Susitna-Watana Hydroelectric Project
(FERC No. 14241)

Fish Passage Feasibility at Watana Dam
Study Plan Section 9.11

2014 Study Implementation Report

Prepared for

Alaska Energy Authority

SUSITNA-WATANA HYDRO

Clean, reliable energy for the next 100 years.

Prepared by

R2 Resource Consultants, Inc.

October 2015

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LIST OF ACRONYMS AND SCIENTIFIC LABELS

Abbreviation	Definition
AEA	Alaska Energy Authority
BPT	Biological Performance Tool
FERC	Federal Energy Regulatory Commission
FPTT	Fish Passage Technical Team
ILP	Integrated Licensing Process
ISR	Initial Study Report (AEA 2014)
PRM	Project River Mile
RM	River Mile
RSP	Revised Study Report
SPD	Study Plan Determination

1. INTRODUCTION

This Fish Passage Feasibility at Watana Dam Study, Section 9.11 of the Revised Study Plan (RSP) approved by the Federal Energy Regulatory Commission (FERC) for the Susitna-Watana Hydroelectric Project, FERC Project No. 14241, focuses on developing, to the feasibility level, a fish passage strategy in support of the license application for the proposed Project (AEA 2012).

A summary of the development of this study, together with the Alaska Energy Authority's (AEA) implementation of it through the 2013 study season, appears in Part A, Section 1 of the Initial Study Report (ISR) filed with FERC in June 2014. As required under FERC's regulations for the Integrated Licensing Process (ILP), the ISR describes AEA's "overall progress in implementing the study plan and schedule and the data collected, including an explanation of any variance from the study plan and schedule." (18 CFR 5.15(c)(1)).

Since filing the ISR in June 2014, AEA has continued to implement the FERC-approved plan for the Fish Passage Feasibility at Watana Dam Study. For example:

- As described in detail below, AEA initiated Task 4 of the study, which involves the development of fish passage concepts, in 2014.
- On October 15, 2014, AEA held an ISR meeting for the Fish Passage Feasibility at Watana Dam Study.

In furtherance of the next round of ISR meetings and FERC's Study Plan Determination (SPD) expected in 2016, this report describes AEA's overall progress in implementing the Fish Passage Feasibility at Watana Dam Study during calendar year 2014. Rather than a comprehensive reporting of all field work, data collection, and data analysis since the beginning of AEA's study program, this report is intended to supplement and update the information presented in Part A of the ISR for the Fish Passage Feasibility at Watana Dam Study through the end of calendar year 2014. It describes the methods and results of the 2014 effort, and includes a discussion of the results achieved.

2. STUDY OBJECTIVES

The goal of this study is to develop, to the feasibility level, a fish passage strategy in support of the License Application for the proposed Project. The methods section of this report outlines the process that was used during 2013 and 2014 to achieve this objective. A variety of engineering, biological, sociological, and economic factors will be considered during this process as it continues through 2014. The study will explore various alternatives in support of three basic strategies related to fish passage: (1) proposed Project without fish passage, (2) integration of upstream and downstream passage features into the current Project design, and (3) the retrofit of upstream and downstream fish passage features to a Project designed without passage.

In the context of this study "retrofit" means that fish passage features would be either geographically or temporally independent from the dam design. A retrofitted passage facility may be constructed some distance upstream or downstream from the dam or later in the future after the construction of the dam, and thus is independent of the dam design process. Option 3, the retrofit option, avoids constraints with having the only option of fish passage being part of the dam structure. Thus, the feasibility evaluation can examine a wider spectrum of passage alternatives.

3. STUDY AREA

As described in RSP Section 9.11.3, the study area (Figure 3-1) extends from the confluence with Portage Creek (Project river mile [PRM] 152.3; historic river mile [RM] 148) upstream to the Oshetna River (PRM 235.1; RM 233.4). It is assumed that any potential upstream passage facilities to be considered (e.g., a trap-and-haul facility) would be located in the mainstem upstream of the confluence with Portage Creek.

4. METHODS

The six tasks defined in RSP Section 9.11.4 to evaluate the technical feasibility of fish passage for the Project are summarized below.

1. Establish a Fish Passage Technical Team (FPTT; Table 4-1) to provide input on the feasibility assessment.
2. Prepare for feasibility study.
3. Conduct site reconnaissance.
4. Develop concepts.
5. Evaluate feasibility of conceptual alternatives.
6. Develop refined passage strategy(ies).

This end of year report summarizes the status of these tasks structured to determine the technical feasibility of fish passage for the Project.

Tasks 1 through 3 were completed in 2013, and their status was reported in the ISR (AEA 2014).

4.1 Task 4: Develop Concepts.

Task 4, as described in RSP Section 9.11.4, was initiated in 2013, and substantial progress was made toward completing this task; the following activities were completed as described below.

Preparation for Workshop #2 (Brainstorm Conceptual Alternatives) was completed in summer 2014. All background information was compiled and posted for the FPTT on September 2, 2014 http://www.susitna-watanahydro.org/meetings/past-meetings/. An example of draft evaluation criteria and an evaluation matrix were prepared and shown to the FPTT during Workshop #2.

Workshop #2 was conducted in Bellevue, WA from September 9 – 11, 2014. This was a facilitated brainstorm session to identify feasible fish passage concepts. The first step of the workshop was to review the physical features of the Project, biological information, and operational information. The second step was to use an iterative approach to brainstorm a full breadth of ideas and then start to organize components into systems. Elements of the brainstorming included collection and transport for upstream and downstream passage. This was the first time the FPTT formally discussed fish passage ideas. The goal of this workshop was to identify concepts for later evaluation.

After completion of Workshop #2, the brainstormed fish passage concepts were organized into a cohesive list. This list was reviewed with the FPTT at Meeting #5 (Regular Check-in) held on December 3, 2014. The list was discussed and edited based on FPTT input and the downstream passage list was reviewed and categories were reassessed by the team http://www.susitna-watanahydro.org/meetings/past-meetings/. Thus, a cohesive list of the fish passage concepts that resulted from the brainstorming workshop were organized and the clarification of concepts was initiated but not completed. The framework and logic of the Biological Performance Tool (BPT) was also prepared (Appendix A).

4.2 Variances from Study Plan

As in 2013, variances from the Study Plan in 2014 were limited to modification of the schedule. Task 4 was initiated in 2014 but not completed. Tasks 5 and 6 have not yet been started. Section 7, below, indicates the tasks remaining to complete the study.

5. RESULTS

5.1 Task 4 Progress in 2014

5.1.1 Workshop #2 – Brainstorm Conceptual Alternatives

The purpose of Task 4 was to identify fish passage concepts based on the project understanding and draft criteria developed in Tasks 1 – 3, and to develop the concepts to a level that would allow the FPTT to begin evaluation and selection of the most feasible fish passage alternatives specifically addressing the three basic strategies related to fish passage listed above in Section 2. The brainstorm workshop was held and the FPTT developed concepts based on the professional judgment of participants as well as on studies, experience, and history of other fish passage facilities and specific criteria and guidelines published by NMFS. There were over 170 fish passage facility concepts (including both upstream and downstream passage) identified and discussed by the FPTT. Concepts ranged from entire fish passage facilities, facility components, and supplemental features or enhancements such as operational procedures and locations of facilities. Supplemental/enhancement features were defined as ideas that could not function as a stand-alone fish passage concept, but could add to the performance of a primary idea. Some concepts were deferred by the group, indicating that they were not suited for further consideration at this time. All other concepts were either clarified and combined, and then prioritized as Priority 1 or 2 indicating a relative degree of confidence by the team that they would have potential for application at this Project, with Priority 1 being the highest confidence. By the end of the workshop, there were 66 upstream passage concepts for further consideration, 51 Priority 1 concepts and 15 Priority 2 concepts. For downstream passage there were 33 concepts to consider further, 32 Priority 1 and 1 Priority 2 concepts.

5.1.2 FPTT Meeting #5 – Regular Update

AEA held Meeting #5 on December 3, 2014 as a follow-up to the brainstorm workshop. AEA facilitated a team review of the organized list of passage concepts. The FPTT also added clarification for some of the concept descriptions and it was decided that re-prioritization of downstream concepts would be undertaken by AEA between Meeting #5 and Workshop #3. AEA was also tasked with reassessing the downstream passage categories and providing them to the FPTT.

At Meeting #5, AEA also introduced the BPT framework, addressed questions to clarify the intent and function of the BPT, presented a draft evaluation matrix and reviewed the process to refine and utilize this evaluation tool.

Further clarification of concepts with text and drawings was initiated by AEA in late December 2014.

Work products that were produced in 2014 related to Task 4 activities include the following:

- Meeting notes and materials from Meeting #5, with an update on action items, are posted on the AEA website http://www.susitna-watanahydro.org/meetings/past-meetings/;
- The framework, operational logic, input, and output parameters were completed for the BPT, and an updated description of the BPT is provided in Appendix A under Item B11.
- An updated version of Item B12, the Summary of Biological Information (Appendix B), was completed to add conceptual life cycle models for Arctic Grayling and Burbot to the one prepared for Chinook Salmon
- A reconciled version of the brainstorm concepts and tally (Appendix C).

6. DISCUSSION

The brainstorm workshop was successful with the FPTT developing a list of passage concepts for upstream collection, upstream passage, and downstream passage. These concepts will be used by the FPTT to develop passage alternatives once the study abeyance is lifted. The BPT is under development and will be useful to compare, in a theoretical way, the fish survival that may be expected from different downstream passage alternatives. Review and comments from the FPTT are needed prior to the finalizing evaluation matrix for use in Tasks 5 of the study.

7. CONCLUSION

The Fish Passage Feasibility Study was initiated in 2013 and will continue with no anticipated modifications to the FERC-approved methods. The successful completion of this Study is dependent on information that will be provided by several interrelated studies (see Section 6). Modifications to the methods of these studies are not anticipated to affect meeting the objectives of Study 9.11.

7.1 Decision Points from Study Plan

There were no decision points in the FERC-approved study plan to be evaluated for this study based on the work completed thus far.

7.2 Modifications to Study Plan

Although the schedule has been modified, no modifications to the Study Plan are needed to complete the study and meet Study Plan objectives.

8. LITERATURE CITED

Alaska Energy Authority (AEA). 2012. Revised Study Plan: Susitna-Watana Hydroelectric Project FERC Project No. 14241. December 2012. Prepared for the Federal Energy Regulatory Commission by the Alaska Energy Authority, Anchorage, Alaska. http://www.susitna-watanahydro.org/study-plan.

Alaska Energy Authority (AEA). 2014. Initial Study Report: Susitna-Watana Hydroelectric Project FERC Project No. 14241. June 2014. Prepared for the Federal Energy Regulatory Commission by the Alaska Energy Authority, Anchorage, Alaska. http://www.susitna-watanahydro.org/type/documents/.

9. TABLES

Table 4-1. Fish Passage Technical Team (FPTT) members as of December 3, 2014.

Name	Company	Role
Betsy McGregor	AEA	Environmental Manager
Doug Ott	AEA	Engineer
Dana Postlewait	R2	Study Lead Engineer
MaryLou Keefe	R2	Aquatics Lead
Dan Turner	R2	Lead Engineer
Tim Sullivan	R2	Lead Biologist
Dennis Dorratcague	MWH	Lead MWH Engineer
Dana Schmidt	Golder	expert advisor, biologist
Chick Sweeney	Alden	expert advisor, engineer
Al Giorgi	BioAnalysts	expert advisor, biologist
Ed Meyer	NMFS	Agency Representative
Sue Walker	NMFS	Agency Representative
Ron Benkert	ADF&G	Agency Representative
Betsy McCracken	USFWS	Agency Representative
George Gilmour	Meridian	Biologist under contract to Services
Ed Zapel	NHC	Engineer under contract to Services
Graham Hill	NHC	Engineer under contract to Services

APPENDIX A: INFORMATION ITEM B11. BIOLOGICAL PERFORMANCE TOOL

1. BIOLOGICAL PERFORMANCE TOOL

In support of the Study of Fish Passage Feasibility at Watana Dam (RSP 9.11, AEA 2012), a Biological Performance Tool (BPT) is proposed to evaluate the relative success of fish passage alternatives to attract, collect, and transport downstream migrants through Watana Dam and reservoir; a given alternative may include one or more facility concepts. Biological performance will consider a range of contributing factors including constructability, maintenance, reliability, certainty, and effectiveness. Evaluation of conceptual-level fish passage facility designs will follow criteria considering structural, operational, environmental, and biological conditions. These criteria will be quantitatively scored and individual criteria will be ranked on a relative level of importance. Criteria scorings reflect the opinions of the fish passage panel members based on consideration of site specific information, panel member experience, fish passage industry experience, and conceptual-level calculations incorporating facility size, capacity, and design. Within the overall evaluation process, the BPT will be used to help score passage alternatives on the relative effectiveness for passing fish. The BPT is intended to evaluate the success of alternatives in passing downstream migrants from immediately above the reservoir to immediately below the dam. It not a life-cycle model, but only considers outmigrant survival and passage during transit of the dam and reservoir.

