Middle Fork Nooksack River Fish Passage Project
DRAFT Effectiveness Monitoring & Adaptive Management Plan

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For Review and Approval by:
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And

The PROJECTS Programmatic River Restoration Team

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1 Introduction

1.1 Background and Plan Requirement

The Middle Fork Nooksack River Fish Passage Project (Project) will restore access to approximately 16 miles of pristine spawning and rearing habitat in the upper Middle Fork Nooksack River for three fish species listed as threatened under the Endangered Species Act (ESA): spring Chinook salmon (*Oncorhynchus tshawytscha*), Steelhead (*O. mykiss*), and Bull Trout (*Salvelinus confluentus*). Project elements and related benefits include dam removal to restore habitat connectivity and natural riverine processes; moving the point of diversion just upstream of the existing location to eliminate dependence on the dam; and installation of fully compliant fish screens for fish protection against entrainment into the City of Bellingham's water supply diversion system.

The benefits of implementing an innovative solution to restore fish passage at the Project site affect a wide range of partners and stakeholders. The Project Partners include the City of Bellingham (City), Lummi Nation, Nooksack Indian Tribe, Washington Department of Fish and Wildlife (WDFW), and American Rivers. Project funding is provided by a collection of private and public sources, including Paul G. Allen Philanthropies, the Resources Legacy Fund, American Rivers, the City of Bellingham, U.S. Fish and Wildlife Service (USFWS).

In 2002, the City (landowner) and the Water Resource Inventory Area (WRIA) 1 Fishery Co-managers: the Lummi Nation, Nooksack Indian Tribe, and WDFW, signed a Memorandum of Agreement (MOA), to collaborate on a project to restore anadromous fish passage and enable access to habitat upstream of the dam. Efforts taken since 2002 created a foundation for the current project proposal, which was initiated in 2017 when the City entered into an expanded partnership with American Rivers for this project.

A Partner Advisory Committee (PAC) was formed to pursue the original goals of the MOA partners and receive important input and feedback throughout the formal project planning process. The PAC consists of representatives from the original project partners, and American Rivers, USFWS, and HDR, Inc., the project's lead design consultant. HDR, Inc. is leading a team of consultants including R2 Resource Consultants, Inc. (R2), Northwest Hydraulic Consultants (NHC), Wilson Engineering, Shannon & Wilson, and Drayton Archaeology to provide Project design and permitting services.

This Draft Project Effectiveness Monitoring & Adaptive Management Plan (Plan) is prepared for PAC review, discussion, and ultimate approval consensus, and preliminary review by the River Restoration Team (RRT) as part of ESA Section 7 consultation under the *Programmatic Restoration Opinion for Joint Ecosystem Conservation by The Services* (PROJECTS) program. The PROJECTS ESA Section 7 programmatic consultation is a Joint-Services (i.e., NMFS and USFWS) consultation that covers potential take of ESA-listed species, critical habitat, and Essential Fish Habitat for specific activities, including dam removal, and intake screening and replacement.

Under PROJECTS, representatives from the USFWS and NMFS combine to form the RRT, which must review and approve the proposed action for consistency with PROJECTS, or minor variances. The Final Plan is a requirement for dam removal actions under PROJECTS and has been prepared to pursuant to guidelines provided under the programmatic consultation.

As project design progresses, the PAC will collaborate in further development and refinement of this Draft Plan until it is finalized. Roles and responsibilities will be confirmed by collaborative participation of the Project Partners and incorporated into the Final Plan. After construction of the Project is completed, the City will implement monitoring, evaluate the project results, and collaborate with the WRIA 1 Salmon Work Group and Management Team as necessary for adaptive management as described in this Plan.

The project analysis and design efforts have provided an extensive background of technical data informing the current design. Data collection efforts for river and geomorphic response include physical scale modeling, digital numerical hydraulic modeling, extensive field survey work, and geotechnical studies and subsurface investigations. This data has been documented in previous studies and has been refined into supporting documentation and technical memos as part of the proposed project. The resulting design for the river channel and dam removal has carefully considered the compendium of all available data and analysis. The proposed restored channel represents an optimized configuration to meet project goals and objectives and promote natural river processes in this dynamic reach. The partial dam removal and channel design as proposed minimizes the long-term risks associated with channel instability and migratory headcut, while restoring the channel to a state similar to its historic, pre-dam configuration and removing the man-made blockage to fish passage at this site.

The purpose of this Plan is to verify the project meets the intended project goal of restoring the channel to a natural configuration, by monitoring the physical river responses that improve fish passage and habitat connectivity. Due to the inherently dynamic nature of the glacially influenced Middle Fork Nooksack River, it is fundamentally challenging to completely predict the response of the channel via the quantitative and qualitative assessment and design tools available for a project of this type. The river response to the proposed changes at any specific stream site is complex and cannot be made definitively. A level of uncertainty will remain for the channel response element of the design. Given the river's dynamic nature and inherent natural variability, post-project monitoring and adaptive management at the project site is critical to confirm that the project goals continue to be met after project completion (Skidmore et al. 2011).

