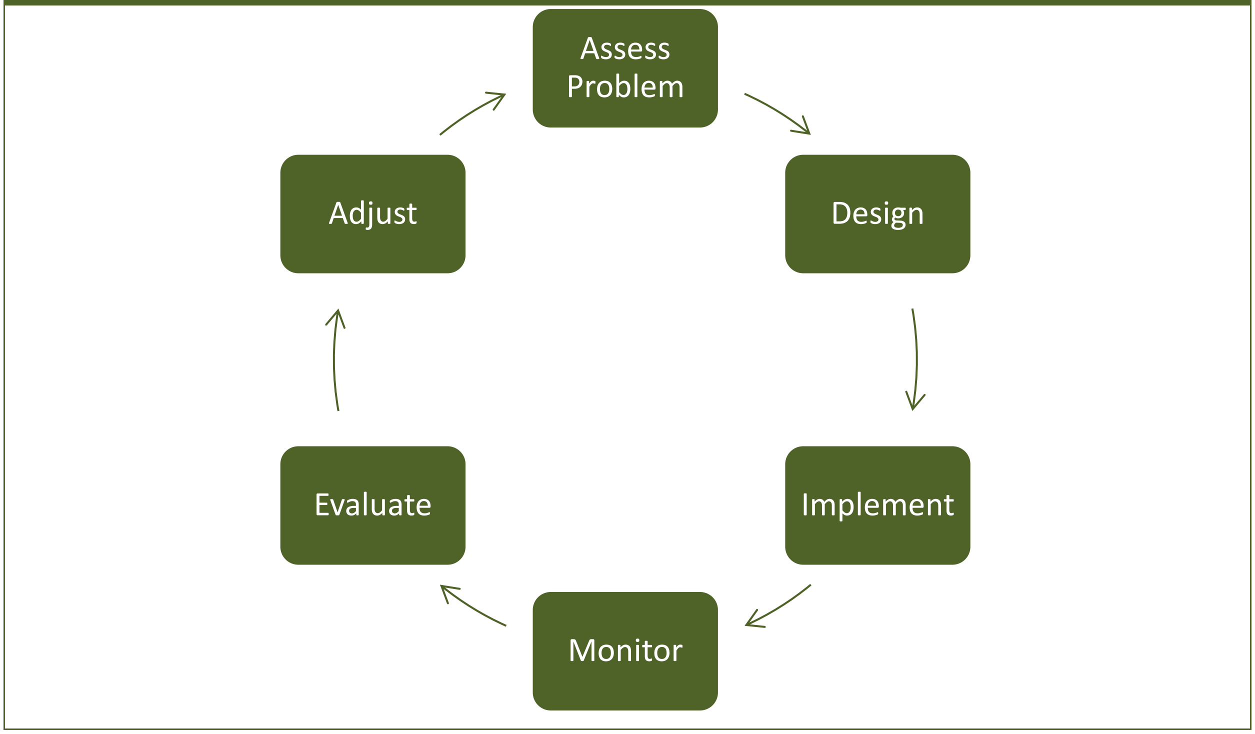
1 OVERVIEW AND BACKGROUND

The Monitoring and Adaptive Management (M&AM) Team is a subcommittee of the Steering Committee, who in conjunction with the Science and Technical Review Team (SRT) recognized the need for a formal monitoring program evaluating the effects of restoration actions and an integrated adaptive management program to improve the restoration program. The formal monitoring program is meant to build off the foundations documented in the Scientific Foundation (Appendix A), as those principles are applicable in a robust and comprehensive M&AM Plan. The M&AM Team was tasked with developing the M&AM Framework for the Aquatic Species Restoration Plan (ASRP) Phase 1 document. This group includes SRT members, other regional experts, and practitioners of monitoring programs in Washington State that are appointed by the Steering Committee. The purpose of the framework is to lay the foundation for the overall M&AM Plan, which will provide a comprehensive approach to M&AM of the actions associated with the implementation of the ASRP.

