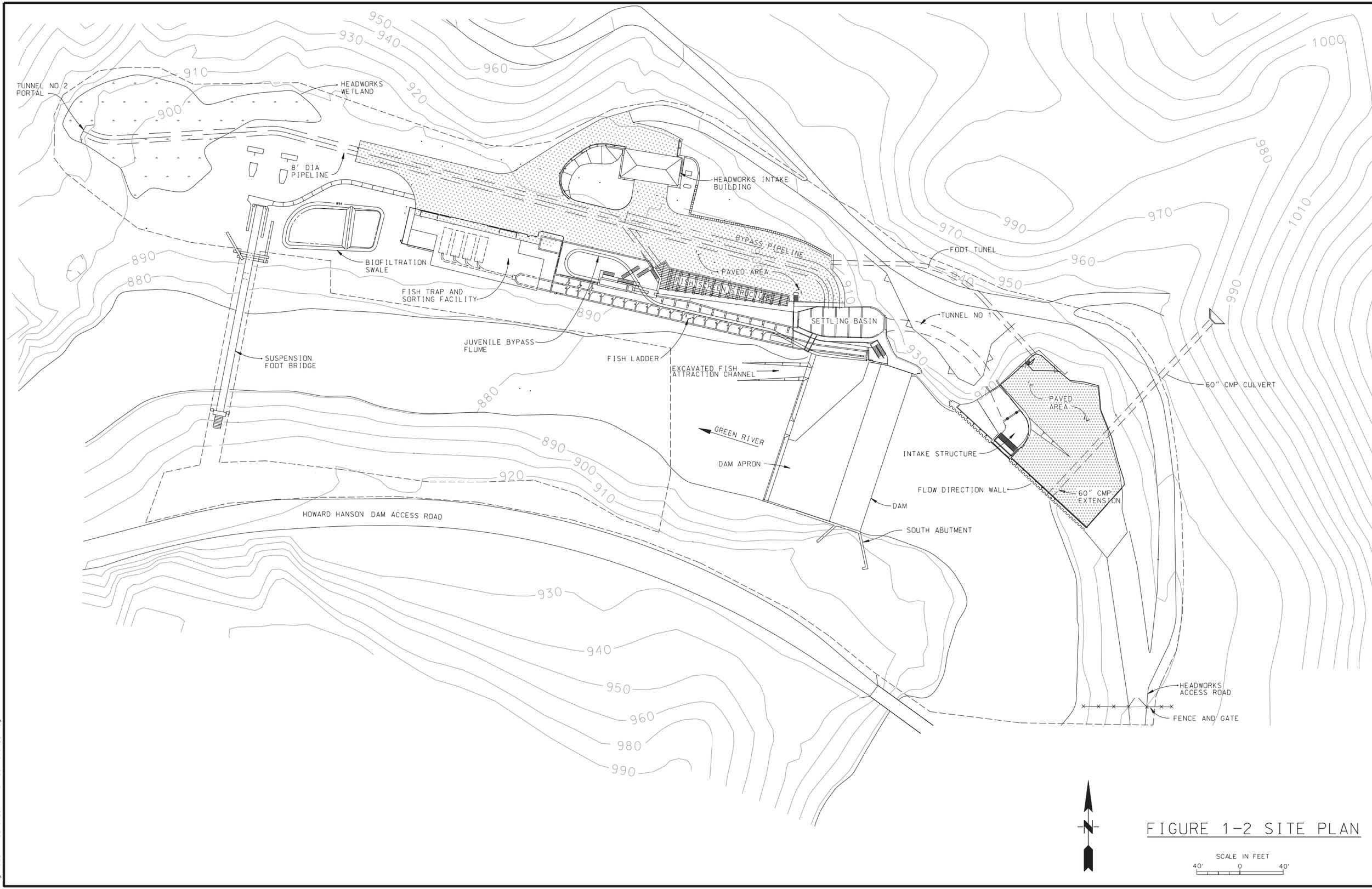

FIGURE 1-2 SITE PLAN

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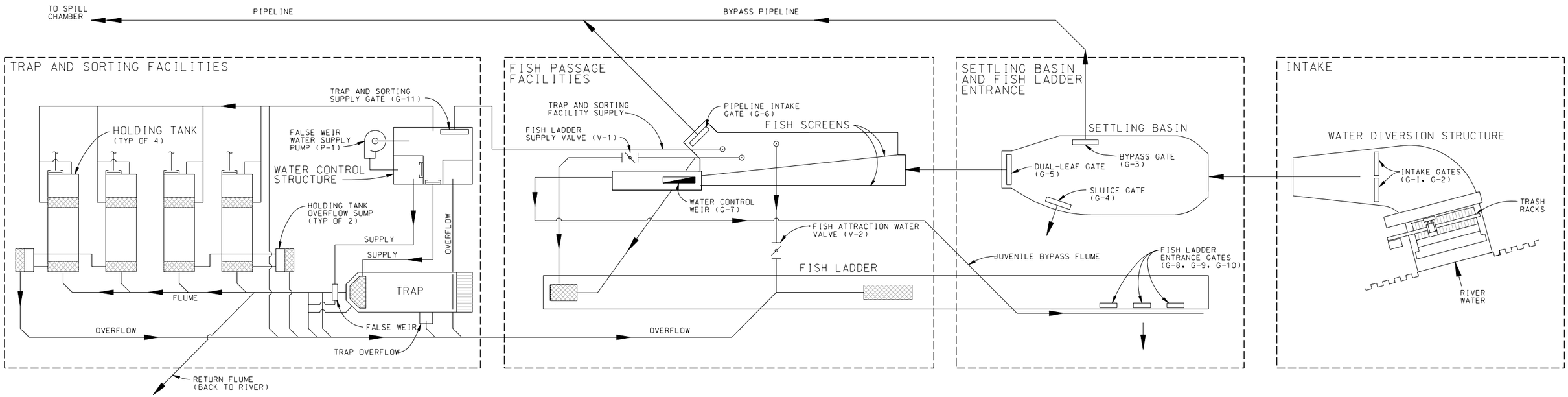

FIGURE 1-3 FLOW DIAGRAM

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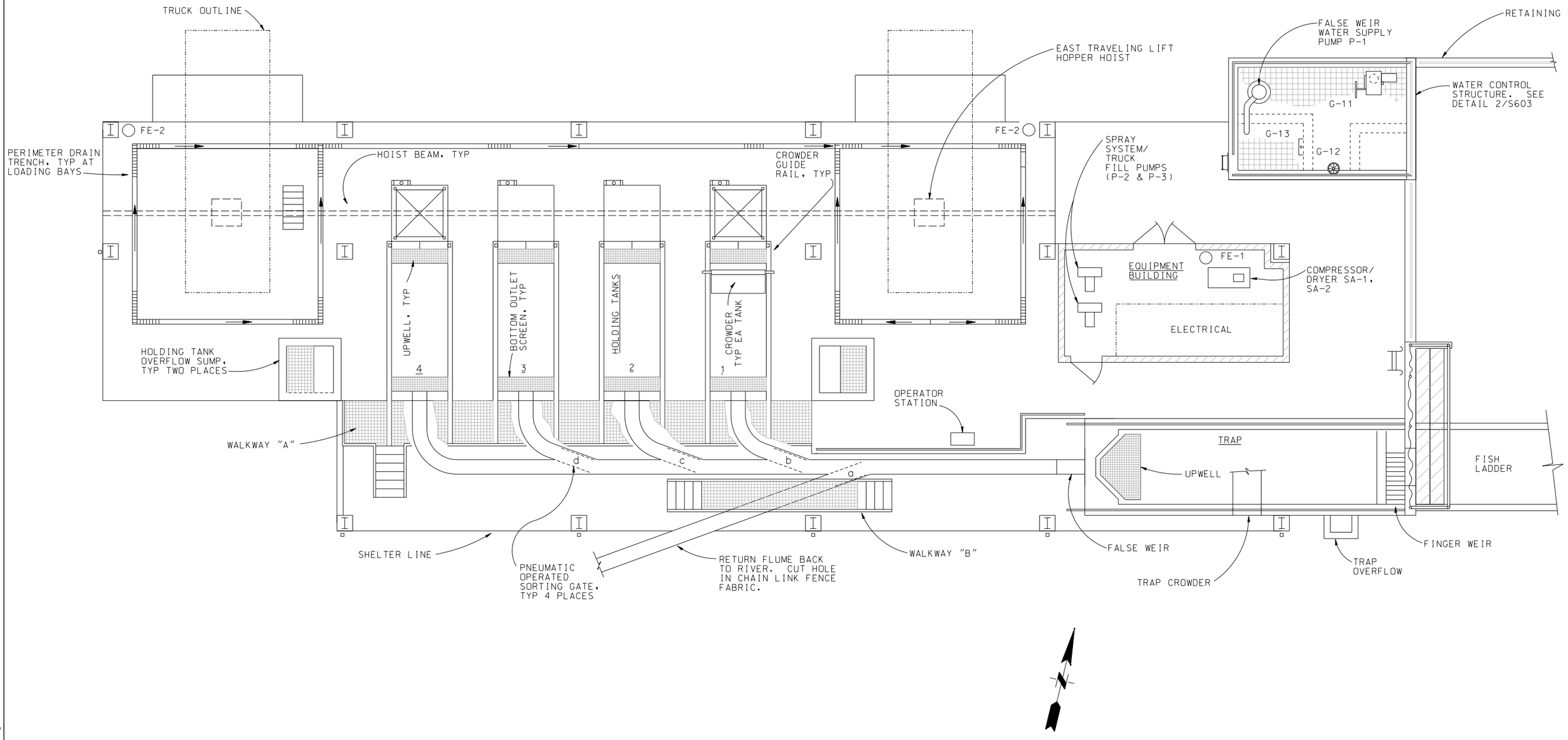

FIGURE 1-4, ADULT TRAP AND SORTING FACILITY GENERAL ARRANGEMENT

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1.2 Agency Coordination

In conjunction with the City of Tacoma Department of Public Utilities, the following agencies were involved with the planning and design of this facility:

- Tacoma Water operating division of Tacoma Public Utilities
- Muckleshoot Indian Tribe (MIT)
- Washington Department of Fish and Wildlife (WDFW)
- National Oceanographic and Atmospheric Association, Fisheries (NOAA Fisheries) (formerly known as National Marine Fisheries Service)
- United States Fish and Wildlife Service (FWS)

1.3 Permit Compliance

The following Green River Headworks Project permits (Table 1-1) were issued with regard to the Adult Trap and Sorting Facility.

Table 1-1. Green River Headworks project permits.

Permit Name	Date	Issuing/Preparing Agency
Revised Code of Washington, Chapter 35.92.010		Washington State
Ordinance No. 19185	Aug 25, 1970	Tacoma City Council
Revised Ordinance No. 20053	Feb 13, 1974	Tacoma City Council
Ordinance No. 10776	Mar 1993	King County Council
Shoreline Management Substantial Development and Conditional Use Permit		King County
Grading Permit		King County
Haul Road Agreement		King County
Hydraulic Project Approvals		Washington State Department of Fish and Wildlife
Water Quality Certification		Washington State Department of Ecology
Temporary Codification of Water Quality		Washington State Department of Ecology
Dam Safety Section Approval		Washington State Department of Ecology
Public Water Supply Approval		Washington State Department of Health
Office of Archaeology and Historic Preservation		Washington State Department of Community Development
Archaeological Excavation Permits (as required)		Washington State Department of Community Development
Section 106 Review (as required)		Washington State Department of Community Development
Section 10 Rivers and Harbors Act		U.S. Army Corps of Engineers
Section 404 Clean Water Act		U.S. Army Corps of Engineers
Sewage Disposal System Permit		Seattle-King County Department of Health
Asbestos Removal Permit		Puget Sound Air Pollution Control Agency
Pipeline No. 5 Draft EIS	Jul 73	City of Tacoma, Department of Public Utilities, Water Division
Pipeline No. 5 Final EIS	Mar 74	City of Tacoma, Department of Public Utilities, Water Division
Tacoma Water System Plan Draft EIS	Sep 80	City of Tacoma, Department of Public Utilities, Water Division

Permit Name	Date	Issuing/Preparing Agency
Tacoma Water System Plan Final EIS	Dec 80	City of Tacoma, Department of Public Utilities, Water Division
Tacoma Pipeline No. 5 Draft EIS	Aug 87	City of Tacoma and King County
Tacoma Pipeline No. 5 Final EIS	Jun 88	City of Tacoma
Tacoma Pipeline No. 5 Final Supplemental EIS	Oct 94	City of Tacoma and King County
Ordinance No. 10776, with attached Comprehensive Mitigation Plan	Mar 93	King County

1.4 Safety

This section should be carefully read before proceeding with any maintenance or operation of equipment. It is important to observe existing safety precautions, laws, codes, regulations, and insurance requirements to protect employees and visitors from possible injury while equipment, addressed in this Operations and Maintenance Manual, is being operated.

This manual presumes that all personnel are qualified to perform their duties and are adequately trained in the proper use of equipment. Precautions must be considered before performing any task. There are many inherent risks in every job. A well thought out emergency response and first aid plan must be developed.

Among many other considerations, personnel should be instructed with regard to the following:

- Compliance with all posted warning signs and the need to exercise adequate general safety precautions when working in or passing through an equipment area.

- Requirement to understand procedures that are to be performed prior to operating or initiating maintenance on any equipment. Only qualified personnel or unqualified personnel under the direct supervision of qualified personnel shall operate equipment or perform maintenance on it. Attempting to perform activities by unqualified personnel could cause serious personal injury or damage to the equipment.

CAUTION

- Prior to starting any pumps or equipment involving water or other fluid flow, ensure that the corresponding system valves or gates are in the proper open or shut position.

WARNING

- Prior to performing maintenance on any electrical equipment, ensure that the equipment is completely de-energized and tagged in the OFF position in accordance with the Tacoma Water's Tag ON/Off System.

WARNING

- Observe confined space safety procedures prior to entering any manhole, vault, sump, or tank.

- Compliance with all equipment manufacturers' published operating, maintenance, and safety procedures. These procedures are available and are located in the _____.

- Compliance with all applicable OSHA, State, County, Tribal, and other appropriate agency published safety and operating procedures, including, but not limited to:

  - First Aid requirements
  - Electrical safety requirements
  - Hazardous material handling safety requirements
  - Applicable Material Safety Data Sheets
  - Applicable Fish Handling Regulations
  - Applicable Tacoma Water Division Regulations
  - Applicable Standard Highway Transportation Regulations
  - Applicable Hazardous Material Transportation Regulations

1.5 Emergency Contacts

Appendix A is a listing of personnel, and their telephone numbers, to be contacted in the event of an emergency situation. Laminated copies of Appendix A are provided for posting in operating spaces.

1.6 Purpose and Use of this Operations & Maintenance Manual

The purpose of this Operations and Maintenance Manual is to provide an on-the-job reference for the operators involved with the Adult Trap and Sorting Facility component of the Green River Headworks. It is intended to assist facility supervisory personnel, and others, in establishing normal operating techniques in optimizing the adult sorting and transfer objective for this particular facility.

This manual focuses on the equipment and processes that are essential to normal fish handling activities.

It is assumed that all personnel working at the Green River Headworks Trap & Sorting Facility are adequately trained in the proper use of each piece of equipment and the required safety precautions. It is the responsibility of the Facility Manager to institute and maintain a comprehensive training and safety control program.

This manual is intended to provide the operator with a basic understanding of the functional operation and maintenance of those components related to fish handling. Descriptions, locations, basic operational procedures, and maintenance requirements are outlined for easy reference.

Manufacturer's manuals, construction specifications and drawings, and other reference materials are considered to be important documents that supplement this manual. These documents are maintained in the Facility Manager's or Maintenance Supervisor's complex.

This manual has been prepared to the best available knowledge of the personnel involved, based on construction documents, design information, and materials supplied by the contractor. This manual is not intended to be all-inclusive.

1.6.1 Manual Organization

The manual is divided into 5 major sections:

Section 1 - Introduction
Section 2 - Fish Health Management
Section 3 - Detailed Functional Description
Section 4 - Operating Procedures
Section 5 - Maintenance Program

Appendix A Emergency Contacts
Appendix B Valve Identification Table
Appendix C Gate Identification Table
Appendix D Listing of Manufacturer's Product Data and O&M Information

The Table of Contents, located at the front of the manual, lists all the major subsections within each section. Before the operation or maintenance of any equipment is performed, it is suggested that the operator refer to the appropriate section for a general understanding of the actual position, appearance, and function of that equipment in relation to other facility processes.

Appendix D contains a listing of documents of equipment information as provided by the contractor and manufacturers. These volumes should be reviewed prior to operating or maintaining any equipment.

NOTE

Photographs in this manual are used to identify and illustrate the location of valves and components. They are not intended to illustrate the desired valve or component setting, position, or operational configuration being discussed.

1.6.2 Manual Changes

Every page in this manual is dated to avoid confusion when changes are incorporated.

Descriptions of new equipment or changes made to existing systems must be incorporated into this manual. The month and year of the update should be printed on each page. A revised Table of Contents should be included, showing the revised dates of the latest issue.

The Operation and Maintenance Manual will be distributed as follows:

- Green River Headworks Adult Trap and Sorting Facility (2 copies)
- Tacoma Water (1 copy)
- FishPro, a division of HDR (1 copy)

Each holder of the Operations and Maintenance Manual is responsible for keeping the manual up to date. The issuance of new and/or revised sheets shall be initiated by and coordinated through Tacoma Public Utilities Water Division.

Chapter 2. Fish Health Management

The Adult Trap and Sorting Facility, if not carefully managed and operated, provides an opportunity to harm fish due to stressful conditions or injure fish through improper handling. Therefore it is imperative that the facility operation is diligently monitored and that the best fish handling procedures are employed. This chapter provides recommendations and considerations to ensure that fish passing through the facility are not harmed.

2.1 Fish Handling Requirements

As addressed in Chapter 10 of *Wedemeyer, Gary A., editor. 2001. Fish Hatchery Management, 2nd Edition. American Fisheries Society, Bethesda, Maryland,* mortality related to the transport or delivery of fish in poor condition may be the result of, among other things, one of the following:

- A severe stressor (physical or chemical agent that causes pain or discomfort)
- Multiple mild stressors
- Infectious diseases induced by the stress associated with transport techniques

It is recommended that the facility manager responsible for transferring fish be one who is familiar with the information in *Fish Hatchery Management, Chapter 10.* The most common sources of stress are handling activities such as sorting, holding, and transporting.

The transfer tank loading evolution is often the most stressful segment of the transport sequence. Therefore, the ATSF is designed to keep fish in water at all times, even during the transfer of fish between a holding tank and the truck transfer tank. The transfer hopper is designed to allow a *water-to-water* transfer from the hopper into the transfer tank. It should also be noted that the water used to fill the truck transfer tank is the same water used to supply the holding tanks and the fish trap, thus diminishing the possibility of a thermal shock during transfer tank loading.

Fish Hatchery Management, Chapter 11 addresses fish release following truck transfer. The avoidance of thermal shock at the point of release may require tempering fish to the receiving water temperature by mixing hauling and receiving site water for a period of time. A general rule is to allow one hour of acclimation in the hauling tank for every 5°F difference in temperature to acclimate the fish to the receiving water.

If ambient conditions result in prolonged elevated water temperature (greater than 65°F), extra care in holding and handling adults should be implemented. As the water temperature increases, the dissolved oxygen level decreases and the fish respiratory/metabolic rate increases rapidly, thus depleting the oxygen supply. This can result in a stressful situation or even death if not closely monitored. Measures such as reducing the number of adults held per tank, reducing the number of fish within the transfer hopper, and minimizing handling activities can increase the likelihood of a successful fish transfer.

2.2 Fish Health Maintenance

Two primary concerns in operating the ATSF are 1) the amplification of fish pathogens, and 2) the inducement of a stress response that could lead to disease manifestation in fish as a result of their presence in the facility. Therefore, an appropriate long range goal for operating the ATSF would be to minimize handling and stress-inducing operations associated with fish passing through the facility. The primary action toward meeting this goal is the proper handling of fish, as mentioned above.

2.3 Drugs and Chemicals

The use, handling, and storage of drugs and chemicals is not an ATSF design requirement. However, in the event that they are incorporated in the operation of the facility, their use should be guided by the following:

- Ensure permits are in place for the drug or chemical of interest (the facility is located within a portion of the City of Tacoma's water supply)
- Read and understand the product label
- Apply all drugs and chemicals according to label directions or at the direction of a licensed veterinarian
- Follow all required withdrawal times
- Store, handle, mix, dilute, reconstitute, and discard regulated products per their label directions

2.4 Facility Disinfection

During periods of non-operation, all water supply and drain lines, tanks, and hoppers should be drained and allowed to air dry completely. Organic material such as sticks, leaves, or soils should be removed. These materials can maintain moist environments and can be reservoirs of fish pathogens. Sunlight and drying can be a very effective disinfectant for many fish pathogens. If a chemical disinfection process is determined to be required, consultation with the appropriate authorities (Washington Department of Fish and Wildlife and Washington Department of Ecology) should be conducted.

Chapter 3. Detailed Functional Description

As stated in the introduction, the Green River Headworks Adult Trap and Sorting Facility receives upstream migrating adult fish from the top of the fish ladder located in the Fish Passage Facility. Upon direction from the ATSF manager, fish are removed from the trap by crowding them from the east to the west end of the trap toward the false weir. When the False Weir Water Supply System is actuated, fish are attracted to and cross the false weir and enter a flume system containing diverter gates used to route the fish back to the river or to one of the four holding tanks. The diverter gate controlls allow an operator to manually sort and route the fish as desired.

When an appropriate number of fish are in the holding tanks, they are removed from the tanks by crowding them into a transfer hopper. They are then loaded into fish tanker trucks and transferred to off site locations.

3.1 Component Functional Description

The Adult Trap and Sorting Facility is comprised of the following components (See Figure 3-1):

3.1.1 Water Control Structure

The Water Control Structure (See Figure 3-2) receives gravity fed water from the downstream side of the fish screens in the Fish Passage Facility and distributes the water to the Fish Trap, Holding Tanks, False Weir, Truck Fill System, Spray System, and Overflow. Table 3-1 lists the major components in the Water Control Structure and their function.

Table 3-1. Water control structure component functions.

Component	Function	Note
Gate G-11	Control the gravity fed water flow into the Water Control Structure to maintain a main sump water surface elevation at or below 903 feet.	Level sensor controlled electric motor operated modulating gate to maintain water level.
Gate G-12	Control water flow from the Water Control Structure to the Fish Trap upwell.	Manually operated. (Maximum design flow rate of 2,120 gpm.)
Gate G-13	Connect main sump with the false weir supply sump.	Manually operated. Normally open. Closed when the False Weir Pump is required to provide driving head for operating the False Weir (Main sump elevation below 901.75).
False Weir Pump	Pump water from the main sump into the false weir supply sump to produce an adequate water level to supply the false weir.	The pump motor is turned ON or OFF in the Equipment Building and is controlled by a water level sensor in the false weir supply sump to maintain a water surface elevation between 901.5 and 901.9 feet.
Valve V-13	Butterfly valve used to control discharge rate from False Weir Pump.	Manually operated.
False Weir Supply Sump	Produce an adequate water supply head for the False Weir.	Maximum design flow rate of 1,350 gpm.
Overflow Sump	Prevent main sump water surface from exceeding 902 feet.	

Screen	Prevent turbulent flow into the False Weir Pump intake.	

3.1.2 Holding Tanks

There are four holding tanks, numbered 1 through 4 from east to west. Each tank is separated into a holding area, designed to hold a minimum of 40 to 63 adult fish, and a lifting well. Table 3-2 lists the major components associated with the Holding Tanks and their function:

Table 3-2. Holding tank component functions.

Component	Function	Note
Main Water Supply Valve (4 ea) (V-5 thru V-8)	Control water supplied from the Water Control Structure to the Holding Tank up-wells.	Individual holding tanks are supplied with water via a common tank supply header from the main sump in the Water Control Structure. Maximum design flow rate is 162 gpm per tank.
Up-well	Provide even distribution of fresh water into the holding tank.	The up-well sump is covered with grating. The up-wells drain into the fish lift hopper wells.
Down-well	Provides effluent outlet.	The down-well sump is covered with grating.
Fish Lift Hopper Well	Receive and hold a Fish Lift Hopper.	Well is located at the north end of each Holding Tank.
Hopper Well Separation Screen	Separate the holding area from the hopper well and prevent fish from entering the hopper well when the lift hopper is not in the well.	If a hopper is not in the hopper well, either the isolation screen or the crowder leaf must be in place to prevent fish from entering the hopper well.
Tank Water Level Control Sump (2 ea) (One per two tanks.)	Manually control the water level in the holding tanks. East and west sumps control tanks 1 & 2 and 3 & 4, respectively.	Level is controlled by the height of stoplogs in the sumps.
Tank Crowder	Crowd fish from the south end of a holding tank into the lift hopper located in the hopper well at the north end of the tank.	Crowder leaf is raised and lowered by a local pendant controlled electric chain hoist. Crowder is manually moved along the length of the tank. The crowder is normally positioned, with the leaf lowered, between the holding area and the hopper well unless the lift hopper or isolation screen is in place.
Fish Lift Hopper (2 ea)	Remove fish from a holding tank and move them to a fish transfer truck.	Hopper is raised and lowered by an electric chain hoist and is moved east and west by a motorized trolley.
Emergency Fish Release Gate (4 ea) (G-14 thru G-17)	Release fish from a holding tank and return them to the river under emergency conditions as determined by the facility manager.	The gate is located at the bottom of the Fish Lift Hopper Well and therefore, the hopper, separation screen, and crowder leaf must be out of the tank in order to use the emergency release feature. This gate also functions as a drain for the hopper well.
Secondary Water Supply Valve (4 ea) (V-9 thru V-12)	To ensure sufficient fresh water is being supplied to fish in the hopper while the hopper is positioned in the hopper well.	Secondary water is supplied via the common tank supply header from the main sump in the Water Control Structure.
Spray System	Control fish jumping in a holding tank.	See section 3.1.6 for more detail. (Design flow rate of 16 gpm.)

Component	Function	Note
Flow Sensor (4 ea)	Detect a no water flow condition in the individual tank main water supply lines.	An electrical signal is sent to the alarm system to illuminate an alarm indicator on the Annunciator Panel located in the Equipment Building.
Level Sensor (4 ea)	Detect a Holding Tank low water level condition.	An electrical signal is sent to the alarm system to illuminate an alarm indicator on the Annunciator Panel located in the Equipment Building.

Each Holding Tank independently receives water from a common water supply header fed from the Water Control Structure. Water enters each tank through the up-well and exits the tank through the down-well. Water flow rate through the tanks is controlled by the Main Water Supply Valves (V-5 through V-8) and the water level in the tanks is controlled by the corresponding stoplog height in the adjoining Tank Water Level Control Sump. Since the invert elevation of the flumes entering the tanks is unique for each tank, it is recommended that each tank be operated at the water levels listed in Table 3-3.

Table 3-3. Holding tank recommended operating levels.

Tank #	Water Elevation (ft)	Water Depth (ft)	Water Volume (ft^3)	Recommended Maximum # of Adult Fish
1	897.25	5.25	504.00	63
2	896.67	4.67	448.32	56
3	896.00	4.00	384.00	48
4	895.33	3.33	319.68	40

Each Holding Tank independently receives fish from the Fish Trap through a flume located at the south end of the tank. A fish lift hopper is used to remove fish from a tank, upon direction of the facility manager. With the hopper positioned in the hopper well at the north end of a tank, the isolation screen and/or the crowder leaf is raised and the crowder is manually positioned to the south end of the tank. The crowder leaf is lowered and manually repositioned to the north end of the tank, thus crowding the fish into the hopper. With the separation screen reinserted or the crowder leaf in the separation position, the hopper is raised and moved to an awaiting fish transfer truck. The separation screen or crowder leaf remains in the separation position until the hopper is again positioned in the tank.

Each Holding Tank is furnished with the following additional systems or equipment:

- An emergency fish release gate (G-14 through G-17) to route fish back to the river under emergency conditions. Note: the hopper must be out of the holding tank in order for the emergency release system to function.
- Secondary water supply (V-9 through V-12) from the Water Control Structure to ensure fresh water is supplied to the fish being crowded into the hopper.
- A spray system to minimize fish jumping in the tank.
- A water flow sensor to initiate an alarm indicating a NO FLOW condition in the main water supply to the tank.
- A water level sensor to initiate an alarm indicating a LOW LEVEL condition in the tank.

3.1.3 Fish Trap

The Fish Trap, which is located in the southeast area of the facility, receives fish from the top of the fish ladder in the Fish Passage Facility and holds them for routing back to the river or sorting and routing to the Holding Tanks. The trap is designed to hold a maximum of approximately 250 adult fish. Table 3-4 lists the major components associated with the Fish Trap and their function.

Table 3-4. Fish trap component functions.

Component	Function	Note
Water Supply Gate (G-12)	Control the water flow from the Water Control Structure to the up-well in the Fish Trap.	This gate is located in the Water Control Structure and is manually operated. (Maximum design flow rate of 2,120 gpm.)
Up-well	Provide even distribution of fresh water into the Fish Trap.	The up-well is a sump covered with grating.
Up-well Drain Valve (V-15)	Drain the Fish Trap when it is not in use.	
Trap Water Level Control Sump	Manually control the water level in the fish trap.	Level is controlled by the height of stoplogs in the sump. Sump is located on the south side of the trap, just west of the east end.
Trap Crowder	Crowd fish from the east to the west end of the fish trap toward the false weir.	Crowder leaf is raised and lowered by an electric cable hoist and is moved along the length of the trap by a motorized trolley. Hoist and trolley are remotely controlled at the operator's panel or from a pendant attached to the panel. East & west travel and hoisting are limited by limit switches.
False Weir	Create an attraction riffle (flow) to entice fish to jump "upstream" and into the flume routing and sorting system.	See section 3.1.4 for more detail.
Spray System	Control fish jumping in the trap.	See section 3.1.6 for more detail.
Finger Weir	Prevent fish in the trap from returning to the top of the fish ladder.	
Level Sensor	Detect a Fish Trap low water level condition.	An electrical signal is sent to the alarm system to illuminate an alarm indicator on the Annunciator Panel located in the Equipment Building.

The Fish Trap receives fresh water from the Water Control Structure through gate G-12. Water enters the trap through the up-well at the west end of the trap. The water level in the trap is controlled by the height of the stoplogs in the Trap Water Level Control Sump.

Fish enter the east end of the trap and are prevented from returning to the ladder by a finger weir. Fish are removed from the trap, upon direction of the facility manager, by way of the false weir. With the false weir in operation at the west end of the trap, the "L" shaped trap crowder leaf is positioned to the east end of the trap and lowered. In the lowered position the crowder is moved to the west end of the trap, thus crowding the fish toward the false weir. With the "L" shaped crowder leaf at the west end of the trap, it can be raised to further vertically crowd fish to the false weir. Crowding fish to the west end of the trap does not prevent additional fish from

entering the east end of the trap, therefore, the crowder leaf needs to be raised and repositioned to the east end to repeat the fish removal process.

The Fish Trap is furnished with the following additional systems or equipment:

- A spray system to minimize fish jumping in the trap.
- A water level sensor to initiate an alarm indicating a LOW LEVEL condition in the trap.

3.1.4 False Weir System

The False Weir System (See Figure 3-3), located at the west end of the Fish Trap, is used to create an artificial "upstream" attraction riffle (flow) to entice trapped fish to jump into the flume routing and sorting system. In addition, the false weir provides sluicing water for the flume system. Table 3-5 lists the major components associated with the False Weir and their function.

Table 3-5. False weir system component functions.

Component	Function	Note
False Weir Supply Sump	Produce an adequate water supply head for the False Weir.	Water elevation of 901.75 is required. Sump is a part of the Water Control Structure.
False Weir Pump	Pump water from the Water Control Structure Main Sump into the False Weir Supply Sump.	The pump motor is turned ON or OFF in the Equipment Building and is controlled by a water level sensor in the false weir supply sump to maintain a water surface elevation between 901.5 and 901.9 feet.
False Weir Pump Discharge Control Valve (V-13)	Control False Weir Pump discharge flow rate into the False Weir Supply Sump.	Valve is located in the Water Control Structure.
False Weir Supply Valve (V-3)	Actuate false weir by controlling supply water flow from the False Weir Supply Sump to the false weir.	Valve is electric motor operated and remotely controlled from the Operator's Panel.
Sorting Flume Supply Screen	Supply sluicing or wetting water to the sorting flume.	
Sorting Flume Wetting Water Supply Valve (V-32)	Control sluicing water flow from the False Weir Water Supply line to the sorting flume.	This manually operated valve controls the main water supply to the sorting flume. Its normal operating position is initially determined as part of the construction testing and certification process.
Sorting Flume Supply Screen Flow Control Valve (V-4)	Adjust quantity of sluicing or wetting water allowed to flow through the sorting flume by controlling water drained through the Sorting Flume Supply screen.	Valve is electric motor operated and remotely controlled from the Operator's Panel to "fine tune" the sorting flume sluicing flow.

The False Weir receives water from the False Weir Supply Sump in the Water Control Structure. Water enters the sump via gate G-13 or via the False Weir Pump. With gate G-13 open and the Main Sump water elevation at 901.75 or above, operation of the False Weir Pump is not required. However, if the Main Sump water elevation is below 901.75, operation of the False Weir Pump is required and gate G-13 must be closed. The water flow rate to the false weir is

controlled by motorized valve V-3 operated from the Operator's Panel (See Figure 3-4). The false weir system also has a dewatering screen between the weir and the flume entrance to control the amount of water entering the flume system. The dewatering screen flow rate is controlled by motorized valve V-4 operated from the Operator's Panel (See Figure 3-4).

When not in operation, the False Weir can be drained to the overflow system through valve V-50.

3.1.5 Flume Sorting System

The Flume Sorting System, located between the False Weir and the Holding Tanks, is used to sluice fish that jump across the false weir to one of the four holding tanks or back to the river, as determined by the sorting system operator. The flume has four pneumatically actuated diverter gates used to route fish to the desired destination. The diverter gates are remotely actuated at the Operator's Panel (See Figure 3-5). Table 3-6 lists the major components associated with the Flume Sorting System and their function.

Table 3-6. Flume sorting system component functions.

Component	Function	Note
Diverter Gate Operating Push Buttons & Toggle Switch	Position diverter gates to route fish to the desired location.	Push buttons and a toggle switch are located on the Operator's Panel. The switches operate solenoids that operate pneumatic control valves.
Pneumatic Control Valves	Deliver pressurized air to the appropriate side of the diverter gate actuator to shift the diverter gate to the desired position.	Solenoid operated pneumatic control valves are located in the vicinity of the respective diverter gates.
Diverter Gate Actuators	Shift diverter gates to the desired position.	
Diverter Gates	Route fish to one of two flume sections.	

Table 3-7 summarizes the function of each Fish Flume Diverter Gate.

Table 3-7. Fish flume diverter gate functions.

Diverter Gate	Function	Note
A	Route fish coming from the false weir to the river or to one of four holding tanks.	The toggle switch for Diverter Gate A is spring loaded to the *Return to River* position.
B	Route fish to Holding Tank #1 or tanks #2 through #4.	
C	Route fish to Holding Tank #2 or tanks #3 and #4.	
D	Route fish to Holding Tank #3 or tank #4.	

Table 3-8 is a matrix that identifies required diverter gate positions to route fish to the various desired locations.

Table 3-8. Fish sorting diverter gate positions.

Destination	Gate A	Gate B (1)	Gate C (2)	Gate D (3)
River	O (R)	NA	NA	NA
Tank #1	C (F)	O (T)	NA	NA
Tank #2	C (F)	C (F)	O (T)	NA

Destination	Gate A	Gate B (1)	Gate C (2)	Gate D (3)
Tank #3	C (F)	C (F)	C (F)	O (T)
Tank #4	C (F)	C (F)	C (F)	C (F)

"C" implies fish stays in the flume.
"O" implies fish goes to the river or a tank.
"NA" implies that the gate's position has no affect on the desired routing.

Sluicing (wetting) water is supplied to the sorting flume via the Sorting Flume Wetting Water Supply Valve (V-32) and False Weir Supply Valve (V-3). Sluicing water flow rate in the flume is controlled by the Sorting Flume Supply Screen Flow Control Valve (V-4). The sluicing or wetting water flow ensures that a minimum amount of water is flowing in the flume system to carry fish to the holding tanks. Sluicing water for the Return to River Flume is supplied directly from the common holding tank supply header from the main sump in the Water Control Structure. There is no flow control valve for this sluicing water.

3.1.6 Spray System

The spray system supplies pressurized water to nozzles located along the sides of the Holding Tanks and the Fish Trap. Water from the False Weir Supply Sump is pressurized by the Spray System Pump located in the Equipment Building. The pump is controlled by START & STOP push buttons on the Operator's Panel. Each of the five individual spray systems has a three way control valve that directs pressurized water to the spray headers or drains the headers to the river. Table 3-9 lists the major components associated with the Spray System and their function.

Table 3-9. Spray system component functions.

Component	Function	Note
Spray System Pump (P2)	Pump water from the False Weir Sump to the spray nozzle headers located along the sides of the Holding Tanks and the Fish Trap.	
Three Way Valves (V-16 thru 19)	Route water from the main spray system supply header to individual holding tank spray headers or isolate the individual headers and drain them to the *Drain To River* piping system.	
Three Way Valve (V-20)	Route water from the main spray system supply header to the fish trap spray header or isolate the trap header and drain it to the *Drain To River* piping system.	
Spray System Header Supply Line Drain Valve (V-22)	Drain the Spray System header supply line to the *Drain To River* piping.	
Nozzles	Convert pressurized water to a spray to control fish jumping.	

The output piping from the Spray System and Truck Fill System Pumps is configured to provide redundancy by allowing either pump to be connected to either system.

3.1.7 Truck Fill System

The truck fill system supplies pressurized water to hydrants located east and west of the east and west truck fill stations, respectively. Water from the False Weir Supply Sump is pressurized by the Truck Fill System Pump located in the Equipment Building. The pump is controlled by a pressure switch on an associated hydrostatic tank in order to provide an on-demand water supply

if any of the hydrants is opened. Hoses are attached to the filling hydrants for filling the transfer tanks. Table 3-10 lists the major components associated with the Truck Fill System and their function.

Table 3-10. Truck fill system component functions.

Component	Function	Note
Truck Fill System Pump (P3)	Pump water from the False Weir Sump to the truck fill header and hydrants located east and west of the east and west truck fill stations, respectively.	This pump is provided with a pressure tank in order to provide an on-demand water supply if any of the hydrants is opened.
2" Truck Fill Hydrants (2 ea)	Provide a place to attach hoses for filling transfer truck tanks.	
1" Truck Fill Hydrants (4 ea)	Provide a place to attach hoses for general housekeeping functions.	
Truck Fill System Header Supply Line Drain Valve (V-21)	Drain the Truck Fill System header supply line to the *Drain To River* piping.	

The output piping from the Truck Fill System and Spray System Pumps is configured to provide redundancy by allowing either pump to be connected to either system.

3.1.8 Overflow & Drain Systems

The facility has one Overflow system, one Clean Water Drain System, and one Storm Water Drain System described in the following paragraphs.

The Overflow System collects water from the following locations and routs it to the Attraction Water Outlet Diffuser at the base of the Fish Ladder in the Fish Bypass Facility:

- Tank Water Level Control Sumps (2 ea)
- Return to River Flume sluicing water supply line drain (V-49)
- False Weir dewatering pipe
- False Weir supply pipe drain
- Fish Trap upwell drain
- Fish Trap Water Level Control Sump

The Clean Water Drain System collects water from the following sources and routs it to the river at a discharge station located southwest of the facility:

- Truck Fill System supply header via drain valve V-21
- Spray System main supply header via drain valve V-22
- Holding Tank Spray System individual spray header drains
- Fish Trap Spray System header drain
- Facility roof gutter down spouts

A Drain System cleanout is located south of the Fish Trap in the vicinity of the southwest corner of the Trap Water Level Control Sump.

The Storm Drain System collects water from the floor drains and the Transfer Truck Station trench drains and routs it to a catch basin west of the Water Control Structure. From there the storm water is routed to Biofiltration Swale located west of the facility.

3.1.9 Alternate/Emergency Fish Release System

The Alternate/Emergency Fish Release System provides a means of releasing fish in the holding tanks directly back to the river. The system consists of a slide gate (G-14 thru G-17) located at the bottom of the northwest corner of each holding tank and a fish return piping system that discharges to the river at a location southwest of the facility. Note: The fish return piping supports the fish release from only one holding tank at a time. Flushing water is provided by the water in the holding tank.

3.1.10 Fish Transfer System

The function of the Fish Transfer System is to move fish, by means of a *water-to-water* transfer scheme, from a holding tank and place them into a fish transfer tank for relocation to other sites.

The Fish Transfer System consists of two lift hoppers, chain hoists and trolleys, an overhead hoist beam, and a transfer truck (The transfer truck itself is not considered a part of the Adult Trap and Sorting Facility.) The hoppers are raised and lowered by the electric chain hoist and are moved between the holding tanks and transfer trucks by the motorized trolley. The hoist and trolley are locally controlled by an attached pendant.

Note: Fish transfer should be expeditious so that fish in the hopper are held for as short a period of time as possible.

3.1.11 Pneumatic System

The Pneumatic System compresses and conditions air for the operation of the fish sorting diverter gates. Table 3-11 lists the major components associated with the Pneumatic System and their function.

Table 3-11. Pneumatic system component functions.

Component	Function	Note
Air Compressor	Supply compressed air to the diverter gate solenoid controlled pneumatic actuators.	The air compressor is located in the Equipment Building, is controlled by an air pressure switch on the air receiver, and is Enabled or Disabled at the Operator's Panel.
Refrigerated Air Dryer	Remove moisture from the compressed air.	
Filter/Desiccant Dryer	Remove additional moisture from the compressed air.	
Pressure Regulating Valve (V-51)	Regulate air pressure to the Diverter Gate actuators.	The air pressure regulating valve is initially adjusted as part of the construction testing and checkout process.
Air Lubricator (4 ea)	Add lubricant to the compressed air to support proper operation of the air actuated diverter gates.	Lubricators are located near each diverter gate pneumatic control valve and actuator.

3.1.12 Electrical Power System

Electrical power is supplied to the ATSF from a City of Tacoma utility line via the main power board in the Electrical Room in the Headworks Intake Building. 480 Volt, 3 phase power enters the TSF Equipment Building on the south wall through the Main Distribution Panel and the Panel-board DP, which is backed up by a standby generator. Figure 3-6 is a one line diagram of the electrical distribution and Table 3-12 lists the major components associated with the Electrical Power System and their function.

Table 3-12. Electrical power system component functions.

Component	Function	
	Input	Distribute To
Panel-board MDP	480v, 3ø power from the Headworks Building	Transformer T1, P-1 False Weir Pump Starter, P-2 Spray System Pump Starter, P-3 Truck Fill Pump Starter, SA-1 Contactor, E-4 East Hopper Hoist/Trolley, E-5 West Hopper Hoist/Trolley, E-6 Trap Crowder, G-11 TFS Supply Gate, V-3 & 4 False Weir Supply & Drain Valves, E-7, 8, 9, & 10 Holding Tank Crowders
Transformer T1	480v, 3ø power from MDP	Step down to 120/208, 3ø power and distribute to Panel-board LP
Panel-board DP	480v, 3ø power from the Headworks Building	UH-1 Equipment Building Unit Heater, UH-4 & 5 Operator Station Unit Heaters
Panel-board LP	120/208, 3ø power from T1	Lighting East, Lighting West, Exterior Lighting, Perimeter Lighting, Lighting Operator Station & Equipment Building, Receptacles, Operator's Panel, & Alarm Panel

3.1.13 Lighting System

The Lighting System is partitioned into the following three groups:

- Equipment Building Inside Lights
- Trap & Sorting Facility Interior Lights

- Trap & Sorting Facility Exterior Lights

The Equipment Building light switches are located inside the equipment access and personnel access doors.

The TSF Interior Light switches are located in the Equipment Building on the south end of the west wall. Table 3-13 lists the switches associated with the interior Lighting System and their function.