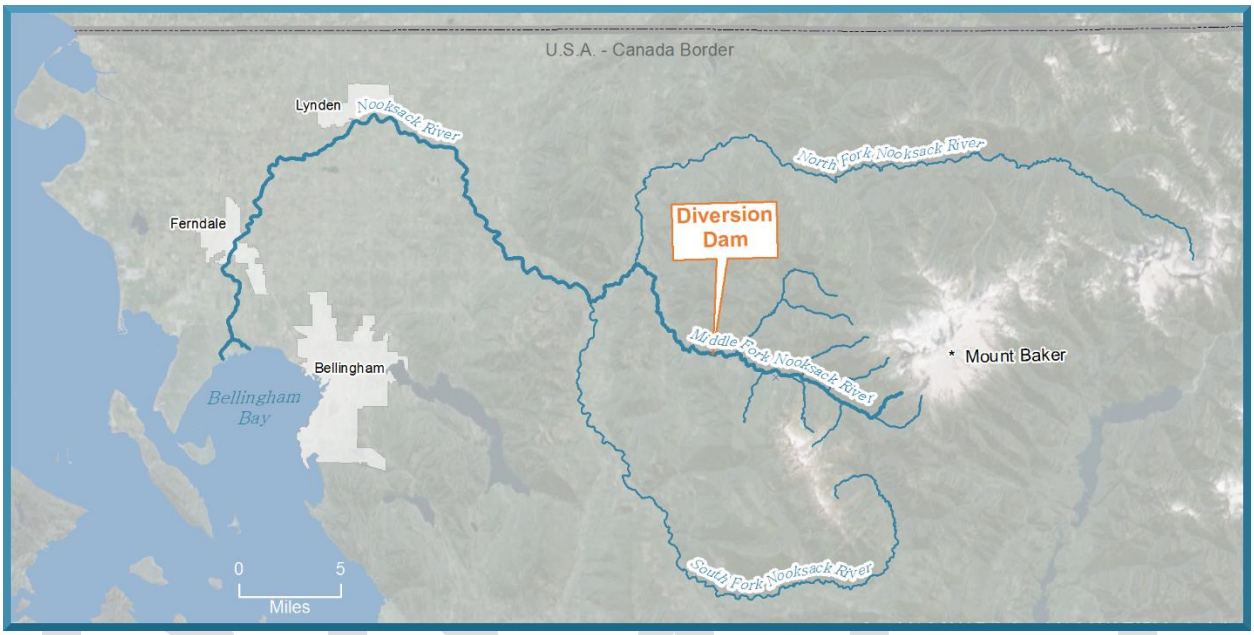

Figure 1. Project vicinity map.

1.2 Project Goals and Objectives

The Project goal is to restore habitat connectivity, fish passage, and increase species protection at the site of the Middle Fork Nooksack River diversion facility while ensuring sustainability of the City's supplemental water supply. Project objectives were developed with an understanding of the site and system characteristics and target restoration of natural channel processes for passage improvement.

The Project goal, objectives, and supporting elements are as follows:

GOAL: Restore habitat connectivity, fish passage, and increase species protection at the site of the Middle Fork diversion facilities while ensuring sustainability of the City's supplemental water supply from the Middle Fork Nooksack River.

- OBJECTIVE 1: Restore the channel through the dam site to a natural configuration to provide upstream fish passage to 16 miles of spawning and rearing mainstem and tributary habitat for three ESA-listed, threatened species (Puget Sound spring Chinook Salmon, Puget Sound Steelhead, and Coastal Recovery Unit of Bull Trout) by 2020.
  - ELEMENT: 2, 3 (See tables below)
- OBJECTIVE 2: Construct a gravity-fed diversion intake on City property upstream of the existing location to eliminate the need for the dam while maintaining the City's existing ability to divert supplemental municipal water supply.
  - ELEMENT: 1 (see table below)
- OBJECTIVE 3: Protect fish from entrainment by complying with current NMFS and WDFW fish screening criteria.
  - ELEMENT: 1 (see table below)

Project Elements:

Element 1. **Water Diversion Infrastructure Components**

Project Element	Function and Intent
Intake structure	Provides diversion point for the City's existing water supply, including fish bypass flow. Protected with a steel trash rack. Allows for sediment passage and management with bypass sluice and design features.
Water supply pipeline connecting intake to the fish screening facility	Provides a controlled path to move water, entrained fish, and sediment from the intake to the screening facility and fish bypass pipe.
Fish screening facility	Provides water supply to the City while meeting juvenile fish screening and bypass criteria. Has automated screen cleaning system and provisions to manage entrained sediment. Designed to meet all current fish passage and entrainment criteria.
Fish bypass pipe	Returns bypass water with fish to the river via open channel flow in a suitable location to facilitate downstream passage without injury or disorientation.
Sediment sluice pipe and control gate	Allows for flushing of fine and coarse sediment that will enter the diversion system during operation. Designed for higher velocity flows to mobilize and transport deposited sediment.
Water supply pipeline system	Controls and conveys flow into the diversion conveyance system. Provides hydraulic connection to the existing sedimentation channel, tunnel, and conveyance pipeline.
Replace the existing intake trashrack with a concrete wall	Removes the ability to draw water off the river at the existing diversion location. Ensures all flow provided to the existing diversion channel enters via the Intake structure and Fish screening facility.
Programmable logic controller	Provides control system to automate the water diversion infrastructure. Monitors water surface elevations, automates fish screen cleaning and bypass flow control. Controls the intake diversion rate. Automation reduces maintenance and control trips to the site by city personnel. Used in conjunction with City operation Supervisory Control and Data Acquisition (SCADA) system(s).
Electrical service generator and support building.	Provides power to the site. Provides the ability to operate mechanical equipment associated with gate operation, monitoring, screen cleaning, and flow control.