Monitoring, in this context, is a key component of adaptive management of the ASRP. Adaptive management is defined as a "systematic approach for improving resource management by learning from management outcomes . . . [It] makes use of management interventions and follow-up monitoring to promote understanding and improve subsequent decision-making" (Williams et al. 2009; see Figure B-1). The components of the framework were selected to assess the outcomes of ASRP implementation at multiple scales and to provide relevant, timely feedback from which more informed management decisions could be made. This document will outline the framework elements, discuss the development of subprograms where applicable, and describe the applicable scales of monitoring to document the M&AM Team's approach to developing the full M&AM Plan as part of the ASRP. As a framework, this document does not include details about protocols or methods. The comprehensive M&AM Plan will be developed in a future ASRP phase.

Figure B-1
Adaptive Management Cycle



Note:
Adapted from Williams and Brown 2012.

1.1 Framework Development

The M&AM Team began developing this framework by reviewing the basic documents and observations that underpin and drive ASRP development, including the Chehalis Basin Strategy, the Scientific Foundation (see Appendix A of the ASRP Phase 1 document), and SRT observations from site tours. Building from the specific focus on the ASRP *Initial Outcomes and Needed Investments for Policy Consideration* (Initial Document; ASRP SC 2017) as well as the Scientific Foundation as updated for the ASRP Phase 1 document, the M&AM Team used the ASRP Initial Document's vision statement, approach description, and expected outcomes to identify elements critical to focusing monitoring efforts. The Scientific Foundation was a key resource for developing the monitoring program framework. Specific assumptions and uncertainties in the Scientific Foundation led to the development of hypotheses that require validation to assure ASRP benefits are realized and to adjust the ASRP if warranted. Input from SRT field visits in the Chehalis Basin helped inform testable hypothesis development.

The ASRP Initial Document's vision statement (ASRP SC 2017) was used to guide the M&AM Framework development. Four focus areas distilled from the ASRP Initial Document's vision statement are featured in Table B-1.

Table B-1
Monitoring and Adaptive Management Framework Focus Areas

FOCUS AREAS FROM THE ASRP INITIAL DOCUMENT VISION STATEMENT
1. Support healthy, harvestable salmon populations.
2. Maintain robust diverse populations of native aquatic and semiaquatic species.
3. Maintain productive ecosystems that are resilient to climate change and other anthropogenic stressors.
4. Honor the social, economic, and cultural values of the region.

These focus areas formed the basis for the development of monitoring programs, with different approaches and scales needed to address each monitoring program. M&AM Team members then integrated the first three focus areas into this M&AM Framework. The fourth focus area would be developed in a future phase by a policy- and community outreach-oriented team of experts.

2 PURPOSE

The overarching purpose of the M&AM Framework is to outline a monitoring program for the ASRP that can provide the information necessary to assure the success of the ASRP through adaptively managing its implementation. The M&AM Framework is designed to not only determine the effectiveness of the restoration in improving aquatic species habitat and population health but also serve as a course correction and feedback tool to assess progress. The monitoring program is intended to determine whether the level of effort, specific actions, and rate of restoration are sufficient to achieve the vision of the ASRP. An integrated array of monitoring approaches is needed to achieve that purpose. This M&AM Framework will ultimately guide development of a more detailed M&AM Plan to be completed in a future ASRP phase.