Table 3-13. Lighting system switch functions.

Switch	Function	Note
A	Operator's Station, Low	
B	Operator's Station, High	
C	Fish Trap Lighting	
D	Perimeter Lighting	
E	East Truck Loading Station	
F	Holding Tanks 1 & 2	
G	Holding Tanks 3 & 4	
H	West Truck Loading Station	

The TSF Exterior Lights are manually controlled from the Night Lighting Contactor Cabinet on the Equipment Building inside east wall or remotely controlled from the Alarm Panel, depending on the position of the HOA switch on the front of the Night Lighting Contactor Cabinet.

3.1.14 Instrumentation System

The instrumentation System contains several sensors to monitor various parameters and develop an electrical signal to display status, control equipment, or generate an alarm. Table 3-14 lists the sensors (devices) associated with the facility and their function.

Table 3-14. Instrumentation system sensor functions.

Sensor	Function	Note
Ladder Water Level	Detect water level at the top of the fish ladder to initiate a high or low level alarm.	
Water Control Structure Main Sump Water Level	Detect main sump water level to control the position of gate G-11.	
False Weir Supply Sump High & Low Water Level	Detect False Weir Supply Sump water level to Start or Stop the False Weir Pump.	
Holding Tank #1 Low Level	Initiate Holding Tank #1 low level alarm.	
Holding Tank #2 Low Level	Initiate Holding Tank #2 low level alarm.	
Holding Tank #3 Low Level	Initiate Holding Tank #3 low level alarm.	
Holding Tank #4 Low Level	Initiate Holding Tank #4 low level alarm.	
Trap Water Level	Initiate high or low water level alarm in the fish trap.	
Diverter Gate Limit Switches	Indicate position of diverter gates B, C, & D.	
Holding Tank #1 Main Water Supply Flow	Detect a lack of Holding Tank #1 main water supply flow to initiate a NO Flow alarm.	
Holding Tank #2 Main Water Supply Flow	Detect a lack of Holding Tank #2 main water supply flow to initiate a NO Flow alarm.	
Holding Tank #3 Main Water Supply Flow	Detect a lack of Holding Tank #3 main water supply flow to initiate a NO Flow alarm.	
Holding Tank #4 Main Water Supply Flow	Detect a lack of Holding Tank #4 main water supply flow to initiate a NO Flow alarm.	
Spray System (High Pressure) Water Supply Flow	Detect a lack of Spray System main supply header flow to initiate a NO Flow alarm.	

The Alarm System receives low voltage electrical signals from various sensors throughout the facility and compares the values represented by these signals to pre-programmed threshold values to determine whether an alarm condition exists. If an alarm condition does exist, the system displays the alarm on an annunciator window on the front of the Alarm System Panel located on the inside south wall of the Equipment Building. An Alarm System Summary Alarm, indicating the existence of an alarm condition at the Alarm Panel is located on the Operator's Panel. There probably is a remote Alarm System annunciator window in the Headworks Intake Building. Table 3-15 lists the various alarm conditions displayed on the annunciator window.

Table 3-15. Alarm annunciator display.

Low Level Holding Tank 1	Low Level Holding Tank 2	Low Level Holding Tank 3	Low Level Holding Tank 4
No Flow Holding Tank 1	No Flow Holding Tank 2	No Flow Holding Tank 3	No Flow Holding Tank 4
Low Level Trap	High Level Trap	Low Level Ladder	High Level Ladder
No Flow Spray System	Loss Of Power	Spare	Spare

Table 3-16 illustrates the alarm processing sequence.

Table 3-16. Alarm processing sequence.

Alarm Processing Sequence	
Condition	System Response
Normal	All lamps are OFF. If any of the Bypass Toggle Switches are in the Bypass position, the Bypass indicator light is on.
Alarm	Corresponding window light flashes. Panel chime sounds. Horn sounds after 30 seconds (adjustable).
Acknowledge	Corresponding window light burns steady. Chime and horn stop sounding.
Reset	If alarm condition is normal, window light is extinguished.
Test	All window lights flash, chime sounds, and horn sounds after programmed delay.
Note: The Summary Alarm light on the Operator's Panel flashes whenever any alarm occurs and burns steady when the alarm is acknowledged. The light will flash if subsequent alarms are received. The light will extinguish when all alarms have been reset or bypassed.	

The Alarm System Auto-Dialer is incorporated into the system to dial preprogrammed telephone numbers in the event that alarm conditions are not acknowledged within a preprogrammed period of time.

The Operator's Panel, located west of the Fish Trap, is an interface station from which the operator can remotely control various functions, with the exception of lighting. The panel contains pushbuttons; pilot lights; and rotary and toggle selector switches, as illustrated in Figure 3-4, to control and monitor various functions as listed in Table 3-17.

Table 3-17. Operator's panel function controls and indicators.

Function	Controls/Indicators	Note
Operate Fish Trap Crowder	Using the set of Trap Crowder pushbuttons on the panel or the attached pendant, the operator can raise or lower the crowder leaf and move the crowder east or west.	Limit switches prevent hoisting the crowder leaf too far and moving the crowder too far east and west.
Operate Control Station Infrared Unit Heaters	Using the set of Infrared Heating Controls, the operator can turn the unit heaters ON or OFF.	Pilot lights illuminate and extinguish when the heater ON & OFF pushbuttons are depressed, respectively.
Monitor Alarm Annunciator Window	A flashing pilot light indicates an unacknowledged alarm condition and a steady light indicates an acknowledged alarm condition.	The specific alarm condition is identified on the Alarm Annunciator Window in the Equipment Building.
Operate False Weir Supply Valve	Using the set of False Weir Supply Valve pushbuttons, the operator can adjust valve (V-3)	Pilot lights only indicate whether the valve is fully open or fully shut. *
Operate False Weir Drain Valve	Using the set of False Weir Drain Valve pushbuttons, the operator can adjust valve (V-4)	Pilot lights only indicate whether the valve is fully open or fully shut. *
Operate the Air Compressor	Using the Air Compressor selector switch, the operator can Enable or Disable the air compressor.	Pilot light illuminates when the Air Compressor is enabled.
Operate the Spray System Pump	Using the Spray System Pump set of pushbuttons, the operator can Start or Stop the pump.	Pilot light illuminates and extinguishes when the pump START & STOP pushbuttons are depressed, respectively.
Energize the Diverter Gate System	Using the Diverter Gate selector switch, the operator can turn the gate operating system ON or OFF.	This allows an electrical signal to be sent to various solenoid controlled pneumatic valves.

Function	Controls/Indicators	Note
Operate Diverter Gate A	Using the Diverter Gate A toggle switch, the operator can shift the gate between *Return To River* and *Holding Tank* positions.	The toggle switch is spring loaded to the *Return To River* position.
Operate Diverter Gates B, D, & D	Using the Diverter Gate B, C, or D pushbutton/pilot light switches, the operator can shift the corresponding gate between the *To Tank* or *To Channe*l positions.	See (Table 3-8), Fish Sorting Diverter Gate Positions, for required gate positions to accomplish desired fish routing.
Monitor Selected Tank to Receive Fish	An illuminated light in the set of Tank Selected pilot lights indicates which tank is lined up to receive fish.	The pilot lights are illuminated depending upon the position of the diverter gates.
* False Weir Supply and Drain Valve Operation: Momentary contact pushbuttons open and close the supply and drain valves. As long as a pushbutton is depressed, the valve continues to open or close. When the pushbutton is released, the valve stops in the current position.		

3.2 Operational Modes

Evolutions performed at the ATSF can be grouped into the following operational modes:

- Trapping Fish
- Sorting Fish
- Holding Fish
- Transferring Fish

All TSF components or systems do not need to be in simultaneous continuous operation. In fact, it will probably be rare for all components or systems to be operating simultaneously. The following paragraphs step through a more detailed description of the various modes of operation. Refer to Figures 3-1, 3-2, & 3-3 to identify components addressed in the following paragraphs.

3.2.1 Trapping Fish

The trapping evolution involves attracting fish into the trap from the top of the fish ladder and preventing them from returning to the ladder. The following components are required for trapping fish:

- Water Control Structure
- Fish Trap
- Spray System (as required)

Water is gravity fed to the Water Control Structure (WCS) via gate G-11 and is supplied to the Fish Trap from the WCS via gate G-12. The water level in the trap is controlled by the height of the stoplogs in the Trap Water Level Control Sump.

Fish at the top of the Fish Ladder are attracted into the trap by the water flowing from the upwell located at the west end of the trap. A finger weir at the east end of the trap prevents the fish from returning to the ladder. During the trapping evolution, the trap crowder leaf is in the raised position and the trap spray system is turned ON as required.

3.2.2 Sorting Fish

The sorting evolution involves transferring fish from the trap into the sorting flume for further routing back to the river or to one of the four holding tanks. Fish are crowded to the west end of the trap and are attracted into the sorting flume via the false weir. In addition to the Water Control Structure and the Fish Trap, the following components are required for sorting fish:

- Holding Tanks (At least one unless all fish are being returned to the river.)
- Flume System
- False Weir System
- Spray System (as required)
- Trap Crowder

Prior to receiving fish, a holding tank must be filled and constantly supplied with water. If a lift hopper is not in place in the hopper well, the hopper well separation screen or crowder leaf must be in place to prevent fish from entering the hopper well.

When the holding tank is ready, the False Weir is started and adjusted to provide attraction water for fish to enter the sorting flume and sluicing or wetting water to allow fish to slide through the flume system.

Fish are crowded toward the False Weir and as they enter the Sorting Flume, the operator, at the Operator's Panel (See Figure 3-5), positions the appropriate diverter gates (See Table 3-8) to route the fish to the desired location. The holding tank spray system may or may not be operating.

3.2.3 Holding Fish

The fish holding process involves supplying water to the holding tanks containing fish; therefore, only the following components are required to be operating:

- Water Control Structure
- Holding Tanks containing fish
- Spray System (as required)

As stated above, a lift hopper must be positioned in the hopper well at the north end of a holding tank or the isolation screen or crowder leaf must be in place to prevent fish from entering the fish hopper well.

3.2.4 Transferring Fish

The normal fish transfer process involves transferring fish from a holding tank to a fish transfer truck. With a lifting hopper lowered into the lift hopper well at the north end of a holding tank, the separation screen or crowder leaf is removed or raised. The tank crowder leaf is positioned to the south end of the tank where it is lowered and moved north to crowd fish into the hopper.

With the lowered crowder leaf at the north end of the tank or the isolation screen in place, the hopper is raised, along with fish and water, and moved to the awaiting transfer truck tank, which has been filled with water. (Note: The transfer tank is filled with water from the Water Control Structure, thus preventing any appreciable temperature difference between the holding tank and transfer tank water.) The hopper is then positioned on the transfer truck tank, as illustrated in Figure 3-7. The void between the water in the hopper and the water surface in the tank is filled with water from the hopper (see Chapter 4). When ready, the hopper's fish transfer hatch is opened to release fish into the tank and the truck transfer tank's drain valve is then partially opened to establish water flow from the hopper.

Fish can be transferred from the holding tanks under emergency conditions by releasing them back to the river via the Alternate/Emergency Fish Release System described in paragraph 3.1.9, above.

Note: The Instrumentation System is functional in all Operational Modes. Unnecessary alarm circuits, such as holding tank low level, when there is no water in the tanks, should be disabled to prevent false alarms.

3.3 Operating Parameters

Table 3-18 lists operational parameters that need to be maintained to normally operate the ATSF.

Table 3-18. ATSF operating parameters.

Parameter	Value	Note
Water Control Structure Normal Water Level	903.0	Maintained by gate G-11.
Fish Trap Normal Water Level	900.0	High & Low Level alarm at elevation 900.5 & 899.5, respectively.
Fish Trap Minimum Water Flow Rate	TBD	Determined by measuring depth of flow over stoplogs.
Holding Tank #1 Minimum Water Level	897.25	Low Level Alarm at elevation 894.25*
Holding Tank #2 Minimum Water Level	896.67	Low Level Alarm at elevation 894.25*
Holding Tank #3 Minimum Water Level	896.00	Low Level Alarm at elevation 894.25*
Holding Tank #4 Minimum Water Level	895.33	Low Level Alarm at elevation 894.25*
Holding Tank Minimum Water Flow Rate	TBD	Determined by measuring depth of flow over stoplogs.
Pneumatic System Operational Pressure	65 psi	Maintained by pressure regulating valve (V-51)

* Field Verify

The flow rate through the trap or a tank can be determined by measuring the water depth over the stop-logs at the corresponding level control sump and correlating this depth to the weir flow equation below:

$$Q = 35.95 \times L \times D^{1.5}$$

Where: Q = flow in gpm
L = weir length in feet
D = depth of water over weir in inches

3.4 Routine Maintenance Requirements

Table 3-19 identifies equipment requiring routine preventive maintenance per the manufacturer's Installation & Operation Manuals (This list should not be considered all inclusive.).

Table 3-19. ATSF equipment requiring maintenance.

Equipment
Manual Gates (6)
Motorized Gate (1)
Diverter Gates (4)
Diverter Gate Actuators (4)
Pneumatic Control Valves (4)
Motorized Valves (2)
Air Compressor
Refrigerated Dehydrator
Filter Desiccant Air Dryer
Air Lubricators (4)
Trap Crowder
Tank Crowders (4)
Lift Hopper Hoists (2)
False Weir Pump
Spray System Pump
Truck Fill Pump
Unit Heaters (3)
Exhaust Fan (1)
Instrumentation Equipment (verify calibration)
Alarm Circuits (verify operation)
Electrical Distribution Equipment

In addition to performing routine equipment preventive maintenance, Table 3-20 identifies recommended facility maintenance requirements (This list should not be considered all inclusive.).

Table 3-20. Recommended ATSF maintenance requirements.

Component	Recommended Maintenance	Periodicity
Concrete Water Holding Structures	Visually inspect for deterioration especially in area of surface finish, embeds, pipe penetrations, and grating supports.	Annually (as required)
	Clean & Disinfect	Prior to extended shutdown period
Fish Trap & Holding Tanks	Remove upwell and downwell grating and verify that wells are clean and free of debris. Verify that the holding tank upwell to lift hopper well drain is open, free of debris, and clear to drain.	Prior to extended shutdown period
Truck Fill Station trench drains	Open, inspect, and clean	Prior to startup and operational period
Valves & Gates	Exercise to verify proper performance throughout full range of operation.	Annually
Crowders	Exercise throughout full range of operation.	As part of startup prior to operational period
Lift Hopper Transfer System	Exercise throughout full range of operation.	As part of startup prior to operational period

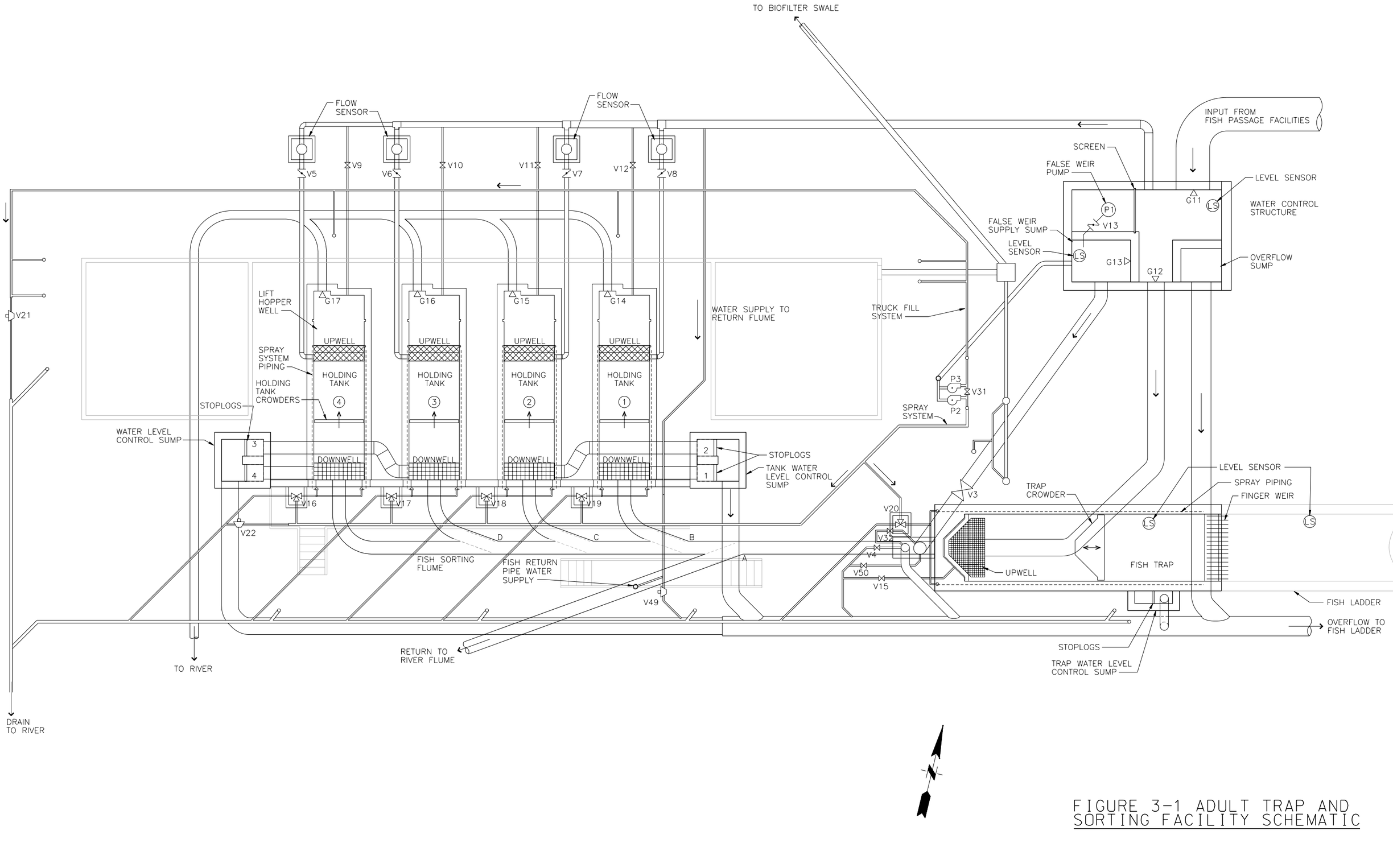

FIGURE 3-1 ADULT TRAP AND SORTING FACILITY SCHEMATIC

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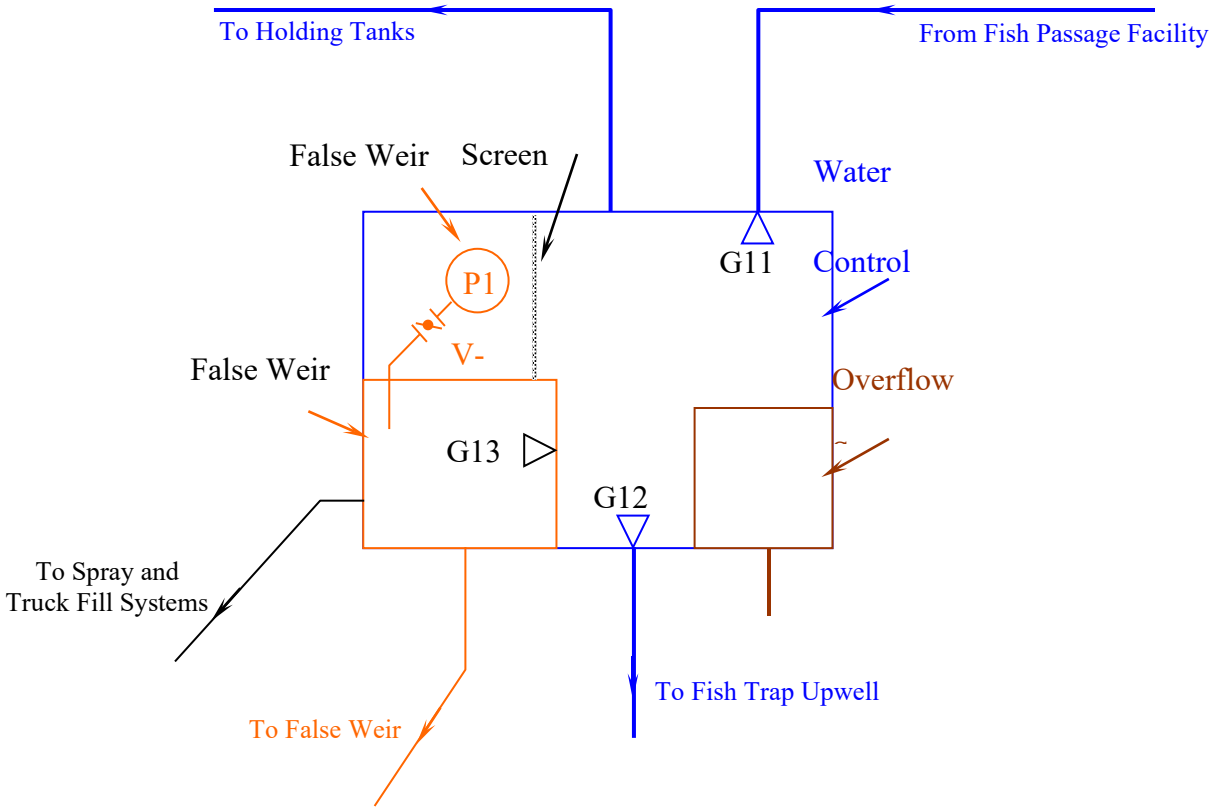

Figure 3-2. Water Control Structure.

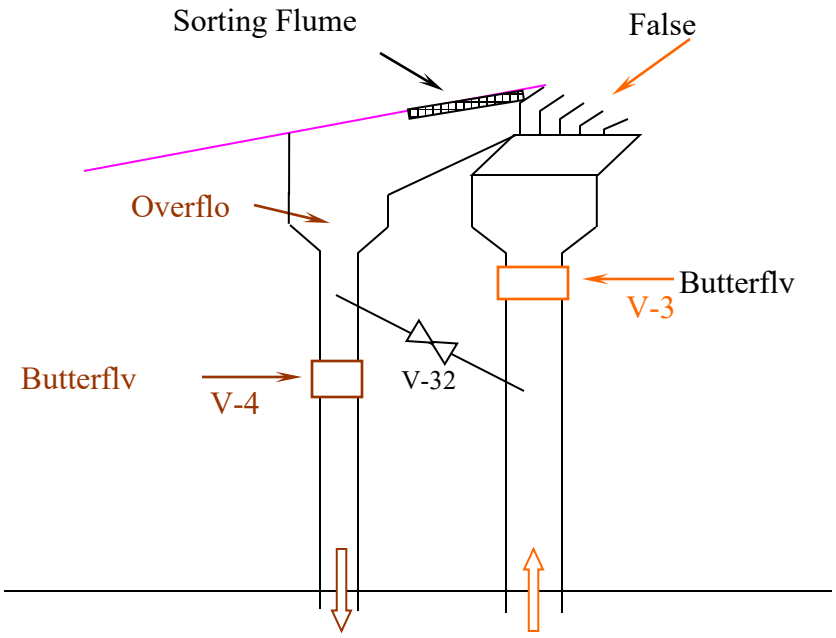

Figure 3-3. False Weir.

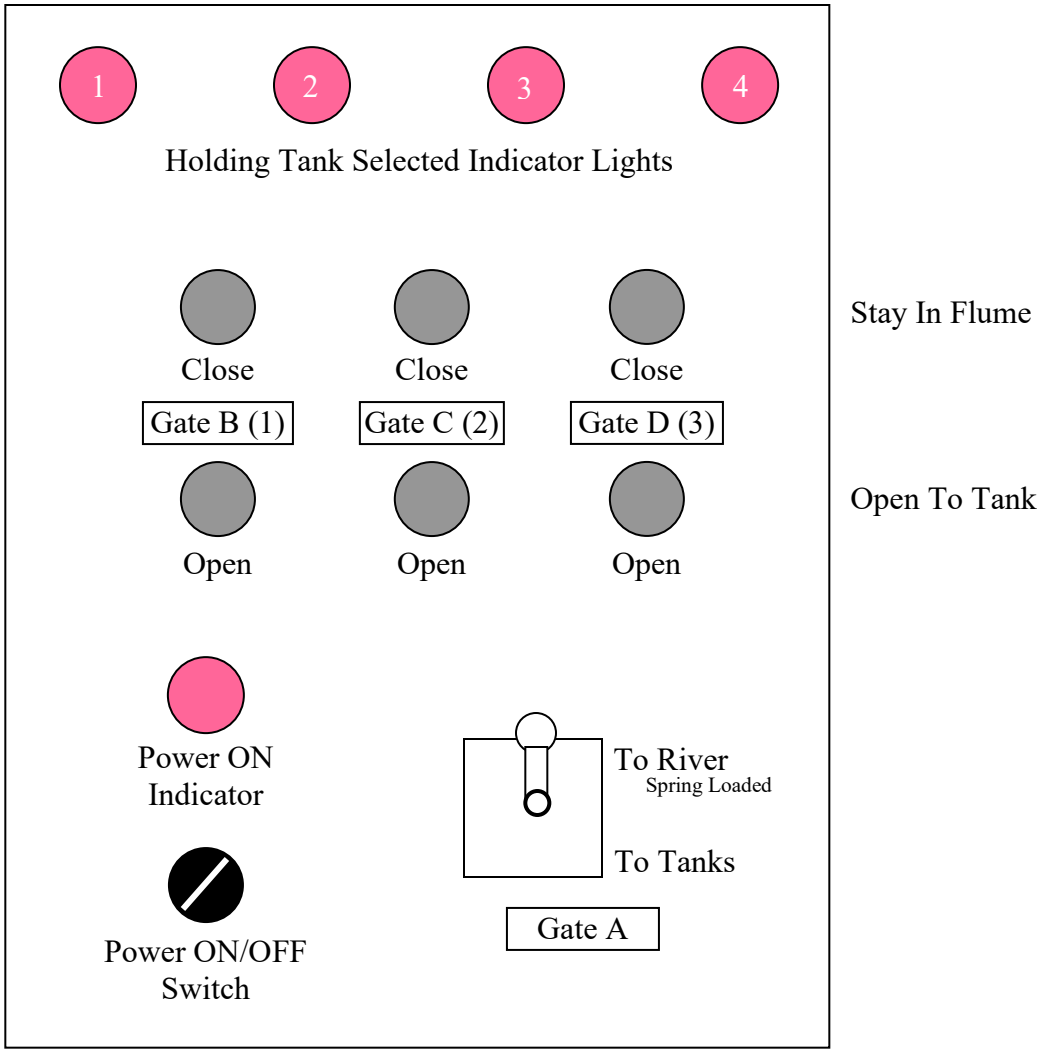

Figure 3-4 Sorting Gates Controls & Indicators

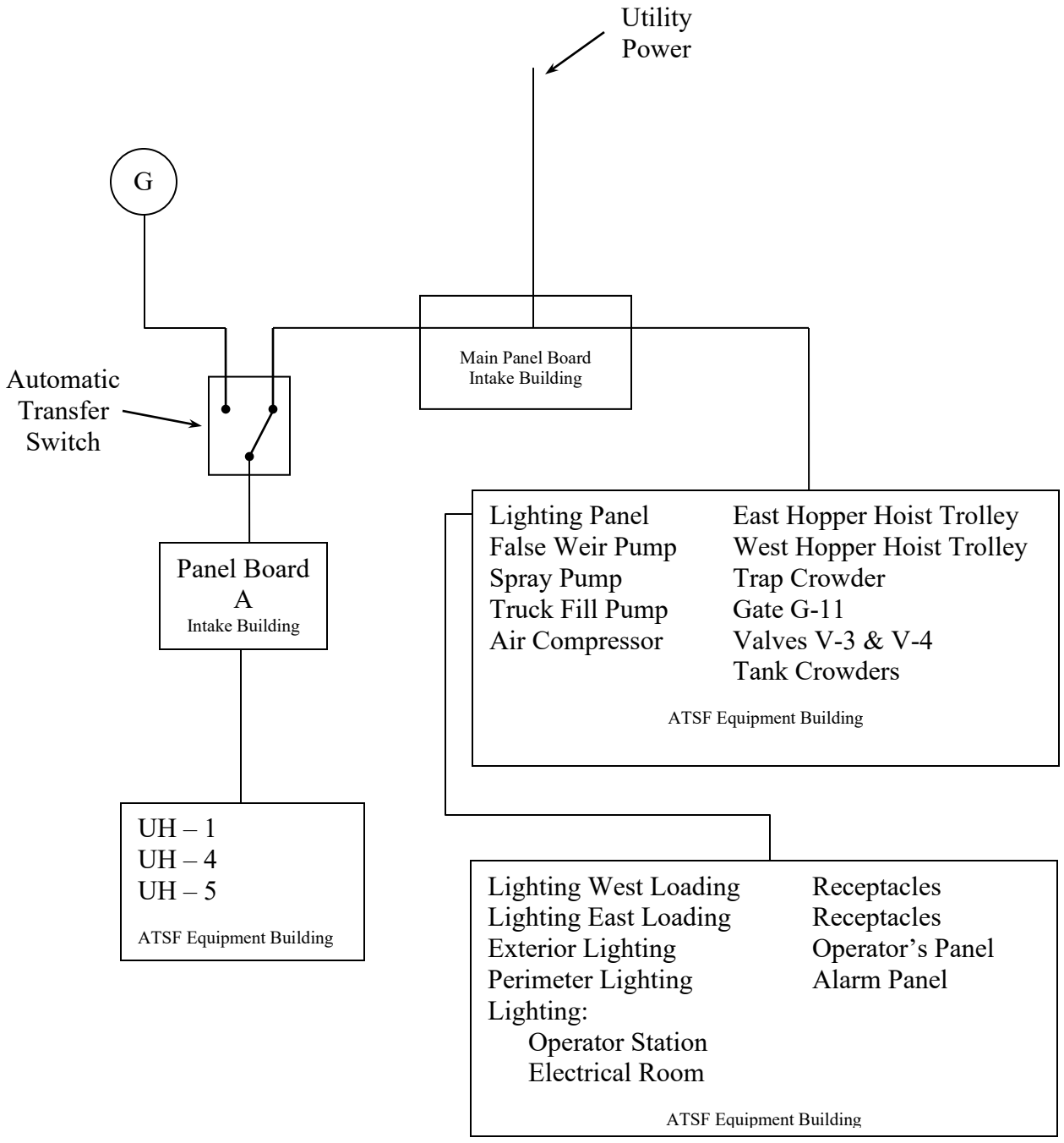

Figure 3-5 Electrical System One Line Diagram

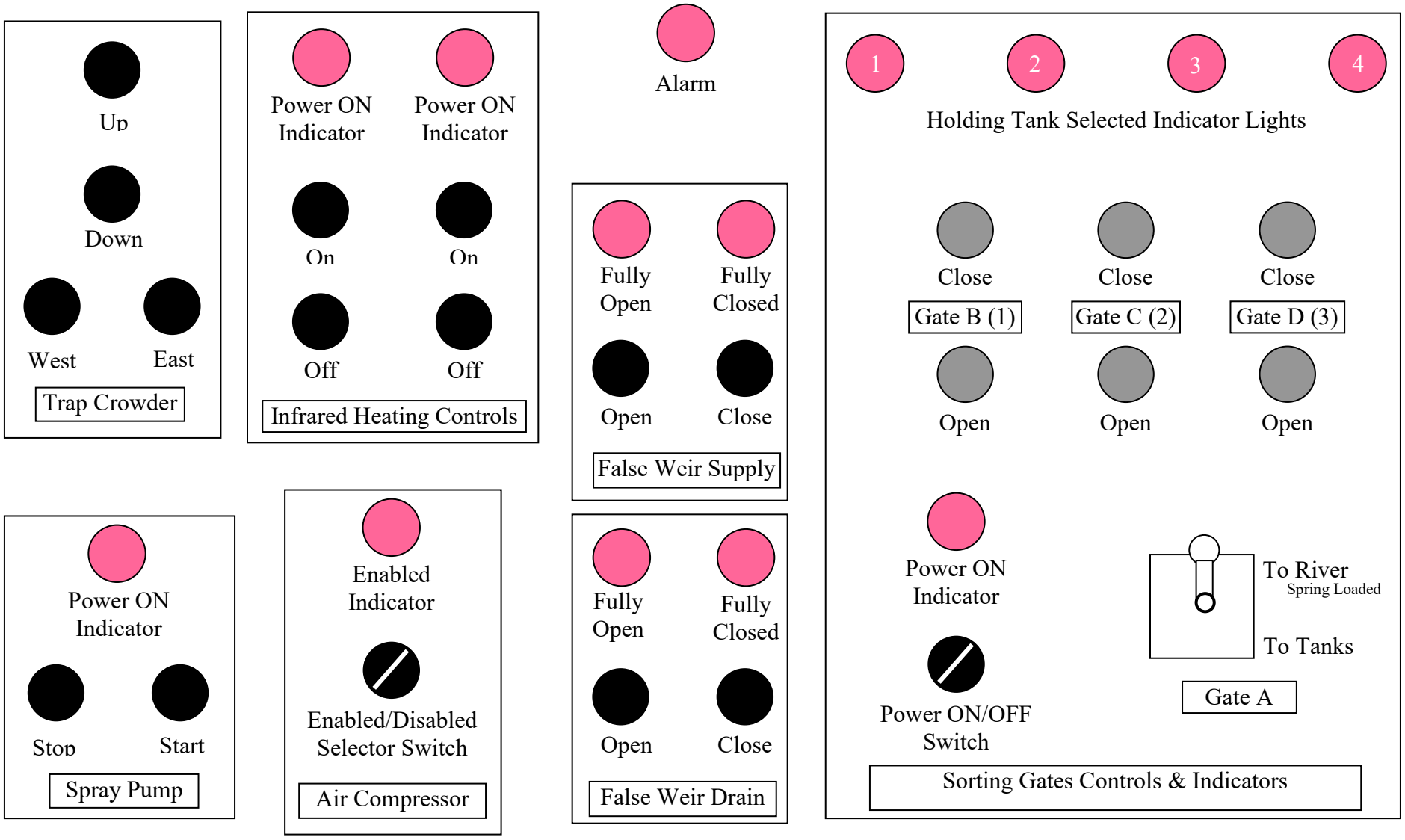

Figure 3-6 Operator's Panel

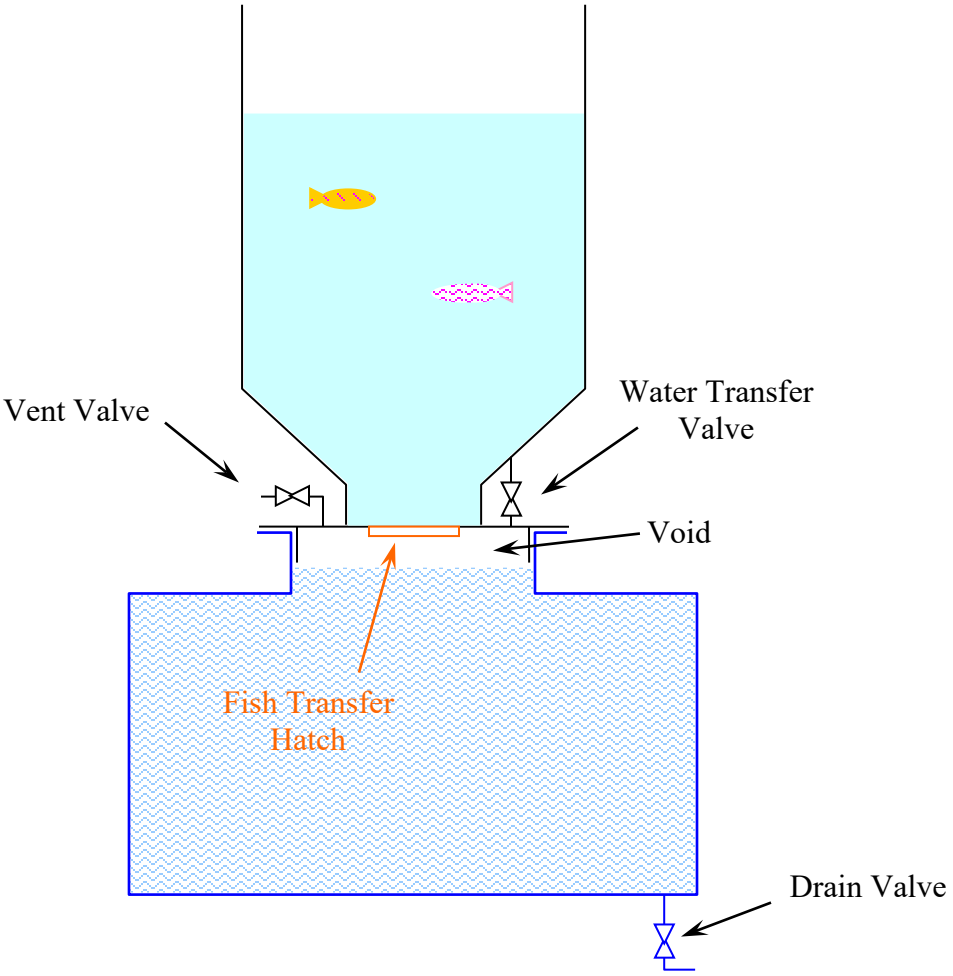

Figure 3-7. Hopper to Transfer Tank Interface.

Chapter 4. Operating Procedures

The Green River Headworks Adult Trap and Sorting Facility will be operated whenever adult fish are present and a transfer program is established. The following paragraphs present procedures for operating the facility under various scenarios; however, these procedures should not be considered compulsory. Standard and appropriate operational practices should be considered and exercised at all times.

4.1 Normal Operations

Normal operating procedures are subdivided into Startup, Daily Operations, and Shutdown procedures.

4.1.1 Startup Procedures

Purpose

Bring water into the facility from a complete shutdown condition.

Prerequisites

Water from the Fish Passage Facility is available at Gate G-11.

Procedures

Table 4-1 lists recommended procedural steps to bring water into the ATSF.

Table 4-1. Recommended startup procedures.

Step	Description	Note
1	Verify that the required facility maintenance actions are satisfactorily completed, to date.	See Chapter 3, Section 3.4.
2	Verify that electrical power is available and energize all circuits identified in Table 3-12	
3	Verify that valves and gates are lined up per the Start-up Valve & Gate Line-up in Table 4-2, below.	
4	Turn electrical power ON to the Instrumentation System and verify proper operation of sensor and alarm circuits per the manufacturer's Installation & Operation Manuals.	
5	Verify that the screen to the False Weir Pump Sump is in place in the Water Control Structure.	
6	Under manual control, slowly open gate G-11 and flood the Water Control Structure.	The Holding Tank Water Supply Header will also fill and water will flow through the Return-to-River Flume water supply line. In addition, if V-32 is not closed, water will flow into the sorting flume.
7	Under manual control, fully open gate G-11 to verify proper operation of the Overflow Sump.	The Overflow Sump should drain freely to prevent the Water Control Structure from flowing over. This step requires a high river water level.

Step	Description	Note
8	Shift gate G-11 to automatic sensor control to maintain desired level in the Water Control Structure.	Gate G-11 control circuitry is normally set to prevent a water elevation in excess of 903 feet.

Table 4-2. Startup valve and gate lineup.

Valve/Gate #	Name	Position
G-11	Trap & Sorting Facility Water Supply Gate	Closed
G-12	Fish Trap Upwell Supply Gate	Closed
G-13	False Weir Supply Sump / Main Sump Cross-connect Gate	Closed
V-3	False Weir Supply Valve	Closed
V-5	Holding Tank #4 Main Supply Valve	Closed
V-6	Holding Tank #3 Main Supply Valve	Closed
V-7	Holding Tank #2 Main Supply Valve	Closed
V-8	Holding Tank #1 Main Supply Valve	Closed
V-9	Holding Tank #4 Secondary Supply Valve	Closed
V-10	Holding Tank #3 Secondary Supply Valve	Closed
V-11	Holding Tank #2 Secondary Supply Valve	Closed
V-12	Holding Tank #1 Secondary Supply Valve	Closed
V-13	False Weir Pump Discharge Control Valve	Closed
V-23	Spray System Pump Suction Valve	Closed
V-24	Truck Fill System Pump Suction Valve	Closed
V-32	Sorting Flume Wetting Water Supply Valve	Closed
V-49	Return To River Flume Water Supply Line Drain Valve	Open

The facility is now ready for Daily Operations.

4.1.2 Daily Operation Procedures

Purpose

Trap, sort, and transfer fish as required.

Prerequisites

Start-up procedures satisfactorily completed per paragraph A, above.

Procedures

Table 4-3 lists recommended daily operations procedural steps for trapping, sorting, and transferring fish.

Table 4-3. Recommended daily operation procedures.

Step	Description	Note
	Trapping Fish	
1	Verify that the trap crowder leaf is at the extreme west end of the trap and in the fully lowered position.	
2	Place stoplogs in the Trap Water Level Control Sump to obtain the desired trap water surface elevation and flow into the top of the fish ladder.	
3	Verify that the Trap Upwell Drain Valve V-15 is closed.	
4	Verify that the trap upwell is free of debris and that the grating is in place.	Grating should be installed with the smooth side toward the fish.
5	Slowly open gate G-12 at the Water Control Structure to supply water to the trap.	When the trap is filled to the desired level, adjust gate G-12 to obtain the desired water flow rate through the trap as determined by the height of water over the top of the stoplogs. See equation below.
	$Q = 35.95 \times L \times D^{1.5}$ Where: Q = flow in gpm L = weir length in feet D = depth of water over weir in inches	
6	If desired, start the trap spray as follows (See Figure 4-1): • Verify that valves V-16, 17, 18, 19 & 20 are in Position 2 (closed or drain position). • Verify that valve V-22 is open. • At the Spray Pump, verify that: o Valve V-31 is closed o Discharge vent connection is plugged o Valves V-23, 27, & 29 are open o The discharge pressure gauge isolation stop is open. • At the operator's panel, start the spray pump and monitor system performance. • Place valve V-20 in Position 1 (open or supply position). • Close V-22. • Make adjustments as required.	**CAUTION** Exercise caution to prevent pumping into a deadhead, ensure that a spray header supply valve is open. Also ensure that the *No Flow Spray System* alarm circuit is enabled.
	Sorting Fish	
1	Verify that the Air Compressor and the refrigerated drier are enabled and there is sufficient air pressure in the pneumatic system.	
2	Determine which Holding Tanks will receive fish.	
3	Place stoplogs in the corresponding Tank Water Level Control Sumps to the desired tank water surface elevation.	Refer to Chapter 3, Table 3-3 for holding tank water elevations.
4	Verify that upwells and downwells are free of debris and that the grating is in place.	Grating should be installed with the smooth side toward the fish.
5	Verify that gates G-14, 15, 16, & 17 are closed.	

Step	Description	Note
6	Open the appropriate Holding Tank Main Supply valve (V-5, 6, 7, or 8)	When the tank(s) is(are) filled to the desired level, adjust valve V-5, 6, 7, or 8 to obtain the desired water flow rate through the tank as determined by the height of water over the top of the stoplogs. See Trapping Fish Step 5 above.
7	Verify that the tank separation screen(s) or crowder leaf (leaves) is(are) in place.	**CAUTION** This is required to prevent fish from entering the hopper well if a lift hopper is not in the tank.
8	If desired, start the tank spray as follows (See Figure 4-1): • If the Spray Pump is ON, place the appropriate valve(s) V-16, 17, 18, or 19 in Position 1 (open or supply position). If the Spray Pump is not ON: • Verify that valves V-16, 17, 18, 19 & 20 are in Position 2 (closed or drain position). • Verify that valve V-22 is open. • At the Spray Pump, verify that: o Valve V-31 is closed o Discharge vent connection is plugged o Valves V-23, 27, & 29 are open o The discharge pressure gauge isolation stop is open. • At the operator's panel, start the spray pump and monitor system performance. • Place the appropriate valve(s) V-16, 17, 18, or 19 in Position 1 (open or supply position). • Close V-22. • Make adjustments as required.	**CAUTION** Exercise caution to prevent pumping into a deadhead, ensure that a spray header supply valve V-22 is open. Also ensure that the *No Flow Spray System* alarm circuit is enabled.
9	Verify that the Return To River Flume Water Supply Line Drain Valve V-49 is closed.	
10	At the Operator's Panel, verify proper operation of the sorting flume diverter gates.	
11	Start the False Weir as follows: • Verify that the False Weir Supply Drain Valve, V-50 is closed. • Verify that Sorting Flume Wetting Water Supply Valve V-32 is open to predetermined position. • If the Water Control Structure water elevation is 901.75 or higher, go to Step 12, otherwise, start the False Weir Pump to raise the water elevation in the False Weir Supply Sump and close gate G-13.	**CAUTION** If the Spray System or Truck Fill System pumps are on, ensure that the False Weir Pump is on and operating properly prior to closing gate G-13.
12	At the Operator's Panel: • Open the False Weir Supply Valve V-3 to establish desired flow over the weir. • Adjust Sorting Flume Supply Screen Flow Control Valve V-4 to establish desired flow into the sorting flume.	
13	Raise the trap crowder leaf and position it to the east end of the trap.	Be prepared for fish to volitionally jump over the false weir into the sorting flume.