Element 2. **Dam Removal**

Project Element	Function and Intent
Removal of portions of the existing dam.	Removes barrier to upstream fish passage. Includes removal of approximately 1,500 cubic yards of concrete, reinforcing steel, and non-native materials from within the river channel.

Project Element	Function and Intent
Retention of portions of the existing dam.	Promotes effective fish passage via channel stability and width through the removed portions of the dam. Recreates a passable river configuration which is similar to the channel geometry that existed prior to construction of the dam.

Element 3. **Channel Restoration**

Project Element	Function and Intent
Restoration of the river channel at and adjacent to the removed dam	Reshape channel to appropriately blend and match to adjacent upstream and downstream river reaches. Includes localized regrading of channel in the immediate vicinity of the dam. Designed to rely on natural river processes for long-term channel regrade and maintenance of upstream and downstream fish passage.

2 Monitoring Guidance

Monitoring guidance is referenced in Table 1 from which specific protocols for parameter measurement have been selected for this project to target measurement of effectiveness in meeting project objectives, given the constraints inherent to the site. Table 1 describes the relevant guidance and a brief description. Standardized methods used to measure the specific parameters identified in this Plan are drawn from Table 1 guidance.

Table 1 - Summary of relevant Monitoring Protocols.

Protocol	Description
PACFISH/INFISH Biological Opinion Effectiveness Monitoring Program *Effectiveness Monitoring for Streams and Riparian Areas* *Sampling Protocol for Stream Channel Attributes* (PACFISH 2009)	The primary objective is to determine whether priority biological and physical attributes, processes, and functions of riparian and aquatic systems are being degraded, maintained, or restored.
State Water Resources Control Board (California) *Standard Operating Procedure 4.2.1.4 Stream Photo Documentation Procedure* (California SWRCB 2001)	Provides systemic procedures for visual assessment and photo documentation of stream reaches.

The above protocols provide guidance for monitoring changes in stream channel attributes. Baseline elements of these protocols will be utilized and incorporated into the project-specific monitoring technique protocols described in Section **Error! Reference source not found.**.

3 Project Effectiveness Monitoring Plan Purpose

Effectiveness monitoring for this Project is designed to measure progress toward achieving the project objectives, assess adaptive management needs and provide input into whether the restoration project is trending towards or away from achieving project goals. Monitoring will occur for a period of 10 years using standardized field techniques that will produce data used to evaluate changes and to make adaptive management decisions.

> **Objective 1: Restore the channel through the dam site to a natural configuration to provide upstream fish passage to 16 miles of spawning and rearing mainstem and tributary habitat for three ESA-listed, threatened species (Puget Sound spring Chinook Salmon, Puget Sound Steelhead, and Bull Trout) by 2020.**

The existing condition (i.e., dam and sluiceway in place) creates a man-made vertical barrier of between 15 and 20 feet that is recognized as a total barrier to upstream fish passage. The upstream and downstream reaches adjacent to the dam are characterized by steep gradient and boulder rapids, but are considered passable by upstream migrating salmonids under naturally varying flow conditions. Prior to dam construction, anecdotal observations of anadromous salmonids present in the watershed above the dam are documented (see *WRIA 1 Salmonid Recovery Plan*). A summary of anecdotal observations is provided in the *Alternatives Analysis and Conceptual Design Report* (HDR 2018). Based on the observed vertical drop and hydraulic conditions at the existing dam structure, it is expected that upstream passage at the dam is non-existent for migrating anadromous salmonids.

The proposed condition (i.e., partial dam removal and sluiceway removal) will provide reconnection of the upstream and downstream stream reaches by removal of the man-made vertical barrier, and through restoration of the impacted reach using a design approach that creates low risk of channel instability outside of the range of natural variable changes that would occur. The proposed project condition removes the vertical height barrier presented by the dam structure and provides a channel gradient and hydraulic conditions similar to adjacent river reaches. The proposed restoration configuration is designed to be compatible with natural fish passage conditions existing within the greater Middle Fork Nooksack basin. Modeling performed during project design shows that hydraulic conditions through the post-project reach are anticipated to be within the migration capability of anadromous salmonids. Volitional passage of anadromous salmonids is expected upon implementation of project elements under this objective (R2 Resource Consultants, Inc. 2018b). The Geomorphic Assessment Technical Memorandum (R2 Resource Consultants, Inc. 2018a) and Design Criteria Report (HDR, 2018) provides the basis for this expectation and establishes design criteria for this element.

Proposed monitoring for this objective is related to physical condition of the restored channel as summarized in Table 2 below.

Table 2 - Summary of monitoring metrics.