Building on the focus areas listed in Table B-1 and other supporting documentation, the M&AM Team identified the following management questions to guide framework development and link to specific sampling programs:

1. What is the current watershed condition in the Chehalis Basin?
2. What is the trajectory of change in watershed condition in the Chehalis Basin?
3. Will implementation of the ASRP restoration actions have a significant effect on the aquatic habitat in the Chehalis Basin?
4. What restoration is enough to improve aquatic habitats at a watershed scale?
5. What amount of restoration is necessary to benefit aquatic species at a watershed scale?
6. What is the project-level effect of restoration actions?
7. What can be learned from early action projects (see Section 6 of the ASRP Phase 1 document for project details) to inform subsequent reach scale actions?
8. Which of the hypotheses or assumptions included in the development of the ASRP have substantial uncertainty around them and have the potential to affect the implementation of the ASRP?
9. How would these hypotheses or assumptions be prioritized for additional study?
10. What are the known data gaps that are currently outside of the scope of this monitoring program that may affect the interpretation of the data collected (e.g., estuary conditions)?

> **Watershed scale** refers to a subdivision of the Chehalis Basin Ecological Regions that includes relevant sub-basins (e.g., approximately Hydrologic Unit Code [HUC] 10).
>
> **Project-level effects** are those effects that occur and are measured at the location of the project action.

These management questions naturally break out into different scales and approaches for monitoring. Some of the questions are at the project level, while others need to be assessed at the watershed scale. Hypothesis testing, given the variable nature of uncertainties, would need to be addressed at multiple scales. Using standard monitoring terminology from the Pacific Northwest, these questions can be grouped into the following four major monitoring types: implementation, project effectiveness, status and trends, and validation.

The M&AM Team recommends the following sampling programs (monitoring approaches or studies) to address differences in spatial scale, sampling approach, metrics, and analyses inherent in the questions and focus areas:

- **Implementation monitoring** tracks whether projects were constructed as planned (e.g., number of wood structures, acres of riparian planted, or length of side channel) (RCO 2019). Implementation monitoring should occur at all project locations to document construction and other project actions relevant to permit compliance. This monitoring could include as-built surveys of project topography, verification of quantities and specifications of wood placed, acres and quantities planted, measurements of habitat length and area constructed, and survivability of specified plantings.
- **Project effectiveness monitoring** evaluates whether the habitat and biological outcomes for each project were achieved (e.g., did wood structures scour pools, were floodplain habitats reconnected, or did the local abundance of Oregon spotted frogs increase) (RCO 2019). Under this framework, implementation monitoring would be included as part of project effectiveness monitoring at the locations where effectiveness monitoring is completed. Otherwise, implementation monitoring would be completed separately at each project site. To assess the effects of project actions on aquatic species and their habitat, it is recommended that effectiveness monitoring be conducted at a subset of the locations to assess the habitat outcomes (e.g., number and depth of pools created, area and survival of plantings, or floodplain connectivity of off-channel habitats). This monitoring could combine direct field sampling (e.g., pool measurements, wood counts, or crest gauges) and remote sensing (e.g., bathymetric light detection and ranging [LiDAR] and National Agriculture Imagery Program [NAIP] imagery). Limited information on biological community response would be collected (e.g., macroinvertebrate samples), but additional biological monitoring would not be conducted due to the high level of variability in biological sampling.
- **Status and trends monitoring** is a general approach to assessing the "status" or condition of the physical, biological, and chemical characteristics of a river or stream at a single point in time. These same locations are resampled at future time points to determine the "trend" in condition (Ecology et al. 2006). Under this framework, the status and trends approach is used to assess the change in habitat conditions at the watershed scale and to assess the impacts of actions that are outside the influence of the ASRP restoration efforts. Watershed scale refers to select sub-basins within the larger ecological regions defined in the ASRP Phase 1 document. An example of watershed scale could be the entire Newaukum River sub-basin.

> **Population health** is a combined assessment of abundance, distribution, diversity, and spatial structure.
>
> **Ecosystem resiliency** is the ability of an ecosystem to remain functional (provide the diversity and quantity of habitats needed to support healthy populations of the suite of native species) in the face of climate change and anthropogenic disturbance.