Upstream fish passage facility concepts at Watana Dam are expected to comprise a limited range of entrance, transport and release options; and factors affecting the performance of these concepts are relatively well understood in the industry. Therefore, a biological performance tool to evaluate upstream passage alternatives is thought to be unnecessary at this time. Although downstream fish passage alternatives at Watana Dam could be evaluated without the use of a biological performance tool, the science of downstream fish passage is less developed than upstream passage, and results in the industry can vary widely depending on site specific conditions. Additionally, downstream passage involves the integration of fish movement, periodicity, channel and flow conditions, dam and reservoir features, and project operations. Rather than relying on panel members to mentally integrate these factors, the BPT will provide a structured process to calculate downstream fish passage effectiveness as the proportion of outmigrants successfully passed downstream of Watana Dam. The model can be used to provide information on facility sizing, siting, range of operations, and effectiveness of individual facility concepts. It can also be used to evaluate the relative sensitivity of data assumptions and associated research needs.

Chinook Salmon have been proposed for consideration as the priority species in evaluating fish passage alternatives because they are the only documented species present in the Upper River with an obligate anadromous life history. Other target species may benefit from passage provisions and discussions regarding their relative importance for evaluating different passage alternatives are continuing. However, Chinook Salmon smolts must exhibit downstream migrations to fulfill their life history, whereas the motivation for downstream movements by other species is less clear. In addition, our relative understanding of response variables such as collection rate and mortality rate is generally greater for salmon than for other species. The degree of uncertainty in modeling these variables limits the value of the BPT for other species such as Burbot and Arctic Grayling. For this reason, the BPT is currently focused on evaluating downstream passage alternatives exclusively for Chinook Salmon outmigrants.

Model outputs include the number of outmigrants that pass the Project (Project outmigrants), outmigrant mortalities, and the number of outmigrants remaining in the reservoir from a theoretical 10,000 outmigrants annually entering the reservoir over the user-specified outmigration season. The selection of 10,000 outmigrants is an arbitrary annual starting condition; it serves as a normalizing factor to provide comparative evaluations between downstream passage alternatives. The model output, in terms of the number of Project outmigrants, is not a function of any actual estimated fish production from tributaries, but represents that proportion of the initial 10,000 fish assumed to be migrating into the reservoir that make it downstream past the dam. The BPT will not estimate the number of outmigrants entering the reservoir, nor the number of adults returning to the Project. This evaluation tool provides a relative comparison of alternative performance and should not be considered an indication of the future passage rate of constructed facilities.

To date, evidence of Chinook Salmon spawning in the Upper River has been limited to the Oshetna River and Kosina Creek. Thus, these two tributaries are included in the BPT as possible input sources from which juvenile Chinook Salmon would enter the reservoir. Because a mainstem collector upstream of the Oshetna River confluence also was identified as a potential collection location during the brainstorming process, the BPT has been developed to accommodate the potential for juvenile Chinook Salmon inputs to the reservoir from the mainstem. The total of 10,000 theoretical Chinook Salmon outmigrants from the system can be apportioned to these three input sources by the user.

An inclusive approach was taken in accommodating different collection locations in the BPT, reflecting the current state of potential downstream collection alternatives following recent brainstorming and refinement efforts. As the feasibility study progresses, some collection locations may be eliminated from further consideration. However, the BPT is being developed to accommodate evaluation of any one or a combination of the collection locations identified in Figure A-1. The model allows for collection facility concepts at the following general locations: dam, reservoir (multiple locations), mainstem Susitna River, and tributary (i.e., Oshetna River and Kosina Creek). For the purposes of routing fish through the Project, a mid-reservoir collection location is included downstream of Kosina Creek and an upper-reservoir collection location is included downstream of the Oshetna River below the upstream reservoir extent during low pool. Because the Oshetna River joins the mainstem Susitna River several miles upstream of the reservoir's full pool extent, two potential mainstem collection locations could be evaluated, either downstream or upstream of the Oshetna River.

The BPT is an executable program developed using Visual Basic 2010 to quantify the expected response of outmigrants to conditions encountered along migratory pathways through Watana Dam and reservoir. The BPT is based on the evaluation of daily inflow, outflow and reservoir water surface elevation at Watana Dam over a predetermined period. The proportion of the theoretical 10,000 outmigrants that successfully pass downstream of Watana Dam is determined by collection and mortality rates (i.e., response functions) assigned to available migratory pathways or associated with reservoir rearing. If fish remain in the reservoir, they may rear and subsequently pass downstream, or be exposed to mortality associated with predation, water quality, harvest and other factors. Figure A-2 shows conceptual passage routes as well as the steps at which various response functions (i.e., collection rates, collection mortality rates, and reservoir mortality rates) are applied in the model. In order of preference, biological response functions will be developed based on 1) site-specific, 2) region-specific, or 3) species-specific life history information depending on data availability. Performance functions for facility concepts will be based on the results of evaluations at similar facilities and/or similar environments. Ultimately, response functions will reflect assumptions regarding fish behavior and the effectiveness of various downstream fish passage facility concepts based on best professional judgment. A response function can be applied across multiple passage alternatives (and the facility concepts of which they are comprised) for a comparative analysis or can be modified specific to each alternative as part of sensitivity analyses. Beyond collection and mortality response functions, other user-defined model inputs include migration periodicity and a fish-flow response function that apportions the timing of fish entry to the reservoir on the basis of stream flow. Table A-1 provides a description of response functions and other parameters that form the basis of the BPT, and identifies likely information sources for each.

Within the BPT framework, the user apportions fish entering the reservoir from three possible sources (Figure A-2); any fish from the Oshetna River would enter the upper reservoir, while fish from Kosina Creek would enter mid-reservoir. The theoretical 10,000 outmigrants can be apportioned by the user based on the observed distribution of Chinook Salmon or other factors deemed important by the user.

Various permutations of possible collection facility concepts can be accommodated by the BPT. Each of the collection locations shown in Figure A-1 could be evaluated as a single collector, or in conjunction with one or more other collectors. For example, a dam collector could be evaluated independently by setting the collection rate functions of all other locations to zero. Alternatively, an Oshetna River collector could be operated first and any remaining fish that pass downstream through the reservoir would be available to a dam collector.

As an example of the BPT framework shown in Figure A-2, the percentage of Chinook Salmon smolts successfully passed downstream of Watana Dam under an alternative utilizing a dam collector incorporates the percentage of fish surviving the reservoir, the percentage of reservoir survivors collected in and surviving the fish passage facility, and the percentage of reservoir survivors not collected by the fish passage facility that are entrained and survive passage through the dam (i.e., via turbines, cone valves, or spill). The model output would provide numbers of surviving system outmigrants, mortalities, and uncollected fish remaining in the reservoir at the end of the model period.

The results of the BPT will be used to score the relative performance of downstream fish passage alternatives in collecting and passing outmigrants past Watana Dam as part of the evaluation matrix. The evaluation matrix will consider biological performance as a criterion, but fish passage alternatives also will be scored based other criteria as listed below.

- Biological Criteria
    - Potential for biological monitoring
    - Compatibility with upstream passage facilities
    - Effects on other species
    - Adaptability of collection and passage
- Technical Criteria
    - Functional precedent

  - Simplicity of operations and maintenance
  - Ice/debris management and structure durability
  - Availability of utilities
  - Safety of operation
  - Access to collection, holding, transport, and release facilities
  - Compatibility with project operations
- Other Criteria
  - Public safety
  - Land rights
  - Permitting and environmental impact

The goal of Study of Fish Passage Feasibility at Watana Dam (RSP 9.11, AEA 2012) is to assess the technical and biological feasibility, including biological performance, of fish passage at Watana Dam. After an initial set of fish passage concepts is identified during the brainstorming workshop, they will be refined and developed into fish passage alternatives that will be evaluated for their relative performance. The results of the BPT can be used as one of several criteria to evaluate the feasibility of alternatives. This model is a tool at the disposal of the Fish Passage Technical Team that can be employed during the feasibility assessment process. The value of using the BPT will depend on the degree of certainty in model inputs, which in turn will depend on the level of existing information. The BPT may also help in identifying what data are important and where uncertainty has the greatest influence. Applying the BPT to the full suite of individual facility concepts identified during brainstorming sessions would be impractical and would not provide meaningful results in terms of system outputs. Rather, the BPT is best applied after facility concepts are pre-screened and develop into a set of passage alternatives.

2. LITERATURE CITED

Alaska Energy Authority (AEA). 2012. Revised Study Plan: Susitna-Watana Hydroelectric Project FERC Project No. 14241. December 2012. Prepared for the Federal Energy Regulatory Commission by the Alaska Energy Authority, Anchorage, Alaska. http://www.susitna-watanahydro.org/study-plan.

3. TABLES

Table A-1. Description of Biological Performance Tool input parameters and likely data sources.

Category	Parameter	Description/units	Source data
Physical Environment	Reservoir Inflow	Daily flow (cfs) at Kosina Cr., Oshetna R., and Upper River mainstem.	Tributary gauging efforts and hydrologic analysis.
	Reservoir Morphology	Size and shape of reservoir	
	Reservoir Water Surface Elevation	Average daily reservoir water surface elevations (ft) for a given operational scenario.	Provided for 61-yr period by Project operations model. OS1b and ILF-1 currently available.
	Timing of fall freeze-up and spring break-up	Will influence operational periods for collection facilities.	Results from Ice Processes Study (7.6).
	Reservoir Conditions	Will influence whether reservoir transit positively (e.g., increased productivity or rearing/overwintering habitat) or negatively (e.g., increased predation or adverse conditions) affects outmigrant survival.	Water Quality Modeling Study (5.6) will provide information on reservoir flow/circulation, mixing, thermal dynamics and stratification, sediment transport, and nutrient fate.
	Generation Flows	Hourly flow (cfs) through turbines for a given operational scenario. Will influence	Provided for 61-yr period by Project operations model. OS1b and ILF-1 currently available.
	Cone Valve Flows	Hourly flow (cfs) through cone valves for a given operational scenario.	Provided for 61-yr period by Project operations model. OS1b and ILF-1 currently available.
	Operational Scenarios	Will influence reservoir pool levels, magnitude and timing of flow releases, collection rates and passage facility operational periods.	Operations model.
	Other Studies	Tributary delta formation, bank erosion, LWD, timing and type of organic debris.	
Fish Migration	Outmigrant Source	Total of 10,000 theoretical Chinook Salmon outmigrants entering reservoir from documented Chinook Salmon sources (Kosina Cr. and Oshetna R.) and/or mainstem above Oshetna R. confluence.	Can be user-apportioned based on basin-specific considerations (e.g., drainage area, documented Chinook Salmon distribution).
	Life Stage / Life History	Some model parameters will vary by life stage (i.e., age-0 vs. age-1). The BPT can be run independently for each potential outmigrant life stage.	Uncertainty remains as to the proportional age of Chinook Salmon outmigrants from the Upper River, particularly post-impoundment.
	Migration Periodicity	Migration distribution of all juvenile life stages at a specific location, e.g., mouth of trib, at dam, etc. Units expressed as weekly frequency of occurrence over entire year. Values may differ by life stage (age-0 vs. age-1).	Local data from screw traps at Kosina Cr., Oshetna R., and dam site or adjusted from Middle River traps. Sampling periods restricted by ice/flow. May not represent early life stages migrating prior to ice breakup.
	Reservoir Mortality	Daily mortality rate applied to outmigrant cohort upon reservoir entry. Reflects factors such as predation, water quality, and natural mortality.	No local information. Literature based assumptions applied to site conditions.