Project Objective	Monitoring Technique	Monitoring Metrics	Existing Condition	Design Condition	Acceptable Range	Frequency/ Duration
Channel stability and habitat connectivity	Photo points and review		n/a	As-built photos at monitoring locations		As-built, Semi-annual (Yr 1-3), Annual (Yr 4-10). Ref. Section 5.3.1
Channel stability	Digital Elevation Model Development and Analysis		n/a	As-built water surface elevation (WSE)	Minimum: Channel slope 3-7%	
Habitat connectivity for passage improvement	Longitudinal Profile Development and Analysis	Longitudinal profile average slope	Vertical drop. Height varies 6 - 25ft	6.2% slope	7-12%	As-built, Initial response ~bi-annual 10-year duration Ref. Section 5
Channel stability	Cross-section Profile Development and Analysis	Cross-section profile average depth	n/a	As-built Water Surface Elevation	Drop > 5ft below boulder jam at low flow	n/a

Objective 2: Construct a gravity-fed diversion intake on City property upstream of the existing location to eliminate the need for the dam while maintaining the City's existing ability to divert supplemental municipal water supply.

The construction of an upstream gravity-fed diversion intake is necessary to achieve the primary project goal (i.e., fish passage improvement) by eliminating the need for the passage barrier (i.e., the diversion dam). Upon Project completion, the new intake and associated appurtenances will be adopted as an integral part of the City's water supply infrastructure. The City has full and sole responsibility for the maintenance of its water supply infrastructure and diversion facilities at the Project site, and in ensuring compliance with all pertinent regulatory requirements.

Monitoring and maintenance requirements related to the City's water supply infrastructure will be covered in detail in an Operations & Maintenance (O&M) Manual. Inspection and monitoring of diversion elements as detailed in the O&M Manual will be completed for the life of the facility and exceed the Plan monitoring term identified in Section 5. As such, there are no related Review Triggers included in this Plan; however, a general summary of monitoring associated with the diversion infrastructure is provided in Section 6.2.

Objective 3. Protect fish from entrainment by complying with National Marine Fisheries Service (NMFS) and Washington Department of Fish and Wildlife (WDFW) fish screening criteria.

The proposed project will include decommissioning of the existing water intake. All diversion flows through the proposed system will be screened with a modern fish exclusion screening system to prevent the entrainment of juvenile fish into the system. The Fish screen facility is designed to be compliant with current NMFS and WDFW guidelines and regulations for screen facilities. Fish screened from the diversion flows will be bypassed directly back to the Middle Fork Nooksack River channel, enabling these fish to continue downstream without delay. It is not expected that adult fish migrating upstream will be affected by diversion operations, as in general they are often exposed to much greater velocities at flow splits that occur naturally within the complex system of the Middle Fork Nooksack River.

The proposed Fish screen facility will utilize a brush-based screen cleaner. This automated system will monitor and remove accumulated floating debris that may adversely affect screening performance. Should the automatic cleaning system fail to maintain the system within the required regulatory parameters, the diversion will automatically shut down until manual inspection, cleaning, or repair can be initiated to correct the problem.

Project elements that achieve Objective 3 are integral to the diversion infrastructure. Inspection and monitoring requirements for proper operations and compliance will be detailed in the O&M Manual. As such, there are no related Review Triggers included in this Plan; however, a general summary of monitoring associated with the diversion infrastructure is provided in Section 6.2.

4 Monitoring Attribute Review Triggers

The Plan includes key monitoring attributes that will provide a feedback loop of the trends and trajectory of the restoration efforts. If a Monitoring Metric is a “Pass”, no discussion or action is required. If a Monitoring Metric is trending toward a “Fail”, or has exceeded the trigger for failure, additional evaluation will be performed on the identified issue, and additional monitoring frequency, geomorphic assessment efforts, channel maintenance, and/or corrective actions will be implemented, depending upon the severity, root cause, and type of issue identified.

Table 3 - Monitoring Attribute Metrics

Monitoring Technique	Monitoring Metric	Thresholds	Decision Pathway
Photo/Visual Survey	N/A Provides indication of channel changes to inform field work.	N/A	N/A
Digital Elevation Model Development and Analysis	N/A Provides indication of channel changes to inform field work.	N/A	N/A
Channel Longitudinal Profile derived from Digital Elevation Model	Average Water Surface Elevation slope along low flow centerline	1. >8% average slope over the entire monitoring site length. 2. >12% slope occurring over a 200ft length within the monitoring site.	1a. <7% Average (Pass) 1b. >7% (Monitor) 2a. >7% in any 200ft segment (Monitor) 2b. >10% in any 200ft segment (Evaluate Adaptive Management Action)
Channel Cross Sections derived from Digital Elevation Model	Channel Water Surface Elevation at Minimum Instream Flow	> 3ft water surface elevation decrease at any channel cross section	1. <1ft decrease (Pass) 2. >1ft decrease (Monitor/Investigate) 3. >3ft decrease (Evaluate Adaptive Management Action)

5 Monitoring Techniques, Frequency and Duration

5.1 Monitoring Techniques

The following section outlines the field methods that have been or will be used to inform the above described monitoring surveys.