To assess the overall impact of restoration implementation and larger-scale elements—such as watershed condition and trajectory, aquatic species population health, and ecosystem resiliency—status and trend monitoring at a watershed scale is recommended. This sampling could include habitat monitoring using a network of sites and selected biological monitoring as follows:

- **Physical Habitat Sampling:** Habitat monitoring could include sampling sites across a spatially balanced network using varied critical indicators of watershed condition (e.g., water temperature, levels of large wood) as well as remote sensing data (e.g., NAIP imagery) to assess changes at a watershed scale.
- **Biological Sampling:** Biological sampling at the population scale occurs for selected salmon populations and for the diversity of selected native aquatic and semiaquatic species, as well as for macroinvertebrates. Population scale can differ depending on spatial distribution in the basin but informs watershed monitoring programs. Overlapping assessment strategies allow relationships between macroinvertebrate metrics, fish abundance, survival, and growth to be evaluated at multiple scales. Some salmon populations are currently being monitored using a "fish in/fish out" approach of spawner returns and smolt outmigration, and these efforts would continue under this framework. Aquatic species diversity could be measured across the suite of aquatic habitats (stillwater and flowing water habitats) present in the Chehalis Basin.

- **Validation monitoring** is recommended via hypothesis testing at case-specific scales. Validation monitoring is designed to evaluate the specific cause and effect relationships between habitat conditions resulting from the implementation of restoration actions and the populations the actions are intended to benefit (WDNR 2019). Under this framework, the validation monitoring is achieved via hypothesis testing, which looks at the underlying assumptions (i.e., cause and effect relationships between habitat conditions and species response) that have high levels of uncertainty and are likely to affect the interpretation of monitoring results.
  - **Case-Specific Sampling:** Focused case-specific sampling would be recommended to test hypotheses about species/habitat relationships that currently have high uncertainty and are likely to affect the implementation of the ASRP and the interpretation of other monitoring data. This sampling would be dependent on the specific hypotheses identified in future phases and is not further developed for this M&AM Framework stage. In addition, any data gaps (which are currently outside the scope of this framework) that are determined to be critical to implementation could be addressed under this type of sampling through coordination with the SRT and Steering Committee.

3 FRAMEWORK ELEMENTS

A framework element is a concept that the M&AM Team identified as being inherent across sampling programs that should be woven throughout the M&AM Plan in order to improve efficiency and effectiveness in sampling. These elements emerged throughout discussions of the M&AM team as "lessons learned" from the group's experience implementing other large-scale monitoring programs across the state.

3.1 Technical Elements of Sampling

3.1.1 Similar Protocols and Data Compatibility

It is important to have consistency in protocols and in how data are collected; this allows information to be compatible among different aspects of the monitoring program and increase cost efficiency by allowing for comparability between the different study designs and scales. Sampling programs included in this framework are designed to interact and complement each other in terms of the methods used to collect the data and the ability to share data across sampling programs described in this plan and other existing monitoring programs across the state. A basic principle would be to use consistent monitoring protocols so that information will be compatible across programs. Adhering to this principle would provide important overlap between the watershed status and trends and project effectiveness programs.

3.1.2 Remote Sensing

Remote sensing would complement field sampling and provide continuous imagery over large areas—for example, sub-basins targeted for multiple restoration actions. Remote sensing serves multiple purposes, including planning and design of restoration projects, evaluation of floodplain connections, analysis of changes in land use and performance of upland vegetation, and analysis of watershed condition on a broader scale than is possible with alternative methods. Remote sensing examples include analysis of NAIP imagery, LiDAR, bathymetric (green)-LiDAR, and varied georeferenced data to detect changes in landform, floodplain topography, channel migration and network (such as meanders and side channels), and riparian condition. Methods such as geomorphic change detection, hydraulic modeling, and habitat suitability modeling can be applied to these datasets and are often more efficient than field surveys for larger areas. Specifically, the use of hydraulic modeling could be key to evaluating floodplain connectivity, in conjunction with crest gauges in off-channel and side-channel habitats and drone-based video and images collected during high flows.