Step	Description	Note
14	As fish enter the sorting flume, shift the diverter gates to route them to the desired location. Refer to Table 3-8.	As required, lower the crowder leaf and move it toward the west end of the trap to crowd fish over the weir. When at the west end of the trap, the crowder leaf can also be raised to crowd fish over the weir.
15	Repeat steps 13 and 14 to sort additional fish, as desired, then go to step 16.	When the sorting evolution is completed, leave the crowder leaf fully lowered at the west end of the trap.
16	Shut down the False Weir as follows: Close V-3 Close V-32 or consider leaving it as is. If closed, open gate G-13 If closed, open V-4. If ON, turn the False Weir Pump OFF	
17	If desired, turn the Air Compressor and refrigerated drier OFF.	
	Transferring Fish	
1	Start the Truck Fill System as follows (See Figure 4-1): • Verify that Truck Fill hydrants are closed. • Verify that valve V-21 is open. • At the Truck Fill Pump, verify that: o Valve V-31 is closed o Discharge vent connection is plugged o Valves V-24, 28, & 30 are open o The discharge pressure gauge isolation stop is open. • Start the truck fill pump and monitor system performance. • Close valve V-21 • Attach a truck filling hose to the appropriate hydrant and fill the transfer tank. • Make adjustments as required.	
2	Verify that a transfer truck is in place, filled, and ready to receive fish.	
3	Position a lift hopper over the desired tank lift hopper well and lower it into the fill position.	Prior to lowering the hopper, verify that it's fish transfer hatch and water transfer valve are shut.
4	Open the appropriate Holding Tank Secondary Supply Valve V-9, 10, 11, or 12.	
5	Raise the separation screen and/or crowder leaf.	**CAUTION** Ensure a lift hopper is positioned in the lift hopper well prior to raising the separation screen or crowder leaf.
6	With the crowder leaf raised, move the crowder to the south end of the tank, lower the leaf and move it to the north end of the tank to crowd fish into the hopper.	
7	Raise the hopper and position it over the transfer tank. Refer to Figure 3-4.	**CAUTION** Never raise a lift hopper from the lift hopper well without the separation screen or crowder leaf in place. When the lift hopper is not in the well, the separation screen or crowder leaf remains in place.

Step	Description	Note
8	Open the Water Transfer Valve and Vent Valve to fill the void between the hopper water and the transfer tank water surface.	This is required to setup for a *water-to-water* fish transfer.
9	When water flows through the Vent Valve, close the Vent Valve and Water Transfer Valve, open the Fish Transfer Hatch, and partially open the Transfer Tank Drain Valve to transfer fish from the hopper into the transfer tank.	Use the transfer tank drain valve to control the water flow rate out of the fish hopper.
10	When the transfer is complete, remove the hopper from the transfer tank, close the transfer hatch, and stow the hopper for future use.	
11	Repeat steps 3 through 10 to transfer additional fish.	
12	When the lift hopper is not in the tank the Holding Tank Secondary Supply Valve V-9, 10, 11, or 12 may be closed.	

4.1.3 Shutdown Procedures

Purpose

Shutdown and drain the facility for an extended period of time and make it ready for a future startup.

Prerequisites

Disable the *Low Level* and *No Flow* alarm circuits unless it is desired to check their operation during the drain-down process.

Procedures

Table 4-4 lists a set of steps that can be followed to shutdown and drain the facility and prepare it for a future startup.

Table 4-4. A set of recommended shutdown procedures.

Step	Description	Note
1	Turn all pumps OFF.	False Weir Pump Spray System Pump Truck Fill System Pump
2	Close gate G-11.	
3	Open gate G-12.	
4	Open gate G-13.	
5	Open Fish Trap Upwell Drain Valve V-15.	
6	Open False Weir Supply Drain Valve V-50.	
7	Open False Weir Supply Valve V-3.	
8	Open Sorting Flume Supply Screen Flow Control Valve V-4.	
9	Open Holding Tank Supply Valves, V-5 through V-12.	
10	Open Holding Tank Emergency Fish Return Gates G-14 through G-17.	The holding tank upwells should drain to the corresponding lift hopper wells. Clear the drain as necessary.
11	Remove stoplogs from the Trap and Tank Water Level Control Sumps.	

Step	Description	Note
12	Shift Spray System Supply Valves V-16 through V-20 to the closed or drain position.	
13	Open Spray System Water Supply line Drain Valve V-22.	At the spray system pump, remove the discharge line vent connection plug to vent the line. Replace the plug.
14	Open Truck Fill System Water Supply line Drain Valve V-21.	At the truck fill system pump, remove the discharge line vent connection plug to vent the line. Replace the plug.
15	Open Return To River Flume Water Supply Line Drain Valve V-49.	
16	It is recommended that facility maintenance identified in Chapter 3 be performed.	

4.2 Alternative Operating Procedures

The following alternate operating procedures (Table 4-5) can be used as desired or required:

Table 4-5. Alternate operating procedures.

Step	Description	Note
	Use Spray Pump as Truck Fill Pump	
1	Close V-29 to isolate the Spray System.	
2	Close V-28 to isolate the Truck Fill Pump.	
3	Open V-31 to cross-connect the spray pump to the truck fill system.	
4	Verify that a Truck Fill System hydrant is open.	**CAUTION** To prevent pumping into a deadhead, ensure that a Truck Fill System hydrant is open. The *No Flow Spray System* alarm circuit sensor is not functional with this procedure.
5	Start the spray pump and operate the truck fill system.	Monitor pressure on the discharge pressure gauge.
	Use Truck Fill Pump as Spray Pump	
1	Close V-30 to isolate the Truck Fill System.	
2	Close V-27 to isolate the Spray System Pump.	
3	Open V-31 to cross-connect the truck fill pump to the spray system.	
4	Start the truck fill pump and operate the spray system.	Monitor pressure on the discharge pressure gauge. (Normal pressure reading is ± xx psi.)

4.3 Emergency Procedures

The following procedures (Table 4-6) are used to release fish from the Holding Tanks under emergency conditions:

Table 4-6. Emergency fish release procedures.

Step	Description	Note
1	Remove lift hoppers and separation screens from the holding tanks.	
2	Crowd fish to the north end of the tanks.	
3	Open an Emergency Fish Return Gate G-14 through G-17, as required, to sluice fish to the river.	**CAUTION** Release only one tank at a time.
4	Repeat steps 1 through 3, as required, to release fish from other holding tanks.	

4.4 Winterization

Table 4-7 identifies recommended procedures to be performed to prepare the facility for freezing conditions.

Table 4-7. Recommended winterization procedures.

Step	Description	Note
1	Blow down the Air Compressor tank through the low point drain to remove moisture.	
2	Vent the pneumatic system components and ensure all moisture is removed to prevent damage due to freezing.	Pneumatic Control Valves (4) Exhaust Flow Control Valves (8) Pneumatic Cylinders (4)
3	Verify that all system drains are open.	Refer to Shut Down procedures in paragraph 4.1.C above.

4.5 Spill Containment

Contain spills per regulating agency and locally prepared Spill Containment Procedures.

4.6 Records Management

Maintain operational records as required by regulating agencies and best fish handling practices.

Maintain maintenance records as required by Tacoma Water and regulating agencies and recommended by equipment manufacturers.

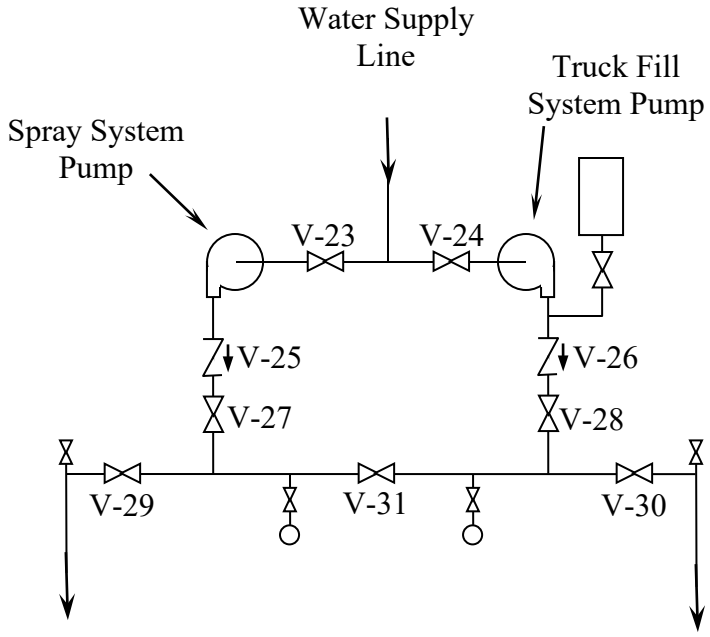

Figure 4-1 Spray System & Truck Fill System Schematic

Chapter 5. Maintenance Program

The satisfactory operation and prolonged longevity of the Green River Headworks Adult Trap and Sorting Facility is directly related to a successful preventive and corrective maintenance program. The following paragraphs address such programs.

5.1 Preventive Maintenance

It is recommended that the equipment manufacturer's preventive maintenance requirements be identified, reviewed, scheduled, and routinely accomplished by trained, qualified, and authorized personnel.

Table 5-1, repeated here for clarity and ease of use, identifies facility equipment requiring routine preventive maintenance per the manufacturer's Installation & Operation Manuals (This list should not be considered all inclusive.).

Table 5-1. ATSF equipment requiring maintenance.

Manual Gates (6)
Motorized Gate (1)
Diverter Gates (4)
Diverter Gate Actuators (4)
Pneumatic Control Valves (4)
Motorized Valves (2)
Air Compressor
Refrigerated Dehydrator
Filter Desiccant Air Dryer
Air Lubricators (4)
Trap Crowder
Tank Crowders (4)
Lift Hopper Hoists (2)
False Weir Pump
Spray System Pump
Truck Fill Pump
Unit Heaters (3)
Exhaust Fan (1)
Instrumentation Equipment (verify calibration)
Alarm Circuits (verify operation)
Electrical Distribution Equipment

In addition to performing routine equipment preventive maintenance, Table5-2, repeated here for clarity and ease of use, identifies recommended facility maintenance requirements (This list should not be considered all inclusive.):

Table 5-2. Recommended ATSF maintenance requirements.

Component	Recommended Maintenance	Periodicity
Concrete Water Holding Structures	Visually inspect for deterioration especially in area of surface finish, embeds, pipe penetrations, and grating supports.	Annually (as required)
	Clean & Disinfect	Prior to extended shutdown period
Fish Trap & Holding Tanks	Remove upwell and downwell grating and verify that wells are clean and free of debris. Verify that the holding tank upwell to lift hopper well drain is open, free of debris, and clear to drain.	Prior to extended shutdown period
Truck Fill Station trench drains	Open, inspect, and clean	Prior to startup and operational period
Valves & Gates	Exercise to verify proper performance throughout full range of operation.	Annually
Crowders	Exercise throughout full range of operation.	As part of startup prior to operational period
Lift Hopper Transfer System	Exercise throughout full range of operation.	As part of startup prior to operational period

5.2 Corrective Maintenance

All corrective maintenance should be accomplished by trained, qualified, and authorized personnel in accordance with the manufacturer's Maintenance Manuals.

Facility	Intake Structure	Tunnel No. 1	Settling Basin	Fish Screen Structure	Plunge Pool
# of Basins	1	1	1	1	1
Water Depth (Ft)	18	8	16	15	9.25
Width (Ft)	20	10	28	27	5
Length (Ft)	43	125	85	120	25.67
Gal/Ft/Basin	6,433	9,351	17,804	24,237	960
Gal/Basin	115,798	74,805	284,858	363,553	8,880
Gal Total	115,798	74,805	284,858	363,553	8,880
Intake Dwg #	S-308	-	S-403	S-501	S-520, S-524
TW Dwg #	15-98-51	13-1-1	15-98-67	15-98-80	15-98-90, -94

Facility	Fish Ladder Pools	Water Control Structure	Fish Trap	Holding Tanks
# of Basins	18	1	1	4
Water Depth (Ft)	13	8.75	8	3
Width (Ft)	8	12	8	6
Length (Ft)	10	18	30	16
Gal/Ft/Basin	598	1,616	1,795	718
Gal/Basin	7,780	14,138	14,363	2,154
Gal Total	140,035	14,138	14,363	8,618
Intake Dwg #	S-533	C-600, S-603	A-600	A-600, S-611
TW Dwg #	15-99-03	15-99-08, -17	15-99-10	15-99-10, -25

Total Intake Volume (Gal): 1,025,049

Assumed Water Surface at Intake (ft): 902

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Executive Summary

The Green River Headworks Project (the "Project") is a water diversion and fish handling facility owned and operated by Tacoma Water. The Project has been providing drinking water for the City of Tacoma since 1913. It is located 3.5 miles downstream of the U.S. Army Corps of Engineers (USACE) Howard Hanson Dam (HHD). Water is diverted upstream of the Green River Headworks Diversion Dam, through trash racks, a sediment settling basin, and eventually into the fish screening basin. The fish screens were installed in 2004 in anticipation of the reintroduction of salmon and steelhead upstream of Howard Hanson Dam. Since that time, numerous improvements have been made to the facilities; however, construction of a new treatment facility for the Green River supply requires increased reliability and changes to historical operations to allow the facility to divert water when river turbidity and debris loading is high.

Headworks improvements, completed in 2014, included replacement of the screen brush cleaner system, installation of a hydraulic vane array in the settling basin to improve sediment removal, installation of a water jet sparger system upstream of the fish screens to prevent accumulations of sediment, a sediment eductor system downstream of the fish screen to remove sediment, and other miscellaneous improvements.

The purpose of the work described in this report was to hydraulically balance the distribution of flow through the fish screens to facilitate efficiency of the screen cleaning systems and remove high velocity areas that will collect debris and possibly injure fish passing through the facility. The flow distribution resulting from the hydraulic balancing work was compared to applicable National Marine Fisheries Service (NMFS) criteria for hydraulic performance of screens used to exclude anadromous juvenile fish.

The target diversion flow rate is 450 cfs (425 cfs of screened flow with 25 cfs over the downstream fish return weir). Meeting this condition requires a HHD discharge of 470 cfs in order to meet instream flow requirements below the diversion dam. The target diversion flow rate was achieved in late October of 2014, during a period of heavy rain and significant spill at HHD. Phase I measurements were conducted with the target diversion flow and included mapping the distribution of flow entering the screening basin and determination of a single surrogate velocity for subsequent monitoring of the flow entering the fish screen basin. Heavy debris in the river interfered with attempts to collect data along the screen in Phase II, thus the evaluation was delayed until late March of 2015. The second phase of measurements included collecting direct measurement of screen approach and sweeping velocity components (hereafter termed approach and sweeping velocities), using an Acoustic Doppler Velocimeter (ADV), and accompanying water surface elevation measurements. Diversion flow rates during the second phase ranged between 226 and 241 cfs.

Based on the measurement results, the approach velocities at the design flow are expected to exceed the NMFS criterion maximum of 0.44 fps (an average of 0.40 fps plus an allowable 10% spatial variation) at 7 of 56 (12.5%) of the measurement positions. The approach velocities near the downstream end of the fish screen will always be higher than the average due to the

proximity of this region of the screen to gate G6, the main flow withdrawal from the basin, and the inability of the existing screen baffle system to redistribute the flow. Further attempts to balance the screen flow distribution with the existing baffle system are not recommended.

Sweeping velocities meet the criterion of being higher than approach velocities. The velocity gradient through the screen channel occasionally exceeds the 0.2 fps/ft criterion. Fish transported at the fish screen channel velocities will be exposed to the screens for approximately 47 seconds at 210 cfs and 28 seconds at the design flow, meeting the maximum exposure time criterion of 60 seconds.

1.0 Introduction

The Green River Headworks Project is a water diversion and fish handling facility owned and operated by Tacoma Water. The Project has been providing drinking water for the City of Tacoma since 1913. It is located 3.5 miles downstream of the U.S. Army Corps of Engineers (USACE) Howard Hanson Dam (HHD). Water is diverted upstream of the Green River Headworks Diversion Dam, through trash racks, a sediment settling basin, and eventually into the fish screening basin. The fish screens were installed in 2004 in anticipation of the reintroduction of salmon and steelhead upstream of Howard Hanson Dam. Since that time, numerous improvements have been made to the facilities; however, construction of a new treatment facility for the Green River supply requires increased reliability and changes to historical operations to allow the facility to divert when river turbidity and debris loading is high.

Headworks improvements, completed in 2014, included replacement of the screen brush cleaner system, installation of a hydraulic vane array in the settling basin to improve sediment removal, installation of a water jet sparger system upstream of the fish screens to prevent accumulations of sediment, a sediment eductor system downstream of the fish screen to remove sediment, and other miscellaneous improvements.

The purpose of the work described in this report was to hydraulically balance the distribution of flow distribution through the fish screens to facilitate efficiency of the screen cleaning systems and remove high velocity areas that will collect debris and possibly injure fish passing through the facility. The flow distribution resulting from the hydraulic balancing work was compared to applicable National Marine Fisheries Service (NMFS) criteria for hydraulic performance of screens used to exclude anadromous juvenile fish. This work also satisfies the requirements of the Habitat Conservation Plan (HCP) for Compliance Monitoring Measure No. 5 (CMM-05) which requires:

"An evaluation of the hydraulic conditions at the completed project will be made over the range of flows expected during downstream migration……"

1.1 Objectives

The hydraulic evaluation of the fish screens included:

- recording velocities within the fish screen basin ;
- adjusting screen baffles to balance the flow between screen panels; and
- documenting final screen approach and sweeping components (hereafter termed approach and sweeping velocities) along with detailed water surface elevation measurements.

2.0 Facility Information and Criteria

2.1 Project Facilities

The Project facilities consist of the Headworks Diversion Dam, intake structure, settling basin, fish screen structure, auxiliary travelling water screen and bypass pipeline, juvenile fish bypass, fish ladder, fish trap and sort facility, and pipelines that transmit the screened water to a spill chamber and treatment facilities. See Photo 1 below.

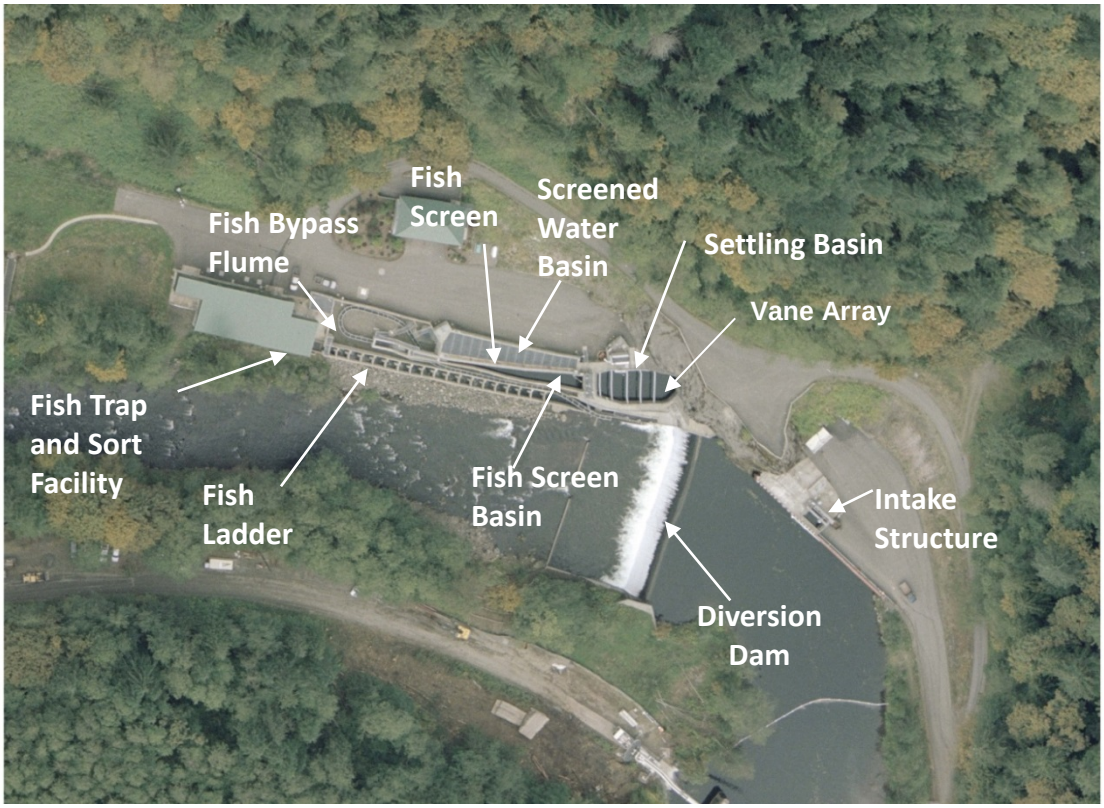

Photo 1 Aerial view showing the intake structure and fish handling facilities

Flow through the facility and the flow control devices are shown on the schematic in Figure 1. From the river intake, flow passes underground (Tunnel 1) to the settling basin and into the fish screen basin. Flow in the fish screen basin either passes through the fish screens into the screened water basin or it is conveyed downstream to the fish return (bypass) which is regulated by control weir gate G7. The fish screen basin can be isolated from the settling basin by gate (G5). This gate is normally full open.

On the downstream side of the screens, water exits the screened water basin from four outlets. The majority of the flow passes through Gate G6 to the pipelines and treatment facility. The other three outlets supply water to the holding facility and fish ladder when they are in operation.

Valve G11 controls flow to the water control structure that supplies the Fish Trap and Sorting Facility. Valves V1 and V2 supply operating water for the fish ladder.

The design capacities (based on Green River Headworks Project, Fisheries Design Criteria, Summit Technologies, 1997) for each outlet are as follows:

Water Supply Pipeline (Gate G6)	290 cfs
Upper Fish Ladder (Valve V1)	25 cfs
Lower Fish Ladder, Attraction (Valve V2)	75 cfs
Trap and Sorting Facility (Valve G11)	35 cfs
Fish Bypass Flume (Gate G7)	25 cfs
Total Fish Screen Basin Flow	**450 cfs**
Screened Water Basin Flow (Fish Screen Basin Flow – G7)	425 cfs

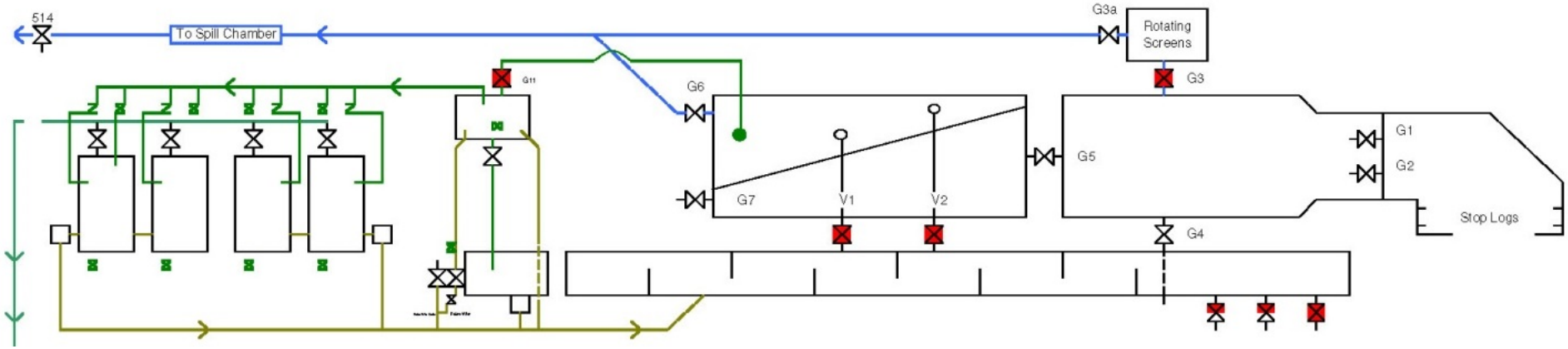

Figure 1 Flow Schematic for the Headworks Facilities

Figure 2 Green River Headworks Fish Screens

2.1.1 Fish Screens

The fish screen basin is shown in Photo 2. The screen structure contains fourteen screens, all located on one side of the basin. The screens are comprised of eleven 13-ft high screens, one 8-ft high screen, and two 4-ft high screens, totaling 1,272 square feet of screening area when fully wetted (MWH, 2015b) (see Figure 2, Photo 3, and Photo 4). Water passing through the fish screens enters the screened water basin. The wedge wire screens have 1.75 mm openings and are designed to pass a maximum of 450 cfs and still meet the 0.4 feet per second approach velocity criterion (NMFS, 1995).

Adjustable baffles are located just downstream of the fish screens in the screened water basin to enable flow balancing to achieve a uniform approach velocity to meet NMFS criteria. Individual baffle vanes are one-piece and extend the full height of the screens (Photo 5). The baffle vanes are adjusted by moving a handle pinned to the baffles. The handle is placed between slots at 22.5-degree increments (see Photo 6).

A mechanical brush cleaner mounted to a rail located above the fish screens cleans the entire screen surface. The brush can be operated manually, at timed intervals, or based on head differential between the upstream/downstream sides of the screens.

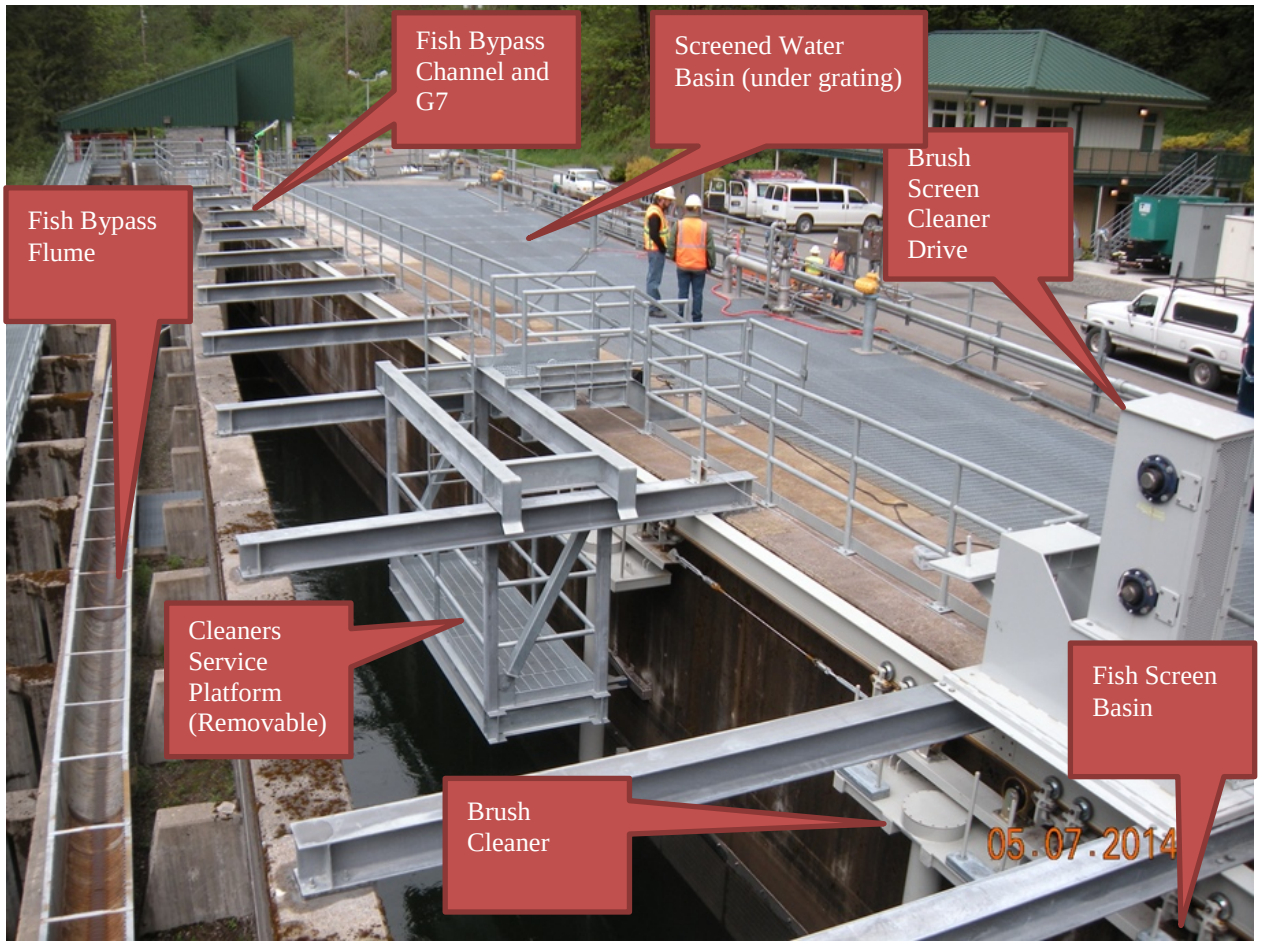

Photo 2 Overview of Fish Screen Basin

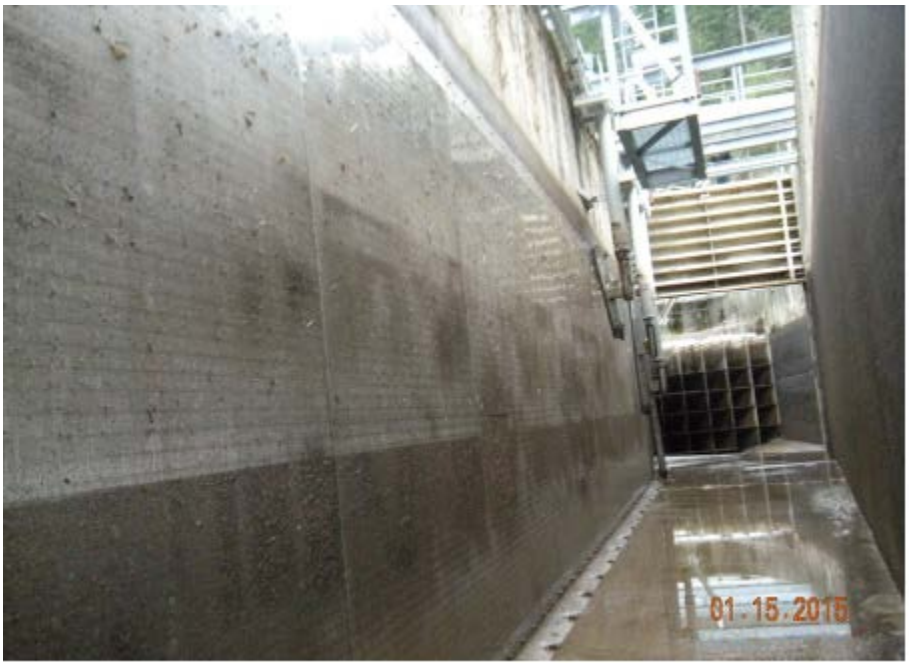

Photo 3 Screens 1-8, Looking Upstream

Photo 4 Screens 7-13 (*14 not visible*), Looking Downstream

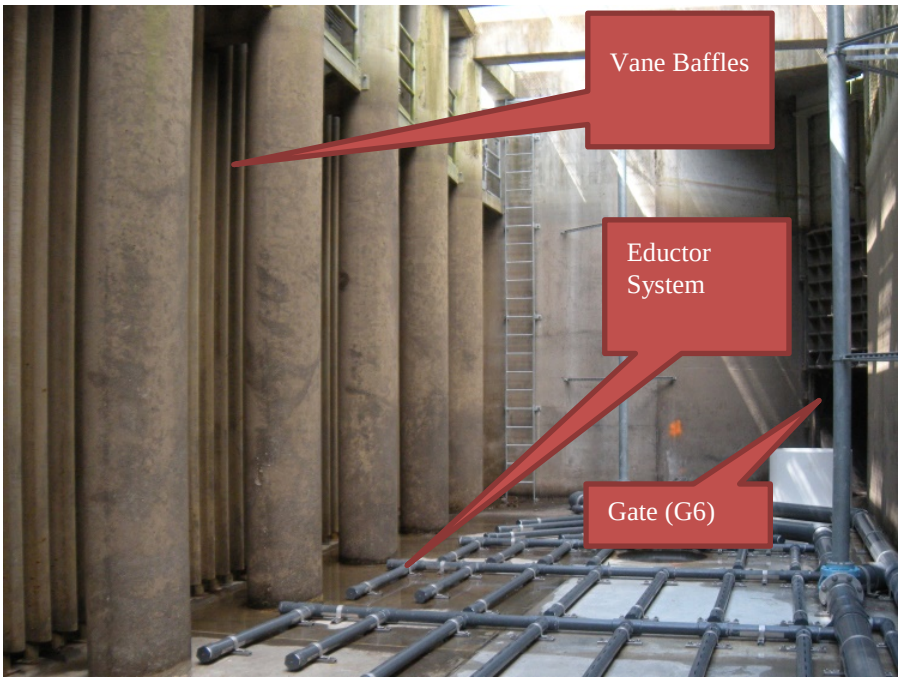

Photo 5 Vane Baffles

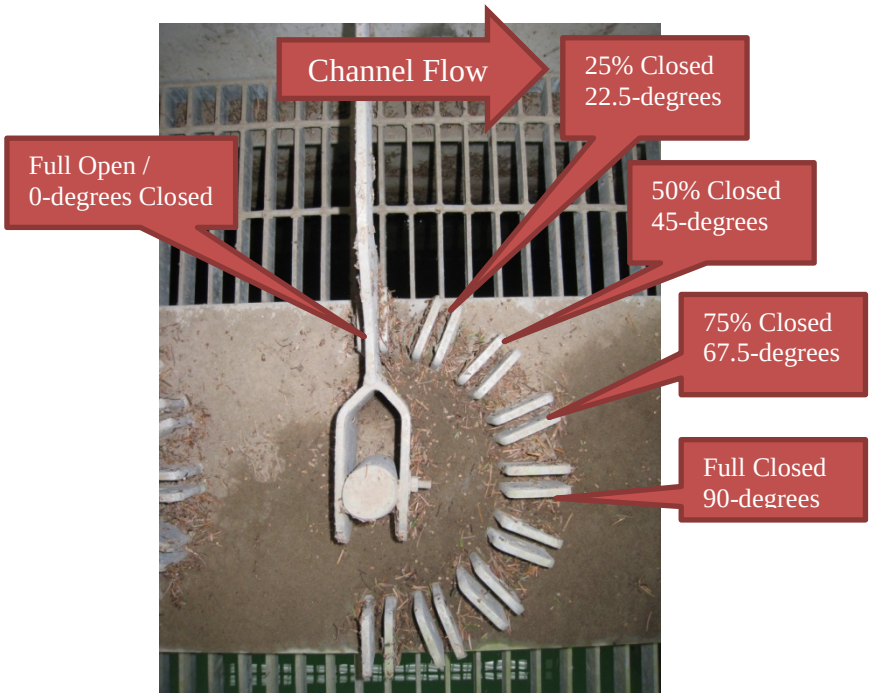

Photo 6 Vane Baffle Adjustment Mechanism

2.2 Hydraulic Criteria

In specifying post construction evaluations, NOAA Fisheries states, "Hydraulic evaluations of juvenile fish screen facilities must include confirmation of uniform approach velocity, V_a, and the requisite sweeping velocity, V_s, over the entire screen face. The approach velocity is the velocity component perpendicular to the screen face calculated by dividing the maximum screened flow by the effective screen area. Uniform approach velocity is achieved when no individual approach velocity measurement exceeds 110 percent of the criterion (0.44 fps). In addition, velocities at the entrance to the bypass, bypass flow amounts, and total flow should be measured and reported." (NMFS, 2011).

Table 1 NOAA Fisheries Hydraulic Criteria (1995 &2011)

Parameter	Criterion
Approach Velocity (V_a) *[component normal to screen face]*	V_a < 0.40 ft/s for actively cleaned screens
Uniform Flow	Point Velocities <Va +10%
Sweeping Velocity (V_S) *[component parallel to screen face]*	$V_s > V_a$
Exposure Time (t)	$t \leq 60$ s
Sweeping velocity gradients (dV_s/dx)(prior to capture)	$0.0 \leq dV_s/dx \leq 0.2$ fps/ft

3.0 Methods and Approach

3.1 Instrumentation and Data Acquisition

Three-dimensional point velocity data (orthogonal V_x, V_y, and V_z velocity vector components) were collected using three Acoustic Doppler Velocimeters (ADVs). The ADVs were used for determining the flow through the first cross-sectional transect of the fish screen basin (Phase I) and for measurement of sweeping (V_s) and approach (V_a) velocities at the screen face (Phase II). An ADV probe with cable and connector is shown in Photo 7. The accuracy of the ADV is 1-percent of the full scale resultant velocity, depending on water quality, velocity range, and electronic noise. Another contributor to measurement accuracy is the precision of the orientation deployment of the ADV with respect to the screen structure. Care was taken to orient the probe within 1-degree of the desired orientation by utilizing an acrylic block which was calibrated for rotation with respect to the probe's axis. Influences of flow induced drag on deployment hardware, however, increase the measurement uncertainty. Rotation of the aluminum deployment stanchion was noticed during deployment as is discussed further in Section 4.0.

Diversion flow was measured by collecting velocities at several locations across a lateral transect upstream of the first fish screen panel. The average of the collected velocities was multiplied the cross sectional area of the flow. At the upstream transect, the probe was oriented such that the x and y-components of velocity were oriented at 45-degrees from the centerline of the channel (Photo 8 and Photo 9). Measurements were collected at 20 points, each representative of 5% of the flow area. From these measurements, a surrogate (representative) point was established. Subsequent measurements of incoming flow were determined by monitoring this single surrogate measurement location.

Measurements along the fish screen face were conducted such that the z-component of velocity was a direct measure of the approach velocity and the resultant of the x and y-components provided the sweeping velocity (Photo 10 and Photo 11). Measurements were collected approximately 2-inches from the screen face and at 2-foot increments along the screen length. Velocities were measured at Screen panels 1-12 at 0.25 and 0.75 times the depth of the screen. At screen panels 13 and 14 measurements were planned for mid-depth of the screen panels.

Water levels were measured by hand with an electronic water level indicator (depth probe – see Photo 12). Measurements were made along the length of the channel in front of the screens and behind the vane baffles. The water level indicator has a graduated resolution of 0.01 ft (0.12-inches). Measurement uncertainty is related to the consistency of datums used for reference. Water levels at the upstream face of the screens were referenced to the top of the screen cleaner's monorail (Photo 13), which was assumed to be Elevation 911.09 ft. (1 1/8" above the deck Elevation of 911 ft.). Water levels behind the screens and baffles were referenced to the top of grating elements (Photo 14), assumed to be at Elevation 911.00 ft. A six foot long level was used to confirm that both the monorail and deck were level along the length of screens. The grating was less reliable as a flat surface, due to its fabrication and installation method; however, repeat

measurements at slightly different locations determined the approximate maximum error to be ± 0.01 ft.

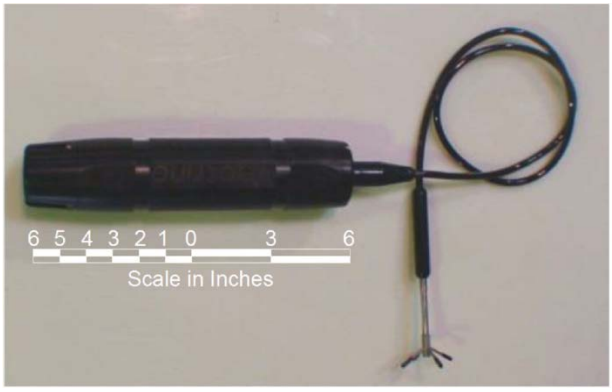

Photo 7 Nortek Vectrino ADV

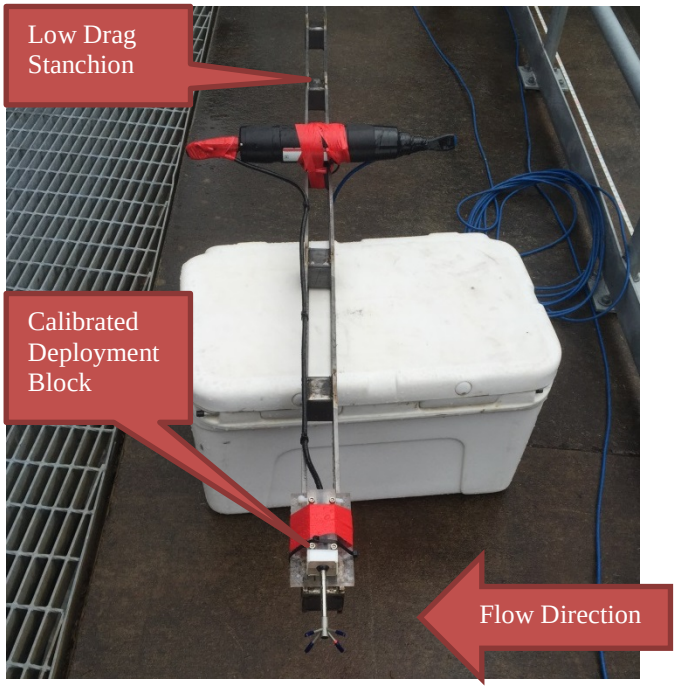

Photo 8 First Transect ADV Deployment Apparatus

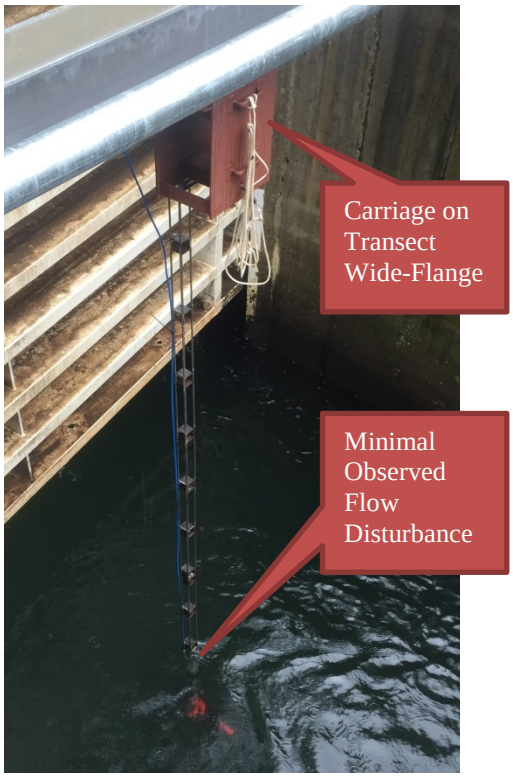

Photo 9 Deployment of ADV at First Transect

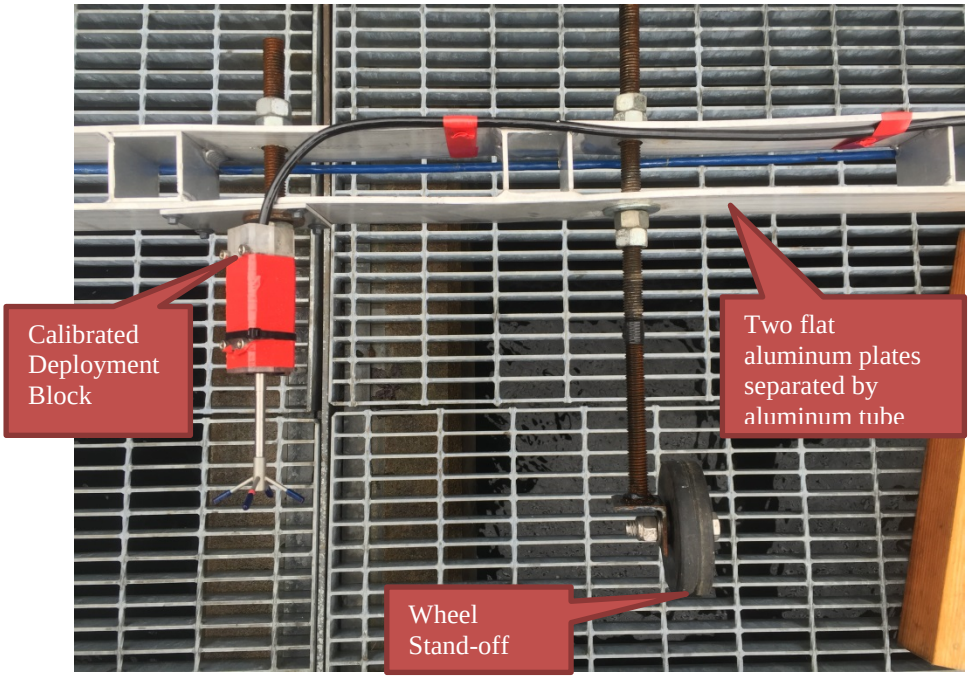

Photo 10 Screen Velocity ADV Deployment Apparatus

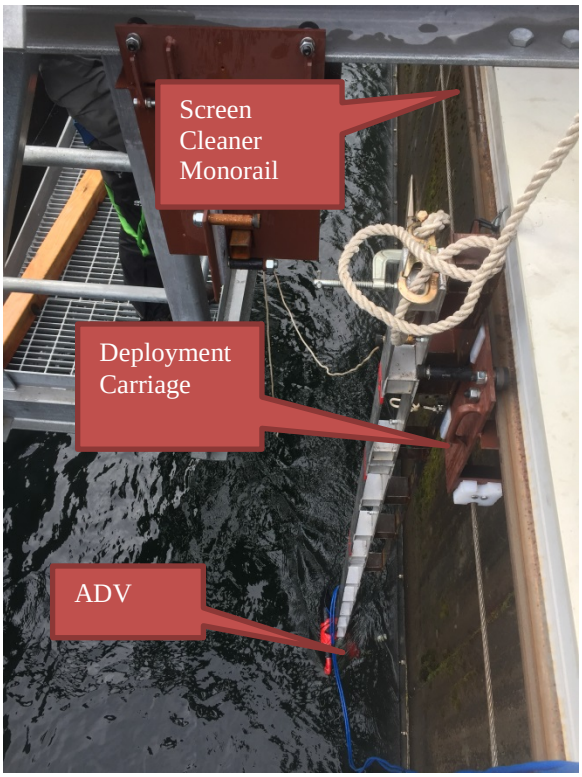

Photo 11 ADV Deployment Along the Screen Face

Photo 12 Water Level Indicator

Photo 13 Water Level Measurements in the Channel

Photo 14 Water Level Measurements Behind the Vane Baffles

3.2 Flow Management

To meet the Habitat Conservation Plan (HCP) requirements, the evaluation was performed during periods of maximum available diversion. Diverted flow rates through the screens were maintained at a relatively steady rate during field operation hours (08:00 to 18:00) so the measurements made each day should correlate to the same approximate diversion flow rate. The target diversion flow rate is 450 cfs (425 cfs of screened flow with 25 cfs over the downstream fish return weir). Meeting this condition requires a minimum HHD discharge of 470 cfs such that approximately 200 cfs would remain at the base of dam to protect any chinook redds in the downstream reach below the diversion (MWH and Alden 2014).