5.1.1 Pre-Construction Channel Topographic Survey

Topographic survey data was collected in early 2018 to supplement and confirm field survey data obtained during previous studies. This combined survey data provides a baseline characterization of existing stream corridor and floodplain conditions. Data collection includes longitudinal profile and cross-section surveys of the existing channel and adjacent areas. Baseline surveys were completed with total station and engineering level instruments, including the establishment of project control points for georeferencing of the project site. Survey included topographic mapping, channel cross-sections, profiles, and general channel characteristics of the existing project site. Additional features, such as existing infrastructure, were located to further characterize the project reach. Survey data were processed, reduced, and incorporated into 2- and 3-dimensional Computer-Aided-Design (CAD) drawings showing the existing condition.

Multiple cross-sections, top of bank lines, bankfull stage indicators, thalweg and water surface elevations and representative channel features were surveyed throughout the existing active channel. The existing baseline longitudinal profile extends from the upstream end of the project

reach (i.e., just above proposed intake location) to the tailwater control below the dam. The profile includes consistent measurement of left and right channel indicators, channel thalweg, and water surface elevations at select locations along the profile typically at delineated channel habitat units (e.g. riffles). Pebble counts were collected through the existing channel to characterize bed material characteristics (Wolman 1954) as well as to complement hydraulic and sediment incipient motion modeling.

The baseline condition channel profile survey information is documented in various locations throughout the relevant project design and construction documents.

5.1.2 Post-Construction/As-built Channel Topographic Survey

Immediately upon completion of the new channel construction, an overall project as-built topographic survey will be completed of the channel to verify the project element is built according to the approved plans and to establish a new baseline for long-term monitoring, as applicable.

As part of the post-construction topographic survey, additional information specific to the restored channel will be gathered and processed specifically to document the as-built condition of the completed channel, and to define the Monitoring Site Layout. Monumented cross-sections will be established throughout the affected reach and surveyed to determine channel dimensions. The channel restoration area will be surveyed and monumented in accordance with standards of practice for topographic survey.

The as-built longitudinal channel survey work will, at a minimum, collect the following elements of data within the Monitoring Site Layout:

1. A longitudinal profile will be developed from the downstream end of the constructed channel to the upstream tie in point within the existing channel alignment. These points will be determined and monumented during the as-built survey work. For this project, the expected river reach subject to this profile is approximately 500 ft.
2. The profile data shall capture all significant slope breaks along the channel bed.
3. Points should be taken along the thalweg and should adequately capture the sinuosity and topography of the channel. Maximum distance between any two points should not exceed 20 feet.

The as-built cross-sectional channel survey work will, at a minimum, collect the following elements of data within the Monitoring Site Layout:

1. Cross section data will collect adequate points to document slope breaks within the cross section. The maximum distance between any two points shall not exceed 10% of the distance between left and right ordinary high-water marks.
2. Identify the cross-section monuments and elevation benchmarks.
3. Identify the left and right ordinary high-water marks/change in vegetation.

4. Identify the left and right top of bank, if applicable, wetted edge, bank toe, thalweg, and major transitions in slope.
5. Record the time and date, and the river flow rate per the USGS river gage.

The as-built channel data as described in this section will be compiled into a Post-Construction/As-built Survey Report which will become a supplement document to this Plan. Future surveys as described in Section 6.1 will follow the reporting format established in the Post-Construction Monitoring Report for ease of future data comparison.

The as-built channel survey work will be supplemented with development of a Digital Elevation Model as outlined in the next section.

5.2 Digital Elevation Model (DEM)

5.2.1 Digital Elevation Model Development Techniques

This plan proposes to collect channel data in the form of a Digital Elevation Model (DEM). The analysis of the data collected for DEM will enable review of the channel response during the monitoring period. Overlays of successive DEM data will allow for identification of changes within the channel.

The Digital Elevation Model data will be gathered utilizing topography mapping technology such as Terrestrial Laser Scanning (TLS), Aerial Structure from Motion (SfM), or Aerial Laser Scanning (ALS), or a combination of these techniques. These technologies will create a high-resolution three-dimensional terrain model of the channel surfaces and water surface. The proposed methods for gathering this data is expected to utilize advanced survey equipment, such as laser scanning total stations and unmanned aerial drones equipped with photogrammetry or laser scanning equipment.

The initial DEM Data survey will require the installation of local survey monumentation to establish site control and provide ground-truthing for data collected. Site control and targets for aerial data gathering will be refreshed with each subsequent DEM Data survey, and the protocols employed for data gathering will be documented and reproducible such that subsequent Digital Elevation Models are comparable to previous versions.

DEM data shall be collected with a vertical accuracy of 6-inches or less, and horizontal accuracy of 1-inch or less, throughout the entire monitoring site, with appropriate tie-in to the local survey control. This resolution accuracy may be increased as the technology associated with DEM data collection advances. DEM data collected by aerial drone shall be supplemented with ground-based survey work to confirm the ground surface information. Ground-based survey work is also expected to capture bathymetric survey information below the water surface, although technology is advancing in the aerial collection of this information.