Importantly, remote sensing data with a history of regular periodic collection and high potential for continued collection should be selected for analysis. It is recommended that standardized methods such as high-resolution change detection methods developed by the Washington Department of Fish and Wildlife (Pierce 2019) and 2D hydraulic modeling that can describe past and current floodplain connection are selected for application to repeated data collection events.

3.1.3 Quality Assurance and Data Management

Data availability is critical for large, multifaceted monitoring efforts, as many groups need access to datasets for analysis and to use information for restoration and other types of work. Assuring that datasets are reliable, in terms of both precision and accuracy, is important across all the sampling programs. Data management systems are expensive, so partnerships across agencies, tribes, and other groups would ensure maximum data quality and accessibility. Online data management systems with automated quality assurance elements are helpful, but the management systems need to be flexible enough to store and organize multiple types of data that may be captured across sampling programs.

3.2 Consolidation of Data Within and Outside of the ASRP

Consolidation of existing data from studies conducted as part of the ASRP is needed to implement a cost-effective monitoring program, and it is a critical first step in program development. This would help to ensure that the M&AM Team and all parties involved in restoration are aware of available data sources and that M&AM Team members can integrate information needs associated with the monitoring program with existing data collection under other programs.

In alignment with that theme is the consolidation of information about active restoration and monitoring efforts that are outside of the ASRP programs entirely. Knowledge of locations, actions, and types of data being collected—similar to the consolidation of data from studies within the ASRP umbrella—helps to ensure cost effective implementation of the monitoring program. The Washington State Lead Entity Program Habitat Work Schedule is a useful tool to comprehensively track other restoration actions in the basin.

3.3 Timely Reporting of Information

In addition to collecting and consolidating data using consistent protocols, there is a need to ensure the data are analyzed and reported out in a timely, consistent manner in order to be useful to managers responsible for adaptive management. Timing and reporting formats will be further refined as part of the plan development process.

4 SAMPLING PROGRAMS

4.1 Project Effectiveness

Project effectiveness monitoring is the tracking of the response of habitats and their associated aquatic and semiaquatic species at the project level to restoration. This monitoring is used to determine the success of restoration actions at the project-level scale and whether actions are achieving their expected outcomes. The assumptions, objectives, and questions that are the basis of the project effectiveness monitoring program are described in the following sections.

Typically, a restoration plan or project includes several interacting treatments (e.g., placed large wood, channel reconfiguration, or levee removal). Monitoring should inform the long-term function of the following: 1) individual treatments (e.g., how are reconfigured channel sites changing and why?); and 2) the entire project (e.g., is the access to the floodplain improved and maintained throughout the reach?).

4.1.1 Key Assumptions

ASRP implementation will have a focus on conducting process-based restoration. Therefore, the following assumptions are maintained:

1. The process-based restoration approach would attempt to reestablish a semblance of functional rates and magnitudes of physical, chemical, and biological processes that create and sustain habitat-forming and riverine ecosystem dynamics (Beechie et al. 2010; Scientific Foundation).
2. The process-based restoration activities of the ASRP would be designed to do the following:
   A. Reconnect off-channel and floodplain habitats.
   B. Restore habitat-forming processes.
   C. Restore habitat connectivity.
   D. Restore self-sustaining riparian processes.
   E. Re-create key habitat features.
   F. Remove and/or relocate infrastructure at a high risk of flooding from restoration actions.
   G. Integrate experimental design into restoration actions to evaluate outcomes for native species other than salmon and steelhead to ensure that successful outcomes have a higher probability in future efforts.

4.1.2 Monitoring Objectives

1. Track project implementation actions.
2. Determine the degree to which restoration projects achieve their expected outcomes by doing the following:
   A. Use a standard monitoring approach to facilitate among-site and through-time comparisons.