Category	Parameter	Description/units	Source data
	Travel Time	Migration rate in miles/day from reservoir entry to collection/passage. Affects application of daily reservoir mortality rate and collection-related reservoir hydrology. Total travel time depends on factors including outmigrant source drainage, lifestage, temperature, reservoir pool level, collection location, and assumptions regarding reservoir rearing.	No local information on reservoir travel time. Literature based assumptions applied to site condition
	Reservoir Fish Populations	Expected development of reservoir-based fish populations (could affect predation, reservoir rearing opportunities	FSP 9.10: The Future Watana Reservoir Fish Community and Risk of Entrainment Study.
Collection/ passage	Collection Location	Allows for selection of tributary (Kosina Cr. or Oshetna River), mainstem (above or below Oshetna R. confluence), reservoir (upper or mid), or dam collector locations.	Suite of potential locations identified in brainstorming exercise and refined during feasibility study. Can be user-specified and include one or more locations.
	Collection/ passage rate	Proportion of outmigrants encountering a collector/passage route entrance that is collected or passes through that route.	Dependent on facility design. From evaluations of similar existing facilities or based on professional judgment.
	Route-specific Mortality	Mortality rate applied to daily outmigrants at each collector/passage route. Reflects mortality during collection, transport, and release. Includes predation, screen impingement, and mechanical injury. Values may differ by collection technology/passage route and can be flow dependent.	Dependent on facility design. From evaluations of similar existing facilities or based on professional judgment.
	Operational Periodicity	Annual period (date range) during which ice/flow conditions and project operations would allow collector to operate. May differ based on collection location and technology. Binary function, independent of collection rate.	Results from Ice Processes Study (7.6), tributary gauging, and operations model.

4. FIGURES

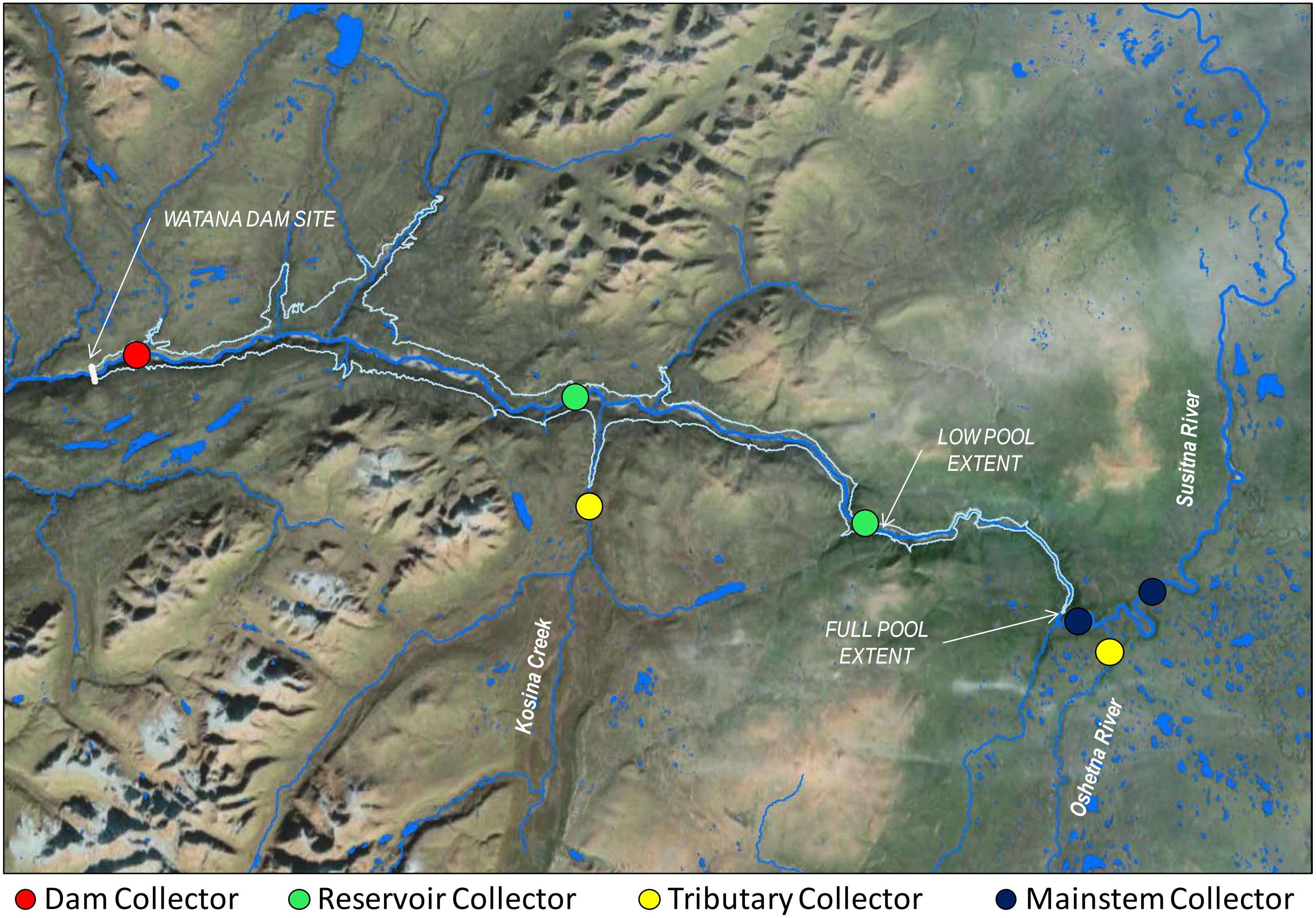

Figure A-1. Potential downstream passage collection locations for the purpose of routing outmigrants through the Biological Performance Tool.

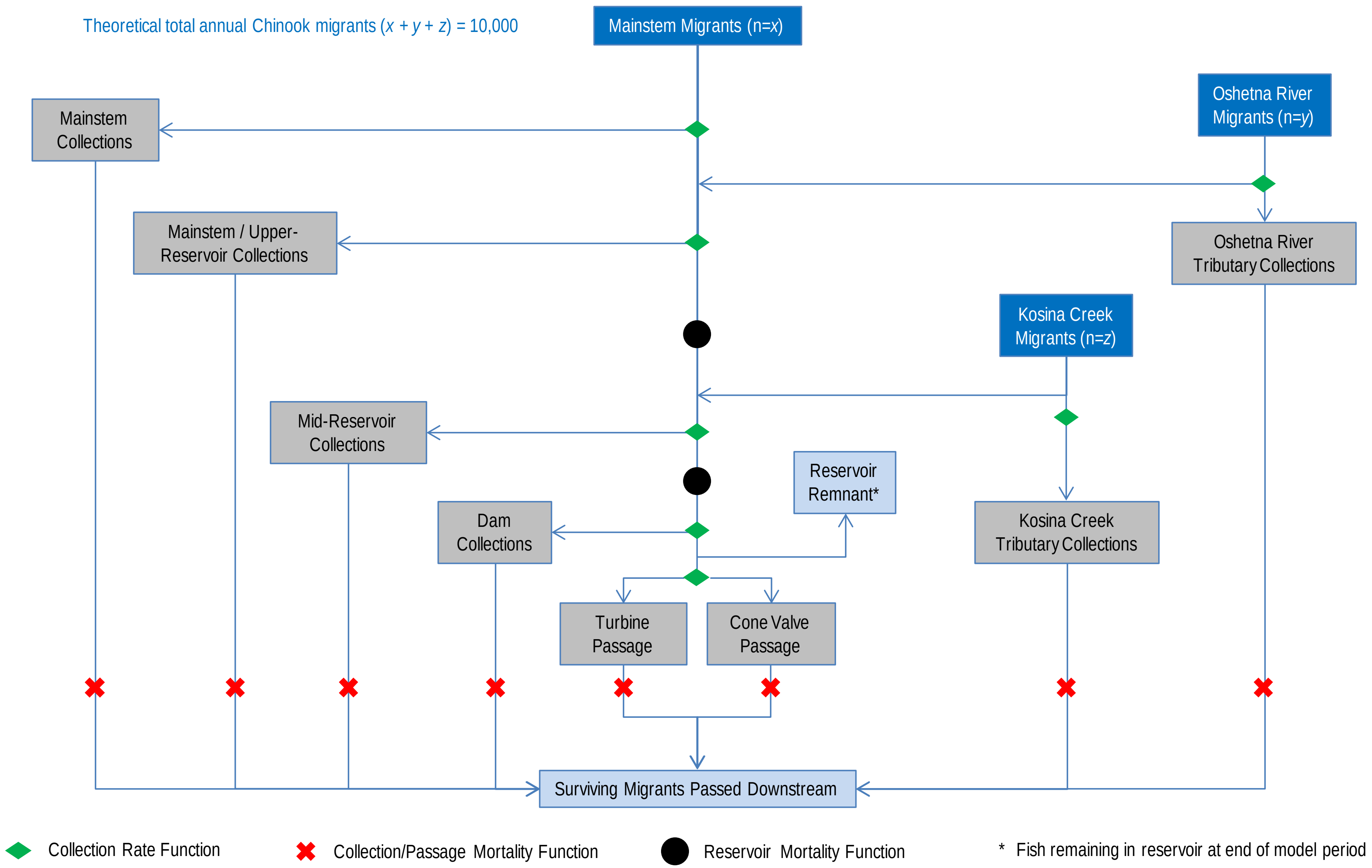

Figure A-2. Conceptual framework of the Biological Performance Tool showing potential outmigrant passage routes, collection locations, and collection rate and mortality functions.

APPENDIX B: INFORMATION ITEM B12. SUMMARY OF BIOLOGICAL INFORMATION

1. INTRODUCTION

The purpose of this information item (B12) is to summarize existing biological information that is pertinent to developing fish passage alternatives at Watana Dam. This summary is intended to organize a simple framework for consideration during the brainstorming and identification of all possible alternatives. This summary includes a conceptual model for select species (i.e., Chinook Salmon, Arctic Grayling, and Burbot) and tables that summarize information related to collection, sorting, and design requirements for upstream and downstream passage facilities.

2. CONCEPTUAL MODELS FOR REPRESENTATIVE SPECIES

Chinook Salmon have been proposed for consideration as the priority species in evaluating fish passage alternatives because they are the only documented species present in the Upper River with an obligate anadromous life history. However, other target species may benefit from passage provisions and discussions regarding their relative importance for evaluating different passage alternatives are continuing. This section provides conceptual models for a subset of species that reflect the range of body sizes, life histories, and swimming abilities of fish that could potentially benefit from passage facilities. In addition to Chinook Salmon, conceptual models for Arctic Grayling and Burbot are provided.[1] Whereas some information exists regarding populations of these species in the Upper Susitna River under existing conditions, empirical information under post-impoundment conditions is not available. Thus, these conceptual models are intended to provide a framework within which the advantages and disadvantages of different passage alternatives can be considered based on our current understanding of the species and our expectations following impoundment.

2.1. Chinook Salmon

The following section provides a conceptual model for the segment of the Susitna River Chinook Salmon population that may use fish passage facilities at Watana Dam. Although some data is available regarding Chinook Salmon in the Upper Susitna River under existing conditions, empirical information regarding this population segment under post-impoundment conditions is not available nor yet attainable. For this reason, the following conceptual model provides a framework for addressing Chinook salmon passage considerations.

Other Pacific salmon species have been identified for consideration by the Fish Passage Technical Team (FPTT). However, only Chinook Salmon have been documented in the Upper River. Moreover, for the purposes of the feasibility study, Chinook Salmon are considered sufficiently representative of other salmon species; they are large-bodied, strong swimmers with an obligate anadromous life history that exhibit life stage periodicities generally similar to other

[1] Arctic lamprey also represent a unique species with respect to passage requirements. However, this species has not been documented upstream of Devils Canyon. Moreover, discussions to date amongst the Fish Passage Technical Team have assumed that specific technical provisions could be added to various passage alternatives to accommodate lamprey based on criteria established elsewhere for this taxon.

salmon (e.g., late summer/early fall spawning, migrate downstream as sub-yearlings and yearlings).

2.1.1. Life History Pattern in Existing Environment

Chinook Salmon life history data are derived from recent studies by AEA (AEA 2014) and ADF&G (Buckwalter 2011). Adults migrate upstream past the proposed dam site from mid-July to early-August and have been documented moving into the Oshetna and Kosina watersheds.