3.3 Debris Management

The fish screens are equipped with three traveling brush-type screen cleaners, which are operated by a Programmable Logic Controller (PLC) either on a timer or a continuous basis. For the duration of the field measurements, the screen cleaners were locked-out for safety reasons. The screen water level differential was monitored at the control room and Tacoma Water's Duty Operator notified Alden of increasing water level differentials to allow planning for safe removal of instrumentation and re-activation of the screen cleaners. Alden also utilized velocity and water level measurements to monitor debris loading on the screens.

Normal operations included running the screen cleaners on a continuous basis for several cycles prior to and after measurements were made.

4.0 Results

4.1 Flow Rates and Field Deployments

Phase I measurements were conducted between October 27th and 28th, 2014 during a period of heavy rain and significant spill at HHD. The incoming flow from HHD was approximately 1,920 cfs – well above the targeted minimum. Approximately 400 cfs was drawn into the fish screen basin by modulating gate G6 to 56% open. Excessive debris loading necessitated screen cleaning every 45 minutes, too frequently to allow screen velocity measurement and balancing operations to take place. Photo 15 shows bigleaf maple debris typical of that experienced during the October 2014 deployment. The next available period for continuation of hydraulic evaluation was in late March[1]. Phase II measurements were conducted between March 24th and March 27th of 2015. The flow and hydraulic conditions for Phase I and the final day of Phase II deployments are presented in Table 2.

The surrogate velocity location was determined from 20 velocity measurements collected at the first (most upstream) transect (Figure 2). The transect was divided into 20 cells, each constituting 5 % of the flow area and velocities were measured at the center of each cell. Table 3 presents the measured channel velocities and illustrates that, as expected, a larger proportion of flow is oriented near the surface. Flow is skewed towards the south (near the river). The table is color-coded to show velocities higher than the average in red and lower than the average in blue, and the color green representing velocities near the average. The color coding illustrates that a single surrogate velocity measurement taken along the centerline of the channel and near the 6/10th depth will be representative of the average velocity on the transect. A single velocity measurement in this location, projected over the entire flow area of the transect will track the incoming flow within an accuracy of ±10%.

Using the surrogate established in Phase I, the average incoming flow during the March deployment was determined to be approximately 230 cfs. The final approach and sweeping velocities were recorded on March 27th at a flow of 235 cfs (Table 2) with gate G6 98% open.

[1] During the period between hydraulic evaluation deployments Tacoma Water required all personnel to support the plant start-up of the new water treatment plant. In addition, it was discovered that screen cleaners were not functioning properly, requiring vendor support adjust the brush mechanism (MWH, 2015a).

Table 2 Flow Total Flow Rates and Water Levels

Date	Flow below HHD (cfs)	Flow approaching Screens (cfs)	Flow over Dam (cfs)	WSEL at Dam (ft)	WSEL at Screens (ft)	Gate G6 Position
27-October, 2014	1,920	400	1,521	903.40	901.23	56% Open
27-March, 2015	507	235	272	901.91	900.72	98% Open

Photo 15 Bigleaf Maple Debris Loading on an ADV

Table 3 Channel Velocity Heat Map

% of Full Depth	Velocity (fps)			
10%	1.88	2.37	2.93	2.62
30%	1.69	2.10	2.62	2.36
50%	1.73	2.04	2.37	1.93
70%	1.76	2.13	1.97	1.77
90%	1.81	1.73	1.67	1.64
% of Full Width	13%	38%	63%	88%

4.2 Approach and Sweeping Velocity Corrections

Baseline measurements of approach and sweeping velocity were recorded with all the baffles in their full-open position during Phase II. The incoming flow determined from the surrogate velocity measurement was 226 cfs (201 cfs passing through the fish screens and 25 cfs passing over the weir) at a water level of 900.69 ft. At this water level, approximately 1238 square feet of screen is wetted, resulting in an average approach velocity of 0.16 fps (201 cfs / 1238 sq. ft.). The average approach velocity actually recorded was 0.60 fps, indicating a large source of error in the measurement. At 0.60 fps, the fish basin would have been experiencing 743 cfs, which is greater than the discharge released from Howard Hanson Dam and in the reach of river upstream of the intake.

During the measurements, instrument settings were adjusted to assure the best possible measurement was being recorded. The velocity range was set to ±1.0 m/s (3.28 fps), which is appropriate for the range of expected sweeping flows. The transmit length and sample volume parameters were adjusted to achieve the best possible signal-to-noise (SNR) level and correlation percentage. The SNR was between 8-15 decibels (10 decibels indicates a signal level 3-times greater than the noise level and is considered a good measurement SNR). The correlation percentage was between 60-95 percent (mostly near 90-percent), where a minimal percentage of 50-percent is acceptable.

A more likely source of error was an angular rotation (σ) in the deployment stanchion, resulting in the Vz-component of velocity (intending to record only the approach velocity) recording components of both the approach velocity and a portion of the sweeping velocity (Figure 3). The probable cumulative sources of this angular rotation error emanate from the need to clamp the stanchion to the traversing carriage (refer to Photo 11), the ability of the traversing carriage to rotate with respect to the monorail, and any twist in the stanchion resulting from flow-induced drag. An approximate cumulative rotational error in deployment of 15-degrees would account for the approach velocities recorded.

Velocities presented below have been scaled such that recorded trends in the data remain, but the screen averages for approach and sweeping velocity match the target averages determined through the continuity equation (Equation 1) and the recorded resultant vector (Equation 2).

$$Va = {(Q_{in} - 25)}/{A_{wetted}} \quad \text{(Eqn. 1)}$$

Where:

Q_{in} = flow entering the fish screen basin (cfs)

A_{wetted} = wetted area of screen (ft^2)

Va = approach velocity (fps)

$$V_s = (V_r{}^2 - Va^2) \quad \text{(Eqn. 2)}$$

Where:

V_r = the recorded resultant velocity (fps)

V_s = the sweeping velocity (fps)

Va = approach velocity (fps)

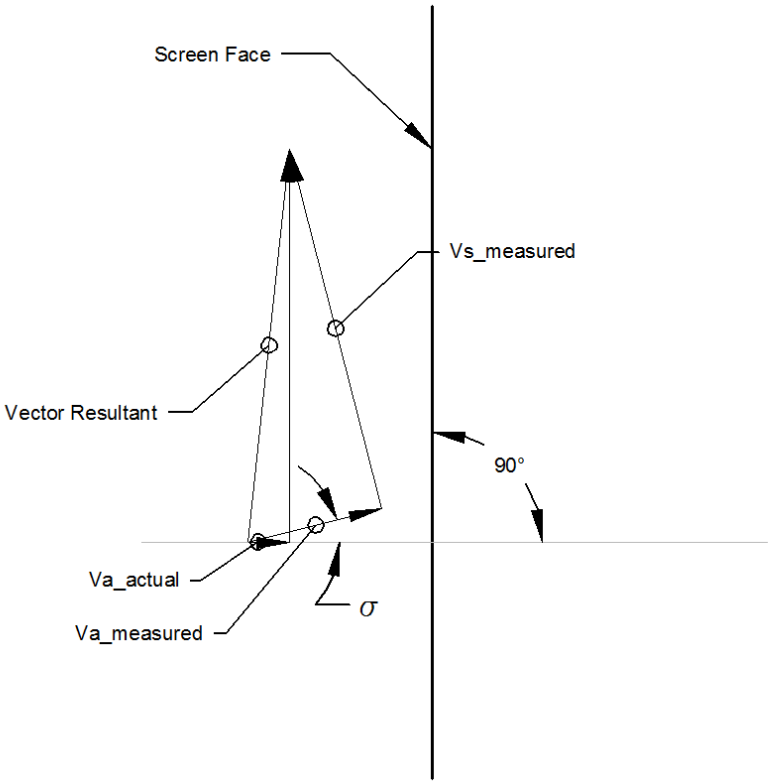

Figure 3 Approach and Sweeping Velocity Correction

4.3 Baseline Approach and Sweeping Velocities

The baseline condition was evaluated on March 25th, 2015 with 226 cfs entering the fish screen basin (201 cfs passing through the screens) at an upstream Water Surface Elevation (WSEL) of 900.69 ft. The top of the screens is located at Elevation 901.00 ft, resulting in approximately 1,238 square feet of wetted screen surface.

The baffle vanes were all oriented 90-degrees to the screen face, in their most open position.

Data were successfully recorded according to the plan with exception of the last 10 data points (or the final 20 feet of screen). These data were not collected as equipment changes and a required screen cleaning would have prolonged collection activities beyond safe working hours. Questions about the recorded approach velocity magnitudes also influenced the decision to make-do with the information collected. *Subsequent balancing activities did not include velocity data collection as will be discussed in Section 4.4.* Prior to data adjustment, linearly extrapolated values were substituted for the missing and spurious data points. The approach and sweeping velocities presented in this report were adjusted using the procedure described in Section 4.2.

Approach velocities were lower than average at upstream screen positions and increased in the downstream direction (Figure 4). This result was logical given the location of the main flow withdrawal through gate G6 (also at the downstream end of the screens – see Figure 2 and Photo 5). Average approach velocity for the top probe, Va_top, bottom probe, Va_bot, and both (depth averaged, Va_depth) with their respective coefficients of variation are presented in Table 4.

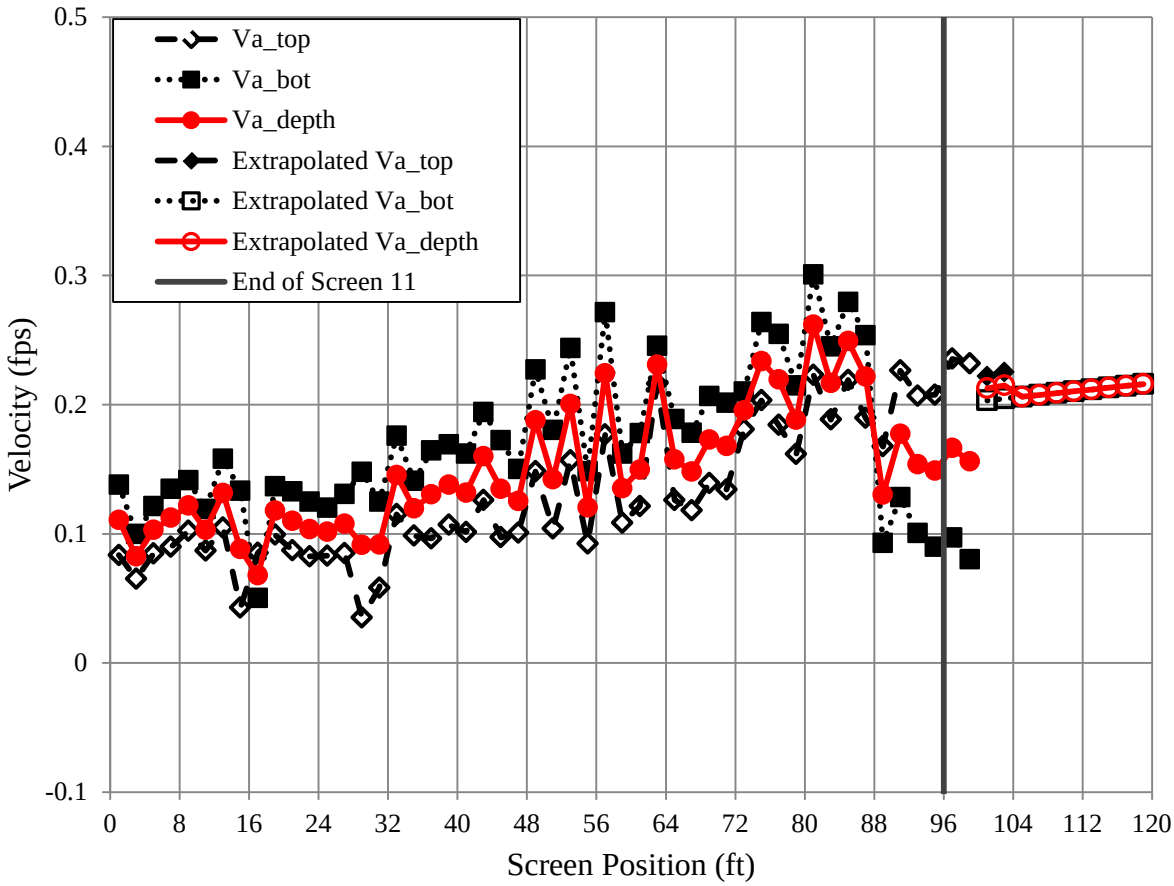

Figure 4 Baseline Approach Velocities (Q = 201 cfs)

Table 4 Baseline Approach Velocity Averages (Q = 201 cfs)

Position	Va (fps)	*Cv*%
Top	0.14	42%
Bottom	0.17	31%
Depth Avg.	0.16	31%

Sweeping velocities for the baseline measurements also generally increased in the downstream direction (Figure 5). Average sweeping velocity for the top probe, bottom probe, and an average of both (depth averaged) with their respective coefficient of variation (*Cv*), expressed as a percentage, are presented in Table 5.

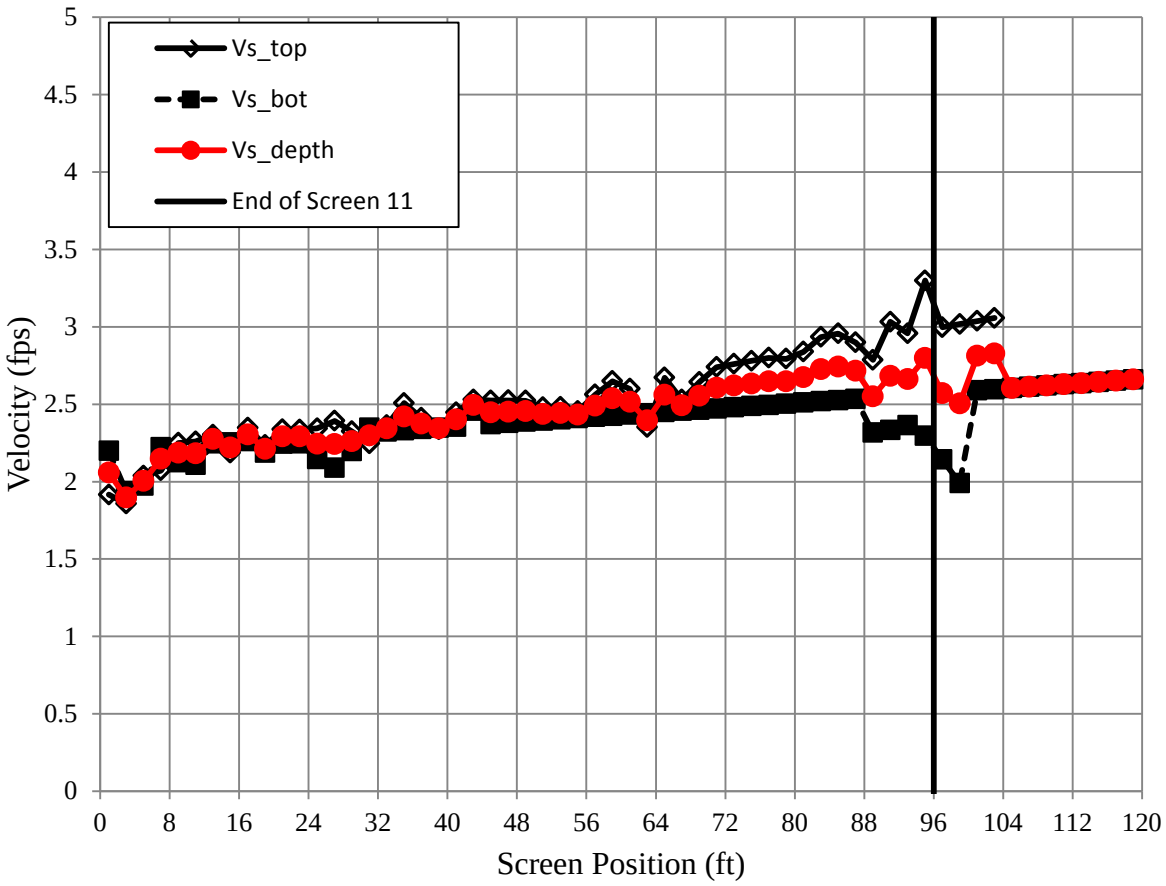

Figure 5 Baseline Sweeping Velocities (Q = 201 cfs)

Table 5 Baseline Sweeping Velocity Averages (Q = 201 cfs)

Position	Vs (fps)	*Cv*%
Top	2.61	12%
Bottom	2.50	12%
Depth Avg.	2.56	10%

Visual observations confirmed the lack of flow passing through the upstream screens as compared to the amount of flow passing through the downstream screens, near gate G6. This trend was confirmed with headloss data, which clearly indicated an increase in the water surface differential across the screen/baffle panels at the downstream end of the screen channel.

The headloss, dH, across the screen/baffle panels can be expressed a function of the approach velocity head and a dimensionless loss coefficient, k, that varies with the geometry of the screen/baffle panel and support structures:

$$dH=k(\frac{V_a{}^2}{2g}) \quad \text{(Eqn. 3)}$$

Where:

dH = head loss (ft)

Va = approach velocity (fps)

g = gravitational constant (32.2 ft/s^2)

k = dimensionless head loss coefficient

The measured headloss, presented in Table 6, confirms that approach velocities increased with distance downstream along the screen. The headloss data also indicate a zone of low flow passing through screens 3-6.

Table 6 Baseline Water Surface Measurements & Estimated Va (k = 87)

Screen Position	U/S Freeboard	D/S Freeboard	dH	Estimated Va	Baffle
#	(ft)	(ft)	(ft)	(fps)	° of Closure
Beginning of 1	10.40	10.43	0.03	0.16	0
1/2	10.39	10.42	0.03	0.16	0
2/3	10.40	10.41	0.01	0.10	0
3/4	10.39	10.40	0.01	0.10	0
4/5	10.40	10.41	0.01	0.10	0
5/6	10.40	10.41	0.01	0.10	0
6/7	10.41	10.43	0.02	0.13	0
7/8	10.41	10.45	0.04	0.18	0
8/9	10.42	10.45	0.03	0.16	0
9/10	10.42	10.46	0.04	0.18	0
10/11	10.42	10.46	0.04	0.18	0
11/12	10.41	10.46	0.05	0.20	0
12/13	10.41	10.46	0.05	0.20	0
13/14	10.41	10.46	0.05	0.20	0
End of 14	10.40	10.48	0.08	0.25	0

Headloss data were subsequently used to guide changes in baffle vane adjustments to balance the screens.

4.4 Baffle Vane Adjustments for Balancing

A series of test were performed to determine the variation of k-values with baffle vane position by setting all baffle vanes to the same position for each test. Tests were performed with all baffles set to 67.5-degrees, 45-degrees, and 22.5-degrees of closure (refer to Photo 6). The k-values determined from the application of Equation 3 to the headloss data from these tests were used to guide subsequent baffle adjustments.

The first test was conducted by closing all of the baffles to 67.5-degrees closed. The results from this experiment indicated that the zone of low flow passing through screens 3-6 was still present (Table 7).

Table 7 Baffle Vanes at 67.5-degrees closed; Headloss and Estimated Va (k=196)

Screen Position	U/S Freeboard	D/S Freeboard	dH	Estimated Va	Baffle
#	(ft)	(ft)	(ft)	(fps)	° of Closure
Beginning of 1	10.31	10.37	0.06	0.14	67.5
1/2	10.32	10.37	0.05	0.13	67.5
2/3	10.33	10.38	0.05	0.13	67.5
3/4	10.34	10.36	0.02	0.09	67.5
4/5	10.35	10.37	0.02	0.09	67.5
5/6	10.33	10.35	0.02	0.09	67.5
6/7	10.32	10.36	0.04	0.12	67.5
7/8	10.33	10.39	0.06	0.14	67.5
8/9	10.34	10.43	0.09	0.18	67.5
9/10	10.34	10.44	0.10	0.18	67.5
10/11	10.34	10.48	0.14	0.22	67.5
11/12	10.35	10.48	0.13	0.21	67.5
12/3	10.35	10.48	0.13	0.21	67.5
13/4	10.34	10.49	0.15	0.22	67.5
End of 14	10.33	10.50	0.17	0.24	67.5

The k-value determination tests were interrupted by a test attempting to increase flow through screens 3-6 by opening the baffles behind them to their full open position and closing the baffles behind screens 10-14 to 90-degrees closed. Even at 90-degrees of closure with the vane parallel to the screen and perpendicular to the flow, there are gaps between vanes allowing the passage of flow. **This test was aborted prior to data collection because a resonant vibration, which shook the entire steel grating walkway attached to the vane structure behind the screens, occurred during closure of the downstream screen baffles.** Instead, the baffles behind screens 10-14 were positioned at alternating angles of 67.5-degrees and 90-degrees (an average of 78.75-degrees, k=187). This test slightly increased the flow passing through screens 3-6 (Table 8).

Table 8 Initial Balancing Test; Headloss and Estimated Va

Screen Position	U/S Freeboard	D/S Freeboard	dH	Estimated Va	Baffle
#	(ft)	(ft)	(ft)	(fps)	° of Closure
Beginning of 1	10.32	10.38	0.06	0.14	67.5
1/2	10.33	10.37	0.04	0.12	67.5
2/3	10.33	10.36	0.03	0.11	67.5
3/4	10.34	10.34	0.00	0.05	0
4/5	10.33	10.35	0.02	0.13	0
5/6	10.34	10.34	0.00	0.05	0
6/7	10.34	10.35	0.01	0.07	67.5
7/8	10.33	10.38	0.05	0.13	67.5
8/9	10.33	10.44	0.11	0.19	67.5
9/10	10.32	10.44	0.12	0.21	78.75
10/11	10.32	10.47	0.15	0.23	78.75
11/12	10.33	10.48	0.15	0.23	78.75
12/3	10.32	10.47	0.15	0.23	78.75
13/4	10.31	10.48	0.17	0.24	78.75
End of 14	10.31	10.50	0.19	0.26	78.75

For the next test all vanes were set to 45-degrees of closure, for refining the estimation of the gross k-value (Table 9). This test resulted in the smallest lateral change in approach flow, but the approach velocity still increased with distance along the screens. The estimated k-value for the test was 235, an increase from the 67.5-degrees closed test. This contradictory result may be explained by the vanes being oriented perpendicular to the direction of flow behind the screens, which influenced the headloss more than the effective porosity increase.

Table 9 Baffle Vanes at 45-degrees closed; Headloss and Estimated Va (k=235)

Screen Position	U/S Freeboard	D/S Freeboard	dH	Estimated Va	Baffle
#	(ft)	(ft)	(ft)	(fps)	° of Closure
Beginning of 1	10.24	10.32	0.08	0.15	45
1/2	10.24	10.33	0.09	0.16	45
2/3	10.25	10.31	0.06	0.13	45
3/4	10.25	10.30	0.05	0.12	45
4/5	10.25	10.32	0.07	0.14	45
5/6	10.25	10.31	0.06	0.13	45
6/7	10.25	10.31	0.06	0.13	45
7/8	10.26	10.32	0.06	0.13	45
8/9	10.26	10.34	0.08	0.15	45
9/10	10.27	10.35	0.08	0.15	45
10/11	10.27	10.39	0.12	0.18	45
11/12	10.29	10.39	0.10	0.17	45
12/3	10.26	10.41	0.15	0.21	45
13/4	10.27	10.41	0.14	0.20	45
End of 14	10.22	10.44	0.22	0.25	45

For the final k-value test, the baffles were set to 22.5-degrees of closure (Table 10). The test results are similar to those from the baseline test (where baffles were full open), with the exception that some flow may have actually exited screens 3-6 (reverse flow), which was confirmed with observations made by dropping dirt/leafy debris on the water surface as flow tracers.

Table 10 Baffle Vanes at 22.5-degrees closed; Headloss and Estimated Va (k=46)

Screen Position	U/S Freeboard	D/S Freeboard	dH	Estimated Va	Baffle
#	(ft)	(ft)	(ft)	(fps)	° of Closure
Beginning of 1	10.17	10.20	0.03	0.22	22.5
1/2	10.16	10.20	0.04	0.25	22.5
2/3	10.16	10.17	0.01	0.14	22.5
3/4	10.18	10.17	-0.01	-0.09	22.5
4/5	10.18	10.17	-0.01	-0.09	22.5
5/6	10.18	10.15	-0.03	-0.19	22.5
6/7	10.18	10.17	-0.01	-0.09	22.5
7/8	10.18	10.21	0.03	0.22	22.5
8/9	10.17	10.21	0.04	0.25	22.5
9/10	10.19	10.21	0.02	0.18	22.5
10/11	10.19	10.24	0.05	0.27	22.5
11/12	10.20	10.24	0.04	0.25	22.5
12/3	10.15	10.24	0.09	0.36	22.5
13/4	10.17	10.24	0.07	0.32	22.5
End of 14	10.15	10.27	0.12	0.42	22.5

The k-value determination tests led to several conclusions:

- the vanes should NOT be positioned in a full-closed position to avoid resonance;
- headloss (resistance to flow) does not consistently correlate with vane position;
- the effect of the location of G6 at the downstream end of the basin overpowers the flow control effectiveness of the vanes; and
- the control of flow passing through the upstream screens is difficult without establishing more headloss across the entire screen structure.

The final screen balancing attempt utilized these conclusions and the k-values estimated from the tests. For the final balancing test (Table 11) upstream baffles were oriented parallel to the flow direction downstream from the screen to try and capture more flow(along the approximated streamline from the channel to G6, to minimize flow resistance). Photo 16 and Photo 17 show the final baffle settings. The baffles behind screens 1-3 were opened into the flow by 22.5-degrees (negative 22.5-degrees of closure) (Photo 18). Baffles behind screens 4-7 were opened by 45-degrees (Photo 19). Baffles behind screens 9-14 were left in the 67.5-degrees closed position (Photo 20), which was the most restrictive position for flow[2].

[2] Closing the baffles further was considered unsafe due to the potential for resonant vibrations.

Table 11 Final Balancing Test; Headloss and Estimated Va

Screen Position	U/S Freeboard	D/S Freeboard	dH	Estimated Va	Baffle
#	(ft)	(ft)	(ft)	(fps)	° of Closure
Beginning of 1	10.12	10.19	0.07	0.20	-22.5
1/2	10.13	10.18	0.05	0.17	-22.5
2/3	10.13	10.18	0.05	0.17	-22.5
3/4	10.15	10.16	0.01	0.09	-45
4/5	10.13	10.17	0.04	0.16	-45
5/6	10.16	10.16	0.00	0.05	-45
6/7	10.15	10.19	0.04	0.16	-45
7/8	10.15	10.19	0.04	0.16	67.5
8/9	10.14	10.21	0.07	0.16	67.5
9/10	10.15	10.23	0.08	0.17	67.5
10/11	10.13	10.26	0.13	0.21	67.5
11/12	10.14	10.27	0.13	0.21	67.5
12/3	10.13	10.26	0.13	0.21	67.5
13/4	10.13	10.28	0.15	0.23	67.5
End of 14	10.11	10.31	0.20	0.26	67.5

The results from this final balancing test appeared to be favorable. The zone of low flow through screens 3-6 was reduced and the lateral variation in approach flow was reduced.

Photo 16 Final Baffle Configuration (Looking Upstream)

Photo 17 Final Baffle Configuration (Looking Downstream)

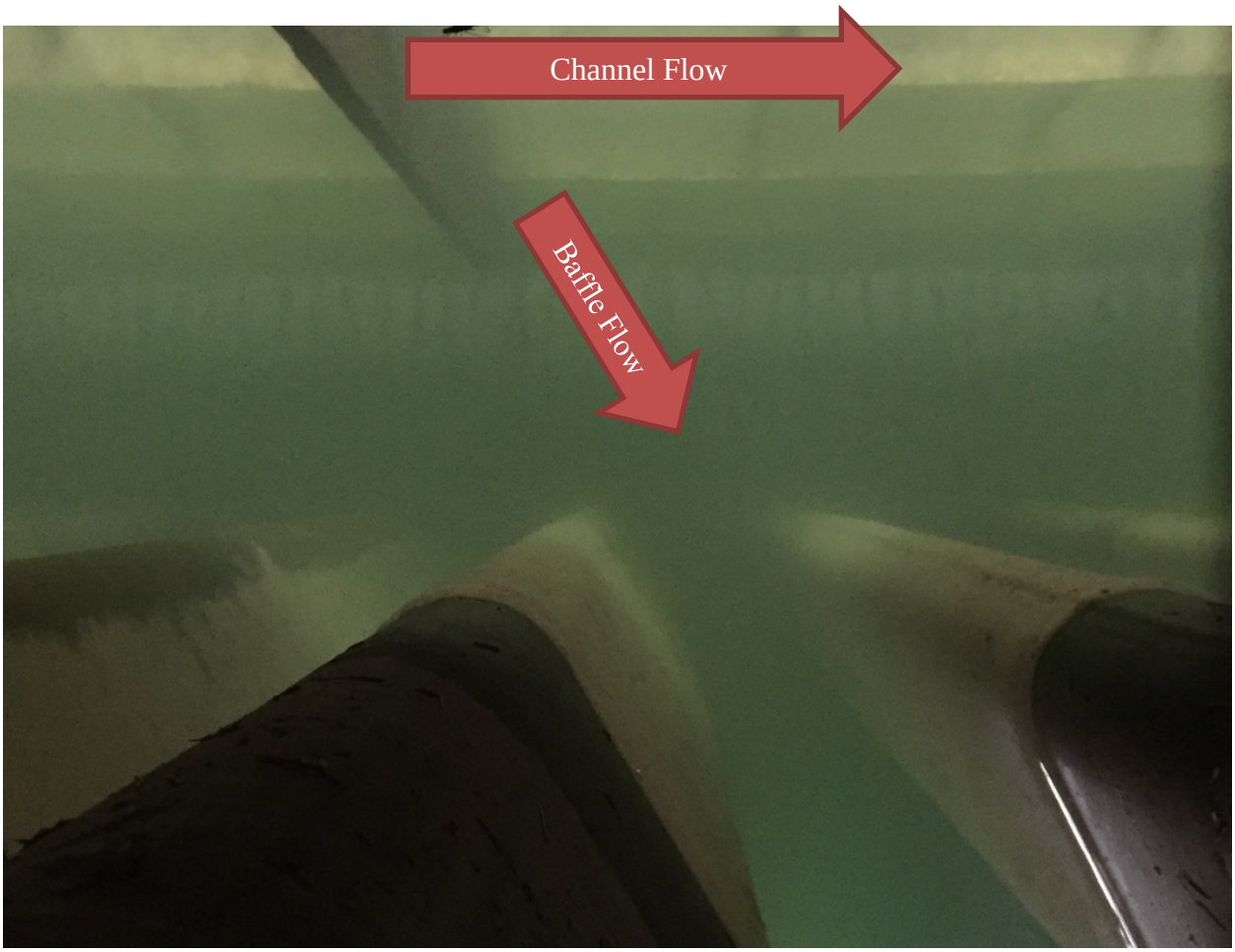

Photo 18 Baffles Open Towards the Flow by 22.5-degrees (Screens 1-3)

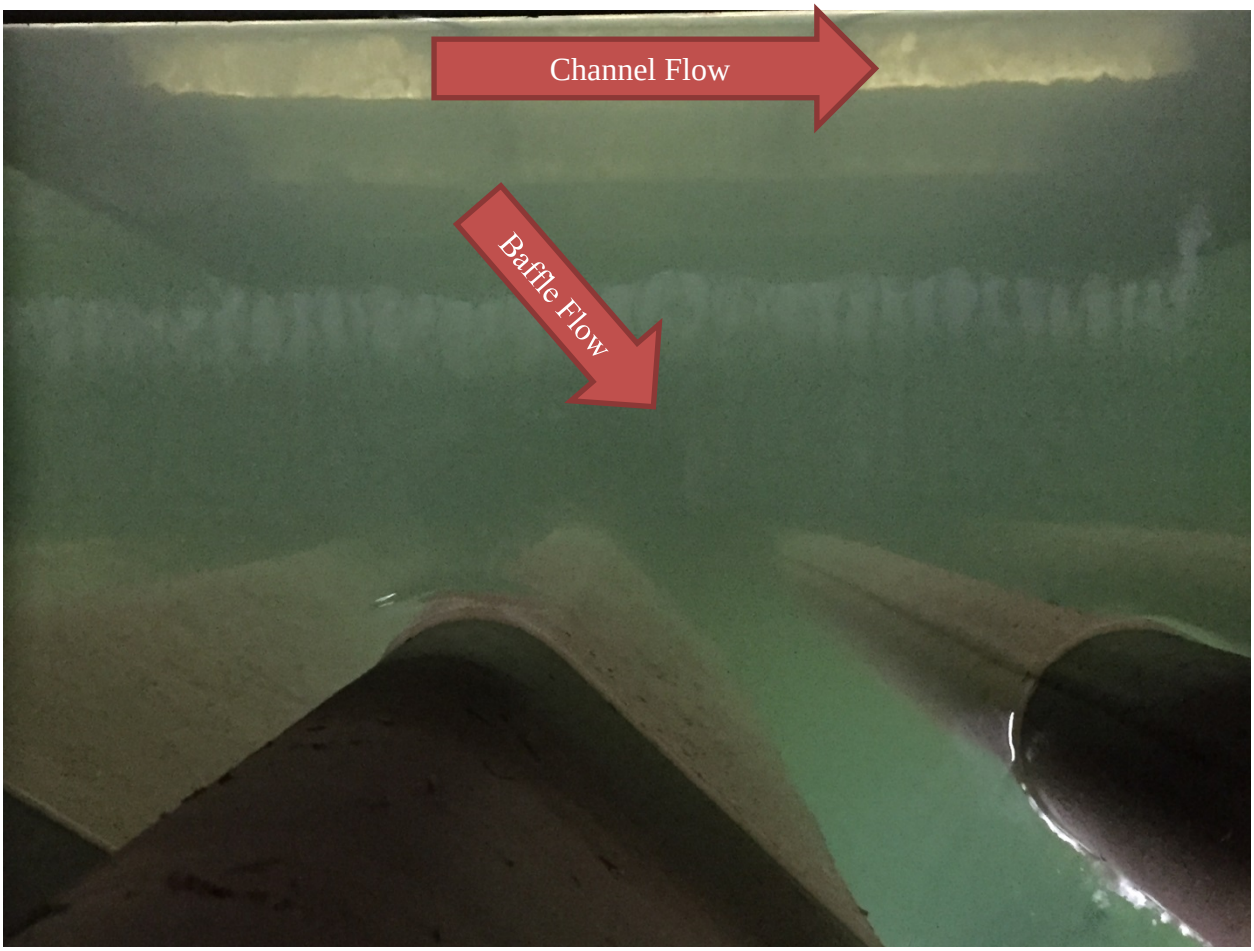

Photo 19 Baffles Open Towards the Flow by 45-degrees (Screens 4-7)

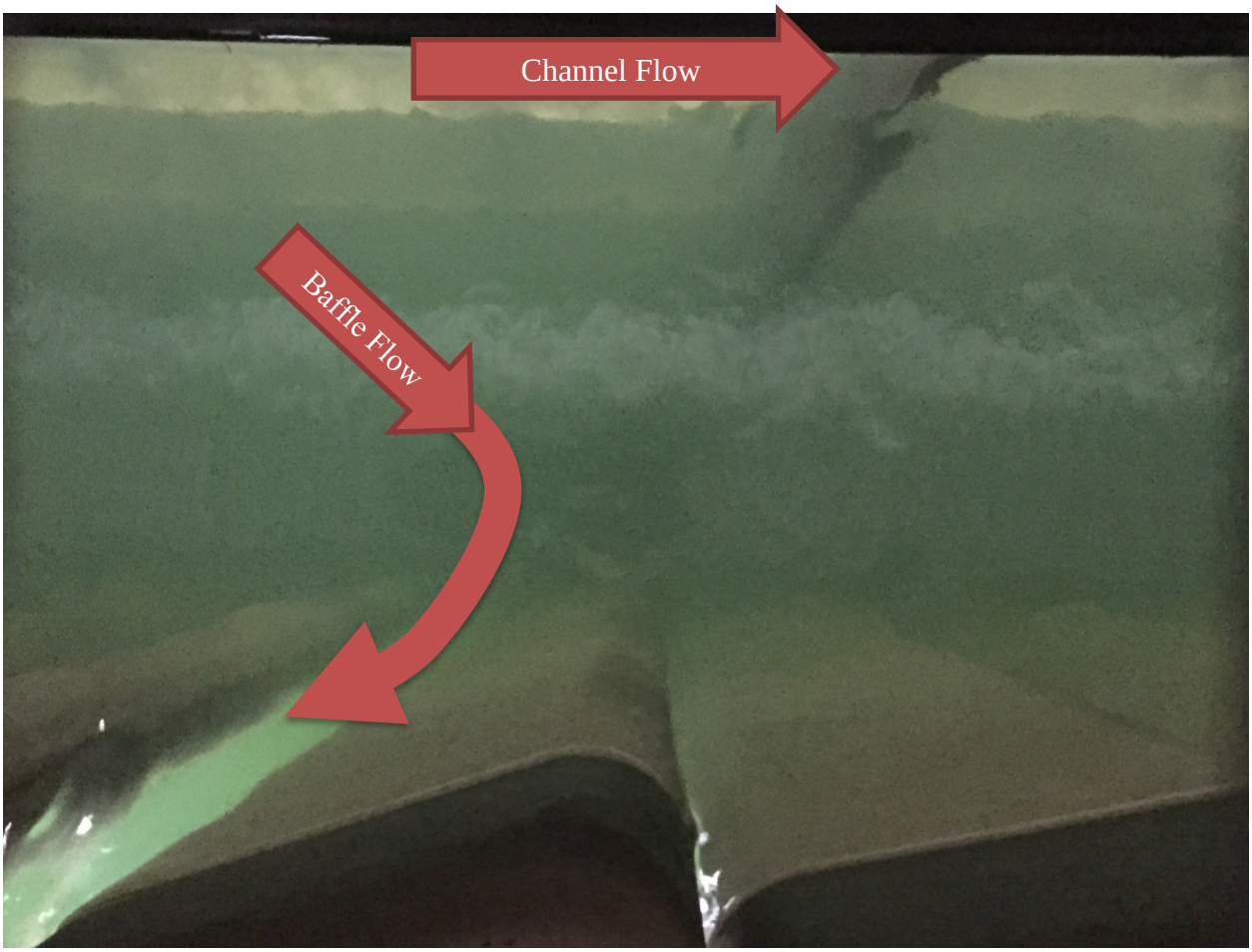

Photo 20 Baffles Closed by 67.5-degrees from Full Open (Screens 9-14)

4.5 Final Approach and Sweeping Velocities

The final condition was evaluated on March 27th, 2015 with 235 cfs entering the fish screen basin (210 cfs passing through the screens) at an upstream Water Surface Elevation (WSEL) of 900.72 ft. The top of the screens is located at Elevation 901.00 ft, resulting in approximately 1,240 square feet of wetted screen surface.

Baffles behind screens 1-3 were opened towards the flow by 22.5-degrees. Baffles behind screens 3-6 were opened towards the flow by 45-degrees. All other baffles were closed by 67.5-degrees (against the flow).

Data were successfully recorded according to the plan with exception of the last 4 data points (Screen 14). Data collection slowed substantially downstream from the 11th screen due to the increased difficulty in safely reaching planned data collection locations in the narrow reach of the channel. Screen 14 data was not recorded due to noticeable debris accumulation. Prior to

adjusting the data, linearly extrapolated values were substituted for the missing data points. The approach and sweeping velocities were adjusted using the procedure presented in Section 4.2.

Approach velocities still increased from the upstream to downstream end of the screens, however, in comparison to the baseline condition, the gradient was reduced (Figure 6). The increase of flow through screens 3-6 was accompanied by a reduction in flow through the first screen. The flow deficiency at the first screen cannot be improved without increasing the headloss across the entire screen length. Average approach velocity for the top probe, bottom probe, and both (depth averaged) with their respective coefficient of variation, expressed as a percentage, are presented in Table 12.

The flow in front of and behind the screens and baffles is presented in Photo 21and Photo 22, respectively.