   B. Include supplemental monitoring at projects (e.g., tracking channel development and measuring inundation timing and depths) to help determine how a project is functioning and to allow for adaptive management.
3. Evaluate the effectiveness of how restoration actions re-establish physical, chemical, and biological processes over time by tracking conditions.
4. Provide reliable information for scientifically based adaptive management decisions within a useful timeline. Reliable information should allow for the detection of differences between regional and local (project) trends in important conditions.

4.1.3 Monitoring Questions

1. To what degree are ASRP restoration projects achieving their expected outcomes and performance measures?
2. Are the restoration projects implemented through the ASRP creating the necessary physical, chemical, and biological conditions to achieve ASRP program goals?

4.1.4 Scale

Project-level effectiveness monitoring is designed to evaluate restoration projects implemented at the reach and site scales. Early Action Reach projects, described in Section 6 of the ASRP Phase 1 document, are considered reach-scale.

4.1.5 Spatial Design

Early Action Reaches and future project-level effectiveness monitoring could occur at the targeted fixed restoration locations.

4.1.6 Temporal Design

The temporal design addresses monitoring through a project's life (timeline). Pre-implementation monitoring ideally would occur in enough time before project implementation to capture between-year variability when applicable, though pre-implementation monitoring will be focused on the physical characteristics of the site. Post-implementation monitoring would occur immediately after treatment and subsequently on the most suitable year-scale rotation for each metric. Some metrics could be monitored more frequently, while other metrics could be monitored less frequently over a longer timeline. This sampling frequency would allow the detection of immediate responses and emerging trends in order to recommend adaptive management alternatives to design teams and restoration implementers.

4.1.7 Restoration Project Template

Templates similar to those used in the Lower Columbia River Estuary Program (USEPA 1999) could be used to document habitat restoration project information and existing data and integrated as part of the planning process for restoration project-level monitoring. These templates would be used to clearly document and communicate habitat project objectives and outcomes and identify the best methods to measure the achievement of quantifiable objectives and outcomes.

A standard form/questionnaire is expected to be used to collect consistent information about the restoration project site, design, and expected outcomes. Important uses include having the project sponsors (designers) identify the specific site characteristics that they intend to change; estimates of the types, locations, and quantities of changes; and the area affected by site changes or treatments. Such characteristics or attributes should be monitored to allow for adaptive management of the project and stronger inferences about the changes from the project. Specifically, the template would identify and quantify intended changes to habitats and help clearly specify objectives.

4.1.8 Native and Invasive Species Screen

An initial screen for native and invasive species should occur prior to the design process for each ASRP project. The purpose of the screen is to identify areas where the current diversity of aquatic species is potentially high (areas to protect), areas where restoration could improve habitats, and areas where invasive species could interfere with restoration or protection efforts. The native species screen has already occurred as part of the Early Action Reach design process. This step provided design teams with information about existing high-quality habitats for aquatic and semiaquatic species, known occurrences of rare species, sensitive areas that should not be further disturbed by restoration projects, and infestations of invasive species that should not be allowed to further proliferate in restored environments.

4.1.9 Example Metrics

Many metrics have been identified to be included as part of the Project Effectiveness Sampling Program. Table B-2 identifies some example metrics and associated protocols to give a sense of the type of habitat sampling that could be included as part of the program. Additional detail on protocols, methods, and selected priority metrics will be included in the M&AM Plan developed in Phase 2 of the ASRP.

Table B-2
Example Metrics for Project Effectiveness Monitoring

LOCATION	METRIC	METHOD/PROTOCOL
Channel	Channel dimensions	EAPSOP113, Channel Dimensions
	In-channel and side-channel habitat units	EAPSOP120, Habitat Units
	Thalweg profile	EAPSOP119, Thalweg Profile
	Large woody debris	EAPSOP121, Large Woody Debris Tally
	Fish cover	EAPSOP116, Fish Cover
	Riparian cover	EAPSOP115, Riparian Cover
	Substrate/embeddedness	EAPSOP114, Substrate
	Benthic macroinvertebrates	EAPSOP073, Benthic Macroinvertebrates
	Temperature (continuous)	EAPSOP80 Continuous Temperature (linked with ThermalScape modeling)