Spawning has been documented in both the Oshetna River and Kosina Creek based on historic and recent observations and fish capture. In 2013 and 2014, juvenile Chinook Salmon were captured in these tributaries during summer months and also in downstream migrant traps located near tributary mouths. The size range of juveniles that were captured in traps (46 to 114 mm) indicates that some juveniles migrate out of the tributary into the mainstem Susitna River during their first summer of life, while others rear in Kosina Creek for more than one year, and migrate downstream as yearlings. Data from July 2014 included captures of Chinook smolts at the Upper River mainstem downstream migrant trap (at approximately RM 200) as well as in mainstem off-channel habitats further upstream.

2.1.2. Expectations Following Impoundment

The construction of a dam will present migratory and passage challenges to this species. Additionally, the impoundment will dramatically alter habitat characteristics within the Susitna River as well as the lower reaches of a major tributary used by Chinook Salmon. In terms of migratory impacts, both adult and juvenile life stages will be affected. For adults the timing of migration in the vicinity of the dam could be altered due to changes in the hydrograph (timing and velocity) and/or water temperature in the tailrace and downstream environs. Those same factors can potentially affect juveniles as well. Experience in other river systems has revealed that migration timing and speed are sensitive to both water temperature and water velocity. Any shift from baseline conditions is difficult to predict until operations are finalized and effects on water flow/velocity and temperature downstream from the project are analyzed. However, water quality models are being developed that will help us to predict both reservoir and riverine conditions under future operational scenarios (Study Plan Section 5.6 – Water Quality Modeling).

Within the reservoir, if adults are released in the forebay, observations from other impounded river systems suggest that Chinook can successfully navigate reservoirs in route to destination tributaries (e.g., Keefer et al. 2004, 2006, 2008). Observations from populations inhabiting river systems with lakes in the migratory path exhibit the same behavior. We do not expect the reservoir to impede adult migration. In contrast, with respect to juveniles the reservoir will likely impede migration downstream. Water velocity will decrease dramatically, diminishing an important migratory cue, thereby slowing the migration seaward, increasing exposure to predators, and decreasing the probability of survival through the project area.

An additional consideration may be needed regarding tributaries where the water elevation in the reservoir will provide access to new streams suitable for, but not currently inhabited by, Chinook Salmon. Successful colonization of virgin streams requires both access (flooded natural barriers) and availability of habitat suitable to promote successful spawning, egg incubation and juvenile rearing. Fish passage alternatives will consider the possibility of colonization into any tributary with newly accessible habitat due to inundation from the reservoir; at this time it is thought that Deadman Creek is the only Upper River tributary that meets this description.

The dam structure itself will be a direct impediment to passage, although our collective experience at numerous other dam sites suggests there are viable options for safely passing adults with negligible effects on survival. However, dams can have a negative effect on downstream migrating juveniles that encounter the structures. Not all fish will be able to locate passage routes, and those that do will incur varying levels of mortality associated with the specific route. Providing suitable and effective juvenile passage for anadromous salmonids at dams has proved to be a challenging endeavor at sites throughout the Pacific Northwest. Solutions are usually site-specific and tailored to the unique environmental conditions and operational constraints at the project. The FPTTis charged with evaluating the feasibility of various passage options to optimize fish passage success at the dam for both juvenile and adult life stages.

2.1.3. Anticipated Impact on the Chinook Population

Viable self-sustaining salmon populations are dependent on successful passage and suitable migration conditions to access critical habitats. However, the existence of effective passage facilities does not necessarily ensure a positive outcome for the Chinook Salmon population in the Upper River. Given the variety of uncertainties regarding the effects of impoundment at this site, it is difficult to predict the net effect at the population level with the data and analyses currently in hand. We have noted that creation of the impoundment may affect habitat-driven life history processes separate from alterations to the migratory corridor. Inundation of currently productive habitat may be offset by providing access to new productive streams or stream segments. Post-impoundment spawning and rearing habitat potential will likely weigh heavily in any final determination of total effects at the population level. Such a population-level evaluation is beyond the scope of the FPTT.

2.2. Arctic Grayling

Arctic Grayling, a salmonid of moderate size and swimming ability, are among the most abundant fish species in the Upper River (AEA 2014, Delaney et al. 1981). They exhibit movement along the mainstem river and between tributaries. As such, grayling are the preferred surrogate to represent other moderately-sized non-anadromous salmonid and catostomid (i.e., longnose sucker) species in considering fish passage alternatives.

2.2.1. Life History Pattern in Existing Environment

In recent Upper River surveys, grayling were distributed throughout the mainstem river, in the majority of tributaries surveyed, and in multiple lakes (AEA 2014). After migrating from overwintering habitat that is thought to include the mainstem Susitna River (Sundet 1986), spawning occurs in tributaries during the spring. Spawning typically occurs in clear, non-glacial tributaries soon after ice breakup. Spawning has been documented in May and early June but timing can vary among tributaries (Sundet and Wenger 1984; Sundet and Pechek 1985). Spawning typically occurs in upper extents of tributaries but also has been documented near tributary mouths (Sundet and Wenger 1984). After spawning, and throughout the open water period, adults remain in spawning tributaries or move into nearby tributaries to feed; they have also been found using main channel and off-channel habitats associated with the mainstem.

Recent PIT tagging and radio-telemetry efforts showed grayling moving between several Upper River tributaries, including Kosina Creek, Oshetna River, Goose Creek and Tyone River (AEA 2014). Most juvenile grayling appear to use their natal tributaries for at least one year before moving between the mainstem and other tributary habitats (Schmidt et al. 1983).

Although found in some lakes, most grayling in the Upper River appear to exhibit a fluvial life history. Recent studies found numerous radiotagged grayling moving downstream past the Dam site during the open water period as well as from the mainstem into Upper River tributaries. During the winter, radiotagged grayling continued to move out of Upper River tributaries and also showed downstream movement in the mainstem, from below of Kosina Creek past the Dam site to overwinter upstream of Devils Island.

2.2.2. Expectations Following Impoundment

Construction of Watana Dam will present migratory and passage challenges for the segment of the Arctic Grayling population that currently move past the dam site. While evaluations of upstream passage facilities for grayling are limited, they have demonstrated an ability to negotiate steep pass (Tack and Fisher 1977) and weir-type fishways (Clay 1994). However, the timing of upstream migration could be altered by changes to the hydrograph (timing and velocity) and/or water temperature resulting from the Project. Both water temperature (warming to 1°C) and discharge have been identified as important stimuli for triggering grayling movements from overwintering areas to spawning habitat in Interior and Arctic Alaska (Tack 1980).

For upstream migrants released into the reservoir and downstream migrants entering from upstream tributaries, there is little available information to predict the ability of migrants to successfully negotiate the reservoir in completing their migrations. Grayling may be particularly susceptible to predation in the reservoir if a population of Lake Trout becomes established.

Following impoundment, grayling habitat in the inundation zone will shift from lotic to lacustrine. While adfluvial arctic grayling populations exist in reservoirs elsewhere in North America (e.g., Peterson and Ardren 2009), the degree to which a fluvial grayling population can adapt to another life history is unclear. Studies have suggested that the degree of positive rheotaxis exhibited by Arctic Grayling fry of fluvial parentage from the Big Hole River, Montana is a heritable trait exceeding that exhibited by fry of lacustrine parentage (Kaya and Jeanes 1995, Kaya 1991). Conversely, in considering the listing of fluvial Big Hole River grayling under the Endangered Species Act, the U.S. Fish and Wildlife Service concluded that they did not represent a distinct population segment relative to other Arctic Grayling in the Upper Missouri River basin based on existing genetic information (USFWS 2010).

Fluvial Arctic Grayling in the Williston Reservoir Watershed, British Columbia, initially maintained a robust population for roughly a decade following impoundment. However, dramatic declines occurred during subsequent decades (Blackman 2002). Blackman (2002) suggests possible mechanisms for the decline, including overfishing, competition with other species more suited to a reservoir environment, a decline in forage and cover, and interruption of their migration patterns by the reservoir. Clarke et al. (2007) contend that early persistence of the robust grayling population in the Williston Reservoir was simply a reflection of residual pre-impoundment fish that masked immediate effects. Clarke et al. (2007) suggest that the formation of the Williston Reservoir primarily affected the grayling population by creating a migratory barrier that prevented grayling from fulfilling their pre-impoundment life history migrations. Currently, grayling in this watershed are found throughout headwater streams, but the degree to which they use the Williston Reservoir as habitat or as a migratory corridor to move among major tributaries was unknown. Based on otolith microchemistry, Clarke et al. (2007) suggest that grayling do not currently move into the reservoir and that the species may now be restricted to several tributary streams with no interconnectivity.

Williston Reservoir is considerably larger than Watana Reservoir and it is unclear whether similar effects could be expected for Susitna River grayling post-impoundment. In a recent modeling exercise, Hawkshaw et al. (2014) evaluated the relationships between existing juvenile grayling occurrence and habitat attributes in tributaries to Williston Reservoir. They found that juvenile grayling occurrence was positively associated with both distance from the reservoir and stream order (i.e., increasing stream size), but negatively associated with water temperature and temperature variance. These results suggest that specific habitat attributes may drive the persistence of grayling in an impounded system and that anticipated impacts of impoundment are project-specific. Nonetheless, the habitat change in the inundation zone is an important consideration in assessing alternatives for fish passage.

2.2.3. Anticipated Impact on the Arctic Grayling Population

Arctic Grayling exhibit complex life histories and movement patterns. Existing migrations in the Susitna River are not yet fully understood and there is much uncertainty as to how such patterns may shift in a post-impoundment environment. The degree to which grayling would rear in the reservoir or use it as a migratory corridor between tributary habitat will have a profound effect on the utility of any passage alternative. Potential scenarios that could arise for grayling populations include: 1) isolated tributary populations, 2) an Upper River population that utilizes the reservoir and moves between Upper River tributaries, and 3) a population that utilizes fish passage facilities at the Dam and moves between tributary and mainstem habitat in the Upper and Middle River. Reservoir habitat conditions and the future fish community will likely be important determinants as to whether reservoir utilization has a positive or negative impact on the grayling population. Reservoir water temperatures, nutrient loads, and shoreline conditions will influence suitability for grayling and the potential presence of predatory lake trout could be an important limiting factor. To the extent that the future physical and biological attributes of the reservoir can be predicted, results from the completion of Study 9.10 *(Future Watana Reservoir Fish Community and Risk of Entrainment)* may help clarify the anticipated impacts on grayling movements and population expectations.

An additional confounding factor is the uncertainty associated with grayling movements. The existing fluvial population exhibits complex movement patterns between various tributaries and the mainstem. Given this complexity, identifying appropriate passage goals and suitable passage alternatives with regard to collection locations and release destinations may pose a significant challenge.

2.3. Burbot

Burbot are distinct from other Upper River fish species in several respects. Burbot exhibit both a planktonic larval stage and a benthic or demersal orientation. Compared to salmonids, they are weak swimmers and unlike other fishes in the Upper River, they typically spawn in the winter.

These unique traits warrant consideration as to how collection depths, water velocities, and operational periods for different passage alternatives could influence passage effectiveness for Burbot. Existing Burbot life history strategies and expectations following impoundment will also influence the benefits of providing passage for this species. Because of their unique traits, the following conceptual model has been developed to help evaluate passage alternatives with respect to Burbot populations in the Susitna River.

2.3.1. Life History Pattern in Existing Environment

Burbot are widely distributed in both the Upper and Middle River, although their relative abundance is low compared to most other species encountered during sampling (AEA 2014; Delaney et al. 1981). While also found at the mouths and in the lower reaches of several smaller tributaries of the Upper River, Burbot were most consistently observed in mainstem habitats and throughout larger tributaries, namely the Oshetna River and its tributary the Black River (AEA 2014). In the Susitna River, spawning is thought to primarily occur from January through February, but may extend from December to as late as April. Specific spawning areas in the Upper River are unknown, but elsewhere in the system broadcast spawning this thought to occur in areas influenced by mainstem flow such as tributary and slough mouths or mainstem areas with upwelling (Schmidt et al. 1983); seasonally consistent observations in much of the Oshetna River system suggest that spawning may also take place there. Egg incubation is poorly understood in the Susitna River due to difficulty of sampling ice covered spawning sites during winter (Sundet and Pechek 1985). The duration of egg incubation varies considerably with temperature, ranging from 30 days (at 6°C) to 100 days or more (near 0°C) (Bjorn 1940, MacCrimmon 1971, McPhail and Paragamian 2000). Based on this range, egg incubation is estimated to occur from mid-January through April. After hatching, larval Burbot drift downstream with the current before demersal settlement occurs; this is thought to occur by early summer when larvae are greater than 15 mm in length (McPhail and Paragamian 2000). Juvenile burbot were infrequently captured in the Susitna Basin (Sundet and Pechek 1985, AEA 2014). Juveniles are believed utilize habitats proximal to the spawning areas from which they originate, although they have been captured in downstream migrant traps (Schmidt et al. 1983; AEA 2014) suggesting some degree of dispersal occurs.