5.2.2 Digital Elevation Model Frequency and Duration

Digital Elevation Model (DEM) Data surveys will be conducted based on the following triggers or frequency intervals:

1. Post-construction, representing the as-built condition,
2. After the initial winter/spring seasonal cycle following construction, to evaluate the initial response of the river channel.
3. After the first winter/spring cycle where a 2-yr flood event occurs,
    a. 2yr flood event discharge = 6,200 cfs flow
    b. If no 2-yr flood event occurs in years 2-3, a DEM survey will occur after the 3rd winter/spring cycle following construction.
4. After the 5th winter/spring cycle following construction.
5. After the first winter/spring cycle where a 10-yr flood event occurs,
    a. 10-yr flood event discharge = 12,000 cfs flow
    b. If no 10-yr flood event occurs in years 2-7, a DEM survey will occur after the 7th winter/spring cycle following construction.
6. After the first winter/spring cycle where a 100-yr flood event occurs,
    a. 100-yr flood event discharge = 22,000 cfs flow
    b. If no 100-yr flood event occurs in years 2-10, a DEM survey will occur after the 10th winter/spring cycle following construction.
7. After the 10th winter/spring cycle following construction.

No more than 3 years will lapse between any DEM survey to ensure that an adequate number of data collection measurements occur under natural river flow conditions within the first 10 years following construction. Digital Elevation Model surveys shall end after the 10th winter/spring cycle following construction, provided that longitudinal channel profile slope measurements are found to be within the thresholds defined in Table 1.

Digital Elevation Model surveys will occur during periods of low-flow when physical survey work at or below the ordinary high-water mark can safely occur in and around the river channel.

River flow for this project is determined through the USGS river gage, “USGS 12208000 MF NOOKSACK RIVER NEAR DEMING, WA”. Gage data is available from the USGS at the following webpage: https://waterdata.usgs.gov/wa/nwis/uv?12208000. The referenced gage is located at river mile 5.6, approximately 2.5 miles downstream of the project site.

The threshold trigger flood events are based on the following estimated flow conditions:

1. 2-yr event (6,200cfs) represents the flow rate where the indigent bedload armoring elements can be fully mobilized. Channel response to this flood event could result in localized scouring of smaller substrate around larger boulders or boulder clusters.
2. 10-yr event (12,000 cfs) represents the flow rate where singular, unprotected boulders of mid-range size (4ft-5ft in average axis dimension) are calculated to begin moving on the re-graded channel slope. Channel response to this flood event could result in localized

transport of single boulders of mid-range size and smaller, and settlement/shift of larger boulder jams.

3. 100-yr event (22,000 cfs) represents the flow rate where singular, unprotected boulders of large size (6ft-8ft in average axis dimension) are calculated to begin moving on the re-graded channel slope. Channel response to this flood event could result in localized transport of single large boulders and smaller material, and movement or changes to the larger boulder jams.

5.2.3 Digital Elevation Model Data Processing and Analysis

The DEM Data will be processed and compared with previous DEM data to identify channel changes occurring over time. Data processing will develop heat maps/color gradient information to pinpoint areas of channel movement or change relative to previously collected DEM data. These areas of noted change will be subsequently reviewed more closely through the visual/photogrammetry data acquired via SfM, photo/visual survey work, and field review within the channel.

DEM data will be processed to develop channel longitudinal profile and channel cross section information, enabling comparison to the Monitoring Attribute metrics identified in Table 3.

5.2.4 Channel Longitudinal Profile Measurement Techniques

The Channel Longitudinal Profile will be developed from the DEM data gathered as described in Section 5.2.1. The DEM data shall be processed to provide a continuous water surface elevation profile along the channel thalweg. Where applicable, ground-based survey information will supplement the DEM data to confirm channel bathymetry or other anomalies and changes along the profile.

Channel Longitudinal Profiles will be developed from each DEM data monitoring survey program, at a frequency and duration as described in Section 5.2.2.

5.2.5 Channel Cross-Section Measurement Techniques

The Channel Cross-Section profiles will be developed from the DEM data gathered as described in Section 5.2.1. The DEM data shall be processed to provide a channel cross sections cut at approximate 20ft intervals throughout the monitoring site. Where applicable, ground-based survey information will supplement the DEM data to confirm channel bathymetry or other anomalies and changes at each cross-section.

Channel Cross-Sections will be developed from each DEM data monitoring survey program, at a frequency and duration as described in Section 5.2.2.

5.3 Photo/Visual Inspection Surveys

5.3.1 Photo/Visual Inspection Survey Techniques

Photo and visual inspection survey efforts will generally follow the procedure outlined in the "Stream Photo Documentation Procedure" document identified in Table 1 and the site-specific techniques described below. Additional photo and video documentation will be gathered by aerial drone during DEM data acquisition flights. Photo and video drone flights will be employed at low flow conditions on years when DEM data acquisition is not performed.