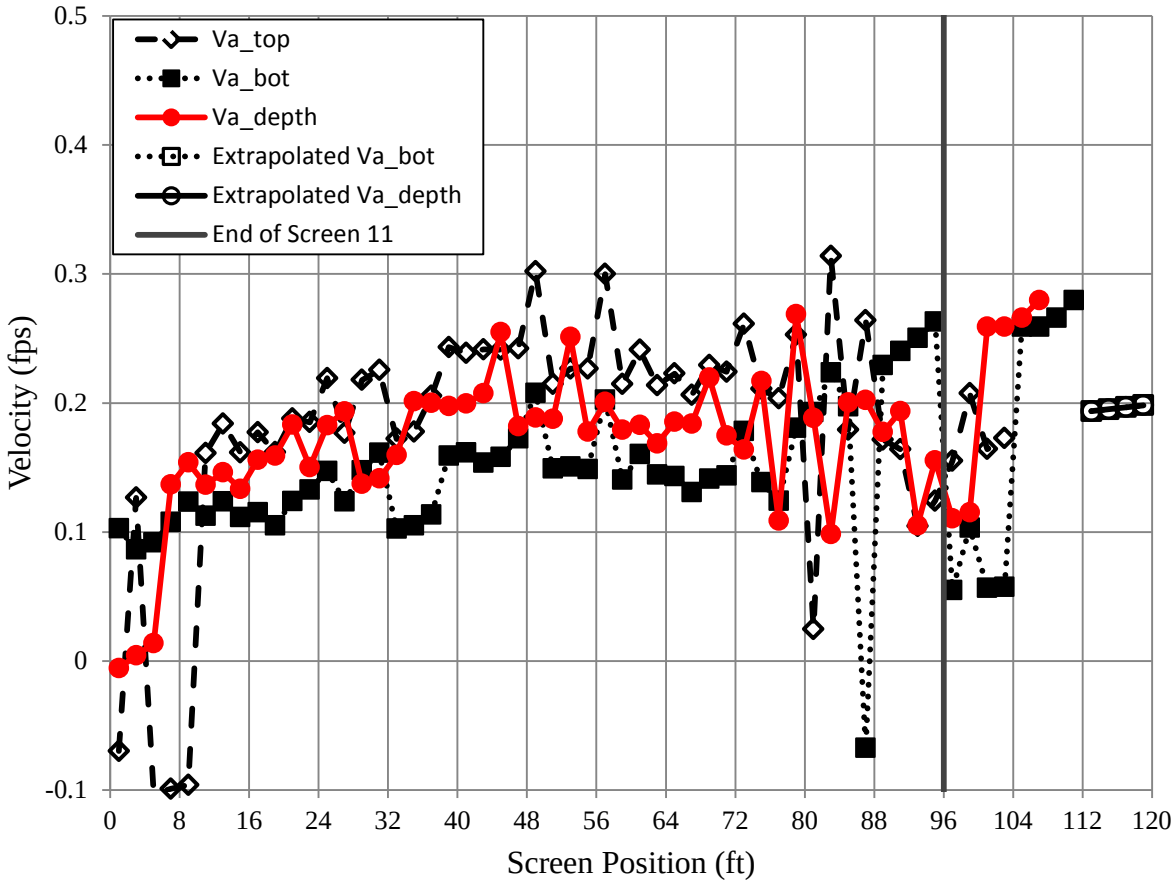

Figure 6 Final Approach Velocities (Q = 210 cfs)

Table 12 Final Approach Velocities (Q = 210 cfs)

Position	Va (fps)	*Cv*%
Top	0.18	52%
Bottom	0.15	41%
Depth Avg.	0.17	37%

Photo 21 Flow In Front of the Screens and Baffles (Fish Screen Basin), Final Configuration (Q = 210 cfs)

Photo 22 Flow Behind the Screens and Baffles (Screened Water Basin), Final Configuration (Q = 210 cfs)

Sweeping velocities (Figure 7) tended to decrease near the beginning of the sloped floor, which is where approach velocities continued to increase due to proximity of the screens to gate G6. This trend was not present in the baseline results since velocities in this region were extrapolated, rather than measured.

Average sweeping velocity for the top probe, bottom probe, and both (depth averaged) with their respective standard deviations expressed as a percentage of the average are presented in Table 13. All sweeping velocities were notably larger than approach velocities, satisfying the NMFS criterion. The sweeping velocity gradient (Figure 8) approached the NMFS criterion ($0.0 \leq dV_s/dx \leq 0.2$) with exception of immediately before the slope in the floor and at the transition between recorded and extrapolated data. Based on the depth averaged sweeping velocity of 2.55 fps, the exposure time of fish to the screen will be approximately 47 seconds, which is less than the 60 second NMFS criterion.

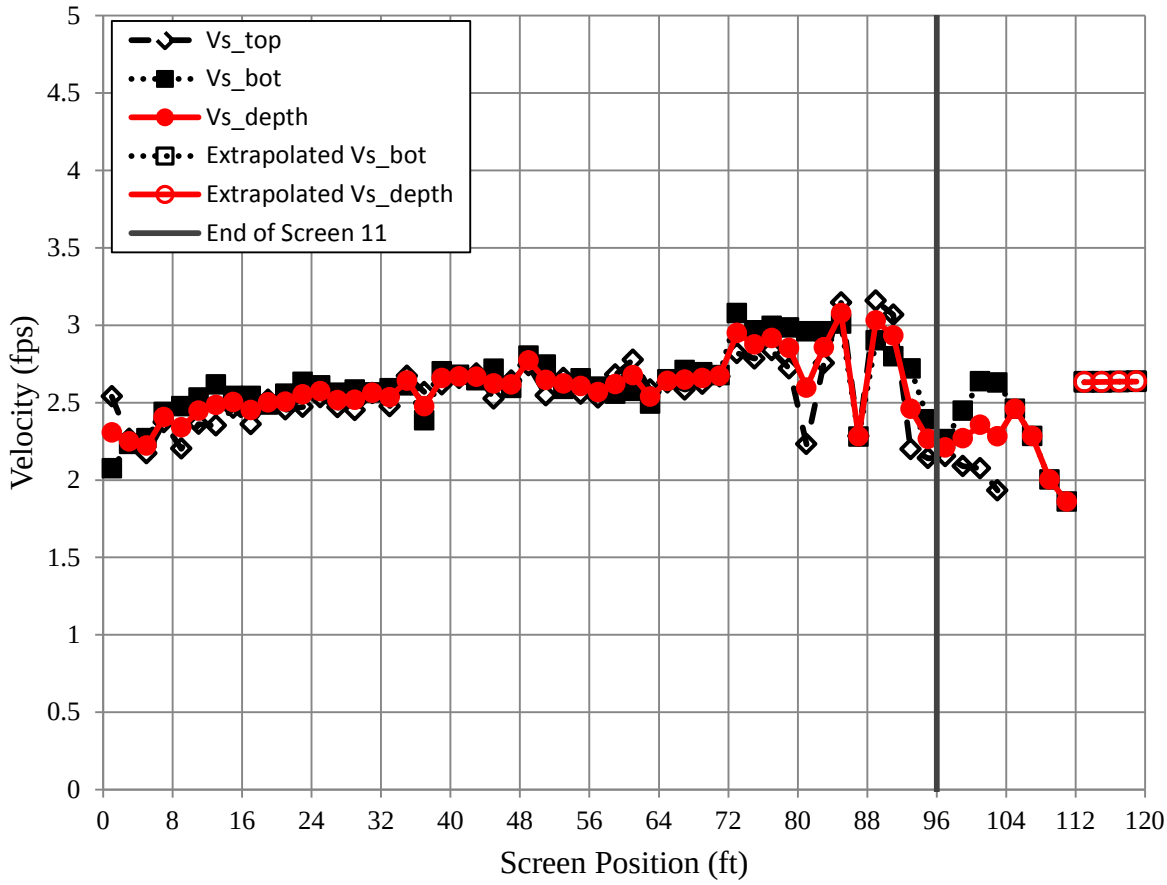

Figure 7 Final Sweeping Velocities (Q = 210 cfs)

Table 13 Final Sweeping Velocities (Q = 210 cfs)

Position	Vs (fps)	*Cv*%
Top	2.53	10%
Bottom	2.59	9%
Depth Avg.	2.55	9%

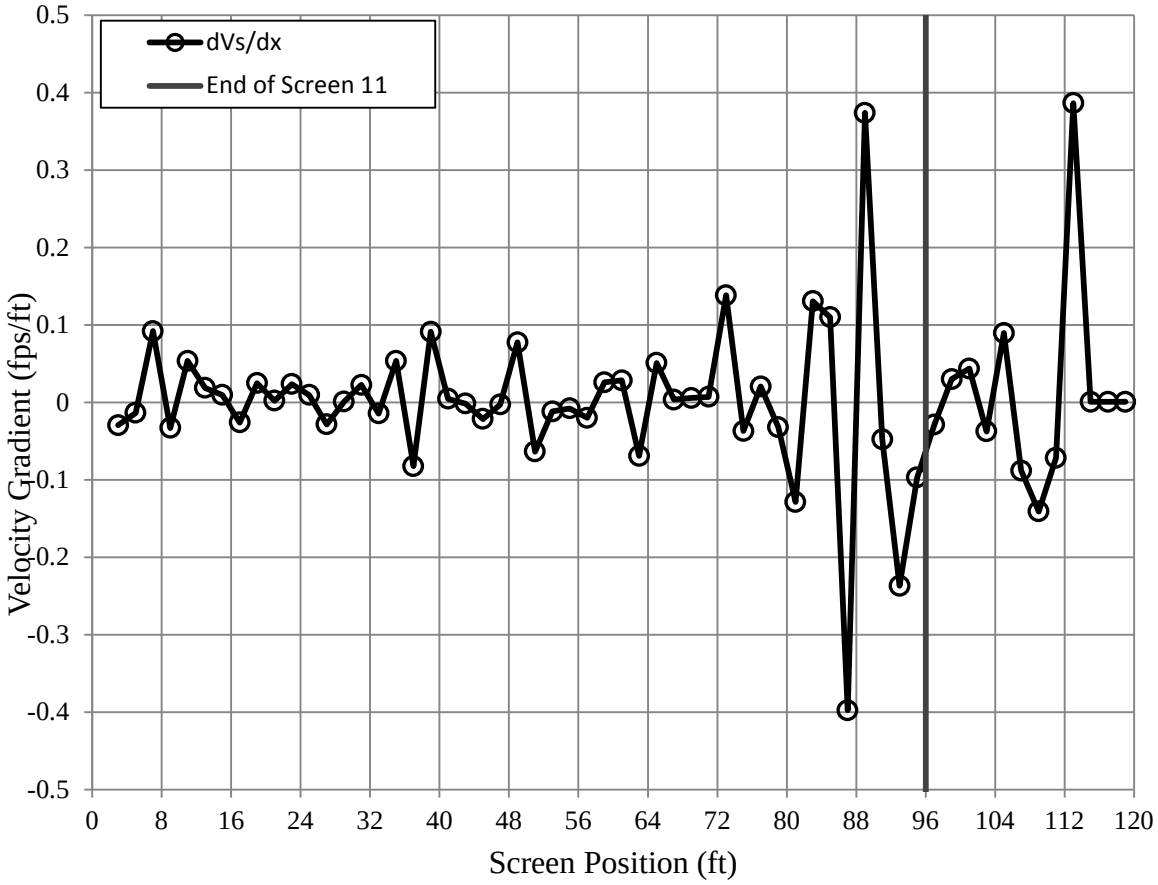

Figure 8 Velocity Gradient (dVs/dx)

4.7 Extrapolation of Results to Design Flow

Final measurements during Phase II could not be made at the target diversion flow rate of 450 cfs due to the lack of available flow. As a result, the baseline testing and subsequent baffle adjustment tests were conducted at flows between 201 cfs and 216 cfs (Table 14). These results were extrapolated to the target diversion flow rate in Figure 9, for both the baseline configuration (baffles fully open) and the final baffle configuration. Both extrapolated sets of point measurements results predict that the 0.40 + 10% approach velocity criterion will be exceeded at the downstream end of the screens near the beginning of the sloped floor. The maximum extrapolated single point approach velocity with the baffle final configuration is 0.54 fps and occurs on screen number 13. Figure 9 also shows that the distribution of flow through the screens can only be mildly affected using the current baffle system. As concluded by comparing Figure 6 and Figure 7, the sweeping velocities will always be higher than approach velocities. The sweeping velocity gradient is not expected to change with a gross increase in flow.

Table 14 Summary of Tests

Date	Baffle Positions	U/S WSEL (ft)	Surrogate Velocity (fps)	Estimated Flow (cfs)	Estimated Screened Flow (cfs)	Screened Area (ft^2)	Calculated Va (fps)*
3/25/2015	Full Open (Baseline)	900.69	1.22	226	201	1238	0.16
3/25/2015	75-degrees Closed	900.78	1.22	227	202	1248	0.16
3/25/2015	Initial Balancing Test	900.77	1.23	229	204	1247	0.16
3/26/2015	50-degrees Closed	900.85	1.22	228	203	1256	0.16
3/26/2015	25-degrees Closed	900.92	1.21	228	203	1263	0.16
3/26/2015	75-degrees Closed	900.94	1.28	241	216	1266	0.17
3/26/2015	Final Balancing Test, Final Baffle Configuration	900.97	1.24	234	209	1269	0.16
3/27/2015	Velocity Documentation of the Final Configuration	900.72	1.27	235	210	1240	0.17
Extrapolated	Final Baffle Configuration	901.90	2.23	450	425	1272	0.33

Calculated Va = Estimated Screened Flow / Screened Area

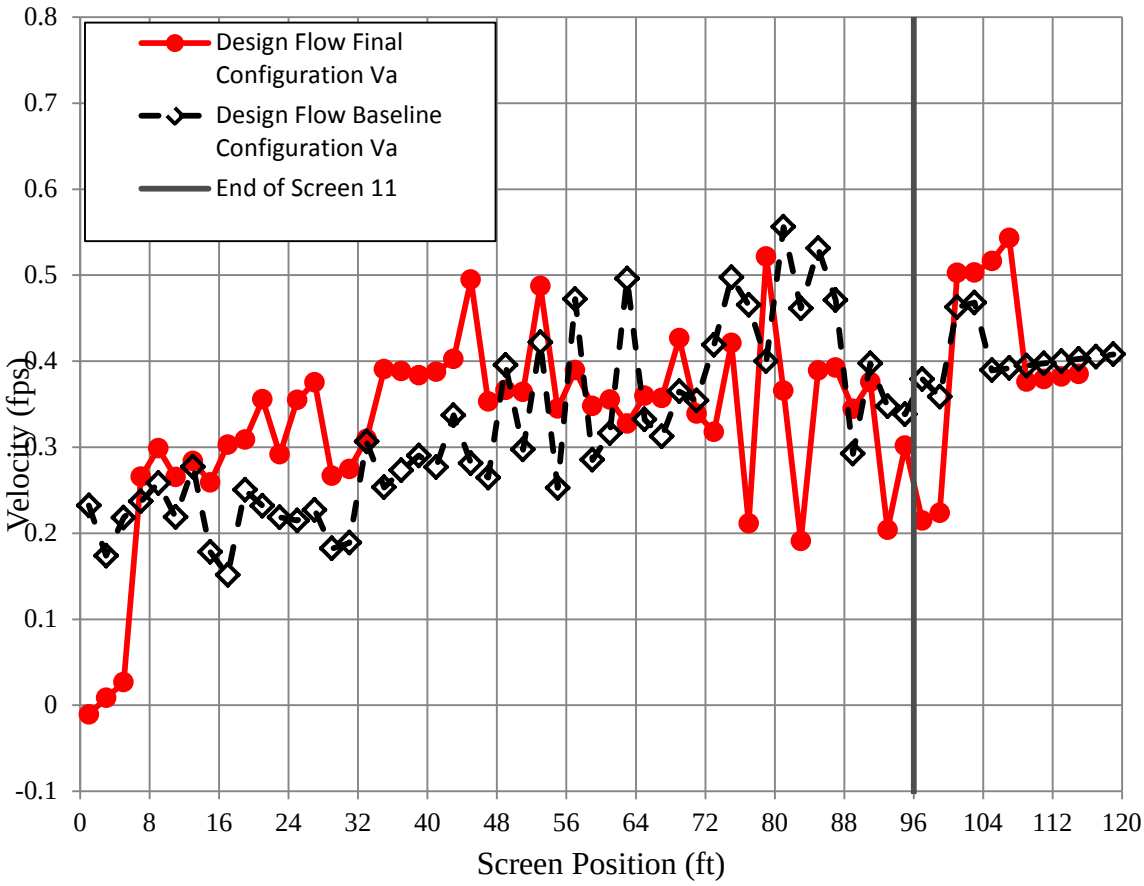

Figure 9 Extrapolated Design Flow Approach Velocities (Q=425 cfs)

5.0 Conclusions and Recommendations

Based on the results of baffle adjustments, no further balancing operations are recommended. The approach velocities at the design flow are expected to be exceed the NMFS uniformity criterion of 10% deviation from 0.40 fps at 7 out of the 56 (12.5%) measurement positions. The approach velocities near the downstream end of the fish screen will always be higher than the average the screen due to the screen proximity to gate G6. The existing baffle system cannot induce enough headloss better balance the approach velocities.

Sweeping velocities will always be higher than approach velocities, and the velocity gradient will be near the 0.2 fps/ft criterion level. Fish exposure time to the screen at the average sweeping velocity is estimated to be 47 seconds at 210 cfs and 23 seconds at the 425 cfs design flow.

6.0 References

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Tacoma Water Trap and Sort Facility

2014 Fish Condition Assessment Report

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Tacoma Water
October 2016

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Introduction

In 2014, Tacoma Water (TW) was granted approval from the Washington Department of Fish & Wildlife and the Muckleshoot Indian Tribe to conduct a study to evaluate fish condition as they routed through the TW Trap and Sort Facility (TSF) created at the Headworks Dam on the Green River. This is an important step to ensure that the facility and handling procedures result in the safe transport of upstream migrants.

The TSF was constructed to assist with the reintroduction of anadromous salmon and steelhead above the Headworks and Howard Hanson Dams. It became operational in 2007. Operations that year were focused on assessing the attraction of adult salmonids into the facility, the movement of adult salmonids through the fishway and into the trap, the routing of adult pink salmon through the sorting passageways and into tanks for transport to the upper Green River, and the routing of adult Chinook and coho salmon through the by-pass and back into the Green River below the Headworks Dam. Through these assessments fish were successfully attracted and passed into the upper Green River and through the bypass. It also appeared that fish were recycling through the facility after being sent back to the river via the bypass, indicating good attraction. However, based on this first year of operation a number of concerns were identified. These included:

1. Potential for injury:
    a. Due to the orientation/condition of the fish bypass,
    b. Due to the physical design of the TSF
    c. Due to handling by operations staff, and
2. Inaccuracy of trap counts due to some fish being captured and counted multiple times as a result of trap re-entry after being bypassed to the river.

Several facility modifications were made since 2007 to address these issues including crowder improvements, transport hopper improvements, jump prevention netting, and by-pass outfall improvements. Fish handling was improved by construction of a fish sampling station in 2011, which efficiently enabled the sedation, sorting, tagging, and collection of biological information and samples.

The newly installed sampling station also provided the opportunity to properly conduct the fish condition assessment to help TW evaluate the concerns identified above.

Results from this study will provide insight to guide future facility and process improvements to correct identified operations or components found to be impacting fish condition. It will also help identify information gaps where additional studies may be warranted to fine tune facility operations or equipment.

Methods

A before-after study design was used to evaluate the impacts of TSF operations on fish. The condition of fish passing through the TSF the first time (maiden captures) were re-evaluated during subsequent re-visits (recaptures) to determine the change in condition resulting from TSF operations. The study also established the rate at which fish were recaptured at the facility.

A total of 50 coho spawners were collected from the trap and sort facility as maiden captures[1]. Each fish was anesthetized with AQUI-S®20E[2]. Length was recorded to the nearest 0.1 centimeter (cm) and weight to the nearest 0.1 kilogram (kg). Each fish was tagged with a ¾ inch uniquely numbered floy tag through the dorsal musculature (Figure 1) and held until revived from the sedative. Once recovered, the fish were released down the fish bypass to the river downstream of the facility.

The TSF was operated for 20 consecutive weekdays (October 19 through November 13, 2015). In order to sample fish in good initial condition, the coho were tagged and evaluated early in the run cycle from Monday, October 19th through Wednesday, November 4th. The condition of maiden captures and subsequent recaptures was assessed by evaluating three types of injuries: descaling, laceration, and abrasion (Table 1). Photographs were taken of each side of the fish to document condition during each capture event.

Figure 1. Photo illustrating the size, type, and location of ¾" Floy disk tags attached to each study fish.

[1] Fish were selected as maiden captures for the study that were in as near as pristine condition as possible (e.g. bright, no de-scaling, no lacerations, and no abrasions).

[2] AQUI-S™20E (10% eugenol) is an investigational new animal drug (INAD) being tested for its effectiveness and safety in coordination with the U.S. Fish & Wildlife Service's Aquatic Animal Drug Approval Partnership Program (AADAP).

In addition to evaluation of recaptures at the TSF, daily surveys of the first half mile below the Headworks Dam (to the gravel supplementation site) were conducted during the study to assess and attempt recovery of any tagged mortalities.

Table 1. Superficial fish condition rating criteria.

Degree of De-scaling	**Score**
<10%	4
11%-20%	3
21%-30%	2
>30%	1
Degree of Laceration (modified from Whiteaker et al. 2006)	**Score**
No major injuries that break the skin	4
Injuries that break the skin	3
Injuries that penetrate the muscle tissue	2
Injuries that penetrate the body cavity or large section of body missing	1
Degree of Abrasion	**Score**
No abrasion on head, belly, or fins	3
Minor abrasion on head, belly, or fins	2
Major abrasion on head, belly, or fins	1

Data Analysis

Tagged fish were allowed to enter and leave the facility on their maiden capture event (M) and/or during one or more recapture events (R_1, R_2, …R_n). The combination of superficial injury data from each M, R_1, R_2, …R_n event provided a sample from which the degree of de-scaling, laceration, and abrasion could be evaluated. Sample distributions from recapture events were compared to the maiden event sample using a Wilcoxon Two-Sample Test. This test was chosen because it is sensitive to the number of interchanges in rank necessary to separate the two samples compared to tests that only measures differences across the entire distribution (e.g. Kolmogorov-Smirnov Two Sample Test) (Sokal and Rohlf 1981). Significant differences ($\alpha = 0.05$) in any of the three superficial fish condition elements or combined would suggest an impact from the facility or its operation. The number of captures per fish tagged at the TSF was determined by taking the total number of captures (maiden and recaptures combined) and dividing them by the maiden captures. The sample data was then resampled with replacement 1,000 times (i.e. bootstrapped) to develop a mean, variance, and 95% confidence interval (CI). In addition, photographs from individual fish were compared over time to determine if new injuries were observed as they recycled through the facility and as a QA/QC measure to ensure that the superficial injury assignments were made in a consistent manner. These data were used to determine whether a problem existed and, based on the combination of data, helped to identify specific mechanisms causing injury.

Results

The study was conducted during weekdays from October 19, 2015 until the TSF was shut down for the season on November 13, 2015 for a total of 20 *study days*[3]. Tagging of the 50 maiden captures was completed between October 19 and November 4, 2015. A total of 25 male and 25 female coho were tagged during the study. All recaptures occurred during this same period. The lack of recaptures after November 4th suggested the focus for this part of the run had changed from active migration to selection of spawning sites.

No tagged fish mortalities were observed downstream of the facility during the study period. The average weight of fish sampled was approximately 2.0 kg and average length was approximately 56.8 cm. There was no significant difference in weight or length between sexes in the sample population (Two sample t-test, $\alpha = 0.05$). Furthermore, observation of behavior of each sex while in the TSF did not detect noticeable difference either. So the potential physical impact of TSF operations on either sex was assumed to be similar (Figure 2).

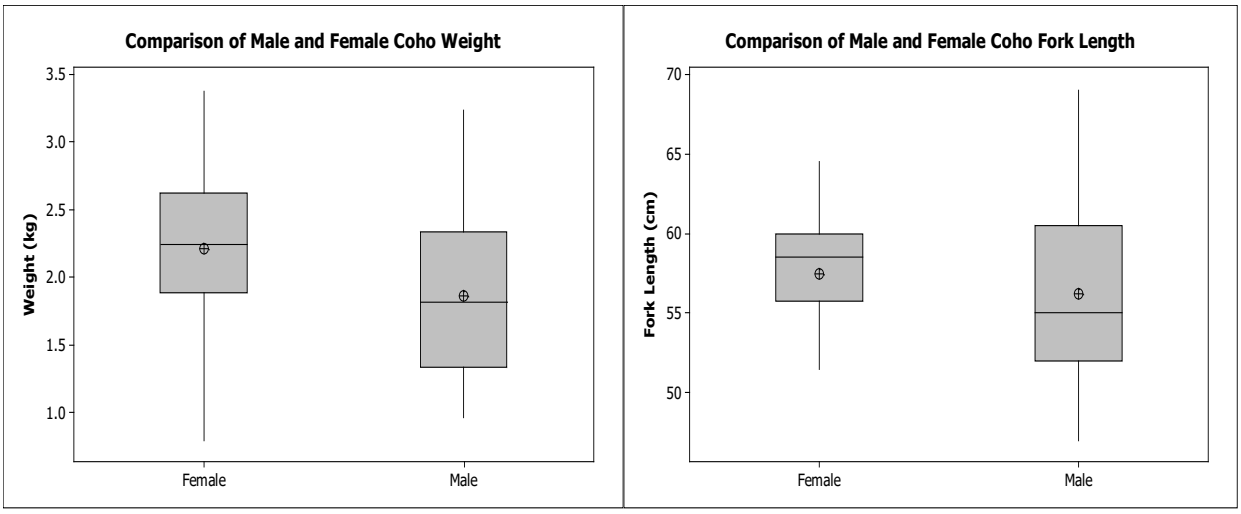

Figure 2. Comparisons of weight and length of male and female coho within the sample population. Median weight is represented by the line within each box and circles are the mean. The boxes represent the inter-quartile range (middle 50%) of weights. The whiskers represent the full range of values observed over the study for that flow category.

Based on visual observations over the study period, using the rating criteria in Table 1, no significant change in fish condition was detected by individual injury type or combined score (Table 2). Only three fish experienced changes in condition score during the study. Two fish had an increased degree of laceration, that were thought to be sustained by jumping into the back side of the crowder in the trap pool (Figure 3) and one had a slightly increased degree of abrasion of unknown origin (Figure 4). Descaling was not a factor for the vast majority of fish, having already absorbed their scales when first captured. No changes in degree of descaling were detected in recapture events, for those few fish with scales.

[3] A study day is defined as a week day, during normal TSF operation, generally between 0700 hours and 1530 hours.

Table 2. Analysis of combined fish condition score change between maiden captures (M) and recaptures (R_n) (Wilcoxon Two Sample Test, $\alpha = 0.05$). Though not shown here, changes in individual injury type scores were also tested and found to be insignificant.

	Combined Fish Condition Scores[1] for M and R_n to the Trap					
Tag[2]	**M**	**R_1**	**R_2**	**R_3**	**R_4**	**R_5**
01	11	11				
02	11	11				
03	11	11	11	11	11	
06	11	11				
08	11	11				
11	10	10				
13	11	11				
14	10	10	10	10		
24	11	11				
29	11	11	11	11	11	11
30	11	10	10			
34	10	10	10	10	10	
40	10	10				
43	11	11				
46	10	10				
48	11	9				
49	10	9	9	9	8	
Significant Difference?	NA	NO	NO	NO	NO	NA

[1]Degree of de-scaling + laceration + abrasion. [2]Three fish (Tag #16, 29 and 34) had one additional recapture event, but were not assessed for condition. Since Tag #16 was only captured twice and didn't receive a condition score upon recapture, it does not appear in this table.

Figure 3. Photos showing deep lacerations in snout and jaw on tagged coho recapture events. Injuries were likely sustained from jumping into the back side of the crowder in the trap pool.

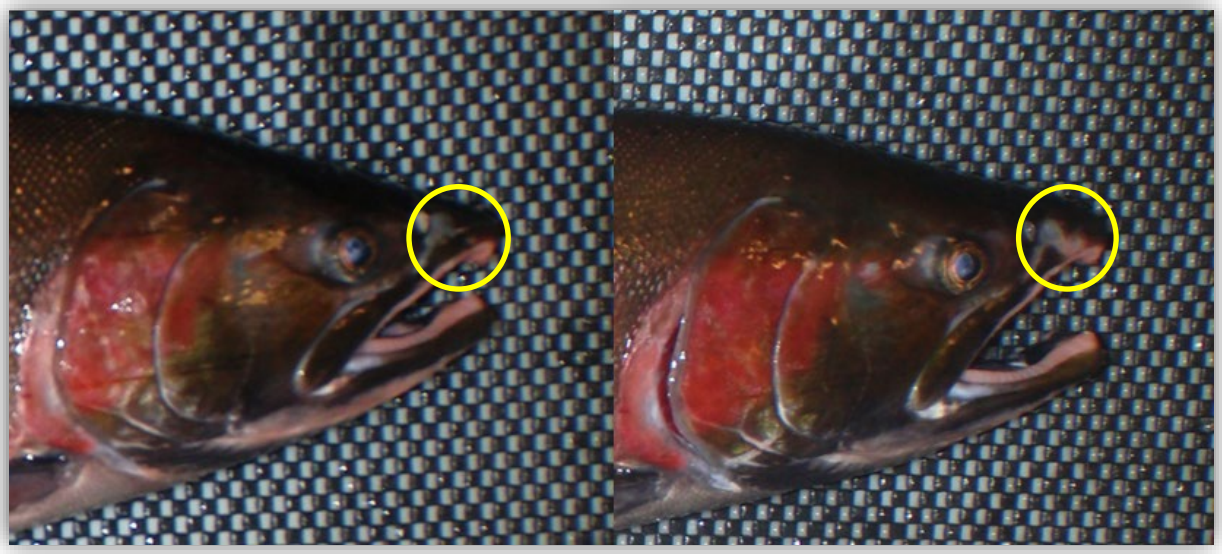

Figure 4. Photo showing slight abrasion formed on subject's snout between M and R_2 inspections.

Of the 50 coho tagged during the study, 18 fish were recaptured a total of 36 times. Twelve fish were recaptured once and 6 fish experienced multiple recaptures. At a gross level, a total of 86 capture events were recorded from 50 coho that were captured and released back to the river, resulting in 1.7 captures/fish (Appendix A). A bootstrap analysis (Minitab 16) was used to resample these data with replacement 1,000 times to derive a mean, variance, and 95% CI (Figure 5).

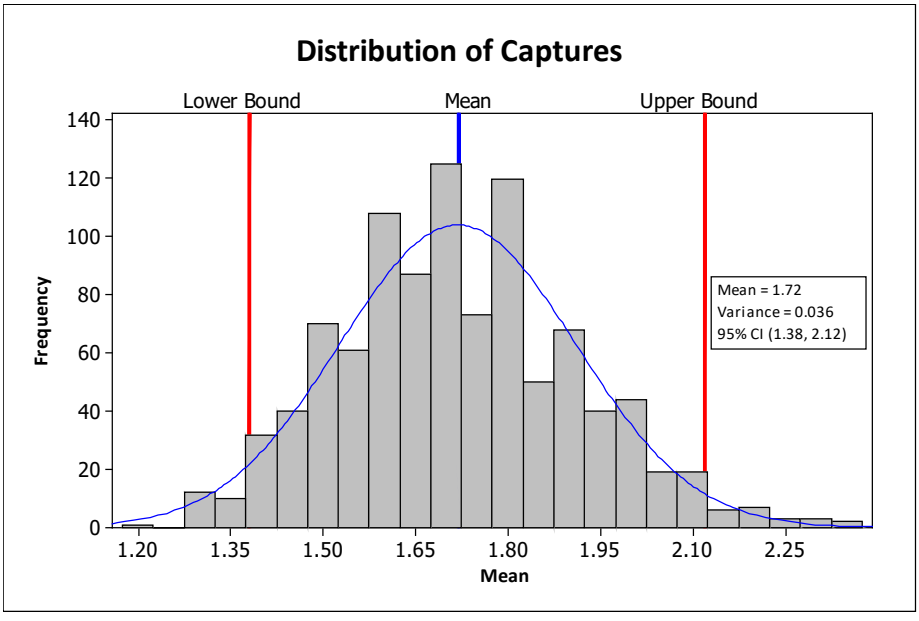

Figure 5. Distribution of fish recycling rates through the Trap and Sort Facility with 95% confidence intervals derived by resampling with replacement 1,000 times.

Discussion

The study did not reveal any significant differences in individual or combined fish condition scores between maiden entries and subsequent re-visits to the TSF. This finding was true for the sample population as a whole and between sexes. A few sample fish did exhibit detectible levels of injury, however only two could be attributed to operation of the facility (4% of tagged fish). No sample fish mortalities were observed during the study period within or downstream of the facility. The median daily rate of coho entering the trap in 2014 was approximately 6.2 fish/day, which was not significantly different than the median daily rate for all years (2008-2014) of 5.3 fish/day (Wilcoxon Two Sample Test, $\alpha = 0.05$) (Figure 6). Therefore the level of injury observed in 2014 represents the level of injury one might expect to see in any year. Based on these results the ongoing operations at the TSF do not pose a significant threat of injury to adult coho salmon.

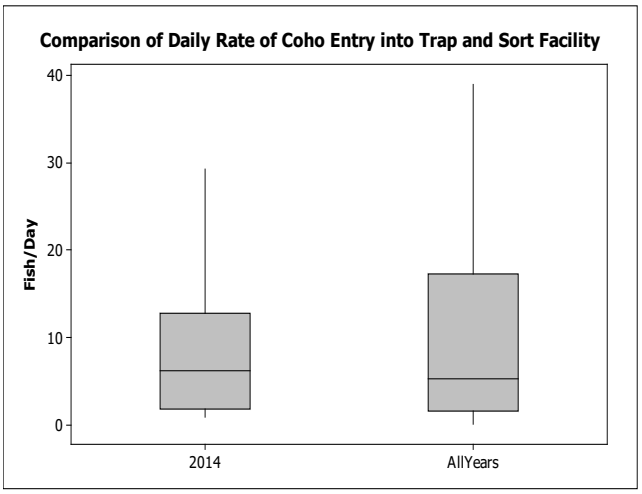

Figure 6. Comparison of daily rates of coho entry into the TSF in 2014 and all years combined. Median weight is represented by the line within each box and circles are the mean. The boxes represent the inter-quartile range (middle 50%) of weights. The whiskers represent the full range of values observed over the study for that flow category.

This study provided a point estimate and confidence interval for a rate at which fish recycle through the facility once released back to the river in 2014. The variability in recycling estimated in this study likely underestimates the variability that would be expected between years and species. Thus, use of these estimates for species other than coho returning in 2014 or for coho in other years was not considered as part of this analysis and should be applied with caution. Production of this recycle rate does provide evidence that annual fish counts are likely an overestimate of actual fish entering the TSF annually.

Slightly over 1/3rd of the tagged coho were recaptured at the TSF (34%) after their maiden entry and 12% were recaptured more than once. Several factors may affect the recycle rate through the facility during the coho spawning season including weather condition, river flow level, and level of maturation. It is well known that upstream migration rates increase during storm events as barometric pressure drops and precipitation and river flows increase. Since flows in the Green River are regulated by Howard Hanson Dam, upstream migration can also be influenced by artificial increases in river flow.

In order to collect fish in good initial condition, the study was conducted early in the coho spawning season. Under its current operating strategy, the TSF shuts down for the season around the middle of November after the final transfer of un-clipped coho has been delivered to the Keta Creek Hatchery. Therefore, while the recycle rate estimated herein was only estimated for a portion of the coho migration period, it represents the period of current TSF operation. Future operation plans may extend the period of operation over the entire run; however, it is expected this will not occur until fish are reintroduced above HHD. When this occurs, the need for estimating recycling rates will be greatly reduced since we expect few fish would be recycled back to the river below the TSF.

Coho were used for this study because they are not currently listed as threatened or endangered under the Endangered Species Act (ESA). They are also particularly active within the TSF and therefore likely more prone to injury. Under its current operating strategy, steelhead enter the TSF in very low numbers relative to coho and chinook. The bulk of steelhead migration occurs after the facility has been closed for the season. Large numbers of pink salmon enter the trap in odd years during the chinook run. Behaviorally, chinook, coho and steelhead exhibit similar traits. Their entry into the trap increases with inclement weather and/or increased river flow and they tend to jump while held in the trap pool prior to sorting. Pinks, on the other hand, tend to enter the trap facility regardless of weather or flow in large numbers for approximately a three week period. While in the trap pool, pinks tend to mill around in the trap rather than jump. Unlike the other species, they are more prone to getting impinged by the crowder due to their small size. Therefore, the results from this study best describe possible impacts to coho, chinook and steelhead than to pinks. Though pink salmon are not an ESA-listed species, facility and operational improvements have been made with this species in mind as well.

Recommendations

Several modifications have been made to the TSF and how it is operated since its initial use in 2007. However, observations made during the fish condition study have indicated fish are being injured when they jump into the back side of the crowder when it is used to block off the entrance to the sorting chute between sorting events. The back of the existing trap pool crowder has a horizontal aluminum support with a square cross-section. The exposed edge of the support is sharp enough to cause lacerations on the heads of fish contacting it while jumping. Welding in a series of vertical aluminum round bars flush with the back of the crowder frame would eliminate blunt-force impact to the horizontal support. Since jumping activity within the trap pool is a function of fish density and residence time, residence time within the trap pool will be reduced to keep fish density low.

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Appendix A

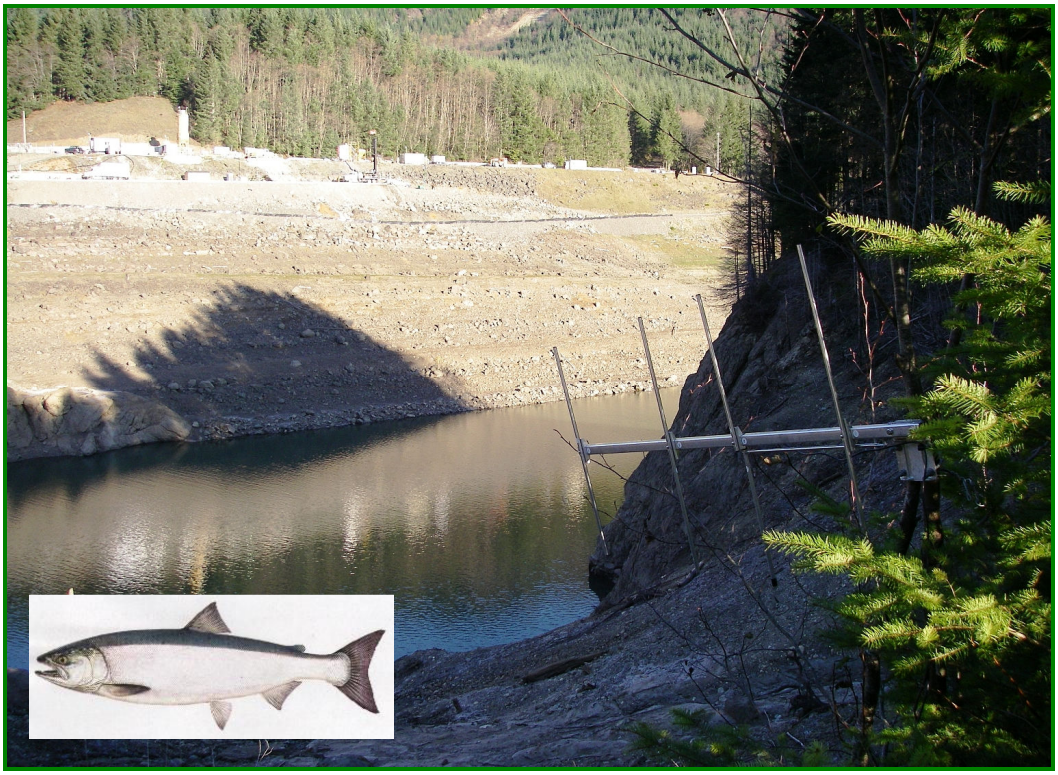
Coho captures per tag#, total captures, and average captures/tag during fish condition study.

Maiden + Recaptures	
Tag #	Captures
00	1
01	2
02	2
03	5
04	1
05	1
06	2
07	1
08	2
09	1
10	1
11	2
12	1
13	2
14	4
15	1
16	2
17	1
18	1
19	1
20	1
21	1
22	1
23	1
24	2
25	1
26	1
27	1
28	1
29	7
30	3
31	1
32	1
33	1
34	6
35	1
36	1
37	1
38	1
39	1
40	2
41	1
42	1
43	2
44	1
45	1
46	2
47	1
48	2
49	5
Total	86
Average	1.7

Coho Salmon Reintroduction above Howard Hanson Dam

A Radio Telemetry Study 2008-2009

-FINAL-



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Seattle District

and

Tacoma Water

Prepared by:

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1. INTRODUCTION

In 1911 the construction of the Tacoma Headworks Diversion Dam blocked the upstream migration of anadromous salmonids to the Upper Green River at RM 61.0. Passage was further impeded in 1962 when the U.S. Army Corps of Engineers (USACE) constructed Howard Hanson Dam (HHD) at River Mile 64.5. Historically, there were no known barriers to salmon passage into the Upper Green River watershed (King County 2001). It is likely that populations of Chinook and coho salmon (*Oncorhynchus tshawytscha* and *O. kisutch*) and steelhead trout (*O. mykiss*) and possibly other anadromous species would have utilized the habitat above the dams for spawning and rearing (King County 2001).

Currently, only the resident form of coastal cutthroat (*O. clarki clarki*) and some anadromous salmonids that have been transported around the dams (juvenile steelhead trout, Chinook and coho salmon, and adult winter steelhead trout) use this portion of the watershed (King County 2001). The Upper Green River and its tributaries are considered to offer substantial potential habitat for spawning and rearing of anadromous salmonids, particularly spring Chinook and/or coho salmon (R2 Resource Consultants 2001).

The Headworks Fish Facility at the Diversion Dam was completed by Tacoma Water in 2005 (King County Department of Natural Resources 2009). This facility includes a redesign of the existing Diversion Dam to attract migrating fish to a new fish ladder entrance. Fish entering the ladder are captured at a trap and can then be transported and released into the Upper Green Watershed above HHD. A new downstream Fish Passage Facility is currently being constructed to enhance survival and passage of out-migrating juvenile fish at HHD. The timing of the transport of salmon will depend upon the completion and evaluation of the downstream fish passage facilities which are not expected to be completed until 2013 (Tacoma Water 2009).

Starting in 2008 and continuing into 2009, coho salmon captured at the Headworks Fish Facility were radio tagged, transported around and released above HHD. These fish were tracked from several fixed antenna receiver stations as well as by mobile surveys performed on foot and by vehicle. The objectives of the study were to:

- Evaluate the survival of transported fish;
- Evaluate the extent of migration of transported fish and

- Evaluate potential release locations in relation to habitat use.

This project was jointly funded by the USACE and Tacoma Water and was conducted by R2 Resource Consultants, Inc. and Tacoma Water biologists. This report describes the results of the radio-tracking studies conducted in 2008 and 2009 and provides recommendations for future trap and haul operations on the Upper Green River.

2. ENVIRONMENTAL SETTING

The Green River drains an area of 484 square miles located in the southern part of King County, Washington. The mainstem Green River flows north and west for approximately 84 miles from its headwaters in the Cascade Mountains. At RM 11 the Green River is joined by the Black River to form the Duwamish River before emptying into Puget Sound at Elliot Bay.

Historically, Lake Washington, Lake Sammamish, and the Cedar, Green and White rivers all drained into the Duwamish River, forming one of the largest basins in Puget Sound, with a drainage area of 1,639 mi^2. Beginning in 1906, a series of natural and man-made events resulted in the separation of the Duwamish basin into three separate and smaller basins: the Lake Washington Basin (663 mi^2), which includes lakes Washington and Sammamish and the Cedar River basin; the White River (494 mi^2); and the Green River (484 mi^2). A large flood in 1906 formed a log jam that blocked the confluence of the Green and White Rivers and shifted the majority of the White River flow south into the Puyallup River. Through channelization efforts authorized by the State Legislature in 1909, this shift was made permanent, and the former White River channel was filled. In 1912, a public improvement district diverted the Cedar River into Lake Washington to maintain the elevation of the lake once the Ship Canal was completed, further reducing the drainage area of the Green River basin.