Burbot exhibit diverse life history patterns (e.g., lacustrine, adfluvial, fluvial, and resident) throughout their range and the extent of their migrations can vary considerably. Burbot are typically sedentary with the exception of pre- and post-spawning migrations. In the Susitna River, predominant life history patterns have not been discerned, although fluvial life histories appear to exist. Spawning migrations generally range from 5-40 miles (100-mile maximum), beginning as early as mid-August and continuing through winter until spawning (Schmidt and Estes 1983, Sundet 1986). Although migrations exhibited by Burbot upstream of Devils Canyon are not fully understood, recent radiotelemetry efforts confirm movement along the mainstem during winter; Burbot tagged in the Middle River moved both upstream and downstream in the mainstem and Burbot tagged in the Upper River moved upstream in the mainstem. While tagged Burbot have not been documented passing the Watana Dam site, no fish were tagged between the Dam site and Devils Canyon.

Given the weak swimming ability of Burbot and the high velocities in Devils Canyon, upstream connectivity between populations below Devils Canyon and the Upper River is currently unlikely[2]. However, larval drift and any downstream migration exhibited by other life stages from the Upper River would provide a source of recruitment for populations downstream of Devils Canyon. In addition, mixing of Upper River Burbot populations with those in the Middle River upstream of Devils Canyon is presumably possible under current conditions. Likewise, individual Burbot may currently be able to utilize habitat (i.e., spawning, foraging, or overwintering) both upstream and downstream of the Dam site.

2.3.2. Expectations Following Impoundment

Construction of Watana Dam will present migratory and passage challenges for the segment of the Burbot population that currently move past the dam site. A limited number of studies have documented Burbot using upstream passage structures such as nature-like (Calles 2005, Calles and Greenberg 2007, Zitek et al. 2012), Denil (Schwalme et al. 1985), vertical slot (Schwalme et al. 1985, Zitek et al. 2012), and step-and-pool (Slavik and Bartoš 2002) fishways. However, the timing of upstream burbot migration could be altered by changes to the hydrograph (timing and velocity) and/or water temperature resulting from the Project. For example, in the Kootenai River, Montana/Idaho, high winter discharges from Libby Dam disrupt Burbot spawning migration in downstream reaches, both as a function of increased velocities and warmer water temperatures from operational flow releases at the dam (Hardy and Paragamian 2012).

There is little available information regarding the need for, or feasibility of downstream passage measures for Burbot at hydroelectric projects, although there are examples of robust Burbot populations inhabiting reservoir systems. The Wind River system in Wyoming is a regulated watershed with several reservoirs, irrigation diversions, and a hydroelectric/flood control project. There are no passage facilities although Burbot have persisted in the system (Hubert et al. 2007). Extensive emigration has been observed from natural lakes higher in the system, which is thought to serve as a recruitment source for downstream reaches. Connectivity was not identified as a limiting factor, although losses to irrigation canals, along with high rates of harvest and habitat degradation, are considered the primary issues affecting Burbot persistence in the watershed.

Following impoundment by Watana Dam, Burbot habitat in the inundation zone will shift from lotic to lacustrine. Fish exhibiting a fluvial life history would be restricted to the Oshetna River system and the mainstem upstream of the reservoir. Assuming that Burbot populations are able to exhibit plasticity in life history strategy (i.e., spawning habitat), a more pronounced adfluvial population may develop in which fish forage and rear in the reservoir and spawn in tributaries or the mainstem upstream of the reservoir. Burbot are also known to spawn in lakes, typically utilizing near-shore shallows or off-shore reefs and shoals (McPhail and Paragamian 2000). To the extent such habitat would persist under post-impoundment conditions, a strictly lacustrine population may also develop.

With respect to Burbot populations upstream of the Watana Dam site, the reservoir may create conditions more favorable than currently exist for certain life stages. Citing a repeated pattern observed in Europe, Siberia, and North America, McPhail (1997) explains that Burbot are often

[2] Persistence of Devils Canyon as an upstream migration barrier for adult Burbot assumes that velocities would still exceed their swimming ability during the low flows that typically occur in winter, when upstream movements have been documented elsewhere.

rare before becoming the dominant species within a few years after impoundment. As possible explanations, he suggests that larval survival in a reservoir is likely greater than in flowing water, and that the amount of forage species generally increases in reservoirs. The amount of suitable spawning habitat, reservoir productivity, thermal regime, and operations could also influence the degree to which impoundment may benefit Burbot populations in the Upper River.

Larval drift is a primary component of downstream dispersal. Post-impoundment, lower water velocities in the reservoir would likely restrict the extent of larval drift. Depending on the degree to which larval drift under existing free-flowing conditions extends past the Dam site, the reservoir would potentially restrict downstream recruitment to the Middle River. There are no known examples of larval burbot being collected for downstream passage, but the general fragility of this lifestage would suggest that such collection efforts with acceptable levels of mortality would be unlikely. Burbot are also a physoclistus species, meaning their swim bladder has no connection to the gut. Potential passage alternatives should account for potential injury associated with any transport from depth at rates that exceed the capacity for burbot to acclimate to resulting pressure changes.

2.3.3. Anticipated Impact on the Burbot Population

Depending on site-specific knowledge of seasonal habitat use, maintaining habitat, genetic, and recruitment connectivity between the Upper and Middle River for Burbot populations could benefit from effective fish passage provisions at the dam. However, the degree to which viable self-sustaining Burbot populations would rely on such connectivity remains unclear. If sufficient suitable habitat exists for each life stage, both in the Upper River and in the Middle River reach above Devils Canyon, then viable Burbot populations would presumably persist, even in the absence of passage such as has occurred in the Wind River basin, Wyoming. However, developing specific predictions regarding life history and population level effects of the Project on Burbot is beyond the scope of the FPTT. In order to accommodate burbot, passage alternatives would need to consider the timing of Burbot movements (e.g., winter spawning), their predominantly benthic orientation, and weak swimming ability.

3. COLLECTION, SORTING, AND DESIGN REQUIREMENTS

The detailed information described in Information Items B1-B11 has been filtered down to those data that are critical for development of passage alternative and is presented below in two tables. This tabular format provides a concise reference for use by the design team during the development of fish passage alternatives. Information relevant to upstream passage is presented in Table B-1 while information relevant to downstream passage is presented in Table B-2. In addition, these tables also have been prepared so as to stimulate discussion regarding management considerations that will influence fish passage facility alternatives, and as such, should be considered a work-in-progress to be completed and refined during the course of alternative development.

As described in the conceptual models, some fish species have similar traits (e.g., body size, swimming ability, life stage periodicity, or general migratory behavior) that could influence the performance of various passage alternatives. Thus, species are grouped in Table B-1 and Table B-2 based on such similarities. *Pacific Salmon* fall under a single group based on their similar life stage periodicities, swimming ability, and body size. Although they exhibit a variety of life history periodicities (e.g., spring vs. fall spawning), non-anadromous salmonids (grayling, char, trout, and whitefish species) and Longnose Sucker (Catostomidae) have been grouped together as a *Salmonid Guild* based on similarities in their relative body size, swimming ability, and scale of migratory behavior. Given the unique life history periodicity, benthic orientation, and weak swimming ability of Burbot and the unique locomotory traits of Arctic Lamprey, these two species are each listed separately.

The tables are organized by fish species; the list of species includes those targeted for fish passage as well as species that may need to be considered during design due to potential collection, holding, handling, or sorting concerns. For example Lake Trout are on the downstream passage list due to their voracious predatory behavior and an anticipated need to minimize risk of exposure of salmon smolts to this species during passage. The information presented in the *Species Information* section of the tables summarizes our current understanding of the life history and distribution of the fishes in the Susitna River.

The development of fish passage alternatives includes the identification of appropriate release destinations for any fishes collected. The *Release Destination* section of the tables reflects an initial suite of potential destinations. As an example, potential release destinations for adult Chinook Salmon would be in the reservoir above the dam, while for juvenile Chinook Salmon collected above the dam an appropriate release would be below the dam. For discussion purposes, these examples are reflected in Tables B-1 and B-2. Table B-2 includes an additional section that describes possible *Collection Location* options; the suite of potential collection locations will be developed further as part of the alternative development.

Each table also provides information under the *Design Data* section that should be considered in the development of fish passage concepts. This includes the identification of potential piscivorous predators, the relative swimming ability of each species (based on *Information Item B6: Life Stage Specific Passage Information*), and estimates of the size and number of fish to be handled. Certain criteria (e.g., design length and weight) may be needed at later stages of alternative development and have been included, herein, as placeholders.

Lastly, each table summarizes our current understanding of the run timing exhibited by each species/life stage. Run timing is based on *Information Item B3: Periodicity* and may be refined as additional site-specific data becomes available.

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5. TABLES

Table B-1. Upstream Passage Sorting Requirements and Design Data by Fish Species.

Species Information									Release Destination [A]						Design Data							Run Timing [B]											
	Documented Distribution				Life History																												
Species	Lower River PRM 3 – 102.4	Middle River: Below DC PRM 102.4 – 153.9	Middle River: DC to Dam PRM 153.9 – 187.1	Upper River PRM 187.1 – 234.5	Anadromous	Freshwater	Unknown	Life Stage [F]	Down-River	Below Dam	Reservoir Above Dam	Upstream Tributaries	Head of Reservoir	Cull	Potential Predator	Relative Swimming Ability	Length Range (mm) [F]	Fish Design Length (mm)	Body Width Range (mm)	Fish Design Weight (lbs)	Design Peak Daily (no.)	J	F	M	A	M	J	J	A	S	O	N	D
Pacific Salmon																																	
Chinook Salmon	✓	✓	✓	✓	✓			A			✓					Strong	550-1250 [L]				290 [C]							X	X				
Chum salmon	✓	✓			✓			A								Strong	550-800 [L]				930 [C]							-	X	-	-		
Coho salmon	✓	✓			✓			A								Strong	450-700 [L]				490 [C]							-	X	-	-		
Sockeye salmon	✓	✓		R	✓			A								Strong	450-750 [L]				16,000 [C]							X	X	-	-		
Mid-sized Salmonids/Catostomids																																	
Arctic Grayling	✓	✓	✓	✓		✓		A								Moderate	190-420 [H]				<100 [D]				-	-	-		-	-	-		
Bering cisco	✓	✓			✓			A								Moderate	240-410 [J]				<100 [D]								-	-	-		
Dolly Varden	✓	✓	✓	✓		✓	✓	A								Moderate	83-370 [M]				<100 [D]					-	-	-		-	-	-	
Humpback Whitefish	✓	✓	✓	✓		✓	✓	A								Moderate	280-350 [N]				<100 [D]							-	X	-	-	-	
Longnose sucker	✓	✓	✓	✓		✓		A								Moderate	188-670 [O]				<100 [D]						X	X					
Rainbow trout	✓	✓	S			✓	✓	A								Moderate	200-620 [P]				<100 [D]			-	-	-	-						
Round Whitefish	✓	✓	✓	✓		✓		A								Moderate	199-440 [Q]				<100 [D]						-		-	-	-		
Burbot	✓	✓	✓	✓		✓		A							✓	Weak	280-740 [K]				<100 [D]	-	-	-					-	-	-	-	-
Arctic lamprey	✓	✓			✓	✓		A								Weak	125-320 [I]				<100 [D]					-	-	-					
Other (i.e., invasive/non-native spp.)	✓ [E]					✓	✓	A, J							✓	NA [G]	NA [G]				<100 [D]	NA [G]											

See key to notes on next page.

Notes:

A Potential destinations provided here have been selected for discussion purposes only and are likely to change during TWG sessions and as management objectives develop.