The following site-specific techniques will be used for photo/visual documentation at this project site:

1. The site will be photographed at the start and end of the reach, and at each monumented cross-section.
2. Standing on the left bank at each monumented cross-section, take a minimum number of photos to catalog conditions looking upstream, looking downstream, and across the cross-section.
3. Establish several additional photo point monuments at high points along the bank and mark them with rebar and flagging, including a GPS-based tagging point of the location. Take at least one photo looking upstream, and one photo looking downstream from each of these locations.
4. Establish a minimum of (2) photo point monuments, one upstream and one downstream as appropriate to record the condition of the dam section remaining on the right bank.
5. Establish a minimum of (2) photo point monuments, one upstream and one downstream as appropriate to record the condition of the river channel and river bank adjacent to the new diversion intake.
6. Establish a photo point monument to document the condition of the fish bypass outfall and the receiving bank or pool.
7. Record the time, date, and location of each photo taken. Correlate each photo with stream flow discharge for the river gage discharge.
8. Anecdotal observations of fish and wildlife presence, habitat feature utilization, boulder and sediment deposition, and other qualitative assessments of site condition will be recorded and included within the monitoring report as relevant.
9. Examine photos taken in comparison with previous photos. Review for changes in passage conditions relative to flow discharge. Review for blockages, major reconfiguration, knickpoints or other detrimental changes impacting fish passage.

5.3.2 Photo/Visual Inspection Survey Frequency/Timing/Duration

Photo and visual inspection surveys will be conducted based on the following frequencies:

1. On a semi-annual basis for the first three years after project construction is complete. Photo/visual inspection work will typically be performed in October-December (higher flows) and in July-September (lower flows).

2. On an annual basis for years 4-10 after project construction is complete, typically in July-September.

6 Monitoring Site Layout

The following methodology will be used to establish the post-construction monitoring condition, which will then be used as the foundation for the subsequent longitudinal profile measurement surveys at the frequency defined in Section 5.

1. The total site length will be measured following the center of the channel from the downstream end of the constructed reach to the upstream tie-in point with the existing channel alignment.
2. Cross-section locations will be identified and selected to capture channel shape characteristics around and between boulder jam locations and similar features.
3. A channel cross-section will be established at the upstream and downstream tie-in points between the re-graded channel segment and the existing channel.
4. Cross-section locations will be marked at each distance moving upstream with flagging tape and labeled sequentially. (e.g., XS1, XS2, XS3, etc.)
5. When the cross-section locations are established, monument each cross-section by driving rebar into the ground on both right and left banks perpendicular to the channel and above the ordinary high-water elevation. Supplement these monuments with additional monument ties placed adequately above the approximate 10-year flood elevation.
6. Supplement cross-section locations with visible targets as required to aid positioning of DEM data gathering.

6.1 Future Channel Monitoring Surveys

After the post-construction/as-built survey and development of the initial digital elevation modeling of the monitoring site, additional DEM data will be acquired and processed, and photo/visual will be taken within the Monitoring Site in accordance with the protocols defined in this section, at the frequency defined in Section 5. Monitoring will cease after results are compiled from the longitudinal channel survey performed after the 10th winter/spring seasonal cycle following construction. If the longitudinal channel profile remains within the acceptable range as defined in Section 4, and channel cross sectional measurements find no significant passage impediment issues, monitoring as directed in this Plan will conclude.

6.2 Diversion Infrastructure Survey

As the new diversion facility is intended to be operated into the foreseeable future, monitoring of the diversion infrastructure will extend beyond the scope of this Plan, and thus is fully detailed in the facility's O&M Manual. A synopsis of expected infrastructure monitoring by element is provided in this section.

6.2.1 Partial Dam Section Remaining

Photo documentation and visual inspection of the former dam crest ogee structure will be performed as part of this Plan. After the monitoring efforts associated with this plan have ceased, and as part of normal operations, the portion of the former dam remaining in the channel will be subject to visual inspection at an interval no greater than 5 years.

If any changes are visually noted in the dam structure element, or the surrounding/supporting bedrock, photo documentation will be obtained and compared to previous surveys obtained as part of this Plan. The condition of the legacy structure and the structure's response to river actions will be determined from the cumulative photo documentation.

6.2.2 Water Intake Structure

Photo documentation and visual inspection of the water intake and associated channel reach at the intake will be performed as part of this Plan. After the monitoring efforts associated with this Plan have ceased, visual inspection of changes in channel form or bed around intake will be performed regularly to ensure the performance of the municipal intake supply. Regular maintenance of the intake facility will occur at a frequency no greater than annually, in accordance with industry standards for municipal water supply infrastructure. All maintenance and inspection activities will be documented in the City's Computerized Maintenance and Management System (CMMS), and maintenance of all components will be performed in accordance with manufacturer's recommendations and the O&M Manual for the diversion facility.

If any changes are visually noted in the intake structure, or the surrounding/supporting river channel and bank, photo documentation will be obtained and compared to previous surveys. The condition of the intake structure and the channel response to river actions will be determined from the cumulative photo documentation.

6.2.3 Fish Screen Facility

Manual measurements of screen approach velocity, screen sweeping velocity, and fish bypass operating hydraulic characteristics, such as depth and velocity, will be made at time of commissioning to ensure compliance with criteria. Adjustment of the screen control system to meet project criteria will be performed as part of the commissioning process. Testing of the automated control for screen cleaning, bypass, and shut down systems will be accomplished at time of commissioning.

Upon acceptance, regular maintenance of the fish screen facility, including visual inspection of the screen and associated cleaning systems will be performed in accordance with regulatory and industry standards for municipal water supply and screening infrastructure. All maintenance and inspection activities will be documented in the City's Computerized Maintenance and Management System (CMMS), and maintenance of all components will be performed in accordance with manufacturer's recommendations and the Operations and Maintenance Manual for the diversion facility.