The Green River watershed can be subdivided into three subbasins. The upper Green River extends from the headwaters to Tacoma's Headworks Diversion Dam at River Mile 61.0, which is located 3.5 miles downstream of HHD. The middle Green River includes areas draining to the mainstem between the Tacoma Headworks and the confluence with Soos Creek near Auburn at RM 33.8. The lower Green River (Duwamish River) continues to the confluence with the Black River at RM 11, which is the upstream extent of the estuary. This study focused on the upper Green River, which hereafter refers to the stream segments located above HHD.

3. METHODS

3.1 TELEMETRY RECEIVERS AND RADIO TAGS

The telemetry receivers used for this study were model SRX_400 built by LOTEK Wireless Inc. of Newmarket, Ontario, and included CODE_LOG version W16 and W31 data processing and storage program. Two tag models produced by Lotek were chosen for this study. These were models MCFT-7F and MCFT-3A digitally coded radio tags (Figure 1). The MCFT-7F tags were 16 mm in diameter, 88 mm long, weighed 31.0 gm in air, and weigh 14 gm in water; the burst rate of signal transmission was every 3 seconds. The MCFT-3A tags are 16 mm in diameter, 46 mm long, weigh 16 gm in air and 6.7 gm in water.

Figure 1. Example Lotek tag used in coho radio tagging study in the upper Green River, Washington 2008 and 2009.

The radio tag frequencies used for this study were 150.300 and 150.450 MHz (assigned to channels 1 and 2 respectively). Two-digit codes that were unique for each frequency were assigned to each radio tag by the manufacturer. Thus, frequency and code combinations were unique to all individual radio tags deployed during the program. All radio tags were tested prior to being used in this study. Detection distance of the tags used in this study varied according to the terrain and proximity of the tags and receivers to interference sources (i.e., powerlines or passing vehicles). In the open reservoir, tag detection radius was up to approximately a half

mile. Detections in the incised river channels were limited by geology and river noise to a few hundred feet, with no fixed receiver location overlapping coverage with any other site.

In 2009, each tag also had an "inactive" code associated with it. When an internal tilt switch in the tag determined a fish had not moved in 24 hours, the tag would switch from transmitting its original code to the inactive code. The inactive code was the original code plus a 1 in front (i.e., code 12 became code 112). When the tilt switch was activated again, the tag resumed active code transmission. However, this feature did not seem to function accurately enough to provide information for behaviour analysis due to the intermittent nature of the movements of pre- and particularly, post-spawn salmon. During all tracking activities, each receiver was set to alternate scanning between the two frequencies for six-second periods during which one or two pulses would be transmitted by a tag. If a signal was received, the receiver decoded the signal, reported the tag code, frequency and signal strength and stored the data in internal memory. As many as 12-15 different fish could be recorded on the same frequency during the same scan cycle (6 sec) so that the probability of a fish not being detected was low if only a few fish were present on a single channel.

Fixed telemetry stations were established to record the code, date, and time any tagged coho migrated past the receiver. Each telemetry station consisted of an antenna connected to a Lotek receiver powered by a 12 Volt deep cycle marine battery. The receiver and battery were contained inside a waterproof storage bin secured near the antenna location (Figure 2). Telemetry station setup followed the procedures outlined in Nelson et al. (2001). Final positions of fixed-station receiver sites were determined based on the following criteria:

1. Secure location with easy access;
2. Adjacent to a section of confined river channel such that signals could be detected from all radio tagged fish passing the location; and
3. Available attachment point (i.e., tree) on which to mount the antenna, with as much height as possible (to provide greater detection ranges than those near water level).

Sixteen telemetry station locations were initially established in 2008 prior to tagging activities (Table 1). The majority of these locations remained unchanged for the 2009 study with some modifications (Figure 3). In 2009, sites Five Mile and Gut were discontinued. An additional

receiver was installed on the Upper North Fork Green River for a total of fifteen telemetry stations in 2009.

Figure 2. Example fixed receiver station on the upper Green River, Washington 2009.

Table 1. Description and GPS coordinates for fixed telemetry receiver stations in 2008 and 2009 in the Upper Green River, Washington.

Water Body	Receiver Name	2008	2009	Latitude	Longitude	RM upstream from HHD	Location Description
Below HHD	Tailrace	X	X	47.28244	121.78905	-0.3	Installed upstream of gage on right bank at pullout
Reservoir	Dam	X	X	47.27591	121.78551	0.0	Installed upstream Dam on left bank
Reservoir	Five Mile	X		47.27543	121.77682	0.4	At 5-mile sign on turnout
Charley Creek	Charley Creek	X	X	47.26117	121.77966	1.4	At road just downstream bridge
Reservoir	Gut	X		47.26044	121.76258	1.8	At road across from train tracks up on hill
N. Fk. Green R.	North Fork	X	X	47.30248	121.77361	2.8	Installed on bridge
Gale Creek	Gale Creek	X	X	47.26306	121.72771	3.2	Installed just downstream on left bank
U. Green R.	Bridge 71	X	X	47.24302	121.72736	3.5	Installed at release location on right bank
N. Fk, Green R.	Upper North Fk. Green		X	47.31767	121.75656	4.2	Approx. 1.5 miles above bridge
U. Green R.	Road Mile 21	X	X	47.22790	121.69754	5.6	Along road between Welcher and Bridge 71
U. Green R.	Welcher	X	X	47.22978	121.64847	7.7	At river by upstream log jam
U. Green R.	Maywood	X	X	47.22492	121.61887	9.1	Installed at Maywood access
Smay Creek	Smay Creek	X	X	47.23475	121.59915	10.5	Installed on right bank at restoration site
U. Green R.	Bedrock Pool	X	X	47.20702	121.55490	13.0	Installed on right bank overlooking pool
U. Green R.	Lester	X	X	47.21309	121.47200	16.1	Right bank just upstream Lester
Sunday Creek	Sunday Creek	X	X	47.21752	121.44864	17.5	Installed on right bank downstream bridge
U. Green R.	Upper Green	X	X	47.21404	121.42667	18.5	Installed on right bank past trestle

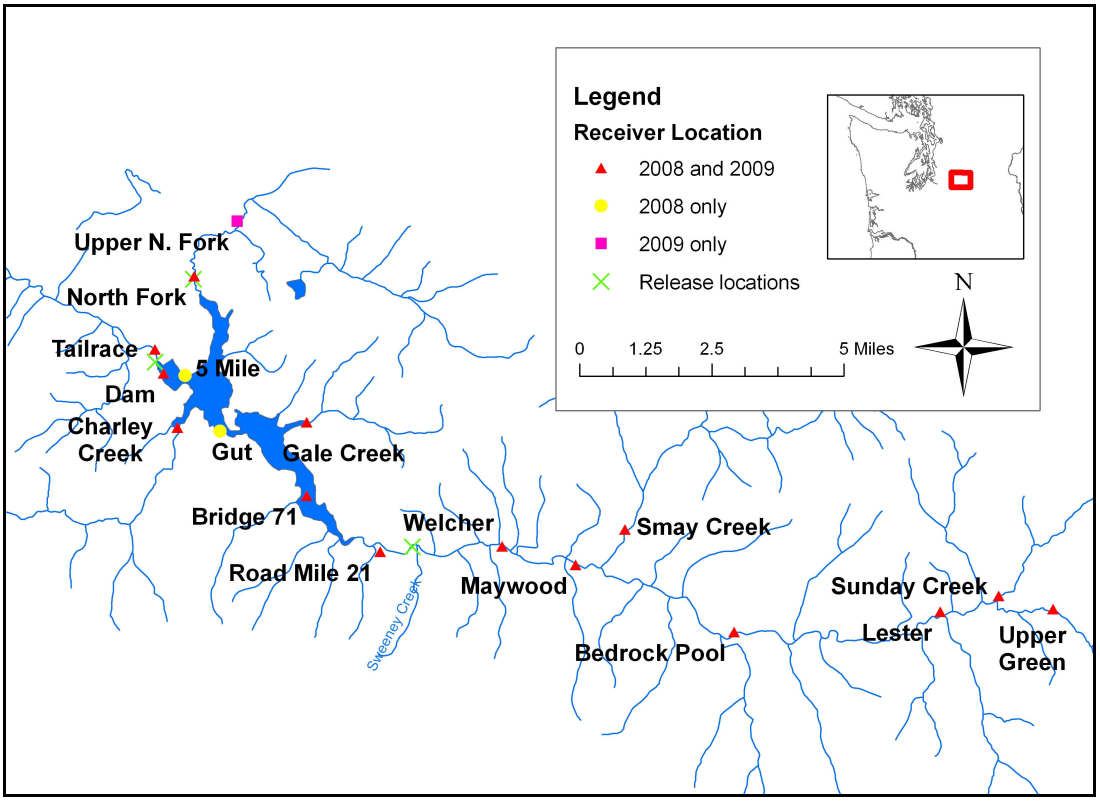

Figure 3. Location of fixed receiver stations in the Upper Green River watershed 2008 and 2009.

Field staff replaced the batteries at all fixed-station sites on a rotating cycle, approximately every 5-7 days, well within the operable range of battery life. Routine data downloading (typically on a weekly basis) was accomplished by connecting the receiver to a portable laptop computer and executing the LOTEK data downloading program WinHost. All data were downloaded in hexadecimal (or .dmp) format and then converted to readable (text) format and browsed for inconsistencies or data errors. Once the data were secure, the receiver memory was reinitialized and scanning was continued.

Mobile telemetry surveys were conducted by Tacoma Water staff by vehicle, boat and/or on foot during both study years. Foot and boat surveys were conducted using a hand-held antenna. Vehicle surveys were conducted with a larger antenna affixed to a moving vehicle. The surveyors drove along the river scanning for radio tag signals, and stopping to confirm the channel and code of any detected signals and document the location of the tag. GPS coordinates were recorded where possible.

3.2 TAGGING

All tagging operations took place at the fish ladder at the Tacoma Diversion Dam. The coho salmon were lightly anesthetized with MS-222 (60 mg/l buffered tricaine methanesulfonate) and the radio tags were inserted carefully into their stomachs (Figure 4). Esophageal tagging is generally considered the best tagging method for adult salmonids during migration and spawning (Ramstad and Woody 2003). In order to ensure tag retention (i.e., no regurgitation) each tag was banded to a piece of sponge to provide a greater surface area and texture. A similar method was used with success on the Columbia River by Keefer et al. (2004). The tag was then placed in a PVC implanting device and inserted into the esophagus of the fish. Great care was taken to not over-insert and puncture the abdominal wall. Tag size has been found to be correlated to increased fish mortality in fish smaller than 480 mm in length (Ramstad and Woody 2003). In this study, coho smaller than 475 mm were tagged with the smaller of the two tag sizes (47 mm). All tagged fish were held overnight to assess their condition and tag retention prior to release.

Figure 4. Radio tag placement in a study coho in the Upper Green River, Washington.

Sixty-eight coho were tagged in 2008 and an additional 89 were tagged in 2009 for a total of 157 radio tagged coho released above HHD. In 2008 all tagged fish were released at the boat launch at HHD (Figure 3). Multiple release locations were used in 2009 (Table 2).

Table 2. Date, location and number of coho salmon released above HHD in the Upper Green River, Washington.

Release Date	**Release Location**	**# Released**
16 October 2008	HHD Boat launch	16
23 October 2008	HHD Boat launch	6
30 October 2008	HHD Boat launch	6
5 November 2008	HHD Boat launch	40
	2008 Total	*68*
23 October 2009	HHD Boat Launch	40
28 October 2009	Sweeney Creek (approx. RM 71.4, between receivers Road Mile 21 and Welcher)	25
6 November 2009	N. Fork Green River	15
14 November 2009	Sweeney Creek	9
	2009 Total	*89*

4. RESULTS

4.1 2008

Sixty-eight tagged fish were released in four groups at the HHD boat launch in 2008 (Table 2). The mean fork length of tagged coho was 680 mm, with a range from 570 to 790 mm. All but one of these tags were detected at least once at a fixed receiver station. In 2008, mobile surveys were only completed above HHD. No additional fish were detected on mobile surveys that were not detected on fixed receivers. See Appendix A for an example fish detection record, Appendix B for first and last detection locations and Appendix C for a complete detection record. Mortality of four fish occurred during the post-tagging recovery period. All mortality occurred during the first week of tagging and was likely attributable to experimentation with the tagging personnel and methodology. All tags were recovered prior to release and re-deployed in subsequent coho.

In 2008, all of the receiver stations (sites) detected at least one tag with the exception of Sunday Creek (Table 3). Thirteen fish (19%) were detected traveling above Maywood (Bedrock Pool, Lester or Upper Green sites). Twenty fish (30%) were not detected above Bridge 71. However, of these 20, 13 were detected at Bridge 71, 1 was detected in the North Fork Green River, and 1 in Charley Creek. The remaining five fish were not tracked leaving the reservoir (Table 4). All fish were detected at either the Dam or Five Mile receivers, and 14 tags were detected below the dam at the Tailrace. No tags were located or tracked below the Tailrace location in 2008.

There did not appear to be any immediate fallback, i.e., no fish were detected for the last time at the Tailrace site within a couple days of their release at HHD. However, tags were often detected intermittently between the Dam, Five Mile and Tailrace sites, indicating an overlap in receiver coverage when fish were in the open center of Howard Hanson Reservoir.

Only six fish were tracked entering stream tributaries (Table 3). The two tagged fish (one male, one female) that were detected in Gale Creek never left the creek after entering. One of the two fish (both males) that entered Charley Creek returned to the reservoir (or was flushed) the next day. One of the two North Fork fish (both males) remained in the North Fork, the other returned to the mainstem Green River.

Table 3. Number of individual tags detected at each receiver location in the Upper Green River, Washington 2008.

Water Body	Receiver Location	Distance from HHD	Individual Tags Detected
Below HHD	Tailrace	-0.3	14
Reservoir	Dam	0.0	65
Reservoir	Five Mile	0.4	64
Charley Creek	Charley Creek	1.4	2
N. Fk. Green R.	North Fork	2.8	2
Reservoir	Gut	1.8	57
Gale Creek	Gale Creek	3.2	2
U. Green R.	Bridge 71	3.5	47
U. Green R.	Road Mile 21	5.6	45
U. Green R.	Welcher	7.7	27
U. Green R.	Maywood	9.1	16
Smay Creek	Smay Creek	10.5	2
U. Green R.	Bedrock Pool	13.0	12
U. Green R.	Lester	16.1	7
Sunday Creek	Sunday Creek	17.5	0
U. Green R.	Upper Green	18.5	1

Table 4. Maximum upstream extent of tag detection of individual coho in the Upper Green River, Washington, 2008.

Detection Location	RM from HHD	Release Date (from HHD)			
		16 Oct	23 Oct	30 Oct	5 Nov
Dam	0				
Five Mile	0.4				2
Gut	1.8	3			2
Bridge 71	3.5	1	1		11
Road Mile 21	5.6	3	4	2	6
RM 21 to Welcher	5.6 – 7.7	1		1	2
Welcher	7.7	5		1	5
Maywood	9.1	1			3
Bedrock	13.0	2			4
Lester	16.1		1	2	3
Upper	18.5				1

Travel times for migrating coho were highly varied. Fish released in early October took on average 22.5 days to reach Bridge 71 (Table 5). Fish released at the end of October and in November were detected at Bridge 71 in an average of two days. At least three fish traveled from their release at HHD to the Maywood site, a distance of approximately 10 miles, in under 36 hours.

Table 5. Average days between release at HHD and detection at Bridge 71 in the Upper Green River, Washington 2008.

	16-Oct	23-Oct	30-Oct	5-Nov
Average days	22.5	12.5	1.8	2.0
No. of fish	4	4	6	33

4.2 2009

A total of 89 unique radio tags were deployed in 2009 (Table 2). The fork length of tagged coho ranged from 385 to 777 mm with an average of 639 mm. Eighty-two of the deployed tags (92%) were detected at least once at a fixed receiver site (Table 6). Two additional tags were detected only during mobile tracking near the Welcher receiver site. A total of 65 tags were detected during mobile tracking activities in 2009. Five tags were not detected anywhere again after release. There was one post-tagging mortality attributed to the poor pre-tag condition of the fish. This tag was recovered prior to release and retained for future use.

The 2008 Gut and Five Mile receiver stations were discontinued in 2009 in order to augment coverage in other areas of the watershed (Upper N. Fork). Gut and Five Mile provided limited unique detection data. As part of the 2009 survey a small number of inactive codes were detected on tags equipped with tilt switches. However, these detections were inconsistently intermittent with the active code associated with the tag, and therefore did not provide reliable information from which to make behavior assumptions. Inactive code detections were included in the following summary tables the same as active code detections. In 2009, no tags were detected at four of the study sites: Sunday and Smay creeks, Upper North Fork and Upper Green River.

Table 6. Number of individual tags detected at each receiver location in the Upper Green River, Washington 2009.

Water Body	Receiver Location	RM from HHD	Individual Tags Detected
Below HHD	Tailrace	-0.3	34
Reservoir	Dam	0.0	47
Charley Creek	Charley Creek	1.4	1
N. Fk. Green R.	North Fork	2.8	1
Gale Creek	Gale Creek	3.2	1
U. Green R.	Bridge 71	3.5	30
N. Fk. Green R.	Upper North Fk.	4.2	0
U. Green R.	Road Mile 21	5.6	26
U. Green R.	Welcher	7.7	43
U. Green R.	Maywood	9.1	20
Smay Creek	Smay Creek	10.5	0
U. Green R.	Bedrock Pool	13.0	12
U. Green R.	Lester	16.1	5
Sunday Creek	Sunday Creek	17.5	0
U. Green R.	Upper Green	18.5	0

The majority (n=56, 67%) of the fish detected in 2009 were detected above Bridge 71 (some having been released at Sweeney Creek). Twenty-eight fish (33%) were not detected above Bridge 71 (some having been released at the North Fork). Thirteen fish (15%) were identified moving above Maywood. Nine of the 13 fish above Maywood were released at Sweeney Creek. Only one fish was detected in Charley Creek, and one fish was detected in Gale Creek, both were released at HHD. Of the 20 fish detected in the North Fork, 15 of them had been released in the North Fork, 4 at Sweeney and 2 at HHD. Twenty-seven of the 40 fish released at HHD were detected at or above Bridge 71 (Table 6). A total of 30 of the 34 fish released at Sweeney Creek were tracked at or above their release location in the mainstem Upper Green River. Two of the 34 fish released at Sweeney were confirmed detected in the North Fork. Only two North Fork released fish were detected above Bridge 71, one of which was detected at Road Mile 21, the other at Road Mile 21 and Welcher (Table 7).

Table 7. Maximum upstream extent of tag detection of individual coho in the Upper Green River, Washington, 2009.

Detection Location	RM from HHD	Release Location		
		HHD Launch	N. Fork Green	Sweeney (approx 6.0 RM from HHD)
Dam	0	8		
Charley Creek	1.4	1		
North Fork	2.8	1	13	
Gale Creek	3.2	1		
Bridge 71	3.5	4		
Bridge 71 to RM 21	3.5 – 5.6	1		
Road Mile 21	5.6	2	1	1
RM 21 to Welcher	5.6 – 7.7	2		4
Welcher	7.7	12	1	11
Welcher to Maywood	7.7 – 9.1			1
Maywood	9.1	2		5
Maywood to Bedrock	9.1 – 13.0			1
Bedrock	13.0	3		4
Lester	16.1	1		4

Of the 34 fish released at Sweeney Creek, 13 were tracked below HHD (includes Tailrace and mobile data) (Table 8). In early November 2009, several tags (n=7) were detected during mobile tracking surveys below the Headworks (Figure 5). The downstream most recorded location was 47º 19.264; -121º 53.824, near Kanasket-Palmer State Park (RM 54). These tags were likely associated with post-spawn coho that had been flushed from Howard Hanson Reservoir (likely carcasses at that point). Some tags were recovered from post-spawn fish to be used in future studies.

Table 8. Maximum downstream extent of individual coho tag detections in the Upper Green River, Washington, 2009.

Detection Location	RM from HHD	Release Location		
		HHD Launch	N. Fork Green	Sweeney (approx. RM 6.0)
Below HHD [1]		15	1	13
Dam	0.0	22	5	1
North Fork	2.8	0	9	0
Bridge 71	3.5	0	0	2
RM 21 to Welcher	5.6-7.7	0	0	11
Welcher	7.7	1	0	4

1-These data are from the Tailrace receiver and mobile tracking efforts.

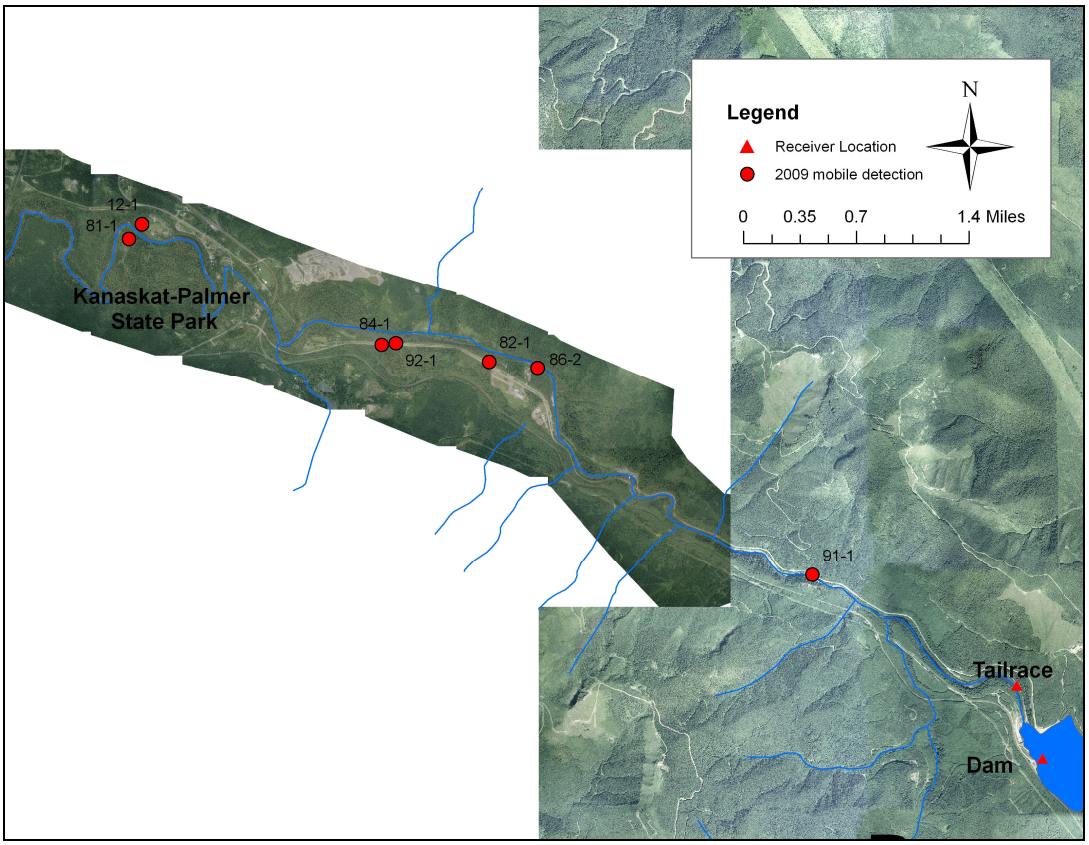

Figure 5. Maximum downstream extent of tags detected during mobile surveys below HHD, Upper Green River, Washington 2009.

5. CONCLUSIONS AND RECOMMENDATIONS

Esophageally administered radio tags were effective in monitoring the migration of coho salmon in the Upper Green Watershed. Results indicate there was minimal immediate tag regurgitation or mortality. The fixed receiver stations provided good coverage of the study area; detecting over 90% of the tags deployed in both 2008 and 2009 (Table 9). The open expanse of Howard Hanson Reservoir allowed for receiver coverage overlap at the Five Mile, Dam and Tailrace sites. In particular, the larger tag size had increased intermittent detections between these sites including through/over the dam to the Tailrace receiver. Removal of the Five Mile and Gut receivers in the 2009 study helped to minimize the coverage overlap. Post-processing of the data in 2008 and 2009 permitted successful interpretation of fish location in the Reservoir.

In general, above HHD the mobile surveys provided data that corroborated with the fixed receiver information, and provided little unique passage information. However, below HHD the mobile surveys provided useful additional data concerning the passage of tagged fish through the dam. All of the seven tags detected during mobile surveys below HHD were also detected at the Tailrace receiver. The seven tags were detected on similar days between mobile and Tailrace receivers, indicating the Tailrace receiver was not detecting these tags through the dam, but rather as they passed by downstream. The furthest downstream mobile detection was near Kanaskat-Palmer State Park.

In both study years there was minimal to no "fallback" of tagged fish passing downstream through the dam shortly after release. Fish did return downstream to the reservoir after migration up into the Upper Green River. However no conclusions could be made regarding whether the downstream migration was active (fish moving prior to spawning) or passive (post-spawn carcasses or tags floating downstream).

Table 9. Total unique tags identified at fixed telemetry stations for each release in the Upper Green River 2008 and 2009.

	2008 Releases				*Total*	**2009 Releases**				*Total*
	16-Oct	23-Oct	30-Oct	5-Nov	*Unique*	23-Oct	28-Oct	5-Nov	14-Nov	*Unique*
Receiver	**HHD**	**HHD**	**HHD**	**HHD**	*Tags*	**HHD**	**Sweeney**	**N. Fork**	**Sweeney**	*Tags*
Tailrace	4	2	1	7	*14*	15	11	2	6	*34*
Dam	15	6	6	38	*65*	36	3	5	3	*47*
Five Mile	16	5	6	37	*64*	-	-	-	-	-
Charley Creek	1	1			*2*	1				*1*
Gut	15	6	5	31	*57*	-	-	-	-	-
North Fork				2	*2*	2	2	15		*19*
Gale Creek				2	*2*	1				*1*
Bridge 71	4	4	6	33	*47*	21	6	2	1	*30*
Upper N. Fork	-	-	-	-	-					*0*
Road Mile 21	12	4	6	23	*45*	16	5	2	3	*26*
Welcher	8		3	16	*27*	17	20	1	5	*43*
Maywood	3		2	11	*16*	6	12		2	*20*
Smay Creek				2	*2*					*0*
Bedrock Pool	2		2	8	*12*	5	7			*12*
Lester		1	2	4	*7*	1	4			*5*
Sunday Creek					*0*					*0*
Upper Green				1	*1*					*0*
Unique detected	16	6	6	39	*67*	38	23	15	6	*82*
Total released	16	6	6	40	*68*	40	25	15	9	*89*
Detection %	100.0	100.0	100.0	97.5	*98.5*	95.0	92.0	100.0	66.7	*93.3*

Note: One additional fish released on 28-Oct 2009 and one fish released on 14-Nov 2009 were tracked manually and not detected on fixed receiver stations.

Results from 2008 indicate that the fish tagged and released later in the season moved through the reservoir much more quickly than those released in early to mid-October (Table 7). This timing is concurrent with increased precipitation/streamflow in the basin (Figure 6). Streamflow may also be the determining factor in upstream migration distance. The upstream extent of fish migration in 2009 was to the Lester site, whereas in 2008 one fish traveled to the Upper Green site, and possibly farther. No fish were detected at the Sunday Creek receiver in 2008 or 2009. While it was proven possible for coho to migrate all the way to the Upper Green River site (approximately 21 miles from release at HHD) the large amount of suitable spawning habitat located in the downstream reaches of the Upper Green River would likely deter fish from traveling further upstream unnecessarily.

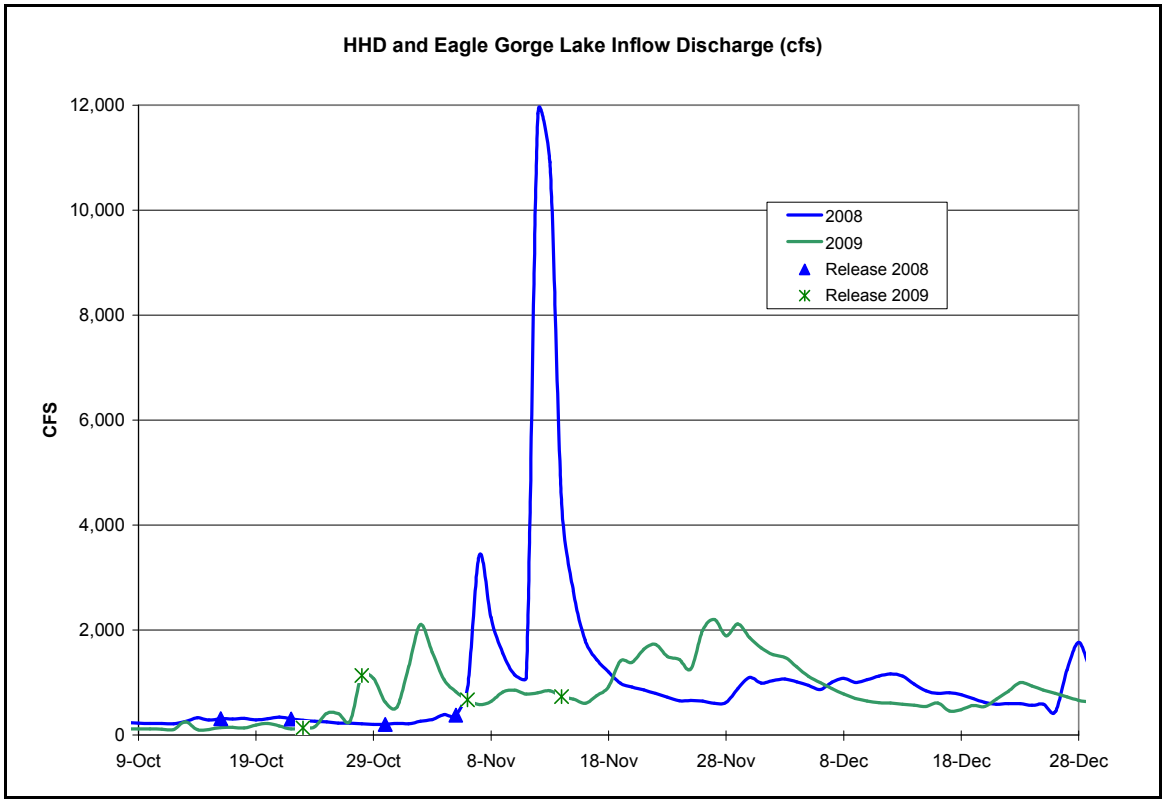

Figure 6. Inflow discharge at HHD and Eagle Gorge Lake, Upper Green River. Data provided by USACE 2010.

In 2008 only four fish (6%) were not tracked leaving the reservoir. The increased percentage of fish not detected above Bridge 71 in 2009 (33%) can be attributed to the releases in the North Fork. Only two of the fish released in the North Fork (13%) migrated above Bridge 71. Interestingly one fish released at Sweeney Creek immediately moved downstream to Bridge 71

and then migrated into the North Fork. However, the majority of the released salmon migrated in the upstream direction, remained for a few days to a week and then migrated (flushed) downstream. Migrating fish were not always detected at every receiver they passed. Upstream migrating fish often passed quickly by Bridge 71 and Road Mile 21 with a greater number of detections in the river at the Welcher site; a likely holding/spawning area for coho salmon that contains good spawning habitat.

It is likely there was increased fish use of the larger tributaries than was represented by the fixed receiver stations. In particular, the Smay Creek receiver station was located approximately one mile upstream from main river channel. There is an abundance of spawning habitat available in the lower reaches of Smay Creek that would not be within receiver range of the fixed station. The lower reaches of Smay Creek are very dynamic, changing greatly with high flow events, such as that which occurred in 2008. Future tracking studies might benefit from exploration of this area for fixed receiver placement or mobile tracking surveys.

All three release locations utilized in this study (HHD, Sweeney Creek and North Fork Green River) were successful at planting migrating coho in the Green River system. However, North Fork released fish appeared to primarily remain in the North Fork. There is suitable spawning habitat available in the North Fork for these fish (R2 2007). Other release locations may not provide good distribution to the North Fork, as only 4 fish that were not released in the North Fork (2 from HHD and 2 from Sweeney release) were later detected in the North Fork Green River.

Fish released at HHD may have delayed migration through the reservoir, particularly with early season releases, with unknown impact on spawning. Twenty percent (8 of 40) fish released at HHD were not detected on any receiver upstream of the dam. Two fish released at HHD (5%) were tracked in Charlie and Gale Creeks. Delayed migration could have been due to higher water temperatures or low water conditions. The fish released from HHD that reached Bridge 71 appeared to move directly upstream, not remaining near the mouth of the river for extended periods, indicating they may not be using this reach for spawning. However, further spawning surveys in this area are needed to describe any spawning behavior. Fish released at Sweeney Creek, particularly late in the season, had the lowest rate of detection. However, the abundance of suitable habitat immediately adjacent to the release site and the later release date may have combined to limit the need for further migration and subsequent multiple detection locations.

Overall, a combination of release locations and timing including untested areas like Bridge 71 may be the best option to maximize fish re-introduction to the watershed. The high detection rate of tagged fish making direct upstream movements indicates a high survival rate of tagged and transported sample fish during both study years.

The methods used in this study worked well, but the following changes are recommended for future studies:

1) Installation of receivers below HHD should be far enough downstream to only detect fish that have passed below the dam, excluding detection of fish in the reservoir.

2) The 'inactive' tag feature did not seem to provide information of sufficient reliability to make decisions regarding salmonid behavior. Furthermore, the inactive codes mimicked erroneous codes created by electrical and/or mechanical interference leading to further false detections.

It is recommended in the future to expand receiver placement (or mobile surveys) in tributaries to investigate specific tributary usage (i.e., lower Smay Creek and upper North Fork Green River). Additional release sites, including Bridge 71, should be tested to determine which provide the best fish distribution according to flow conditions present each year. Spawning surveys would also be useful to detect if tagged fish are actively spawning in the watershed.

This study indicates that coho salmon will utilize the majority of the Upper Green River mainstem and at a minimum the lower portions of several major tributaries including Smay, Gale and Charley creeks and the Upper North Fork Green River, for spawning migration purposes. Transporting salmon above the Tacoma Headworks and Howard Hanson Dam will ensure access to over 60 linear stream miles of suitable habitat that is otherwise unavailable to migrating salmon (R2 Resource Consultants 2001).

6. REFERENCES

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APPENDIX A

Example Coho Detections

Example fish Code 34 Channel 1 – Released 5 November 2008.
This table indicates the first and last hit per day per receiver for tag 34 (1).

CODE	SITE	CHA	DATE	First time	Last time
34	Dam	1	05-Nov-08	12:32	20:34
34	Five Mile	1	05-Nov-08	14:00	14:08
34	Five Mile	1	07-Nov-08	10:08	10:12
34	Gut	1	07-Nov-08	10:41	10:55
34	Bridge 71	1	08-Nov-08	15:22	15:57
34	Road Mile 21	1	09-Nov-08	1:15	23:45
34	Road Mile 21	1	10-Nov-08	0:00	0:00
34	Welcher	1	10-Nov-08	4:46	4:57
34	Maywood	1	10-Nov-08	8:31	23:24
34	Maywood	1	11-Nov-08	18:28	19:08
34	Maywood	1	12-Nov-08	1:10	1:55
34	Bedrock	1	14-Nov-08	15:57	22:23
34	Lester	1	15-Nov-08	16:10	18:09
34	Upper	1	16-Nov-08	3:46	4:19
34	Lester	1	16-Nov-08	7:59	8:50
34	Bedrock	1	16-Nov-08	13:53	13:58
34	Maywood	1	16-Nov-08	15:50	15:56
34	Welcher	1	16-Nov-08	16:52	17:39
34	Road Mile 21	1	16-Nov-08	20:20	20:30
34	Road Mile 21	1	17-Nov-08	0:08	6:37
34	Bridge 71	1	17-Nov-08	16:24	23:59
34	Bridge 71	1	18-Nov-08	0:00	20:54
34	Gut	1	18-Nov-08	12:02	23:17
34	Gut	1	19-Nov-08	0:28	17:46
34	Bridge 71	1	19-Nov-08	19:00	21:34
34	Gut	1	20-Nov-08	1:28	18:18
34	Bridge 71	1	21-Nov-08	13:32	13:55
34	Gut	1	22-Nov-08	6:04	15:09
34	Five Mile	1	22-Nov-08	23:47	23:59

CODE	SITE	CHA	DATE	First time	Last time
34	Five Mile	1	23-Nov-08	0:00	23:59
34	Five Mile	1	24-Nov-08	0:00	19:22
34	Five Mile	1	03-Dec-08	15:16	23:25
34	Five Mile	1	04-Dec-08	0:24	23:59
34	Five Mile	1	05-Dec-08	0:00	23:59
34	Five Mile	1	06-Dec-08	3:40	16:35
34	Five Mile	1	07-Dec-08	4:07	17:25
34	Five Mile	1	08-Dec-08	5:27	13:53

APPENDIX B

Coho Radio Tag Data
-last detection data includes both mobile and fixed receiver data

Code	Channel	Tag Date	Sex	Fork Length	Adipose Clip ?	Tag size	Frequency	Release Date	Release Location	Last Detection Site	Last Detection Date
43	2	15-Oct-08	f	665	n/a	n/a	150.420	16-Oct-08	HHD Launch	Bridge 71	07-Nov-08
44	2	15-Oct-08	f	655	n/a	n/a	150.420	16-Oct-08	HHD Launch	Tailrace	08-Nov-08
45	2	15-Oct-08	m	610	n/a	n/a	150.420	16-Oct-08	HHD Launch	Dam	23-Oct-08
46	2	15-Oct-08	f	605	n/a	n/a	150.420	16-Oct-08	HHD Launch	Gut	19-Nov-08
48	2	15-Oct-08	f	600	n/a	n/a	150.420	16-Oct-08	HHD Launch	Dam	09-Nov-08
49	2	15-Oct-08	f	610	n/a	n/a	150.420	16-Oct-08	HHD Launch	Gut	20-Oct-08
51	2	15-Oct-08	m	615	n/a	n/a	150.420	16-Oct-08	HHD Launch	Gut	23-Nov-08
52	2	15-Oct-08	f	635	n/a	n/a	150.420	16-Oct-08	HHD Launch	Welcher	29-Oct-08
55	2	15-Oct-08	m	675	n/a	n/a	150.420	16-Oct-08	HHD Launch	21 Mile	10-Nov-08
71	1	15-Oct-08	m	730	n/a	large	150.300	16-Oct-08	HHD Launch	21 Mile	14-Dec-08
74	1	15-Oct-08	f	710	n/a	large	150.300	16-Oct-08	HHD Launch	Welcher	16-Nov-08
76	1	15-Oct-08	m	750	n/a	large	150.300	16-Oct-08	HHD Launch	Bridge 71	14-Nov-08
77	1	15-Oct-08	f	693	n/a	large	150.300	16-Oct-08	HHD Launch	Gut	26-Nov-08
78	1	15-Oct-08	m	775	n/a	large	150.300	16-Oct-08	HHD Launch	Five Mile	05-Dec-08
79	1	15-Oct-08	f	705	n/a	large	150.300	16-Oct-08	HHD Launch	Gut	26-Nov-08
80	1	15-Oct-08	m	720	n/a	large	150.300	16-Oct-08	HHD Launch	Five mile	19-Nov-08
40	2	22-Oct-08	m	650	No	small	150.420	23-Oct-08	HHD Launch	21 Mile	31-Oct-08
41	2	22-Oct-08	m	570	No	small	150.420	23-Oct-08	HHD Launch	Lester	04-Nov-08
47	2	22-Oct-08	m	600	No	small	150.420	23-Oct-08	HHD Launch	Bridge 71	12-Nov-08
50	2	22-Oct-08	m	660	No	large	150.420	23-Oct-08	HHD Launch	Bridge 71	12-Nov-08
56	2	22-Oct-08	f	715	No	small	150.420	23-Oct-08	HHD Launch	21 Mile	13-Nov-08
73	1	22-Oct-08	m	760	No	large	150.300	23-Oct-08	HHD Launch	Charley	27-Dec-08
32	2	29-Oct-08	m	645	No	small	150.420	30-Oct-08	HHD Launch	Five Mile	12-Nov-08
33	2	29-Oct-08	f	640	No	small	150.420	30-Oct-08	HHD Launch	Bridge 71	12-Nov-08
34	1	29-Oct-08	f	790	No	small	150.300	30-Oct-08	HHD Launch	Five Mile	08-Dec-08
36	2	29-Oct-08	m	630	No	small	150.420	30-Oct-08	HHD Launch	Lester	12-Dec-08
39	1	29-Oct-08	m	635	No	small	150.300	30-Oct-08	HHD Launch	Tailrace	18-Nov-08
42	2	29-Oct-08	f	665	No	n/a	150.420	30-Oct-08	HHD Launch	21 Mile	03-Nov-08
21	1	04-Nov-08	m	660	No	small	150.300	05-Nov-08	HHD Launch	Five Mile	04-Dec-08
22	1	04-Nov-08	f	685	No	small	150.300	05-Nov-08	HHD Launch	21 Mile	14-Nov-08
23	1	04-Nov-08	f	688	No	small	150.300	05-Nov-08	HHD Launch	Tailrace	17-Nov-08
24	1	04-Nov-08	f	695	No	small	150.300	05-Nov-08	HHD Launch	Bridge 71	10-Nov-08

Code	Channel	Tag Date	Sex	Fork Length	Adipose Clip ?	Tag size	Frequency	Release Date	Release Location	Last Detection Site	Last Detection Date
25	1	04-Nov-08	f	665	No	small	150.300	05-Nov-08	HHD Launch	Welcher	16-Nov-08
26	1	04-Nov-08	f	645	No	small	150.300	05-Nov-08	HHD Launch	Gut	19-Nov-08
27	1	04-Nov-08	m	620	No	small	150.300	05-Nov-08	HHD Launch	Gut	21-Nov-08
28	1	04-Nov-08	m	665	No	small	150.300	05-Nov-08	HHD Launch	21 Mile	17-Nov-08
29	1	04-Nov-08	m	750	No	small	150.300	05-Nov-08	HHD Launch	Five Mile	08-Dec-08
30	1	04-Nov-08	f	705	No	small	150.300	05-Nov-08	HHD Launch	Dam	05-Nov-08
31	1	04-Nov-08	f	685	No	small	150.300	05-Nov-08	HHD Launch	Gut	18-Nov-08
32	1	04-Nov-08	f	710	No	small	150.300	05-Nov-08	HHD Launch	Five Mile	10-Nov-08
33	1	04-Nov-08	f	670	No	small	150.300	05-Nov-08	HHD Launch	Tailrace	17-Nov-08
34	2	04-Nov-08	m	605	No	small	150.420	05-Nov-08	HHD Launch	21 Mile	15-Nov-08
35	1	04-Nov-08	m	655	No	small	150.300	05-Nov-08	HHD Launch	21 Mile	17-Nov-08
35	2	04-Nov-08	m	675	No	small	150.420	05-Nov-08	HHD Launch	Five mile	19-Nov-08
36	1	04-Nov-08	m	620	No	small	150.300	05-Nov-08	HHD Launch	Gut	18-Nov-08
37	1	04-Nov-08	f	660	No	small	150.300	05-Nov-08	HHD Launch	Five Mile	08-Dec-08
37	2	04-Nov-08	m	740	No	small	150.420	05-Nov-08	HHD Launch	Gut	07-Nov-08
38	1	04-Nov-08	f	705	No	small	150.300	05-Nov-08	HHD Launch	Gut	16-Nov-08
38	2	04-Nov-08	m	575	No	small	150.420	05-Nov-08	HHD Launch	Bedrock	19-Nov-08
39	2	04-Nov-08	m	705	No	small	150.420	05-Nov-08	HHD Launch		
40	1	04-Nov-08	m	720	No	small	150.300	05-Nov-08	HHD Launch	Bridge 71	17-Nov-08
57	2	04-Nov-08	m	695	No	small	150.420	05-Nov-08	HHD Launch	Maywood	10-Nov-08
58	2	04-Nov-08	f	635	No	small	150.420	05-Nov-08	HHD Launch	Gut	26-Nov-08
59	2	04-Nov-08	f	678	No	small	150.420	05-Nov-08	HHD Launch	Five Mile	08-Dec-08
60	2	04-Nov-08	f	665	No	small	150.420	05-Nov-08	HHD Launch	Bridge 71	19-Nov-08
61	2	04-Nov-08	f	690	No	small	150.420	05-Nov-08	HHD Launch	Five Mile	08-Dec-08
62	2	04-Nov-08	m	725	No	small	150.420	05-Nov-08	HHD Launch	North Fork	15-Nov-08
63	1	04-Nov-08	f	655	No	small	150.300	05-Nov-08	HHD Launch	21 Mile	21-Dec-08
63	2	04-Nov-08	f	725	No	small	150.420	05-Nov-08	HHD Launch	Bridge 71	17-Nov-08
64	1	04-Nov-08	f	710	No	large	150.300	05-Nov-08	HHD Launch	Five Mile	08-Dec-08
65	1	04-Nov-08	m	775	No	large	150.300	05-Nov-08	HHD Launch	Five Mile	08-Dec-08
66	1	04-Nov-08	f	735	No	large	150.300	05-Nov-08	HHD Launch	Five Mile	08-Dec-08
67	1	04-Nov-08	f	755	No	large	150.300	05-Nov-08	HHD Launch	Gale	14-Dec-08
68	1	04-Nov-08	f	720	No	large	150.300	05-Nov-08	HHD Launch	Gut	26-Dec-08