B “X” denotes peak run-timing; “-” denotes the remaining run timing interval. For some species, periods of peak run-timing could not be discerned from available information.

C Calculated as 10% of total Upper River adult production potential reported by Barrick et al. (1983), rounded to two significant digits. For comparison, maximum daily catch by species at Curry fishwheels comprised 10.7% (Chinook), 10.4% (Chum), 8.0% (Coho), and 7.6% (Sockeye) of total catch in 2012 (LGL 2013).

D For species that do not exhibit an obligate anadromous life history, are not abundant, or for which information is lacking to estimate potential numbers that would utilize passage facilities, “<100” was selected as an initial estimate. These values are subject to refinement during TWG sessions.

E Northern Pike have been documented in the Lower River and their suspected distribution extends to tributaries up to the Three Rivers (Ivey 2009). The distribution of Alaska Blackfish is unknown in the Susitna River basin (AEA 2012, USFWS 2008).

F “A” denotes adult; “J” denotes juvenile. Length distinctions by life stage are based on the classifications provided in Table 4.7-1 of ISR Part A for Study Plan 9.5 (Study of Fish Distribution and Abundance in the Upper Susitna River). Length ranges for the “juvenile-or-adult” category were grouped into the “adult” category for the purposes of this summary.

G “NA” indicates no available information or pending review.

H Maximum length (FL) from Arctic Grayling age-4+ and older captured upstream of Devils Canyon during 1981-1982 (Delaney et al. 1981, Sautner and Stratton 1983)

H Maximum length from Arctic Lamprey captured in the Susitna River during 1981-1982 (Schmidt et al. 1983). Neither life stages nor length-at-age information were provided; thus, this length range likely includes juveniles.

J0 Length range of age-3+ to age-6+ Bering Cisco captured in the Susitna River during 1981-1982 (ADF&G 1981, 1983).

K1 Maximum length from age-3+ to age-10+ Burbot captured upstream of Devils Canyon during 1981-1982 (Delaney et al. 1981, Sautner and Stratton 1982).

L Length range from 2012 Curry fishwheel captures (note, based on 5-cm bin sizes) (LGL 2013)

M Maximum length from sampling by HDR (2012) upstream of Devils Canyon that captured Dolly Varden ranging from 2.6 to 36.6 cm.

N Maximum length from Humpback Whitefish captured upstream of Devils Canyon by HDR (2013) and Delaney et al. (1981).

O Maximum length from longnose sucker age-4+ and older captured upstream of Devils Canyon during 1981-1982 (Delaney et al. 1981, Sautner and Stratton 1982).

P Maximum length from Rainbow Trout age-3+ and older captured in the Middle River during 1981-1983 (Delaney et al. 1981, Schmidt et al. 1983, 1984).

Q Maximum length from Round Whitefish age-6+ and older captured upstream of Devils Canyon during 1981 (Delaney et al. 1981).

R ADF&G indicated that anecdotal reports of Sockeye Salmon were made in Tsisi Lake and at the mouth of the Oshetna River, but that these were visual observations from 20 years ago that were not documented and never confirmed by any subsequent sampling.

S In 2014, one Rainbow Trout was observed in Devil Creek, upstream of impediment 3 at PRM 164.8.

Table B-2. Downstream Passage Sorting Requirements and Design Data by Fish Species.

Species Information									Collection Location [A]			Release Destination [A]				Design Data						Run Timing [D]											
	Documented Distribution				Life History																												
Species	Lower River PRM 3 – 102.4	Middle River: Below DC PRM 102.4 – 153.9	Middle River: DC to Dam PRM 153.9 – 187.1	Upper River PRM 187.1 – 234.5	Anadromous	Freshwater	Unknown	Life Stage [F]	Tributary Collector	Reservoir Collector	Dam Collector	Below Dam	Reservoir	Tributaries	Cull	Potential Predator	Length Range (mm)	Fish Design Length (mm)	Body Width Range (mm)	Fish Design Weight (lbs)	Design Peak Daily (no.)	J	F	M	A	M	J	J	A	S	O	N	D
Pacific Salmon																																	
Chinook Salmon	✓	✓	✓	✓	✓			J				✓					40-120 [P]				9,800 [B]		-	-	-	X	X	X	X	-			
Chum Salmon	✓	✓			✓			J									30-70 [Q]				93,000 [B]					X	X	-	-				
Coho Salmon	✓	✓			✓			J									30-170 [R]				4,900 [B]	-	-	-	-	X	X	X	X	-	-		
Sockeye Salmon	✓	✓		W	✓			J									30-90 [S]				160,000 [B]				-	X	X	X	-	-			
Mid-sized Salmonids/Catostomids																																	
Arctic Grayling	✓	✓	✓	✓		✓		A									190-430 [H]				<100 [C]								-	-	-		
								J [L]									55-189 [H]				<100 [C]					-	-	-	-	-	-	-	
Bering Cisco	✓	✓			✓			A [K]									240-410 [J]				<100 [C]					-	-	-			-	-	
								J									NA [G]				<100 [C]					-	-	-					
Dolly Varden	✓	✓	✓	✓		✓	✓	A								✓	83-370 [M]				<100 [C]					-	-	-		-	-	-	
								J [L]									26-82 [M]				<100 [C]					-	-	-	-	-	-	-	
Humpback Whitefish	✓	✓	✓	✓		✓	✓	A [L]									280-350 [T]				<100 [C]					-	-	-	-	-	-	-	
								J									30-279 [T]				<100 [C]						-	X	X	-	-		
Lake Trout						✓		A								✓	≥300 [F]				<100 [C]	NA [G]											
								J									<300 [F]				<100 [C]												
Longnose Sucker	✓	✓	✓	✓		✓		A									188-670 [V]				<100 [C]						-	-		-	-	-	
								J									<188 [V]				<100 [C]						X	-	X	X			
Rainbow Trout	✓	✓	X			✓	✓	A								✓	200-620 [N]				<100 [C]	-	-						-	-	X	-	X
								J [L]									84-199 [N]				<100 [C]					-	-	-	-	-	-	-	
Round Whitefish	✓	✓	✓	✓		✓		A [L]									199-440 [U]				<100 [C]					-	-	-	-	-	-		
								J									20-198 [U]				<100 [C]					-	X	X	-	-			
Burbot	✓	✓	✓	✓		✓		A								✓	280-740 [O]				<100 [C]	-	-	-					-	-	-	-	-
								J									90-279 [O]				<100 [C]						X	X	-	-			
Arctic Lamprey	✓	✓			✓	✓		J [L]									80-124 [I]				<100 [C]					-	-	-	-	-	-	-	
Other (i.e., invasive/non-native spp.)	✓ [E]					✓	✓	A, J								✓	NA [G]				<100 [C]	NA [G]											

See key to notes on next page.

Notes:

A Potential collection and release locations provided here have been selected for discussion purposes only and are likely to change during TWG sessions and as management objectives develop.
B Calculated as 10% of total Upper River smolt production potential reported by Barrick et al. (1983), rounded to two significant digits.
C For species that do not exhibit an obligate anadromous life history, are not abundant, or for which information is lacking to estimate potential numbers that would utilize passage facilities, "<100" was selected as an initial estimate. These values are subject to refinement during TWG sessions.
D "X" denotes peak run-timing; "-" denotes the remaining run timing interval. For some species, periods of peak run-timing could not be discerned from available information.
E Northern Pike have been documented in the Lower River and their suspected distribution extends to tributaries up to the Three Rivers (Ivey 2009). The distribution of Alaska blackfish is unknown in the Susitna River basin (AEA 2012, USFWS 2008).
F "A" denotes adult; "J" denotes juvenile. Length distinctions by life stage are based on the classifications provided in Table 4.7-1 of ISR Part A for Study Plan 9.5 (Study of Fish Distribution and Abundance in the Upper Susitna River). Length ranges for the "juvenile-or-adult" category were grouped into the "adult" category for the purposes of this summary.
G "NA" indicates no available information or pending review.
H Length (FL) range of Arctic Grayling age-1+ and older captured upstream of Devils Canyon during 1981-1982 (Delaney et al. 1981, Sautner and Stratton 1983) and the length range tagged in the Upper Susitna River in 2013 (AEA 2014).
I Minimum length from Arctic Lamprey captured in the Susitna River during 1981-1982 (Schmidt et al. 1983). Adults die after spawning (Scott and Crossman 1973).
J Length range of age-3+ to age-6+ Bering Cisco captured in the Susitna River during 1981-1982 (ADF&G 1981, 1983). No lengths of Bering Cisco younger than age-3+ were reported.
K The timing of post-spawn Bering Cisco downstream migrations are unknown; in 1982, no adults were captured during winter sampling or sampling methods other than fishwheel traps (Schmidt et al. 1983). As such, post-spawn adults were assumed to move downstream either immediately after spawning or during the spring when juvenile outmigration occurs.
L Life stages for which downstream movement periodicity is unknown tentatively include the entire open water period.
M Upstream of Devils Canyon, HDR (2012) captured Dolly Varden ranging from 2.6 to 36.6 cm FL.
N Length range of Rainbow Trout age-1+ and older captured in the Middle River during 1981-1983 (Delaney et al. 1981, Schmidt et al. 1983, 1984).
O Length range of age-0+ to age-10+ Burbot captured upstream and downstream of Devils Canyon during 1981-1982 (ADF&G 1981, Delaney et al. 1981, Sautner and Stratton 1982) and the length range tagged in the Upper Susitna River in 2013 (AEA 2014).
P Combined length range of age-0+ (3.6-9.5 cm) and age-1+ (6.1-11.7 cm) Chinook Salmon captured at the Talkeetna Station outmigrant trap in 1984 (Roth and Stratton 1985).
Q Length range of age-0+ Chum Salmon captured in the Talkeetna Station outmigrant trap in 1984 (Roth and Stratton 1985).
R Combined length range of age-0+ (2.8-8.7 cm) and age-1+ (5.1-15.0 cm) Coho Salmon captured at the Talkeetna Station outmigrant trap and age-2+ (10.9-17.4 cm) captured throughout the Susitna River in 1985 (Roth et al. 1986).
S Combined length range of age-0+ (2.5-9.1 cm) and age-1+ (5.6-10.2 cm) Sockeye Salmon captured at the Talkeetna Station outmigrant trap in 1984 (Roth and Stratton 1985).
T Minimum length reflects the smallest Humpback Whitefish captured in juvenile outmigrant traps in 1983 (Sundet and Wenger 1984), while maximum length reflects the largest adult captured upstream of Devils Canyon in 1981 (Delaney et al. 1981).
U Minimum length reflects the smallest Round Whitefish captured in juvenile outmigrant traps in 1983 (Sundet and Wenger 1984), while maximum length reflects the largest adult captured upstream of Devils Canyon in 1981 (Delaney et al. 1981).
V Minimum length reflects the smallest Longnose Sucker captured in juvenile outmigrant traps in 1983 (Sundet and Wenger 1984), while maximum length reflects the largest adult captured upstream of Devils Canyon during 1981-1982 (Delaney et al. 1981, Sautner and Stratton 1982).
W ADF&G indicated that anecdotal observations of Sockeye Salmon were made in Tsisi Lake and at the mouth of the Oshetna River, but that these were visual observations from 20 years ago that were not documented or confirmed by any subsequent sampling.
X In 2014, one Rainbow Trout was observed in Devil Creek, upstream of impediment 3 at PRM 164.8.