7 Adaptive Management Strategy Development

7.1 Decision Making Body

Post-project monitoring as described in this report will be undertaken to document the river channel response to natural flows within the Middle Fork Nooksack River, and confirm the geomorphic response of the restored river channel satisfies the project goal of improving fish passage at the site. Post-construction conditions and monitoring reports at the site will be shared with the WRIA 1 Watershed Management Board via the WRIA 1 Management Team and WRIA 1 Salmon Work Group.

The WRIA 1 Watershed Management Board is the salmon recovery Lead Entity for WRIA 1 under RCW 77.85.050, as formalized by a collaborative Interlocal Agreement between the Lummi Nation, Nooksack Indian Tribe, Washington State Department of Fish and Wildlife, Whatcom County, the City of Bellingham, and other Whatcom County agencies and municipalities (COB Interlocal Agreement #2017-0576). As the Lead Entity, the WRIA 1 Watershed Management Board will be responsible for determining appropriate adaptive management strategies in accordance with the decision-making process established in the 2017 Interlocal Agreement, and incorporating WRIA 1 Fishery Co-manager and agency approvals.

Monitoring results will be presented by the City to the WRIA 1 Salmon Work Group. In the event the monitoring program determines the channel response is trending toward or has reached a failure condition which would impede fish passage, the Salmon Work Group will assess deviations from the expected response and recommend contingency actions to the WRIA 1 Management Team. The Management Team will determine the next steps to be taken.

7.2 Tiered Approach

In general terms, it is expected that the adaptive management strategy for any corrective action will implement a tiered approach following the identification of any unexpected condition of channel response. The tiered approach will proceed along the following methodology:

Example: Monitoring results indicate potential blockage to fish passage at the project site related to channel response.

- **Tier 1** - Stakeholders (City in collaboration with WRIA 1 Salmon Work Group) evaluate reported monitoring results.
- **Tier 2** - Implement additional field review, focused monitoring and analysis to determine the severity and permanence of the identified issue.
  Additional field review may confirm the determination of a passage issue, or may determine that no further action is necessary.
- **Tier 3** - The stakeholders will identify potential corrective actions which may be undertaken to re-establish passage conditions.

Corrective actions ratified and implemented, subject to regulatory requirements.

Tier 4 – Implement continued monitoring and evaluation to assess performance of corrective action.

8 Data Storage and Analysis

8.1 Data Storage

Monitoring data will be stored and maintained by the City of Bellingham. Data and reports will be maintained in standard format(s) and will be made available to the project review team within 30 days of such a request.

8.2 Data Analysis and Reporting

8.2.1 Channel Measurement Survey Data Analysis and Reporting

Following channel survey work at the intervals described in Section 5, a monitoring report will be generated to summarize the findings of the survey. The City will prepare a monitoring report that includes:

- Summary of metrics for which data were collected;
- Deviations from established methods and protocols used to collect data;
- Tabular and graphical summaries of results;
- Narrative discussions to explain results in the context of project goals, success criteria, and performance standards; and
- Any recommended actions.

These reports will be submitted to the RRT, the WRIA 1 Salmon Work Group, and American Rivers for review and comment no later than the end of the calendar year in which the survey work was performed. If significant issues or concerns related to the project goals are identified during development of the monitoring report, the City will convene the RRT and Salmon Work Group to present the findings, discuss any comments, and work collaboratively to determine any recommendations for future actions at the project site.

8.2.2 Photo Documentation/Visual Inspection Data Analysis and Reporting

The City will maintain photo documentation and visual inspection data, which will be analyzed after data is gathered per the frequency described in Section 5. A brief memorandum summarizing the photo documentation, visual inspection, and changes in the channel will be issued annually. Products of the photo documentation/visual inspection program will be included in the Middle Fork Nooksack River Fish Passage Project Effectiveness Monitoring Report for reference.

8.2.3 Final Monitoring Report

Upon completion of the 10th year of monitoring, (or the final year of monitoring, if extended via adaptive management action) the compendium of all monitoring results will be combined into a final monitoring report for the project. The final monitoring report will summarize the data

collected and any adaptive management actions taken over the duration of monitoring. The report shall include:

- Metrics describing how data was collected and analyzed, including any adjustments made to the data collection procedures or monitoring program.
- Summary of all monitoring data collected, utilizing summary tables and figures to demonstrate and depict trends in channel response observed over the period of monitoring.
- Conclusions describing the performance of the project in relation to the goals established.
- Narrative discussion as required to explain monitoring results in the context of the project goals.

The final monitoring report will be submitted to the RRT, the WRIA 1 Salmon Workgroup, and American Rivers as final documentation of the Effectiveness Monitoring and Adaptive Management Plan for the Middle Fork Nooksack River Fish Passage Project site.

9 Monitoring Quality Assurance Plan

To ensure the quality of the monitoring program, the City will implement quality assurance (QA) and control (QC) procedures. QA and QC procedures will be applied to the following aspects of the monitoring plan:

1. Data collection
2. Data storage
3. Data analysis and reporting

The City of Bellingham Public Works Department, Natural Resources Division or their designee will be responsible for quality assurance.

10 Literature Cited

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