Code	Channel	Tag Date	Sex	Fork Length	Adipose Clip ?	Tag size	Frequency	Release Date	Release Location	Last Detection Site	Last Detection Date
69	1	04-Nov-08	m	720	No	large	150.300	05-Nov-08	HHD Launch	Tailrace	20-Nov-08
70	1	04-Nov-08	m	740	No	large	150.300	05-Nov-08	HHD Launch	Tailrace	19-Nov-08
72	1	04-Nov-08	m	730	No	large	150.300	05-Nov-08	HHD Launch	Gale	01-Jan-09
75	1	04-Nov-08	f	715	No	large	150.300	05-Nov-08	HHD Launch	Gut	26-Nov-08
11	1	22-Oct-09	m	580	No	small	150.300	23-Oct-09	HHD Launch	Tailrace	04-Dec-09
11	2	22-Oct-09	m	680	No	small	150.420	23-Oct-09	HHD Launch	Tailrace	02-Nov-09
12	1	22-Oct-09	m	525	No	small	150.300	23-Oct-09	HHD Launch	Below HHD	03-Nov-09
13	1	22-Oct-09	m	475	No	small	150.300	23-Oct-09	HHD Launch	Tailrace	23-Dec-09
14	1	22-Oct-09	m	485	No	small	150.300	23-Oct-09	HHD Launch	Maywood	30-Oct-09
15	1	22-Oct-09	f	460	No	small	150.300	23-Oct-09	HHD Launch	21 Mile	24-Nov-09
16	1	22-Oct-09	m	545	No	small	150.300	23-Oct-09	HHD Launch	Dam	29-Oct-09
17	1	22-Oct-09	f	580	No	small	150.300	23-Oct-09	HHD Launch		
18	1	22-Oct-09	f	730	No	small	150.300	23-Oct-09	HHD Launch	North Fork	06-Dec-09
64	2	22-Oct-09	m	635	No	large	150.420	23-Oct-09	HHD Launch	Reservoir	02-Dec-09
65	2	22-Oct-09	m	655	No	large	150.420	23-Oct-09	HHD Launch	Reservoir	02-Dec-09
66	2	22-Oct-09	f	475	No	large	150.420	23-Oct-09	HHD Launch	Tailrace	23-Dec-09
67	2	22-Oct-09	f	620	No	large	150.420	23-Oct-09	HHD Launch	Dam	03-Dec-09
68	2	22-Oct-09	m	685	No	large	150.420	23-Oct-09	HHD Launch	Dam	04-Dec-09
69	2	22-Oct-09	m	695	No	large	150.420	23-Oct-09	HHD Launch		
81	1	22-Oct-09	m	745	No	large	150.300	23-Oct-09	HHD Launch	Below HHD	03-Nov-09
81	2	22-Oct-09	m	670	No	large	150.420	23-Oct-09	HHD Launch	Bedrock	11-Dec-09
82	1	22-Oct-09	m	715	No	large	150.300	23-Oct-09	HHD Launch	Below HHD	04-Nov-09
82	2	22-Oct-09	f	610	No	large	150.420	23-Oct-09	HHD Launch	Gale	02-Dec-09
83	1	22-Oct-09	f	585	No	large	150.300	23-Oct-09	HHD Launch	Dam	19-Nov-09
83	2	22-Oct-09	m	720	No	large	150.420	23-Oct-09	HHD Launch	Welcher	26-Nov-09
84	1	22-Oct-09	m	750	No	large	150.300	23-Oct-09	HHD Launch	Below HHD	04-Nov-09
84	2	22-Oct-09	f	720	No	large	150.420	23-Oct-09	HHD Launch	21 Mile	07-Dec-09
85	1	22-Oct-09	m	655	No	large	150.300	23-Oct-09	HHD Launch	Dam	04-Nov-09
85	2	22-Oct-09	m	770	No	large	150.420	23-Oct-09	HHD Launch	Dam	24-Oct-09
86	1	22-Oct-09	f	560	No	large	150.300	23-Oct-09	HHD Launch	Tailrace	23-Dec-09
86	2	22-Oct-09	f	675	No	large	150.420	23-Oct-09	HHD Launch	Below HHD	04-Nov-09
87	1	22-Oct-09	m	600	No	large	150.300	23-Oct-09	HHD Launch	Welcher	07-Dec-09

Code	Channel	Tag Date	Sex	Fork Length	Adipose Clip ?	Tag size	Frequency	Release Date	Release Location	Last Detection Site	Last Detection Date
87	2	22-Oct-09	m	680	No	large	150.420	23-Oct-09	HHD Launch	Dam	15-Nov-09
88	1	22-Oct-09	f	550	No	large	150.300	23-Oct-09	HHD Launch	Dam	03-Dec-09
88	2	22-Oct-09	f	750	No	large	150.420	23-Oct-09	HHD Launch	Reservoir	02-Dec-09
89	1	22-Oct-09	m	755	No	large	150.300	23-Oct-09	HHD Launch	Dam	27-Nov-09
89	2	22-Oct-09	f	705	No	large	150.420	23-Oct-09	HHD Launch	Reservoir	02-Dec-09
90	1	22-Oct-09	m	705	No	large	150.300	23-Oct-09	HHD Launch	Reservoir	17-Nov-09
90	2	22-Oct-09	m	645	No	large	150.420	23-Oct-09	HHD Launch	Reservoir	02-Dec-09
91	1	22-Oct-09	m	605	No	large	150.300	23-Oct-09	HHD Launch	Below HHD	19-Nov-09
91	2	22-Oct-09	m	710	No	large	150.420	23-Oct-09	HHD Launch	Dam	05-Nov-09
92	1	22-Oct-09	m	535	Yes	large	150.300	23-Oct-09	HHD Launch	Below HHD	04-Nov-09
92	2	22-Oct-09	m	625	No	large	150.420	23-Oct-09	HHD Launch	Tailrace	23-Dec-09
93	2	22-Oct-09	m	595	No	large	150.420	23-Oct-09	HHD Launch	Welcher	14-Dec-09
12	2	27-Oct-09	f	590	No	small	150.420	28-Oct-09	Sweeney Creek	Welcher	04-Nov-09
13	2	27-Oct-09	f	385	No	small	150.420	28-Oct-09	Sweeney Creek	Tailrace	23-Dec-09
14	2	27-Oct-09	f	655	No	small	150.420	28-Oct-09	Sweeney Creek	Maywood	04-Nov-09
15	2	27-Oct-09	m	640	No	small	150.420	28-Oct-09	Sweeney Creek	Tailrace	23-Dec-09
16	2	27-Oct-09	f	645	No	small	150.420	28-Oct-09	Sweeney Creek	Tailrace	23-Dec-09
17	2	27-Oct-09	m	725	No	small	150.420	28-Oct-09	Sweeney Creek	Lester	04-Nov-09
18	2	27-Oct-09	m	640	No	small	150.420	28-Oct-09	Sweeney Creek	Welcher	21-Nov-09
19	1	27-Oct-09	m	615	No	small	150.300	28-Oct-09	Sweeney Creek	Maywood	19-Nov-09
19	2	27-Oct-09	f	580	No	small	150.420	28-Oct-09	Sweeney Creek	21 Mile	09-Dec-09
20	1	27-Oct-09	m	685	No	small	150.300	28-Oct-09	Sweeney Creek	Welcher	06-Nov-09
20	2	27-Oct-09	m	575	Yes	small	150.420	28-Oct-09	Sweeney Creek	North Fork	02-Dec-09
22	2	27-Oct-09	m	640	No	small	150.420	28-Oct-09	Sweeney Creek	Welcher	14-Dec-09
23	2	27-Oct-09	f	625	No	small	150.420	28-Oct-09	Sweeney Creek	North Fork	07-Dec-09
24	2	27-Oct-09	f	675	No	small	150.420	28-Oct-09	Sweeney Creek	Welcher	02-Nov-09
25	2	27-Oct-09	m	745	No	small	150.420	28-Oct-09	Sweeney Creek	Maywood	04-Dec-09
26	2	27-Oct-09	m	630	No	small	150.420	28-Oct-09	Sweeney Creek	Tailrace	04-Dec-09
70	2	27-Oct-09	f	620	No	large	150.420	28-Oct-09	Sweeney Creek	Tailrace	23-Dec-09
71	2	27-Oct-09	m	620	No	large	150.420	28-Oct-09	Sweeney Creek	Maywood	07-Dec-09
74	2	27-Oct-09	f	680	No	large	150.420	28-Oct-09	Sweeney Creek	Welcher	14-Dec-09
75	2	27-Oct-09	m	710	No	large	150.420	28-Oct-09	Sweeney Creek	Maywood	04-Dec-09

Code	Channel	Tag Date	Sex	Fork Length	Adipose Clip ?	Tag size	Frequency	Release Date	Release Location	Last Detection Site	Last Detection Date
76	2	27-Oct-09	m	530	No	large	150.420	28-Oct-09	Sweeney Creek	Tailrace	07-Nov-09
77	2	27-Oct-09	m	725	No	large	150.420	28-Oct-09	Sweeney Creek	Welcher	14-Dec-09
78	2	27-Oct-09	m	745	No	large	150.420	28-Oct-09	Sweeney Creek	North Fork	08-Dec-09
79	2	27-Oct-09	m	650	No	large	150.420	28-Oct-09	Sweeney Creek	Welcher	09-Dec-09
80	2	27-Oct-09	m	745	No	large	150.420	28-Oct-09	Sweeney Creek	Bedrock	11-Dec-09
21	2	5-Nov-09	f	525	No	small	150.420	6-Nov-09	N. Fk. Green R.	North Fork	06-Dec-09
27	2	5-Nov-09	f	600	No	small	150.420	6-Nov-09	N. Fk. Green R.	North Fork	06-Nov-09
28	2	5-Nov-09	f	670	No	small	150.420	6-Nov-09	N. Fk. Green R.	North Fork	21-Nov-09
29	2	5-Nov-09	m	575	No	small	150.420	6-Nov-09	N. Fk. Green R.	North Fork	07-Dec-09
30	2	5-Nov-09	m	650	No	small	150.420	6-Nov-09	N. Fk. Green R.	Tailrace	18-Nov-09
31	2	5-Nov-09	f	575	No	small	150.420	6-Nov-09	N. Fk. Green R.	Dam	13-Nov-09
41	1	5-Nov-09	f	550	No	small	150.300	6-Nov-09	N. Fk. Green R.	Dam	12-Nov-09
42	1	5-Nov-09	m	645	No	small	150.300	6-Nov-09	N. Fk. Green R.	North Fork	15-Nov-09
43	1	5-Nov-09	f	620	No	small	150.300	6-Nov-09	N. Fk. Green R.	North Fork	08-Nov-09
44	1	5-Nov-09	m	730	No	small	150.300	6-Nov-09	N. Fk. Green R.	North Fork	17-Nov-09
45	1	5-Nov-09	f	485	No	small	150.300	6-Nov-09	N. Fk. Green R.	North Fork	12-Nov-09
58	1	5-Nov-09	f	670	No	small	150.300	6-Nov-09	N. Fk. Green R.	North Fork	08-Nov-09
59	1	5-Nov-09	f	650	No	small	150.300	6-Nov-09	N. Fk. Green R.	North Fork	19-Nov-09
62	1	5-Nov-09	f	620	No	small	150.300	6-Nov-09	N. Fk. Green R.	North Fork	01-Dec-09
73	2	5-Nov-09	m	700	No	large	150.420	6-Nov-09	N. Fk. Green R.	North Fork	08-Dec-09
51	1	13-Nov-09	m	710	No	small	150.300	14-Nov-09	Sweeney Creek	Tailrace	23-Dec-09
53	1	13-Nov-09	m	720	No	small	150.300	14-Nov-09	Sweeney Creek	Tailrace	21-Nov-09
54	2	13-Nov-09	f	700	No	small	150.420	14-Nov-09	Sweeney Creek		
55	1	13-Nov-09	f	520	No	small	150.300	14-Nov-09	Sweeney Creek	Tailrace	04-Dec-09
56	1	13-Nov-09	m	740	No	small	150.300	14-Nov-09	Sweeney Creek	Tailrace	21-Nov-09
57	1	13-Nov-09	m	650	No	small	150.300	14-Nov-09	Sweeney Creek	Tailrace	23-Dec-09
60	1	13-Nov-09	f	610	No	small	150.300	14-Nov-09	Sweeney Creek		
61	1	13-Nov-09	f	630	No	small	150.300	14-Nov-09	Sweeney Creek	Welcher	14-Dec-09
72	2	13-Nov-09	m	650	No	large	150.420	14-Nov-09	Sweeney Creek	Tailrace	30-Nov-09

APPENDIX C

2008-2009 Raw Telemetry Data for the Upper Green River

(See Appendix C on Attached CD)

GREEN RIVER HABITAT CONSERVATION PLAN

Headworks Dam Juvenile Salmon Survival Study Report

June, 2010

TACOMA WATER HABITAT CONSERVATION PLAN

Headworks Dam Juvenile Salmon Survival Study Report

Prepared for:

NOAA National Marine Fisheries Service
Northwest Regional Office
Habitat Conservation Division

and

U.S. Fish and Wildlife Service
Western Washington Fish and Wildlife Office
Division of Conservation and Hydropower Planning

Prepared by:

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ACKNOWLEDGEMENTS

We would like to thank the Muckleshoot Indian Tribe for their generous donation of over 20,000 yearling coho salmon for this project. A special thanks goes to Hugo Hernandez, Keta Creek Hatchery Manager, and his staff for their care of the marked fish prior to transfer to the Headworks and for assisting with the seining, fish marking, and transferring of these fish as well as for ensuring the adequacy of our holding facilities. We are also thankful for Dennis Moore, MIT Fishery Enhancement Manager, who advocated for this project.

We would like to thank the Northwest Indian Fisheries Commission including Ron Olson, Hatchery Programs Manager, and Ken Phillipson, Fish Marking Coordinator, for the use of a mobile fish marking laboratory trailer and marking scissors. Marking would have been a long and arduous task if not for the use of their trailer.

We are also very thankful for the biologists that reviewed the study design, which included Tim Romanski, U.S. Fish & Wildlife Service; Steve Fransen, National Marine Fisheries Service; Pete Topping and Mark Hunter, Washington Department of Fish and Wildlife; and Holly Coccoli, Muckleshoot Indian Tribe; as well as Dennis Moore and Ron Olson who were previously mentioned.

We would also like to thank the Washington Department of Fish & Wildlife Green River smolt trapping crew including Bob Green and Josh Weinheimer who worked long hours on the RM 34.5 screw trap to collect and assess condition for this study; as well as their supervisor, fish biologist Pete Topping, who encouraged their participation.

A special thanks goes out to the Eugene Water and Electric Board who loaned us a rotary screw trap for use at the RM 60 trapping site. We are very grateful for the assistance of biologist Andy Talabere who helped to make this happen.

Finally, we are extremely grateful for all of the Tacoma Water staff and volunteers who worked on the fish marking, release, and recapture operations. These included Jeff Gillard, Lisa Sievers, Brian Milliken, Ken Kurfurst, Susan Clark, Dan Muir, Jodi Collins, Rich Carlson, Kurt Kirschner, Chris Webster, Hilary Lorenz, Jarrod Kaiser, Lee Barry, Wade Green, Bret Cook, Bryan King, Ron Markland, and Mark Brons; all from Tacoma Water. We are especially thankful for volunteers from outside Tacoma Water, including Tacoma Power employees Paul Hickey and Chris Sergeant. Finally, we are extremely grateful for the help of Eric Sievers, who volunteered as a non-TPU employee to assist with the fish release.

INTRODUCTION

Tacoma Water built the Green River Headworks Diversion Dam in 1911 and began withdrawing water for municipal use in 1913. Construction of the 17 foot high dam at river mile 61 prevented fish passage into the upper watershed. A second diversion water right was granted in 1986 and planning began for the Second Supply Project. This project involved raising the Headworks Dam an additional 6 ½ feet, constructing a second pipeline, and constructing an upstream trap and haul facility and downstream passage facility at the Headworks to provide fish access to and from the upper watershed (**Figure 1**).

During the planning phase for the Second Supply Project, Tacoma Water developed the Green River Habitat Conservation Plan to address Endangered Species Act concerns relative to municipal water system operations (Tacoma Water et al. 2001). To address potential impacts from raising the Headworks Dam 6 ½ feet, the following was included as part of habitat conservation measure HCM 1-04:

> **HCM 1-04:** ***Tacoma Water will modify the Headworks in such a way to minimize the risk of injury to salmonids passing over the Headworks spillway***

Work to raise the Headworks Dam occurred in 2002-2003 and included the following measures to minimize the risk of injury to salmonids:

- Constructed the top of the dam to provide an even laminar flow across the entire face of the spillway,
- Provided for fish passage over the entire length of the dam to avoid creating predation "hotspots",
- Constructed the spillway in a sinusoidal shape to slide the fish over the dam on a laminar cushion of water, and
- Constructed a pool retention sill below the spillway to provide a plunge pool for fish passing over the dam (Figure 2).

To ensure that dam modifications met the criteria described in HCM 1-04, Compliance Monitoring Measure CMM-05 in the HCP states in part that:

> **CMM-05:** ***A biological test of the modified spillway will be conducted to demonstrate that the risk of injury to salmonids passing downstream over the spillway is minimal.***

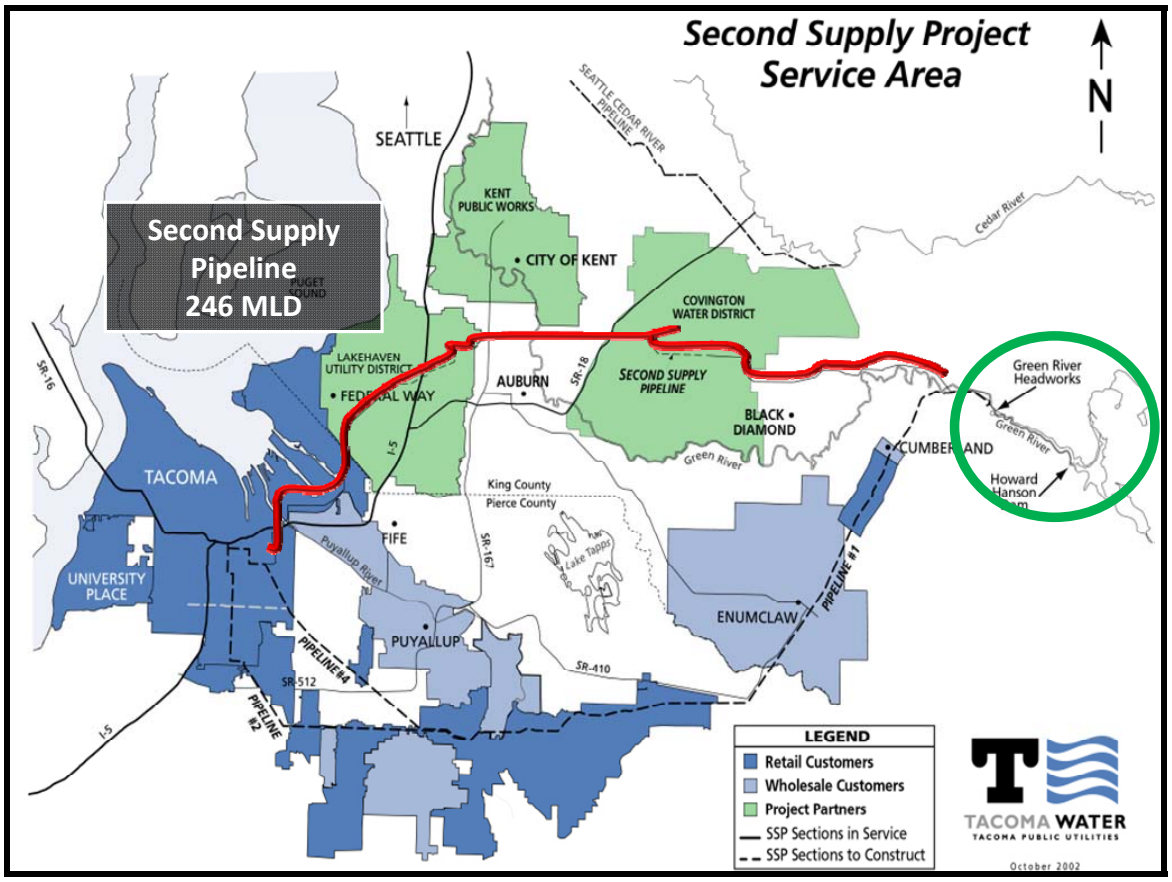

Figure 1. Regional map showing the Headworks Dam, Howard Hanson Dam, and the Second Supply Pipeline.

Designing the biological test required an evaluation of species and life stages likely to pass over the spillway. Before Tacoma's Headworks Trap and Haul Facility is used to move large numbers of adult salmon upstream, a downstream fish passage facility will be constructed by the U.S. Army Corps of Engineers as part of the Howard Hanson Dam (HHD) Additional Water Storage Project (AWSP). The downstream fish passage facility is designed to capture and truck downstream migrants 3 ½ miles to below the Headworks Dam. However, the surface elevation of Eagle Gorge Reservoir (above HHD) is low enough in the winter that migrants leaving the reservoir in November through mid February or early March will be able to exit through a radial gate located at the base of HHD and swim downstream to the Headworks Dam. Based on migration timing from smolt trap operations in the Green River near Soos Creek, January to early February migrants are expected to be comprised primarily of newly emerged chinook fry along with a few steelhead pre-smolts (Volkhardt et al. 2006). Some coho pre-smolts may also migrate in November to find over-wintering habitat in the lower Green River. An unknown portion of these fish will be entrained into the water supply stream and will divert through the Headworks downstream passage facility to the lower river. The remainder will pass over the 23 ½ foot Headworks Dam spillway. The survival and condition of these later migrants is the focus of this study.

A draft study design was developed and distributed on December 24, 2008 to the Muckleshoot Indian Tribe (MIT), National Marine Fisheries Service (NMFS), U.S. Fish & Wildlife Service (USFWS), Washington Department of Fish & Wildlife (WDFW), and the Northwest Indian Fisheries Commission (NWIFC). Comments were received and the study design was finalized on January 20, 2009 (Appendix A).

This report describes the design and outcomes from this study, which was conducted during spring 2009.

Figure 2. Headworks Dam during construction of the dam raising project showing the increased dam height, sinusoidal spillway, and pool retention sill.

METHODS

The biological test employed a control-treatment mark-recapture study design to evaluate survival of juvenile salmonids passing over the Headworks Dam. Coho smolts from the Muckleshoot Indian Tribe (MIT) Keta Creek Hatchery were used in the evaluation. Coho were selected because:

1. They were not ESA listed,
2. They were intermediate in size between chinook fry and steelhead smolts making them a good surrogate for the other species,
3. They were likely to migrate over the Headworks Dam spillway once adults are allowed to spawn naturally upstream of HHD, and
4. They were more easily recaptured than steelhead smolts.

Control and treatment groups were marked at the Keta Creek Hatchery using left and right ventral fin clips, respectively. Marking occurred on March 24 and March 25, 2009. Marked fish were transferred to the Headworks Dam on April 8. One thousand gallon polyethylene circular tanks were placed above the Headworks Dam at the water supply intake, and at the Trap and Haul Facility downstream of the dam to hold the treatment and control fish. Each tank was fitted with a tank liner net to ease fish removal. The fish were not fed for two days prior to transporting them to the Headworks and while they were in the polyethylene tanks. Flow through each tank was estimated at 25 gallons/minute.

The control and treatment groups were released nearly simultaneously at the base and top of the Headworks Dam, respectively. The release occurred at dusk on April 9, 2009. The groups were released by dipnetting fish from the polyethylene tanks into a transport chute constructed from 12 inch PVC pipe. The transport chute used for the treatment group was approximately 60 feet long and was suspended using a boom truck between the fish tank and the upper edge of the spillway (Figure 3). The chute was positioned so that fish exiting the chute could not swim back into the Headworks Dam pool. The transport chute used for the control group was approximately 14 feet in length and routed fish into the bypass chute at the Headworks Trap and Haul Facility. These fish slid down the bypass chute and into the Green River approximately 200 yards downstream of the Headworks Dam (Figure 4). Both chutes had water flowing through them to facilitate fish transport.

Recaptures occurred at two locations. A five foot rotary screw trap mounted on a pontoon barge was positioned approximately one mile downstream of the Headworks Dam at river mile (RM) 60 and was operated from the evening of April 9 through noon on April 10 (Figure 5). A 640 gallon polyethylene tank fitted with a tank liner net was used at this site to hold fish captured during the period of trap operation. Flow through this tank was estimated at 15 gallons/minute. In addition, WDFW operated a five foot rotary screw trap at RM 34.5, approximately 26 ½ miles downstream of the Headworks Dam. This trap was operated nearly continuously through the spring.

Figure 3. Transport chute positioned to transfer treatment group from the polyethylene tank to the edge of the Headworks Dam spillway on the Green River, April 9, 2009.

Figure 4. Discharge end of the bypass chute used to convey control group fish into the Green River downstream of the Headworks Dam (background).

Figure 5. Fish biologists removing captured marked coho from the rotary screw trap at RM 60 on the Green River, April 9, 2009 (photograph was lightened).

Recaptured coho were removed from the traps, anesthetized with MS-222, and enumerated by mark type. Superficial condition of each fish was assessed by rating each of three types of injuries: de-scaling, laceration, and abrasion (Table 1). Fish recaptured at the RM 60 trap were given a small upper lobe caudal clip so that they would not be included in the sample if recaptured at the RM 34.5 trap. After evaluation, all fish were placed in freshwater to recover and released back to the river.

Table 1. Superficial fish condition rating criteria.

Degree of De-scaling	**Score**
<10%	4
11%-20%	3
21%-30%	2
>30%	1
Degree of Laceration (modified from Whiteaker et al. 2006)	**Score**
No major injuries that break the skin	4
Injuries that break the skin	3
Injuries that penetrate the muscle tissue	2
Injuries that penetrate the body cavity or large section of body missing	1
Degree of Abrasion	**Score**
No abrasion on head, belly, or fins	3
Minor abrasion on head, belly, or fins	2
Major abrasion on head, belly, or fins	1

We tested the null hypothesis that the control and treatment groups were captured at the same rate in each trap. Equal capture rates would signify equal survival rates among the two groups. A G-test for goodness of fit was used to evaluate the capture rate for the treatment group against the expected rate estimated by the control group capture rate (α = 0.05). A one-tailed test was used to evaluate difference since the null hypothesis would not be rejected if the capture rates for the treatment group were significantly higher than for the control group.

We also evaluated superficial fish condition ratings between the two groups. Contingency tables developed using condition ratings for each injury type from the treatment group were compared with that from the control group also using a G-test for goodness of fit using expected frequencies based on hypotheses intrinsic to the sample data (Sokal and Rohlf 1981). A one-tailed test was used to assess differences between control and treatment groups since significantly better condition in the treatment group would be an acceptable outcome. Significant differences (α = 0.05) in any of the three superficial fish condition elements would suggest an impact from the fish routing over the dam face.

RESULTS

Fish were transferred from Keta Creek Hatchery to the Headworks on April 8, 2009 and were released from control and test locations at about 1800 hours, April 9, 2009. A total of 9,867 fish were released in the treatment group and 9,951 in the control group (Table 2). Outflow at HHD was 1,900 cfs at the time of the release.

Table 2. Summary of release and recapture data from the Headworks spillway coho survival study conducted April 9 through May 3, 2009 in the Green River, WA.

Location	Datum	Date	Treatment Group (RV Marked)	Control Group (LV Marked)
Headworks	# Released	4/9	9,867	9,951
RM 60 Trap	# Recaptured	4/9-10	346	339
	Capture Rate		3.51%	3.41%
RM 34.5 Trap	# Recaptured Stratum 1[1]	4/9	43	73
	# Recaptured Stratum 2	4/10 – 5/3	135	136
	Total Recaptured	4/9 – 5/3	178	209
	Capture Rate Stratum 1	4/9	0.45%	0.76%
	Capture Rate Stratum 2	4/10 – 5/3	1.42%	1.41%
	Total Capture Rate	4/9 – 5/3	1.87%	2.17%
Pooled Trap Data	Total Recaptured	4/9 – 5/3	524	548
	Total Capture Rate		5.31%	5.51%

[1] Likely data transcription error, see text for explanation.

Relative Survival

The trap at RM 60 was operated from 1800 hrs, April 9 through 1200 hrs, April 10. A total of 685 coho were captured, which included 346 test fish and 339 control fish (Table 2). Recapture rates were higher for the test group (3.51%) compared to the control group (3.41%) indicating no difference in survival as a result of passing over the spillway.

The trap at RM 34.5 was in operation continuously through the test period. Marked coho from this study were recaptured from April 9 through May 3. On the morning of April 10, we were surprised to learn that a substantial number of marked fish had traveled 26 ½ miles on the night of the release to be caught in the RM 34.5 trap. After recording their catch from trapping operations during the night of April 9, the two WDFW technicians operating the RM 34.5 trap came to the RM 60 trap to cross train on the superficial fish condition rating system/form to ensure consistency in data collection between the two trapping sites. The WDFW technicians reported catching 73 RV marked (treatment) and 43 LV marked (control) coho during the night of April 9; however, as we worked up the fish captured at the RM 60 trap, it became apparent that they had some confusion on how to identify left ventral clipped and right ventral clipped fish.

After giving them the appropriate training in mark identification, they reported that the RV and LV marks recorded from the April 9 data collected at the WDFW trap should be switched to show 73 LV marked (control) and 43 RV mark (test) coho captured on the night of April 9. These recaptures are shown as Stratum 1 Recaptures in Table 2. After receiving training on the proper identification of marks, the WDFW crew recorded 135 RV marks and 136 LV marks over the remainder of the trapping period. These are shown as Stratum 2 Recaptures in Table 2. Despite the correction to the WDFW data from April 9, its accuracy is suspect given the lack of agreement with data collected following proper training and the strong agreement between the April 9 to April 10 data collected at the RM 60 trap and the Stratum 2 data collected at the RM 34.5 trap.

Analysis of the data indicated that the capture rate for the test group was not significantly different from the control group at the RM 60 trap site (α=0.05), nor was it significantly different when all of the data from both sites were pooled. However, the capture rate for the test group was significantly lower than that for the control group at the RM 34.5 trap (α=0.05) when all of the data from that site was used.

Superficial Condition

All recaptured fish were examined for superficial condition at the trap sites prior to release. De-scaling never exceeded 10% on any of the recapture fish, nor were any lacerations that broke the skin identified (Table 3). Occasional minor abrasion was identified on some fish in both the control and treatment groups. The rate of minor abrasion was higher at both trap sites for the control group than for the treatment group, which indicated passage over the spillway did not cause injury.

Table 3. Superficial injury scores given to recaptured marked coho released on April 9, 2009 at the Headworks Dam at river mile 61 on the Green River, WA.

	Scoring Categories							
	Treatment (RV Marked)				**Control (LV Marked)**			
Location/ Element	**4**	**3**	**2**	**1**	**4**	**3**	**2**	**1**
RM 60 Trap								
De-scaling	346	0	0	0	339	0	0	0
Laceration	346	0	0	0	339	0	0	0
Abrasion		335	11	0		319	20	0
RM 34.5 Trap (All Data)								
De-scaling	178	0	0	0	209	0	0	0
Laceration	178	0	0	0	209	0	0	0
Abrasion		169	9	0		193	16	0
RM 34.5 Trap (4/10 – 5/3 Data)								
De-scaling	135	0	0	0	136	0	0	0
Laceration	135	0	0	0	136	0	0	0
Abrasion		130	5	0		124	12	0

DISCUSSION

Results from this test strongly indicate no difference in survival between fish passing over the Headworks Dam spillway and those released at the base of the dam. Capture rates were essentially the same for both control and treatment fish at the RM 60 trap, which provides the best direct measure given its proximity to the release site. Findings from the WDFW trap at RM 34.5 corroborate these results if data from the first night's catch is thrown out, which we believe is justified given the high potential for recording errors.

The results also strongly indicate that passage over the Headworks Dam spillway does not result in superficial injury. These results provide further evidence that our conclusions regarding the survival of fish passing over the Headworks Dam is correct. If dam passage negatively affected survival, we would expect to have seen a higher rate of injury to RV marked fish; rather than the lack of difference shown in the data.

All fish in this study were recaptured using rotary screw traps. Capture rates using this gear are affected by flow, visibility, fish size, trap positioning, velocity, and trap noise (Volkhardt et al. 2007). By releasing both groups at the same time, we were able to control potential variability in capture rates caused by different flow or discharge levels, trap placement, visibility, and noise. Differential capture rates could occur if there were size differences between the control and treatment groups. Both groups came from the same rearing pond at the Keta Creek Hatchery. After marking the fish on March 24th and 25th, they were placed in separate raceways for two weeks prior to transport to the Headworks Dam. Fork lengths were taken from recaptures at the RM 60 trap to test for differences. Mean fork lengths between the control and treatment groups were nearly identical at 132.6 mm and 132.1 mm, respectively. Given these results and the manner in which fish were released provides a high degree of confidence that the test was not biased.

We believe coho salmon provided an adequate surrogate for other species that may pass over the Headworks Dam. The potential for injury exists where velocities approach 40 feet/second (Bell 1990). This velocity is attained due to the acceleration imparted by gravity at a drop of approximately 50 feet. The velocity achieved as a result of acceleration due to gravity by fish passing over the Headworks Dam is approximately 27.5 feet/second, much less than the 40 feet/second threshold.

Sub-yearling migrants such as chinook salmon would be expected to develop less velocity as they pass over the spillway since they would experience more drag due to air resistance given their small weight relative to their surface area. Thus, if coho are not injured passing over the dam, then chinook would be even less likely to be injured. Conversely, steelhead smolts typically migrate at a larger size than our test coho. They would be expected to experience greater velocities passing over the Headworks Dam since drag would be even less for this species/life stage. Nevertheless, their size is not substantially larger than hatchery coho smolts.

Their strong swimming ability makes them difficult to catch using trapping gear; thus, using steelhead smolts with this study design is impracticable unless a much larger number of fish are available to release. We believe the lack of evidence of injury does not support additional studies given the current configuration of the Headworks Dam.

LITERATURE CITED

Bell, M.C. 1990. Fisheries handbook of engineering requirements and biological criteria. Fish Passage Development and Evaluation Program, Corps of Engineers, North Pacific Division. Portland, OR.

Sokal, R.R. and F.J. Rohlf. 1990. Biometry: the principals and practice of statistics in biological research, 2nd edition. W.H. Freeman and Co. San Francisco, CA.

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Volkhardt, G.C., S.L. Johnson, B.A. Miller, T.E. Nickelson, and D.E. Seiler. 2007. Rotary screw traps and inclined plan screen Traps. Pages 235-266 in D.H. Johnson, B.M. Shrier, J.S. O'Neal, J.A. Knutzen, X. Augerot, T.A. O'Neil, and T.N. Pearsons. Salmonid field protocols handbook: techniques for assessing status and trends in salmon and trout populations. American Fisheries Society, Bethesda, MD.

Volkhardt, G., P. Topping, L. Kishimoto, D. Rawding, and M. Groesbeck. 2006. 2005 Juvenile salmonid production evaluation report: Green River, Dungeness River and Cedar Creek. Washington Department of Fish & Wildlife. FPA 06-10. Olympia, WA.

Whiteaker J., J.K Fryer, and J. Doyle 2006. Age and Length Composition of Columbia Basin Chinook and Sockeye Salmon and Steelhead at Bonneville Dam in 2005. Columbia River Inter-Tribal Commission Technical Report. Portland, OR.

APPENDIX A

STUDY DESIGN PAPER

Green River Headworks Spillway
Biological Test Study Plan

Introduction

Tacoma Water built the Green River Headworks diversion dam in 1911 and began withdrawing water for municipal use in 1913. Construction of the 17 foot high dam at river mile 61 prevented fish passage into the upper watershed. A second diversion water right was granted in 1986 and planning began for the Second Supply Project. This project involved raising the Headworks Dam an additional 6 ½ , constructing a second pipeline, and constructing a trap and haul and downstream passage facility to provide fish access to and from the upper watershed. During the planning phase for the Second Supply Project, Tacoma Water developed the Green River Habitat Conservation Plan to address Endangered Species Act concerns relative to municipal water system operations. This study will address one of the stipulations in the HCP, Compliance Monitoring Measure CMM-05, which requires Tacoma Water to conduct a biological test of the modified spillway to demonstrate that the risk of injury to salmonids passing downstream over the spillway is minimal.

Before Tacoma's Headworks Trap and Haul Facility is used to move large numbers of adult salmon upstream, a downstream fish passage facility will be constructed by the U.S. Army Corps of Engineers as part of the Howard Hanson Dam (HHD) Additional Water Storage Project (AWSP). The downstream fish passage facility is designed to capture and truck downstream migrants 3 ½ miles to below the Headworks Dam. However, the surface elevation of Eagle Gorge Reservoir (above HHD) is low enough in the winter that migrants leaving the reservoir in November – early February will be able to exit the reservoir through the radial gate and swim downstream to the Headworks Dam. Based on migration timing from smolt trap operations in the Green River near Soos Creek, January to early February migrants are expected to be comprised primarily of newly emerged chinook fry along with a few steelhead pre-smolts (Volkhardt et al. 2006). Some coho pre-smolts may also migrate in November to find over-wintering habitat in the lower Green River. An unknown portion of these fish will be entrained into the water supply stream and will divert through the Headworks downstream passage facility to the lower river. The remainder will pass over the 23 ½ foot dam face. The survival of these later migrants is the focus of this study.

Study Design

A control-treatment study design will be used to evaluate survival. Coho smolts from the Muckleshoot Indian Tribe (MIT) Keta Creek Hatchery will be used in the evaluation. Coho were selected because: 1) they are not ESA listed, 2) they are intermediate in size

between chinook fry and steelhead smolts making them a good surrogate for the other species, and 3) they are more readily trapped than steelhead smolts. A control group will be marked with a right ventral clip. The test or treatment group will be marked with a left ventral clip. Both groups will be released nearly simultaneously at the base and top of the Headworks Dam, respectively. To avoid biasing the study, care will be taken to release fish into the dam spillway in a manner so they cannot swim into the dam pool. The marked fish will travel downstream and a portion will be captured in the WDFW smolt trap operated approximately ½ mile downstream of the Neely Bridge (RM 35) on the Green River.

The release will occur during the last two weeks in April, 2009. Large hatchery releases from the system would likely occur the first week in May, thus this timing would enable recapture prior to the period with the smolt trap crew is processing large numbers of hatchery fish each night. Ideally, this test would be conducted in the winter when fish are most likely to exit HHD via the radial gate. However, since fish migrating that time of year are typically pre-smolts, there was concern that they would seek refuge in habitat between the release and recovery points, thus confounding the study.

Recaptured coho will be removed from the trap(s), anesthetized with MS-222, and enumerated by mark type. Superficial condition of the fish will be assessed by rating each of three types of injuries: de-scaling, laceration, and abrasion (Table 1).

Table 1. Superficial fish condition rating criteria.

Degree of De-scaling	**Score**
<10%	4
11%-20%	3
21%-30%	2
>30%	1
Degree of Laceration (modified from Whiteaker et al. 2006)	**Score**
No major injuries that break the skin	4
Injuries that break the skin	3
Injuries that penetrate the muscle tissue	2
Injuries that penetrate the body cavity or large section of body missing	1
Degree of Abrasion	**Score**
No abrasion on head, belly, or fins	3
Minor abrasion on head, belly, or fins	2
Major abrasion on head, belly, or fins	1

After evaluation, all uninjured fish would be placed in freshwater to recover and would be released back to the river. A sample of fish showing de-scaling, laceration or abrasion will be sacrificed and preserved in alcohol or frozen for further examination.

Through this evaluation we will test the null hypothesis that the control and test groups are captured at the same rate in the trap(s). Equal capture rates would signify equal survival rates among the two groups. A 2x2 G-test of Independence will be used to evaluate the results against the expected binomial frequencies.

We will also evaluate superficial fish condition ratings between the two groups. Sample distributions by injury type from control and treatment groups will be compared using ANOVA. Non-parametric testing may be done if the conditions for ANOVA cannot be met. In that case, a Wilcoxon Two-Sample Test will be used. This test was chosen because it is sensitive to the number of interchanges in rank necessary to separate the two samples compared to tests that only measures differences across the entire distribution (e.g. Kolmogorov-Smirnov Two Sample Test) (Sokal and Rohlf 1981). Significant differences ($\alpha = 0.95$) in any of the three superficial fish condition elements would suggest an impact from the fish routing over the dam face.

Sample Size

An approximate sample size for this test was developed using a 2x2 G-test of Independence (Sokal and Rohlf 1981); making assumptions about capture and mortality rates. For this analysis, I assumed an 80% certainty of detecting a 20% difference in mortality ($\alpha = 0.05$).

I assumed the smolt trap would catch 4% of the marked coho passing the trap, that trap efficiency is that same for both groups, that natural mortality between the Headworks Dam and the smolt trap is 25%, and that marking mortality was 1%. These assumptions estimate the minimum mark group size at 23,600 coho (11,800 per mark type) in order to detect the difference between a 3% and 2.4% capture rate (4% trap efficiency x 75% survival to the trap and a 20% treatment effect). This is the preferred approach as it factors in the actual capture efficiency of the trap.

MIT may consider this group size to be too large to accommodate for logistical reasons or experimental purposes. If so, then another approach would be to assume the trap efficiency estimated for the smolt trap during the time period that the test is conducted is the same as the actual efficiency. Using this approach, the minimum mark group size could be reduced to 6,700 coho (3,350 per mark type) in order to detect the difference between 75% and 60% capture rate (75% survival and a 20% treatment effect). This approach would use the estimated number of smolts of each mark type passing the trap (recaptures/estimated trap efficiency) as the number recaptured. Thus recaptures becomes an estimated value rather than a known value, which adds an unknown variance component to the study design.

Logistics

Fish would be marked by Tacoma Water staff at Keta Creek Hatchery at a time that is agreeable to MIT (late March/early April 2009). Marking scissors will be borrowed from the Northwest Indian Fisheries Commission. MS-222 and marking tubs would be provided by Tacoma Water. Keta Creek Hatchery staff would assist with securing fish for marking and with holding the marked fish, segregated by mark type, in separate rearing containments. Keta Creek Hatchery staff would maintain a count of mortalities from each mark group following marking to help determine the actual release group sizes. Prior to release, MIT will withhold food from the marked fish consistent with their transport policies. On the day of release, Tacoma Water staff will bring two dump trucks

carrying fish totes with lids and oxygen tanks. The totes will be fitted with net pens, filled with water from Keta Creek Hatchery and the fish, segregated by mark, will be placed in each tote. Oxygen will be supplied to each tote via air stones. The lid will be placed over each tote and the fish will be transported to the Headworks Facility.