APPENDIX C: RECONCILED BRAINSTORM CONCEPTS AND TALLY

Upstream Brainstorm Concepts					
No.	**Category**	**Component**	**Priority**	**Description**	**List #**
1	Strategy/ Criteria	Prototype phasing options	1	This is a strategy that would phase installation of facilities. GLOBAL TO ALL FACILITIES. CONSIDER OPTIONS DURING CONSTRUCTION PERIOD.	86
2	Strategy/ Criteria	Ability to retrofit	1	See criteria document	New Today
3	Collection Location	Tsusena Creek (nature like entrance)	1	A high gradient stream not currently used by Spring Chinook. It is used by Grayling. Requires a barrier and attraction flow from mainstem, somewhere upstream. This creek is just below the dam. Example from Graham Hill, built side-channel ½ mile long. Example noted was mainly for coho, 80' head. Similar on Tualatin, bypass a water fall. Could be used as a phased component during construction.	1
4	Collection Location	Tsusena Creek (constructed fishway entrance)	1	A high gradient stream not currently used by Spring Chinook. It is used by Grayling. Similar to #1, but with a constructed weird entrance. Could be used as a phased component during construction.	2
5	Collection Location	Fog Creek (nature like entrance)	1	See List #1. Could be used as a phased component during construction	3
6	Collection Location	Fog Creek (constructed fishway entrance)	1	See List #2. Could be used as a phased component during construction	4
7	Collection Location	At Powerhouse: Right, Left, collection channel	1	Conventional dam entrance.	6

Upstream Brainstorm Concepts					
No.	**Category**	**Component**	**Priority**	**Description**	**List #**
8	Collection Location	At new barrier (where appropriate, at bridge?)	1	Goal of Idea is more focused attraction flows to fishway entrance. Could be used as phased component during construction.	8
9	Collection Location	Sluice tunnel through dam. Submerged lock, would need gates. Utilize dewatering tunnel.	1	Duncan Dam, gated low level port used as a lock. Used for ~30 years. 500 to 1,000 bull trout over last 30 years. This idea was focused on collecting burbot. Could be a supplement to chinook goals. COULD RECLASSIFY AS SUPPLEMENTAL ENTRANCE FOR DEEP MIGRATING SPECIES	12
10	Collection Location	Deep intake below turbine outfall	1	This idea was focused on collecting burbot. Could be a supplement to chinook goals. COULD RECLASSIFY AS SUPPLEMENTAL ENTRANCE FOR DEEP MIGRATING SPECIES	13
11	Collection Location	Diversion bypass channel tunnel outlet	2	Use of diversion tunnel for location/entrance. Could be used as a phased component during construction.	11
12	Collection Location	Downstream of dam on bank (left, right)	2	This is possibly redundant with #8. It could be possible to characterize with auxiliary entrances with #6. Intent is a conventional ladder entrance. Located at a location downstream. Could use if fish shown to accumulate downstream.	14
13	Collection Location	Mobile feature (can be relocated)	2	This is a floating fish trap in tailrace with pumped attraction water at the entrance. It may function as an auxiliary entrance. Example is Cabinet Gorge, bull trout floating collector (it sunk). Movable or fixed.	15
14	Collection Location	Fishwheel	2	Could be a phased or temporary feature, or a feature used during construction.	17

Upstream Brainstorm Concepts					
No.	**Category**	**Component**	**Priority**	**Description**	**List #**
15	Collection Location	Batch vs continuous	Feature		107
16	Collection Location	Count windows	Feature		108
17	Collection Location	Performance Tracking	Feature		109
18	Collection Location	Monitoring trap	Feature		110
19	Collection Location	Species sorting	Feature		111
20	Collection Location	Monitoring facility	Feature		112
21	Collection Location	Video Monitoring facility	Feature		113
22	Collection Location	Size grading	Feature		114
23	Collection Location	Electronic sorting	Feature		115
24	Collection Location	Predator separator	Feature		116
25	Collection Location	Phased implementation	Feature		117
26	Collection Location	Sorted fish fate & transport	Feature		118
27	Collection Location	Upstream of Portage Creek	Defer	Fatal Flaw: lose existing Chinook Salmon habitat. Potential to move unintended fish. Too far downstream.	5

Upstream Brainstorm Concepts					
No.	**Category**	**Component**	**Priority**	**Description**	**List #**
28	Collection Location	At natural barrier: Impediment 1 or Impediment 3	Defer	Fatal Flaw: lose existing Chinook Salmon habitat. Potential to move unintended fish. Too far downstream.	7
29	Collection Location	At dam	Defer	Redundant with List #6	9
30	Collection Location	Collection channel at dam	Defer	Redundant with List #6	10
31	Collection Location	Boat & Anglers	Defer	Better options available, low efficiency, fish handling impacts, unknown success rate with chinook, not feeding.	16
32	Collection Location	Dip net fishery	Defer	Better options available, low efficiency, fish handling impacts. Site specific Performance	18
33	Collector Entrance	Shallow weir	1	Could be used as an exclusion means for pike, non-jumping species	19
34	Collector Entrance	Creek	1	It is Co-located with a tributary. Can be a water source option. Limited to existing creeks.	20
35	Collector Entrance	Deep Portal	1	Goal for deep oriented fish (burbot)	21
36	Collector Entrance	Orifice	1		22
37	Collector Entrance	Vertical slot, submerged weir	1		23

Upstream Brainstorm Concepts					
No.	**Category**	**Component**	**Priority**	**Description**	**List #**
38	Collector Entrance	Natural bedrock, nature like entrance shape	1	Shape, texture, and flow conditions affect location of this component	24
39	Collector Entrance	Hourglass entrance	1	This is an advanced version of a vertical slot entrance	25
40	Collector Entrance	Multi-level entrance	1		26
41	Collector Entrance	Adjustable gate to track water surface	1	An adjustable gate with a floating mechanism; it is typically used in collection channels.	27
42	Collector Entrance	Draft tube entrance	1	Using draft tube with cycling with unit to attract deep oriented fish. Manual or automated salvage operation at a specified frequency. Include idea of emulating draft tube, from experience with turbines sitting idle for a period of time.	29
43	Collector Entrance	Tailrace barrier	1	MOVE TO SUPPLEMENT/FEATURE, NOT STAND ALONE FISH COLLECTION DEVICE	30
44	Collector Entrance	Watana Dam	1		56
45	Collector Entrance	Another dam: fixed, rubber	1	This would be a separate barrier dam located downstream from the Watana Dam.	57
46	Collector Entrance	Scoop (Fishwheel)	2		28
47	Collector Entrance	Picket weir	2	Operation of picket weir would be limited to open-water (ice free) flow period in river. Includes fixed or floating type weirs. FEATURE TO CONSIDER DURING CONSTRUCTION.	58
48	Collector Entrance	Lamprey friendly features	Supple mental	Lamprey have not been observed in the Upper River to date. Confirm won't impact other species (it likely will not, based on today's knowledge). i.e., rounded corners, no wall-to-wall diffusers, no slot guides, etc.	31

Upstream Brainstorm Concepts					
No.	**Category**	**Component**	**Priority**	**Description**	**List #**
49	Collector Entrance	Submerged guide wall for burbot	Supple mental	Engineered wall	61
50	Collector Entrance	Submerged directional features	Supple mental	Cofferdam remnants, directed flows, rocks, etc. Includes guidance characteristics of hydraulic features such as barrier dams to guide, end wall of stilling basin, etc. Faraday example, berms to pinch river, help guide fish. Hanford reach constructed gravel spur dikes to guide fish, historical. East coast native fisheries, more typical to shallow river.	62
51	Collector Entrance	Draft tube barrier	Supple mental		63
52	Collector Entrance	Floating picket	Supple mental	Could be considered during construction	64
53	Collector Entrance	draft tube stop logs	Supple mental		92
54	Collector Entrance	Volitional fish intake	Defer	This is not a unique entrance type and it will be addressed with other components.	32
55	Collector Entrance	Electrical	Defer	This technology is classified as experimental by NMFS. There are wildlife impact concerns, a power source to the tributaries is problematic, and a concern for reliability. Could be revisited as a retrofit type supplemental.	59
56	Collector Entrance	Behavioral (strobe/lights/ bubble curtain/scents /acoustic)	Defer	This is not proven to be reliable as a primary barrier, or enhancement. It is not predictable. Could be revisited as a retrofit type supplemental.	60
57	Collector Entrance	Rotating Screen	Defer	This component would be difficult to implement due to the size/flow of the river.	65
58	Collector Entrance	Louvers	Defer	Maintenance, scale, debris, and ice are concerns for this component. It is not reliably an exclusionary screening facility. Defined as a picket lead. Idea is captured with use of diffusers for AWS, or attraction water.	66

Upstream Brainstorm Concepts					
No.	**Category**	**Component**	**Priority**	**Description**	**List #**
59	Collector Entrance	porous weir/embankment	Defer	This component is not feasible in a river of this scale.	67
60	Collector Entrance	Existing impediment/velocity barrier	Defer	This will result in loss of existing Chinook Salmon habitat. Or movement of unintended fish into other habitats. Too far downstream.	68
61	Attraction	Turbine discharge	1	Direct from draft tubes. Temperature will be dependent on turbine intake design.	34
62	Attraction	Outlet valve discharge	1	Tap off the tube, easier than use of cone valve. Cone valve sprays above water surface. Depending on configuration. Will pass temperature of water based on inlet elevation.	35
63	Attraction	Low-head, electric Pumps	1	Will be used for supply of auxiliary water. Low head pumps in tailrace. Temp is same as tailrace.	36
64	Attraction	Spillway flow	1	Will maintain this idea for use with other components, not a primary use as operational scenarios don't spill.	40
65	Attraction	Fish turbine, dedicated fish attraction flow	1	This would be a power producing turbine, specific for fish passage, or a fish attraction flow source.	41
66	Attraction	Gravity flow	1	Simple design, could be incorporated into any alt. Also as use for backup water. Energy dissipation must be considered.	42
67	Attraction	Turbine pumps	1	A small amount of water is utilized to power a pump. Can use drive water for AWS water.	43
68	Attraction	Susitna Upper River water	1	Upstream water is important source for homing fish. Key requirement of all upstream passage system.	50
69	Attraction	Dewatering flow from other components	1	This source is potentially available from downstream passage components	51

Upstream Brainstorm Concepts					
No.	**Category**	**Component**	**Priority**	**Description**	**List #**
70	Attraction	5-10 percent of fish design flow (near-field)	1	Typical NMFS fish passage criteria/guidelines. Bonneville Dam 3 to 5% as a reference. May not be required for all species, site specific need to discuss more.	53
71	Attraction	Flow shaping/configuration (far-field)	1	Shaping discharge to provide attraction to the fish entrance facility or avoid hydraulic occlusion.	54
72	Attraction	Variable flows that mimic natural conditions (far field operational concept)	1	OPERATIONAL CONSIDERATION OF PROJECT. ADDRESSED WITH OPERATION GROUP. Natural hydrograph idea. Could peak within a band of natural hydrograph. Effect would be limited at this project due to volume. No precedent. Note AWS system must compete with what is happening at dam.	55
73	Attraction	Coffer dam remnant used Upstream	1	Collaborate on design for construction dewatering and fish passage. Could guide towards entrance. Coffer Dam ~100ft. Has been problematic in Columbia	93
74	Attraction	Tributary flows	2	The location is from a specific source. Potentially use spawning stream water as attraction flow.	38
75	Attraction	Bypass tunnel	2	It would be co-located with the dam spillway. Secondary priority due to more practical alts. MAY BE OPTION DURING CONSTRUCTION.	39
76	Attraction	Natural attraction	2	No auxiliary flow associated with this component. MOVE TO DEFERED. WON'T MEET NMFS CRITERIA, WON'T FUNCTION WELL. UNCLEAR DEFINITION, IDEA FROM BRAINSTORM.	45
77	Attraction	Directed flow	Supplemental	Use of flow, not a source. Turbulence or Circulation. Possible from many potential sources. Mixer pumps may create flow. Low head pump used to create flow, flygt pump. EX: Thompson Falls (jet augmentation)	33

Upstream Brainstorm Concepts					
No.	**Category**	**Component**	**Priority**	**Description**	**List #**
78	Attraction	Chemical attraction	Supple mental	Experimental.	46
79	Attraction	Temperature attraction	Supple mental	Could be a feature. No real need to pursue unless different water source from river.	47
80	Attraction	Mixer pumps	Defer	Redundant with List #33	37
81	Attraction	Gravity flow from forebay	Defer	Redundant with List #42	44
82	Attraction	Groundwater	Defer	Not known to be a potential water source at the component project locations.	48
83	Attraction	Drainage galleries	Defer	Construction may limit the availability of flow. This may be good for lamprey. Gravel/silt/etc. contamination is a risk.	49
84	Attraction	Deep pit with flow, for burbot	Defer	Not a source	52
85	Conveyance	Structural Fishway	1	Utilizes slope of 1/10-1/16 with resting pools due to structure height (~600 vertical). Normally has a short segment with a trap to deal with tailrace water surface variations.	69
86	Conveyance	Nature-like Fishway	1	Utilizes 1-3 percent slope with flows ranging from 20-50cfs. Short segments also used with a trap to deal with tailrace water surface variations. Generally most applicable to low head projects.	70
87	Conveyance	Haul: truck, boat/barge, hydrofoil, tram, helicopter, float plane, Sherpa mules, drones, snowmachine	1	Generally a fish transport container with life support and transportation included.	72