At the Headworks, water temperatures in the fish totes will be compared to the river water. If the difference is greater than 2^{o} C, water in the totes will be exchanged with river water to acclimate the fish. The fish will be loaded into buckets and released at dusk at their respective release sites. Transport mortalities will be recorded for each mark group.

The release and processing of marked fish will be coordinated with WDFW smolt trapping staff prior to and during the experiment.

Study Outcomes

Capture rates developed from the actual number of recaptures or the estimated number of smolts passing the trap, depending on the release size, will be calculated for the control and treatment mark groups using the number of smolts from each group that are released. Measured frequencies will be tested against the expected binomial frequencies as described above (α=0.05). A one-tailed test will be used to evaluate differences since the null hypothesis would not be rejected if the recapture rate for the treatment group was significantly larger than for the control group. Not rejecting the null hypothesis would indicate the risk of mortality from the dam was acceptable. If the null hypothesis were rejected, Tacoma Water would discuss options for further evaluation with the U.S. Fish & Wildlife Service and National Marine Fisheries Service.

Similarly, superficial fish condition will be assessed as described above using a one-tailed test (α=0.05). Failure to reject the null hypotheses would indicate the risk of injury from fish passing over the dam was acceptable. A rejection of the null hypothesis for any of the three injury types would trigger a discussion of further evaluation with the U.S. Fish & Wildlife Service and National Marine Fisheries Service.

Citations

Sokal, R. R. and F. J. Rohlf. 1981. Biometry: the principles and practice of statistics in biological research. Second edition. W.H. Freeman and Company, San Francisco, CA.

Volkhardt, G., P. Topping, L. Kishimoto, D. Rawding, and M. Groesbeck. 2006. 2005 juvenile salmonids production evaluation report: Green River, Dungeness River and Cedar Creek. FPA 06-10. Washington Department of Fish & Wildlife, Olympia, WA.

Whiteaker J., J.K Fryer, and J. Doyle 2006. Age and Length Composition of Columbia Basin Chinook and Sockeye Salmon and Steelhead at Bonneville Dam in 2005. Columbia River Inter-Tribal Commission Technical Report. Portland, OR.

APPENDIX B

Signature Page

SIGNATURE PAGE

CITY OF TACOMA
TACOMA WATER

All submittals must be in ink or typewritten, executed by a duly authorized officer or representative of the bidding/proposing entity, and received and time stamped as directed in the **Request for Qualifications page near the beginning of the specification**. If the bidder/proposer is a subsidiary or doing business on behalf of another entity, so state, and provide the firm name under which business is hereby transacted.

REQUEST FOR QUALIFICATIONS SPECIFICATION NO. TW24-0018F
Fish Passage Facility Upgrade

The undersigned bidder/proposer hereby agrees to execute the proposed contract and furnish all materials, labor, tools, equipment and all other facilities and services in accordance with these specifications.

The bidder/proposer agrees, by submitting a bid/proposal under these specifications, that in the event any litigation should arise concerning the submission of bids/proposals or the award of contract under this specification, Request for Bids, Request for Proposals or Request for Qualifications, the venue of such action or litigation shall be in the Superior Court of the State of Washington, in and for the County of Pierce.

Non-Collusion Declaration

The undersigned bidder/proposer hereby certifies under penalty of perjury that this bid/proposal is genuine and not a sham or collusive bid/proposal, or made in the interests or on behalf of any person or entity not herein named; and that said bidder/proposer has not directly or indirectly induced or solicited any contractor or supplier on the above work to put in a sham bid/proposal or any person or entity to refrain from submitting a bid/proposal; and that said bidder/proposer has not, in any manner, sought by collusion to secure to itself an advantage over any other contractor(s) or person(s).

_____
Bidder/Proposer's Registered Name

_____
Address

_____
City, State, Zip

_____
Authorized Signatory E-Mail Address

_____
E.I.No. / Federal Social Security Number Used on Quarterly Federal Tax Return, U.S. Treasury Dept. Form 941

_____
E-Mail Address for Communications

_____
Signature of Person Authorized to Enter into Contracts for Bidder/Proposer — Date

_____
Printed Name and Title

_____
(Area Code) Telephone Number / Fax Number

_____
State Business License Number
in WA, also known as UBI (Unified Business Identifier) Number

_____
State Contractor's License Number
(See Ch. 18.27, R.C.W.)

Addendum acknowledgement #1_____ #2_____ #3_____ #4_____ #5_____

THIS PAGE MUST BE SIGNED AND RETURNED WITH SUBMITTAL.

APPENDIX C

Sample Contract

SERVICES CONTRACT

Click here for the Contract Questionnaire Popup Quick Reference

Start Questionnaire | Finalize Document

THIS CONTRACT, made and entered into effective as of [Month] [Day], [Year] ("EFFECTIVE DATE"), by and between the CITY OF TACOMA, a municipal corporation of the State of Washington (hereinafter referred to as the "CITY"), and **[INSERT legal name of Supplier exactly as it appears in Ariba including any dbas or trade names]**, (hereinafter may be referred to as "CONTRACTOR" or "SUPPLIER");

In consideration of the mutual promises and obligations hereinafter set forth, the Parties hereto agree as follows:

1. **Scope of Services**

   The CONTRACTOR agrees to diligently and completely perform the services or deliverables consisting of [INSERT A BRIEF DESCRIPTION OF THE WORK TO BE PERFORMED] as is described in [Exhibit A, B, ETC., if needed] attached hereto and incorporated herein.

2.

3. **Changes to Scope of Work**

   The CITY shall have the right to make changes within the general scope of services or deliverables upon execution in writing of a change order or amendment hereto. If the changes will result in additional work effort by CONTRACTOR, the CITY will agree to reasonably compensate the CONTRACTOR for such additional effort up to the maximum amount specified herein or as otherwise provided by City Code.

4.

5. **Term**

   All services shall be satisfactorily completed on or before [INSERT CONTRACT TERMINATION DATE] and this Contract shall expire on said date unless mutually extended by a written and executed Amendment to this Contract.

6.

7. **Delay**

Neither party shall be considered to be in default in the performance of this Contract to the extent such performance is prevented or delayed by any cause which is beyond the reasonable control of the affected party and, in such event, the time for performance shall be extended for a period equal to any time lost as a result thereof. In the event CONTRACTOR is unable to proceed due to a delay solely attributable to CITY, CONTRACTOR shall advise CITY of such delay in writing as soon as is practicable.

8. Compensation

The CITY shall compensate the CONTRACTOR for the services and deliverables performed under this Contract [on the basis of] [EXHIBIT XXXX and/or a DESCRIPTION OF COMPENSATION ARRANGEMENTS –MILESTONES, TIME AND MATERIALS, LUMP SUM ETC.]

9. Prevailing Wages

A. If federal, state, local, or any applicable law requires CONTRACTOR to pay prevailing wages in connection with this Contract, and CONTRACTOR is so notified by the CITY, then CONTRACTOR shall pay applicable prevailing wages and otherwise comply with the Washington State Prevailing Wage Act (RCW 39.12) in the performance of this Contract.

B. If applicable, a Schedule of Prevailing Wage Rates and/or the current prevailing wage determination made by the Secretary of Labor for the locality or localities where the Contract will be performed is made of part of the Contract by this reference. If prevailing wages apply to the Contract, CONTRACTOR and its subcontractors shall:

1. Be bound by and perform all transactions regarding the Contract relating to prevailing wages and the usual fringe benefits in compliance with the provisions of Chapter 39.12 RCW, as amended, the Washington State Prevailing Wage Act and/or the Davis-Bacon Act (40 U.S.C. 3141- 3144, and 3146-3148) and the requirements of 29 C.F.R. pt. 5 as may be applicable, including the federal requirement to pay wages not less than once a week.

2. Ensure that no worker, laborer or mechanic employed in the performance of any part of the Contract shall be paid less than the prevailing rate of wage specified on that Schedule and/or specified in a wage determination made by the Secretary of Labor (unless specifically preempted by federal law, the higher of the Washington state prevailing wage or federal Davis-Bacon rate of wage must be paid.

3. Immediately upon award of the Contract, contact the Department of Labor and Industries, Prevailing Wages section, Olympia, Washington and/or the federal Department of Labor, to obtain full information, forms and procedures relating to these matters. Per such procedures, a Statement of Intent to Pay Prevailing Wages and/or other or additional documentation required by applicable federal law, must be submitted by CONTRACTOR and its subcontractors to the CITY, in the manner requested by the CITY, prior to

any payment by the CITY hereunder, and an Affidavit of Wages Paid and/or other or additional documentation required by federal law must be received or verified by the CITY prior to final Contract payment.

10. Not to Exceed Amount

The total price to be paid by CITY for CONTRACTOR'S full and complete performance of the Scope of Work hereunder shall not exceed $ [INSERT TOTAL AMOUNT OF CONTRACT] plus applicable taxes without a written and executed Amendment to this Contract. Said price shall be the total compensation for CONTRACTOR'S performance hereunder including, but not limited to, all work, deliverables, materials, supplies, equipment, subcontractor's fees, and all reimbursable travel and miscellaneous or incidental expenses to be incurred by CONTRACTOR.
In the event the CONTRACTOR incurs cost in excess of the sum authorized for service under this Contract, the CONTRACTOR shall pay such excess from its own funds, and the CITY shall not be required to pay any part of such excess, and the CONTRACTOR shall have no claim against the CITY on account thereof.

11. Payment

CONTRACTOR shall submit [Pick one of the following monthly, weekly, annual, Contract milestone, other (describe in detail)] invoices for services completed and/or deliverables furnished during the invoice period. Upon CITY'S request, CONTRACTOR shall submit necessary and appropriate documentation, as determined by the CITY, for all invoiced services and deliverables. For transactions conducted in SAP Ariba, invoices shall be submitted directly through Ariba. For invoices paid by ACH or by check, unless stated otherwise, invoices shall be electronically submitted by email with corresponding PO number or other identifying number listed in the subject line to accountspayable@cityoftacoma.org.

Payment shall be made through the CITY'S ordinary payment process, and shall be considered timely if made within 30 days of receipt of a properly completed invoice. All payments shall be subject to adjustment for any amounts, upon audit or otherwise, determined to have been improperly invoiced. The CITY may withhold payment to the CONTRACTOR for any services or deliverables not performed as required hereunder until such time as the CONTRACTOR modifies such services or deliverables to the satisfaction of the CITY.

12. Payment Method

The City's preferred method of payment is by ePayables (Payment Plus), followed by credit card (aka procurement card), then Electronic Funds Transfer (EFT) by Automated Clearing House (ACH), then check or other cash equivalent. CONTRACTOR may be required to have the capability of accepting the City's ePayables or credit card methods of payment. The City, in its sole discretion, will determine the method of payment for this Contract.

13. Independent Contractor Status

The services and deliverables shall be furnished by the CONTRACTOR as an independent Contractor, and nothing herein contained shall be construed to create an employer and employee relationship. The CONTRACTOR shall provide at its sole expense all materials, office space, and other necessities to perform its duties under this Contract, unless stated otherwise in this Contract. No payroll or employment taxes of any kind shall be withheld or paid by the CITY with respect to payments to CONTRACTOR. The payroll or employment taxes that are the subject of this paragraph include, but are not limited to, FICA, FUTA, federal income tax, state personal income tax, state disability insurance tax and state unemployment insurance tax. By reason of CONTRACTOR's status as an independent Contractor hereunder, no workers' compensation insurance has been or will be obtained by the CITY on account of CONTRACTOR. CONTRACTOR may be required to provide the CITY proof of payment of these said taxes and benefits. If the CITY is assessed or deemed liable in any manner for those charges or taxes, the CONTRACTOR agrees to hold the CITY harmless from those costs, including attorney's fees.

14. Services Warranty

The CONTRACTOR warrants that all services performed pursuant to this Contract shall be generally suitable for the use to which CITY intends to use said services and deliverables as expressed in the Scope of Work. In the performance of services under this Contract, the CONTRACTOR and its employees further agree to exercise the degree of skill and care required by customarily accepted good practices and procedures followed by professionals or service providers rendering the same or similar type of service. All obligations and services of the CONTRACTOR hereunder shall be performed diligently and completely according to such professional standards.

15.

16. Contract Administration

[INSERT NAME TITLE AND DEPARTMENT OF CONTRACT ADMINISTRATOR] for the CITY shall have primary responsibility for contract administration and approval of services to be performed by the CONTRACTOR, and shall coordinate all communications between the CONTRACTOR and the CITY.

17. Specific Personnel

If before, during, or after the execution of this Contract, CONTRACTOR represents to the CITY that certain personnel would or will be responsible for performing services and deliverables under this Contract, then the CONTRACTOR is obligated to ensure that said personnel perform said Contract services to the maximum extent permitted by law. This Contract provision shall only be waived by written authorization by the CITY, and on a case-by-case basis.

18.

19.

The CONTRACTOR shall establish and maintain records in accordance with requirements prescribed by the CITY, with respect to all matters related to the performance of this Contract. Except as otherwise authorized by the CITY, the CONTRACTOR shall retain such records for a period of _____[INSERT THE TIME THE RECORDS SHOULD BE KEPT. MOST COMMON IS 6 YEARS] years after receipt of the final payment under this Contract or termination of this Contract.

20. Notices

Except for routine operational communications, which may be delivered personally or transmitted by electronic mail all notices required hereunder shall be in writing and shall be deemed to have been duly given if delivered personally or mailed first-class mail, postage prepaid, to the parties at the following addresses:

CITY:	CONTRACTOR:
Name:	Name:
Title:	Title:
Address:	Address:
Telephone No.:	Telephone No.:
E-mail:	E-mail:

21. Termination

A. Except as otherwise provided herein, the CITY may terminate this Contract at any time, for CITY's own reasons and without cause, by giving ten (10) business days written notice to CONTRACTOR. In the event of termination, all finished and unfinished work prepared by the CONTRACTOR pursuant to this Contract shall be provided to the CITY. CITY may terminate this Contract in the event of any material breach of any of the terms and conditions of this Contract if CONTRACTOR's breach continues in effect after written notice of breach and 30 days to cure such breach and fails to cure such breach.

B. In the event CITY terminates this Contract due to the CITY's own reasons and without cause due to the CONTRACTOR's actions or omissions, the CITY shall pay the CONTRACTOR the amount due for actual work and services necessarily performed under this Contract up to the effective date of termination, not to exceed the total compensation set forth herein.

C. In the event of material default or breach by CONTRACTOR of any of the terms or conditions of the Contract, CITY may, at its election, procure services and deliverables under this CONTRACT from other sources, and may deduct from the unpaid balance due CONTRACTOR, or collect against the bond or security (if any), or may invoice and recover from CONTRACTOR all costs paid in excess of the price(s) set forth in the Contract.

D. Termination of this Contract by CITY shall not constitute a waiver of any claims or remaining rights the CITY may have against CONTRACTOR relative to performance hereunder.

22. Suspension

The CITY may suspend this Contract, at its sole discretion, upon seven (7) business days' written notice to the CONTRACTOR. Such notice shall indicate the anticipated period of suspension. Any reimbursement for expenses incurred due to the suspension shall be limited to the CONTRACTOR'S reasonable expenses and shall be subject to verification. The CONTRACTOR shall resume performance of services under this Contract without delay when the suspension period ends. Suspension of this Contract by CITY shall not constitute a waiver of any claims or remaining rights the CITY may have against CONTRACTOR relative to performance hereunder.

23. Federal Funds

If federal funds will be used to fund, pay or reimburse all or a portion of the services or deliverables provided under the Contract, the terms and conditions set forth at Appendix A to this Contract are incorporated into and made part of this Contract and CONTRACTOR will comply with all applicable provisions of Appendix A and with all applicable federal laws, regulations, executive orders, policies, procedures, and directives in the performance of this Contract. If CONTRACTOR's receipt of federal funds under this Contract is as a sub-recipient, Appendix B, "Sub-recipient Information and Requirements" must be completed and incorporated into and made part of this Contract.

24. Taxes

Unless stated otherwise herein, CONTRACTOR is responsible for the payment of all charges and taxes applicable to the services performed under this Contract, and CONTRACTOR agrees to comply with all applicable laws regarding the reporting of income, maintenance of records, and all other requirements and obligations imposed pursuant to applicable law. If the CITY is assessed, made liable, or responsible in any manner for such charges or taxes, the CONTRACTOR holds CITY harmless from such costs, including attorney's fees.

If CONTRACTOR fails to pay any taxes, assessments, penalties, or fees imposed by any governmental body, including by Tacoma City ordinance, and including by a court of law, CITY will deduct and withhold or pay over to the appropriate governmental body those unpaid amounts upon demand by the governmental body. Any such payments shall be deducted from the CONTRACTOR's total compensation.

25. Licenses and Permits

The CONTRACTOR, at its expense, shall obtain and keep in force any and all necessary licenses and permits. The CONTRACTOR shall obtain a business license as required by Tacoma Municipal Code Subtitle 6B.20 and shall pay business and occupation taxes as required by Tacoma Municipal Code Subtitle 6A.30. If applicable, CONTRACTOR must have a Washington state business license.

26. Indemnification

CONTRACTOR shall indemnify, defend, and hold harmless the CITY, its officials, officers, agents, employees, and volunteers, from any and all claims, demands, damages, lawsuits, liabilities, losses, liens, expenses and costs arising out of the subject matter of this Contract; provided that this provision shall not apply to the extent that damage or injury results from the sole negligence of the CITY, or its officers, agents, or employees. This indemnification shall extend to and include attorneys' fees and the cost of establishing the right of indemnification hereunder in favor of the CITY. This indemnification shall survive the termination of this Contract.

It is expressly agreed that with respect to design professional services performed by CONTRACTOR herein, CONTRACTOR's duty of indemnification, including the duty and cost to defend, against liability for damages arising out of such services or out of bodily injury to persons or damage to property shall, as provided in RCW 4.24.115 apply only to the extent of CONTRACTOR's negligence.

27. Title 51 Waiver

CONTRACTOR specifically assumes potential liability for actions brought by the CONTRACTOR'S own employees against the CITY and, solely for the purpose of this indemnification and defense, the CONTRACTOR specifically waives any immunity under the state industrial insurance law, Title 51 RCW. THE CONTRACTOR RECOGNIZES THAT THIS WAIVER WAS THE SUBJECT OF MUTUAL NEGOTIATION.

28. Insurance

During the course and performance of the services herein specified, CONTRACTOR will maintain the insurance coverage in the amounts and in the manner specified in the City of Tacoma Insurance Requirements as is applicable to the services and deliverables provided under this Contract. The City of Tacoma Insurance Requirements documents are fully incorporated herein by reference.

Failure by CITY to identify a deficiency in the insurance documentation provided by CONTRACTOR or failure of CITY to demand verification of coverage or compliance by CONTRACTOR with these insurance requirements shall not be construed as a waiver of CONTRACTOR's obligation to maintain such insurance.

29. Nondiscrimination

The CONTRACTOR agrees to take all steps necessary to comply with all federal, state, and City laws and policies regarding non-discrimination and equal employment opportunities. The CONTRACTOR shall not discriminate in any employment action because of race, religion, creed, color, national origin or ancestry, sex, gender identity, sexual orientation, age, marital status, familial status, veteran or military status, the presence of any sensory, mental or physical disability or the use of a trained dog guide or service animal by a disabled person. In the event of non-compliance by the CONTRACTOR with any of the non-discrimination provisions of this Contract, the CITY shall be deemed to have cause to terminate this Contract, in whole or in part.

30. Conflict of Interest

No officer, employee, or agent of the CITY, nor any member of the immediate family of any such officer, employee, or agent as defined by City ordinance, shall have any personal financial interest, direct or indirect, in this Contract, either in fact or in appearance. The CONTRACTOR shall comply with all federal, state, and City conflict of interest laws, statutes, and regulations. The CONTRACTOR represents that the CONTRACTOR presently has no interest and shall not acquire any interest, direct or indirect, in the program to which this Contract pertains which would conflict in any manner or degree with the performance of the CONTRACTOR'S services and obligations hereunder. The CONTRACTOR further covenants that, in performance of this Contract, no person having any such interest shall be employed. The CONTRACTOR also agrees that its violation of the CITY'S Code of Ethics contained in Chapter 1.46 of the Tacoma Municipal Code shall constitute a breach of this Contract subjecting the Contract to termination.

31.

32. Public Disclosure

This Contract and documents provided to the CITY by CONTRACTOR hereunder are deemed public records subject to disclosure under the Washington State Public Records Act, Chapter 42.56 RCW (Public Records Act). Thus, the CITY may be required, upon request, to disclose this Contract and documents related to it unless an exemption under the Public Records Act or other laws applies. In the event CITY receives a request for such disclosure, determines in its legal judgment that no applicable exemption to disclosure applies, and CONTRACTOR has complied with the requirements herein to mark all content considered to be confidential or proprietary, CITY agrees to provide CONTRACTOR ten (10) days written notice of impending release. Should legal action thereafter be initiated by CONTRACTOR to enjoin or otherwise prevent such release, all expense of any such litigation shall be borne by CONTRACTOR, including any damages, attorneys fees or costs awarded by reason of having opposed disclosure. CITY shall not be liable for any release where notice was provided and CONTRACTOR took no action to oppose the release of information. Notice of any proposed release of information pursuant to Chapter 42.56 RCW, shall be provided to CONTRACTOR according to the "Notices" provision herein.

33. Confidential or Proprietary Records Must be Marked

If CONTRACTOR provides the CITY with records that CONTRACTOR considers confidential or proprietary, CONTRACTOR must mark all applicable pages of said record(s) as “Confidential” or “Proprietary.” If CONTRACTOR fails to so mark record(s), then (1) the CITY, upon request, may release said record(s) without the need to satisfy the notice requirements above; and (2) the CONTRACTOR expressly waives its right to allege any kind of civil action or claim against the CITY pertaining to the release of said record(s).

34.

35. Approval for Release of Information Related to Contract

If requested by CITY, CONTRACTOR shall not release any information or documentation concerning the work under this Contract or any part thereof for marketing, advertising, or other commercial activities or publication including, but not limited to, news releases or professional articles without CITY’s prior written approval. CONTRACTOR may submit at any time for review and approval a generic abstract describing the component parts of the completed Scope of Services (“Project Abstract”). After receiving written approval of the Project Abstract from the CITY, the CONTRACTOR may make minor insignificant changes to the Project Abstract and use all or parts of the Project Abstract in proposals.

This Section shall survive for six (6) years after the termination or expiration of this Contract.

36. Dispute Resolution

In the event of a dispute pertaining to this Contract, the parties agree to attempt to negotiate in good faith an acceptable resolution. If a resolution cannot be negotiated, then the parties agree to submit the dispute to voluntary non-binding mediation before pursuing other remedies. This provision does not limit the CITY’S right to terminate authorized by this Contract.

37. Miscellaneous Provisions

Governing Law and Venue

Washington law shall govern the interpretation of this Contract. Pierce County shall be the venue of any mediation, arbitration, or litigation arising out of this Contract.

Assignment

The CONTRACTOR shall not assign, subcontract, delegate, or transfer any obligation, interest or claim to or under this Contract or for any of the compensation due hereunder without the prior written consent of the CITY.

No Third Party Beneficiaries

This Contract shall be for the sole benefit of the parties hereto, and nothing contained herein shall create a contractual relationship with, or create a cause of action in favor of, a third party against either party hereto.

Waiver

A waiver or failure by either party to enforce any provision of this Contract shall not be construed as a continuing waiver of such provisions, nor shall the same constitute a waiver of any other provision of this Contract.

Severability and Survival

If any term, condition or provision of this Contract is declared void or unenforceable or limited in its application or effect, such event shall not affect any other provisions hereof and all other provisions shall remain fully enforceable. The provisions of this Contract, which by their sense and context are reasonably intended to survive the completion, expiration or cancellation of this Contract, shall survive termination of this Contract.

Entire Agreement

This Contract and the attached Exhibits and Appendices, as modified herein, contain the entire agreement between the parties as to the services to be rendered hereunder. All previous and contemporaneous agreements, representations or promises and conditions relating to the subject matter of this Contract are superseded hereby. The Parties hereto mutually acknowledge, understand and agree that the terms and conditions set forth herein shall control and prevail over any conflicting terms and conditions stated in any attachments hereto.

Modification

No modification or amendment of this Contract shall be effective unless set forth in a written and executed Amendment to this Contract.

IN WITNESS WHEREOF, the Parties hereto have accepted and executed this Contract, as of the Effective Date stated above, which shall be Effective Date for bonding purposes as applicable. The undersigned Contractor representative, by signature below, represents and warrants they are duly authorized to execute this legally binding Contract for and on behalf of Contractor and further represents and warrants that Contractor is not suspended, debarred, or otherwise disqualified under federal, state, or local law from participating in this Contract.

CITY OF TACOMA:	CONTRACTOR:
Signature:	Signature:
Name:	Name:
Title:	Title:

(City of Tacoma use only - blank lines are intentional)

Director of Finance: _____

Deputy/City Attorney (approved as to form): _____

Approved By: _____

Approved By: _____

Approved By: _____

Approved By: _____

Approved By: _____

Approved By: _____

Approved By: _____

Approved By: _____

APPENDIX A

FEDERAL FUNDING

1. COPELAND ANTI-KICKBACK ACT

For Contracts subject to Davis Bacon Act the following clauses will be incorporated into the Contract:

A. CONTRACTOR shall comply with 18 U.S.C. § 874, 40 U.S.C. § 3145, and the requirements of 29 C.F.R. pt. 3 as may be applicable, which are incorporated by reference into this Contract.

B. CONTRACTOR or subcontractor shall insert in any subcontracts the clause above and such other clauses federal agencies may by appropriate instructions require, and also a clause requiring the subcontractors to include these clauses in any lower tier subcontracts. The prime contractor shall be responsible for the compliance by any subcontractor or lower tier subcontractor with all of these Contract clauses.

C. Breach. A breach of the contract clauses above may be grounds for termination of the contract, and for debarment as a contractor and subcontractor as provided in 29 C.F.R. § 5.12.

2. EQUAL EMPLOYMENT OPPORTUNITY

During the performance of this Contract, CONTRACTOR will not discriminate against any employee or applicant for employment because of race, color, religion, sex, sexual orientation, gender identity, or national origin. If the CONTRACTOR does over $10,000 in business a year that is funded, paid or reimbursed with federal funds, CONTRACTOR will take specific and affirmative action to ensure that applicants are employed, and that employees are treated during employment without regard to their race, color, religion, sex, sexual orientation, gender identity, or national origin. Such action shall include, but not be limited to the following:

A. Employment, upgrading, demotion, or transfer; recruitment or recruitment advertising; layoff or termination; rates of pay or other forms of compensation; and selection for training, including apprenticeship. CONTRACTOR agrees to post in conspicuous places, available to employees and applicants for employment, notices to be provided setting forth the provisions of this nondiscrimination clause.

B. CONTRACTOR will, in all solicitations or advertisements for employees placed by or on behalf of the Contractor, state that all qualified applicants will receive consideration for employment without regard to race, color, religion, sex, sexual orientation, gender identity, or national origin.

C. CONTRACTOR will not discharge or in any other manner discriminate against any employee or applicant for employment because such employee or applicant has inquired about, discussed, or disclosed the compensation of the employee or applicant or another employee or applicant. This provision shall not apply to

instances in which an employee who has access to the compensation information of other employees or applicants as a part of such employee's essential job functions discloses the compensation of such other employees or applicants to individuals who do not otherwise have access to such information, unless such disclosure is in response to a formal complaint or charge, in furtherance of an investigation, proceeding, hearing, or action, including an investigation conducted by the employer, or is consistent with the Contractor's legal duty to furnish information.

D. CONTRACTOR will send to each labor union or representative of workers with which he has a collective bargaining agreement or other contract or understanding, a notice to be provided advising the said labor union or workers' representatives of the contractor's commitments under this section, and shall post copies of the notice in conspicuous places available to employees and applicants for employment.

E. CONTRACTOR will comply with all provisions of Executive Order 11246 of September 24, 1965, and of the rules, regulations, and relevant orders of the Secretary of Labor.

G. In the event of CONTRACTOR's noncompliance with the nondiscrimination clauses of this contract or with any of the said rules, regulations, or orders, this Contract may be canceled, terminated, or suspended in whole or in part and the CONTRACTOR may be declared ineligible for further federally funded contracts in accordance with procedures authorized in Executive Order 11246 of September 24, 1965, and such other sanctions may be imposed and remedies invoked as provided in Executive Order 11246 of September 24, 1965, or by rule, regulation, or order of the Secretary of Labor, or as otherwise provided by law.

H. CONTRACTOR will include the portion of the sentence immediately preceding paragraph (A) and the provisions of paragraphs (A) through (G) in every subcontract or purchase order unless exempted by rules, regulations, or orders of the Secretary of Labor issued pursuant to section 204 of Executive Order 11246 of September 24, 1965, so that such provisions will be binding upon each subcontractor or vendor. CONTRACTOR will take such action with respect to any subcontract or purchase order as the administering agency may direct as a means of enforcing such provisions, including sanctions for noncompliance:

Provided, however, that in the event CONTRACTOR becomes involved in, or is threatened with, litigation with a subcontractor or vendor as a result of such direction by the administering agency, the CONTRACTOR may request the United States to enter into such litigation to protect the interests of the United States.

3. CONTRACT WORK HOURS AND SAFETY STANDARDS ACT

A. Overtime requirements. Neither CONTRACTOR or subcontractor contracting for any part of the Contract work which may require or involve the employment of laborers or mechanics shall require or permit any such laborer or mechanic in any workweek in which he or she is employed on such work to work in excess of forty hours in such workweek unless such laborer or mechanic receives compensation at a rate not less than one and one-half times the basic rate of pay

for all hours worked in excess of forty hours in such workweek.

B. Violation; liability for unpaid wages; liquidated damages. In the event of any violation of the clause set forth in paragraph (3)(A) of this section the CONTRACTOR and any subcontractor responsible therefor shall be liable for the unpaid wages. In addition, such CONTRACTOR and subcontractor shall be liable to the United States (in the case of work done under contract for the District of Columbia or a territory, to such District or to such territory), for liquidated damages. Such liquidated damages shall be computed with respect to each individual laborer or mechanic, including watchmen and guards, employed in violation of the clause set forth in paragraph (3)(A) of this section, in the sum of $27 for each calendar day on which such individual was required or permitted to work in excess of the standard workweek of forty hours without payment of the overtime wages required by the clause set forth in paragraph (3)(A) of this section.

C. Withholding for unpaid wages and liquidated damages. The CITY shall upon its own action or upon written request of an authorized representative of the Department of Labor withhold or cause to be withheld, from any moneys payable on account of work performed by the CONTRACTOR or subcontractor under any such contract or any other Federal contract with the same prime contractor, or any other federally-assisted contract subject to the Contract Work Hours and Safety Standards Act, which is held by the same prime contractor, such sums as may be determined to be necessary to satisfy any liabilities of such CONTRACTOR or sub-contractor for unpaid wages and liquidated damages as provided in the clause set forth in paragraph (3)(B) of this section.

D. Subcontracts. The Contractor or subcontractor shall insert in any subcontracts the clauses set forth in paragraph (3)(A) through (D) of this section and also a clause requiring the subcontractors to include these clauses in any lower tier subcontracts. The prime CONTRACTOR shall be responsible for compliance by any subcontractor or lower tier subcontractor with the clauses set forth in paragraphs (3)(A) through (D) of this section.

4. CLEAN AIR ACT

A. CONTRACTOR agrees to comply with all applicable standards, orders or regulations issued pursuant to the Clean Air Act, as amended, 42 U.S.C. § 7401 et seq.

B. CONTRACTOR agrees to report each violation to the CITY and understands and agrees that the CITY will, in turn, report each violation as required to assure notification to the Federal Emergency Management Agency, and the appropriate Environmental Protection Agency Regional Office.

CONTRACTOR agrees to include these requirements in each subcontract exceeding $150,000 financed in whole or in part with federal funds.

5. FEDERAL WATER POLLUTION CONTROL ACT

A. CONTRACTOR agrees to comply with all applicable standards, orders, or

regulations issued pursuant to the Federal Water Pollution Control Act, as amended, 33 U.S.C. 1251 et seq.

B. CONTRACTOR agrees to report each violation to the CITY and understands and agrees that the CITY will, in turn, report each violation as required to assure notification to the appropriate federal agency.

C. CONTRACTOR agrees to include these requirements in each subcontract exceeding $150,000 financed in whole or in part with federal funding.

6. DEBARMENT AND SUSPENSION

A. This Contract is a Covered Transaction for purposes of 2 C.F.R. pt. 180 and 2 C.F.R. pt. 3000. As such, the CONTRACTOR is required to verify that none of the contractor's principals (defined at 2 C.F.R. § 180.995) or its affiliates (defined at 2 C.F.R. § 180.905) are excluded (defined at 2 C.F.R. § 180.940) or disqualified (defined at 2 C.F.R. § 180.935).

B. CONTRACTOR must comply with 2 C.F.R. pt. 180, subpart C and2 C.F.R. pt. 3000, subpart C, and must include a requirement to comply with these regulations in any lower tier Covered Transaction it enters into.

C. This certification is a material representation of fact relied upon by the CITY. If it is later determined that the CONTRACTOR did not comply with 2 C.F.R. pt. 180, subpart C and 2 C.F.R. pt. 3000, subpart C, in addition to remedies available to CITY, the Federal Government may pursue available remedies, including but not limited to suspension and/or debarment.

D. CONTRACTOR agrees to comply with the requirements of 2 C.F.R. pt. 180, subpart C and 2 C.F.R. pt. 3000, subpart C throughout the period of this Contract and to include a provision requiring such compliance in its lower tier covered transactions.

7. BYRD ANTI-LOBBYING AMENDMENT

A. Contractors who apply or bid for an award of $100,000 or more shall file the required certification with CITY. Each tier certifies to the tier above that it will not and has not used Federal appropriated funds to pay any person or organization for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, officer or employee of Congress, or an employee of a Member of Congress in connection with obtaining any Federal contract, grant, or any other award covered by 31 U.S.C. § 1352. Each tier shall also disclose any lobbying with non-Federal funds that takes place in connection with obtaining any Federal award. Such disclosures are forwarded from tier to tier up to the recipient who in turn will forward the certification(s) to the CITY.

B. If applicable, CONTRACTOR certification required by Appendix A to 44 CFR Part 18 contained at Appendix A-1 to this Contract is incorporated into this Contract.

8. PROCUREMENT OF RECOVERED MATERIALS

A. In the performance of this Contract, CONTRACTOR shall make maximum use of products containing recovered materials that are EPA-designated items unless the product cannot be acquired:

1. Competitively within a timeframe providing forcompliance with the contract performance schedule;

2. Meeting contract performance requirements; or

3. At a reasonable price.

B. Information about this requirement, along with the list of EPA- designated items, is available at EPA's Comprehensive Procurement Guidelines web site, https://www.epa.gov/smm/comprehensive- procurement-guideline-cpg-program.

C. CONTRACTOR also agrees to comply with all other applicable requirements of Section 6002 of the Solid Waste Disposal Act.

9. CONTRACTOR shall be required to comply with 2 CFR part 25, and obtain a unique entity identifier and/or be registered in the federal System for Award Management as appropriate.

APPENDIX A-1

APPENDIX A to 44 C.F.R. PART 18 – CERTIFICATION REGARDING LOBBYING
Certification for Contracts, Grants, Loans, and Cooperative Agreements

Supplier certifies, to the best of his or her knowledge and belief, that:

1. No Federal appropriated funds have been paid or will be paid, by or on behalf of the undersigned, to any person for influencing or attempting to influence an officer or employee of an agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with the awarding of any Federal contract, the making of any Federal grant, the making of any Federal loan, the entering into of any cooperative agreement, and the extension, continuation, renewal, amendment, or modification of any Federal contract, grant, loan, or cooperative agreement.

2. If any funds other than Federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with this Federal contract, grant, loan, or cooperative agreement, the undersigned shall complete and submit Standard Form-LLL, “Disclosure Form to Report Lobbying,” in accordance with its instructions.

3. The undersigned shall require that the language of this certification be included in the award documents for all subawards at all tiers (including subcontracts, subgrants, and contracts under grants, loans, and cooperative agreements) and that all subrecipients shall certify and disclose accordingly.

This certification is a material representation of fact upon which reliance was placed when this transaction was made or entered into. Submission of this certification is a prerequisite for making or entering into this transaction imposed by section 1352, title 31, U.S. Code. Any person who fails to file the required certification shall be subject to a civil penalty of not less than $10,000 and not more than $100,000 for each such failure.

Supplier, by Contract signature, certifies or affirms the truthfulness and accuracy of each statement of its certification and disclosure, if any. In addition, the Contractor understands and agrees that the provisions of 31 U.S.C. Chap.38, Administrative Remedies for
False Claims and Statements, apply to this certification and disclosure, if any.

APPENDIX D

City of Tacoma Insurance Requirements

CITY OF TACOMA
INSURANCE REQUIREMENTS FOR CONTRACTS

This Insurance Requirements shall serve as an attachment and/or exhibit form to the Contract. The Agency entering a Contract with City of Tacoma, whether designated as a Supplier, Contractor, Vendor, Proposer, Bidder, Respondent, Seller, Merchant, Service Provider, or otherwise referred to as "Contractor".

1. GENERAL REQUIREMENTS

The following General Requirements apply to Contractor and to Subcontractor(s) performing services and/or activities pursuant to the terms of this Contract. Contractor acknowledges and agrees to the following insurance requirements:

1.1. Contractor shall not begin work under the Contract until the required insurance has been obtained and approved by the City of Tacoma.

1.2. Contractor shall keep in force during the entire term of the Contract, at no expense to the City of Tacoma, the insurance coverage and limits of liability listed below and for Thirty (30) calendar days after completion of all work required by the Contract, unless otherwise provided herein.

1.3. Liability insurance policies, except for Professional Liability and Workers' Compensation, shall:

- 1.3.1. Name the City of Tacoma and its officers, elected officials, employees, and agents as **additional insured**
- 1.3.2. Be considered primary and non-contributory for all claims with any insurance or self-insurance or limits of liability maintained by the City of Tacoma
- 1.3.3. Contain a "Waiver of Subrogation" clause in favor of City of Tacoma
- 1.3.4. Include a "Separation of Insureds" clause that applies coverage separately to each insured and additional insured
- 1.3.5. Name the "City of Tacoma" on certificates of insurance and endorsements and not a specific person or department
- 1.3.6. Be for both ongoing and completed operations using Insurance Services Office (ISO) form CG 20 10 04 13 and CG 20 37 04 13 or the equivalent
- 1.3.7. Be satisfied by a single primary limit or by a combination of a primary policy and a separate excess umbrella

1.4. A notation of coverage enhancements on the Certificate of Insurance shall not satisfy these requirements below. Verification of coverage shall include:

- 1.4.1. An ACORD certificate or equivalent
- 1.4.2. Copies of requested endorsements

1.5. Contractor shall provide to City of Tacoma Procurement & Payable Division, prior to the execution of the Contract, Certificate(s) of Insurance and endorsements from the insurer certifying the coverage of all insurance required herein. Contract or Permit number and the City of Tacoma Department must be shown on the Certificate of Insurance.

1.6. A renewal Certificate of Insurance shall be provided electronically prior to coverage expiration via email sent annually to coi@cityoftacoma.org.

1.7. Contractor shall send a notice of cancellation or non-renewal of this required insurance within Thirty (30) calendar days to coi@cityoftacoma.org.

1.8. “Claims-Made” coverages, except for pollution coverage, shall be maintained for a minimum of three years following the expiration or earlier termination of the Contract. Pollution coverage shall be maintained for six years following the expiration of the Contract. The retroactive date shall be prior to or coincident with the effective date of the Contract.

1.9. Each insurance policy must be written by companies licensed or authorized (or issued as surplus line by Washington surplus line broker) in the State of Washington pursuant to RCW 48 with an (A-) VII or higher in the A.M. Best key rating guide.

1.10. Contractor shall not allow any insurance to be cancelled, voided, suspended, or reduced in coverage/limits, or lapse during any term of this Contract. Otherwise, it shall constitute a material breach of the Contract.

1.11. Contractor shall be responsible for the payment of all premiums, deductibles and self-insured retentions, and shall indemnify and hold the City of Tacoma harmless to the extent such a deductible or self-insured retained limit may apply to the City of Tacoma as an additional insured. Any deductible or self-insured retained limits in excess of Twenty Five Thousand Dollars ($25,000) must be disclosed and approved by City of Tacoma Risk Manager and shown on the Certificate of Insurance.

1.12. City of Tacoma reserves the right to review insurance requirements during any term of the Contract and to require that Contractor make reasonable adjustments when the scope of services changes.

1.13. All costs for insurance are included in the initial Contract and no additional payment will be made by City of Tacoma to Contractor.

1.14. Insurance coverages specified in this Contract are not intended and will not be interpreted to limit the responsibility or liability of Contractor or Subcontractor(s).

1.15. Failure by City of Tacoma to identify a deficiency in the insurance documentation or to verify coverage or compliance by Contractor with these insurance requirements shall not be construed as a waiver of Contractor’s obligation to maintain such insurance.

1.16. If Contractor is a government agency or self-insured for any of the above insurance requirements, Contractor shall be liable for any self-insured retention or deductible portion of any claim for which insurance is required. A certification of self-insurance shall be attached and incorporated by reference and shall constitute compliance with this Section.

2. SUBCONTRACTORS

It is Contractor's responsibility to ensure that each subcontractor obtain and maintain adequate liability insurance coverage that applies to the service provided. Contractor shall provide evidence of such insurance upon City of Tacoma's request. Failure of any subcontractor to comply with insurance requirements does not limit Contractor's liability or responsibility.

3. REQUIRED INSURANCE AND LIMITS

The insurance policies shall provide the minimum coverages and limits set forth below. Providing coverage in these stated minimum limits shall not be construed to relieve Contractor from liability in excess of such limits.

3.1 Commercial General Liability Insurance

Contractor shall maintain Commercial General Liability Insurance policy with limits not less than One Million Dollars ($1,000,000) each occurrence and Two Million Dollars ($2,000,000) annual aggregate. This policy shall be written on ISO form CG 00 01 04 13 or its equivalent and shall include product liability especially when a Contract is solely for purchasing supplies. It includes Products and Completed Operations for three years following the completion of work related to performing construction services. It shall be endorsed to include: A per project aggregate policy limit (using ISO form CG 25 03 05 09 or equivalent endorsement)

3.2 Commercial (Business) Automobile Liability Insurance

Contractor shall maintain Commercial Automobile Liability policy with limits not less than One Million Dollars ($1,000,000) each accident for bodily injury and property damage and bodily injury and property damage coverage for owned (if any), non-owned, hired, or leased vehicles. Commercial Automobile Liability Insurance shall be written using ISO form CA 00 01 or equivalent. Contractor must also maintain MCS 90 and CA 99 48 endorsements or equivalent if "Pollutants" are to be transported unless in-transit Pollution coverage is covered under required Contractor's Pollution Liability Insurance.

3.3 Workers' Compensation

Contractor shall comply with Workers' Compensation coverage as required by the Industrial Insurance laws of the State of Washington, as well as any other similar coverage required for this work by applicable federal laws of other states. Contractor must comply with their domicile State Industrial Insurance laws if it is outside the State of Washington.

3.4 Employers' Liability Insurance

Contractor shall maintain Employers' Liability coverage with limits not less than One Million Dollars ($1,000,000) each employee, One Million Dollars ($1,000,000) each accident, and One Million Dollars ($1,000,000) policy limit.

3.5 Professional Liability Insurance or Errors and Omissions

For contracts with professional licensing, design, or engineering services. Contractor and/or its subcontractor shall maintain Professional Liability or Errors and Omissions with limits of One Million Dollars ($1,000,000) per claim and Two Million Dollars ($2,000,000) in the aggregate covering acts, errors and omissions arising out of the professional services under this Contract. Contractor shall maintain this coverage for Two Million Dollars ($2,000,000) if the policy limit includes the payment of claims or defense costs, from the policy limit. If the scope of such design-related professional services includes work related to pollution conditions, the Professional Liability policy shall include Pollution Liability coverage.

3.6 Other Insurance

Other insurance may be deemed appropriate to cover risks and exposures related to the scope of work or changes to the scope of work required by City of Tacoma. The costs of such necessary and appropriate Insurance coverage shall be borne by Contractor.