Upstream Brainstorm Concepts					
No.	**Category**	**Component**	**Priority**	**Description**	**List #**
88	Conveyance	Fish Lock	1	Could be used in association with a bypass tunnel over the sluiceway. It would consist of a dedicated tower and abutment.	73
89	Conveyance	Fish Lift	1		74
90	Conveyance	Helical Ladder	1	Fishway alignment would weave up a tower. This is a feature of structural fishway.	78
91	Conveyance	Tunnel	1	Potential component for shorter section of passage system or as a means to route a structural fishway. Could potentially be located in north abutment.	80
92	Conveyance	Lamprey passage system: LAPS @ Bonneville	1	Closed duct.	81
93	Conveyance	Lamp ramp @ Willamette Falls	1	Open flume	82
94	Conveyance	Modified tributary (Fog or Tsusena)	2	Use of this existing tributary for a passage route as far upstream as possible, then transition to transport channel/structural fishway/tunnel for remaining distance. Potentially suitable for downstream passage as well. Tsusena Creek preferable due to proximity to dam and reduced impact to Chinook use. Fog Creek has a lower gradient, and also has existing Chinook Salmon use.	71
95	Conveyance	Pescalator	2	The design is based on an archimedes screw principle. It is a potential component of a larger system.	75
96	Conveyance	Rock ramp	2	This is a potential component of a system, used generally for shorter sections at 3-6 percent slope.	79
97	Conveyance	Series of steep pass/Denil	2	This could be a component of a larger system, or a second entrance, or part of a temporary facility.	88
98	Conveyance	Bypass tunnel/diversion tunnel	2	This would repurpose tunnel used for construction of the dam.	89
99	Conveyance	Slow turbine start-up	Supplemental		90

Upstream Brainstorm Concepts					
No.	**Category**	**Component**	**Priority**	**Description**	**List #**
100	Conveyance	Pressurized draft tube	Supple mental		91
101	Conveyance	Fish cannon (whooshh)	Defer	This is an experimental system with long term health concerns. Project scale is too big for this idea.	76
102	Conveyance	Catapult	Defer	There are better options available. This idea was presented to illustrate the value of brainstorming.	77
103	Conveyance	Fish pump & pipe	Defer	System is not feasible for adults, doesn't meet NMFS criteria	83
104	Conveyance	Pneumatic pump & pipe	Defer	System is not feasible for adults, doesn't meet NMFS criteria	84
105	Conveyance	Jet pump & pipe	Defer	System is not feasible for adults, doesn't meet NMFS criteria	85
106	Conveyance	Challenge section	Defer	Potential to use as faunal filter. Potential volitional sorting system.	87
107	Conveyance	Pipe to end of reservoir	Defer	Too long (42mi +/-), no precedent.	94
108	Exit	Fish Slide	1	Feature for ladder or haul release.	95
109	Exit	Multi-port	1	Feature for ladder or haul release. Multi-level, deep to shallow.	96
110	Exit	Truck ramp	1	Location near the quarry on south abutment.	97
111	Exit	Multiple release locations	1	Most compatible with boat, float plane, helicopter, hauling options.	98
112	Exit	Release at dam	1		101
113	Exit	Head of reservoir release	1		102
114	Exit	Release lock	1	Could be tied to ladder, or other feature. Could be duplicated to reduce hold time.	103
115	Exit	Floating exit	1	This used in combination with a variable slope to accommodate pool fluctuation.	104

Upstream Brainstorm Concepts					
No.	**Category**	**Component**	**Priority**	**Description**	**List #**
116	Exit	Hose Release	Supple mental	Design Detail	99
117	Exit	Stress release ponds	Supple mental	Includes acclimation goals, temperature, fallback, etc. More amenable to transport options, not likely to need volitional alts.	100
118	Exit	Submerged exit	Supple mental		105
119	Exit	Cycling lock exit	Defer	Repeat of List #103	106

Downstream Brainstorm Concepts					
No.	**Category**	**Component**	**Priority**	**Description**	**List #**
1	Collection Location	Tributaries	1	Kosina & Oshetna	119
2	Collection Location	Dam	1	Could include right bank, left bank, over turbines, near spillway	120
3	Collection Location	Head of reservoir: above high pool upstream of Oshetna	1	~PRM 235.3	121
4	Collection Location	Head of reservoir: above high pool downstream of Oshetna	1	~PRM 234	122
5	Collection Location	Tributaries and Upper Mainstem Susitna	1	Combination of #119 and #121	123
6	Collection Location	Head of reservoir: below low pool	1	~PRM 222. As far upstream as possible.	124
7	Collection Location	Reservoir below Kosina/ mid-reservoir	1		125
8	Collection Location	Moveable in reservoir	1	For placement anywhere in reservoir	126
9	Collection Entrance	Temporary portable trap Screw trap/inclined plane/ fyke	1	For tributary locations, component of larger system and guidance elements to increase efficiency. CONSIDER FOR USE DURING CONSTRUCTION.	127
10	Collection Entrance	Merwin-type trap in reservoir	1	Net pen with guide nets, floating deck, reservoir/low-velocity locations. CONSIDER FOR USE DURING CONSTRUCTION.	128
11	Collection Entrance	Picket rack	1	In channel, with upstream and downstream collection boxes. Suitable for smaller streams. CONSIDER FOR USE DURING CONSTRUCTION.	129

Downstream Brainstorm Concepts					
No.	**Category**	**Component**	**Priority**	**Description**	**List #**
12	Collection Entrance	Off-channel with weir/rubber dam	1	Exclusionary (NOAA criteria) and directs fish and flow to bypass screen. Tributary collection style/type.	130
13	Collection Entrance	Screened facility	1	Screens in river, assuming exclusionary screening. Tributary. Ice, debris concerns.	132
14	Collection Entrance	Collection tower, in Reservoir near tributaries	1	Fixed concrete tower, requires power, multiple fixed ports or movable screens.	136
15	Collection Entrance	Movable screen inside tower - at Dam with or without pumps	1	Traditional screen inside tower near dam, movable screens to track water surface.	137
16	Collection Entrance	Floating surface collector	1	FSC – often has guide nets in reservoir to assist in directing fish to collector. ice concerns - low/high pool issues	138
17	Collection Entrance	Partial screen collector	1	Columbia River SBS, STS, etc. Turbine based or cone valve based	139
18	Collection Entrance	High velocity screens	1	Do not comply with NMFS criteria for fish screens. Smolt screens, not for fry, 0.8 fps	141
19	Collection Entrance	Conventional screen	1	Low velocity, NOAA criteria screens	143
20	Collection Entrance	Turbine passage/cone valves	1	High head so likely very low survival. Baseline if nothing else is done.	144
21	Collection Entrance	Modification of existing spillway	1	This will requires a safe route downstream and needs to accommodate a fluctuating pool. Notched feature.	147
22	Collection Entrance	Dedicated spillway feature	1	This will requires a safe route downstream and needs to accommodate a fluctuating pool. Design will consist of a 30 percent slope down face of dam with multiple intake ports in pool. No screening involved.	148
23	Collection Entrance	Surface flow outlet/Corner collector	1	Could be full flow unscreened source or fully screened. Fixed height.	149

Downstream Brainstorm Concepts					
No.	**Category**	**Component**	**Priority**	**Description**	**List #**
24	Collection Entrance	Turbine intake screen collection	1	Similar to #141 and 139.	150
25	Collection Entrance	Cycling lock (low level pressurization chamber)	1	Conduit under dam with gates at both ends for benthic species. Not standalone for salmon species. Downstream Migrant Lock	151
26	Collection Entrance	Simulated Wells intakes	1	Location above turbine, can be combined with many elements. Uses bulk flow towards intake (turbines near intake). Entrance type for collection system. Form of Surface Flow Outlet (SFO). Vertical slot collection device.	153
27	Collection Entrance	Floating ice/trash sluiceway	1	Could be positioned over intake or spillway. Higher flows, surface water, dewatering screens or not.	154
28	Collection Entrance	Rearrange intake location	1	Slide intakes towards left bank with diagonal penstocks to current powerhouse location. Move spillway cone valve inlets near turbine outlets to maximize bulk flow. Example of #148. put intakes in corner.	158
29	Collection Entrance	Two-vessel trawl in reservoir	1		172
30	Collection Entrance	Off-channel with weir/rubber dam with FCA (farmers…) screen/Coanda	2	Exclusionary which directs fish and flow to a FCA or coanda screen.	131
31	Collection Entrance	MIS/Eicher screen	2	Passage flow is pressurized in a conduit.	142
32	Collection Entrance	Louvers	Supple mental	In tributaries, could be combined with other facility. Off channel use. Use at dam. More guidance than exclusionary. Doesn't meet NMFS criteria. Mayfield Dam, Holyoke MA, Seton Dam, tributary of Frazier River BC (~10 yrs ago), Skinner & Tracy in CA.	133
33	Collection Entrance	Guide nets/Barrier nets	Supple mental		134
34	Collection Entrance	Behavioral guidance (strobe,	Supple mental		135

Downstream Brainstorm Concepts					
No.	**Category**	**Component**	**Priority**	**Description**	**List #**
		noise, bubbles, turbulence)			
35	Collection Entrance	Modified operations for passage – pool level modification	Supple mental		145
36	Collection Entrance	Floating Guide walls/curtains in forebay	Supple mental		155
37	Collection Entrance	Shoreline alteration to shape flow	Supple mental		159
38	Collection Entrance	Guidance circulation	Supple mental	Induced flow, B2 powerhouse corner collector, turbulence signature.	160
39	Collection Entrance	Simulated lake outlet	Supple mental	Baker FSC, RSW's in Columbia. Velocity, shape, acceleration, substrate/texture.	162
40	Collection Entrance	Modified valves or dedicated fish turbine	Supple mental	Use cone valve discharge to drive collector. Function of frequency, need flow conveyance. Consider use of valve for collector, dedicated or supplement for flow when flow being bypassed anyway.	163
41	Collection Entrance	Fish friendly turbines	Defer	High head of this dam is a fatal flaw	140
42	Collection Entrance	Spillway passage	Defer	Fatal flaw is that the spillway not used regularly.	146
43	Collection Entrance	Decompression raceway	Defer	Experimental technology, not tested, concern for debris, difficult access if something goes wrong.	152
44	Collection Entrance	Rearrange dam axis	Defer	Fatal flaw is that it is structurally challenging for foundation needs. Outside scope of study. Other means may accomplish same goal, such as guidance devices.	157
45	Attraction	Coffer dam remnant use	1	Coffer dam utilized as a potential base of a structure. Used for burbot, upstream cofferdam.	156

Downstream Brainstorm Concepts					
No.	**Category**	**Component**	**Priority**	**Description**	**List #**
46	Conveyance	Nature-like channel	2	Kwoiek project listed as example in brainstorm list, channel from tributaries to dam along reservoir? (I'm not sure about this one), move to deferred?	168
47	Conveyance	Full flow vs partial flow (screening)	Featur e	Feature. Removable Spillway Weir (RSW) on Columbia vs. STS/SBS (partial). Using full collection flow to convey fish to tailrace vs dewatering.	164
48	Conveyance	Continuous vs discrete batch	Featur e	Bypass running all the time, vs. haul (lock/tram/helicopter/truck, etc.). Two categories.	165
49	Conveyance	Truck/boat/float plane/tram/heli	Featur e	Conveyance means.	166
50	Conveyance	Channel/pipe or trough around dam	Featur e	Continuous, what you put it in. Clackamas pipeline, Green Peter, B2 Corner collector, bypass at many dams.	167
51	Conveyance	Small turbine-like shallow intake Surface collector to attract and pass	Featur e	Cowlitz Falls North Shore Collector. Multi port collector, CleElum concept by USBR.	171
52	Conveyance	Sluice tunnel through dam	Featur e	Conveyance piece of burbot passage. Could be standalone for deep species.	173
53	Conveyance	Associated sampling/sorting facilities	Supple mental		174
54	Conveyance	Tributary channel	Defer	Release into a tributary downstream, and allow them to move volitionally. Could imprint on non-natal tributary.	169