LOCATION	METRIC	METHOD/PROTOCOL
	Bank erosion	EAPSOP113, Bank Erosion
	Stream discharge	Continuous stream discharge
Riparian	Riparian structure	EAPSOP117, Riparian Vegetation Structure
	Riparian plantings	Survival, forest cover and function, invasive plant distribution and cover
Floodplain	Floodplain connectivity/water surface elevation	Hydraulic modeling using bathymetric LiDAR; measuring stage height with water loggers/crest gages; EAPSOP072, EAPSOP024, EAPSOP042
	Groundwater levels (continuous)	Piezometers, groundwater standard operating procedures (post-project only)
	Landscape changes such as land use, land cover, or vegetation	High-resolution change detection using LiDAR and NAIP imagery
Overall Project Reach	Project reach conditions	Photograph points at georeferenced locations

Note:
EAPSOP: Washington Department of Ecology Environmental Assessment Program Watershed Health Monitoring Program Standard Operating Procedure

4.2 Status and Trends Monitoring

Status and trends monitoring is a general approach to establishing the current condition (status) of a watershed and then repeat sampling to monitor the change in the condition (trend) through time. Under this framework, the monitoring could include both physical and biological sampling, and it could be distributed across appropriate subunits of the Chehalis Basin (e.g., HUC 10) that are denoted as watershed scale monitoring.

Status and trends monitoring of watershed conditions includes the physical, chemical, and selected biological conditions of aquatic and riparian habitats. This information would provide watershed-level and potentially ecological region- or basin-scale trends and health information to help interpret and provide context for reach- or project-level results. Reliable information about changes in watershed condition requires consistent long-term monitoring at a large number of representative (random) sites that can be used as references to detect treatment effects. The physical habitat sampling methods for the basin-wide efforts would be consistent with the project effectiveness monitoring program to facilitate reliable comparisons. Biotic sampling would also be included in status and trends monitoring, but it would be based on the distribution and habitat use of species. Salmonid sampling has an infrastructure in place to assess the migratory populations of Pacific salmon and steelhead in the Chehalis Basin (fish in/fish out where applicable, run size and escapement estimates). Monitoring of salmon and steelhead populations could be managed separately from the efforts to monitor the diversity of other indicator species.

4.2.1 Watershed Conditions Monitoring

Watershed condition monitoring of physical aspects of stream habitat for status and trends would either use a network of fixed stations from which basin-wide data are modeled (for example, temperature via ThermalScape from the modified Norwest model) or a network of spatially balanced sites to provide inferences over large spatial areas (for example, a Generalized Random – Tessellation Stratified [GRTS] application for selected watershed condition variables, such as large wood). Key assumptions, objectives, and questions that form the basis of the status and trends monitoring of watershed conditions are described in the following sections.

4.2.1.1 Key Assumptions

1. Basin-scale investment (e.g., hundreds of miles) in watershed restoration and protection would improve stream and riparian conditions at the reach scale and cumulatively result in a positive impact at the larger watershed scale.
2. The restoration and protection of natural watershed processes would allow the ecosystem to remain resilient to future perturbations, such as climate change and human stressors, through natural physical and biological adjustments (Beechie et al. 2010).

4.2.1.2 Objectives

1. Track and evaluate how the physical, chemical, and biotic conditions of aquatic and riparian habitats in the Chehalis Basin change over time.
2. Determine the key human and climate change stressors in the Chehalis Basin and impacts of these stressors to watershed conditions over time.
3. Provide the background basin conditions and context to use in interpreting the project-level effectiveness monitoring data.
4. Provide the least-biased, statistically valid, and reliable data on basin conditions, ultimately acting as a basis for determining whether restoration efforts are having a beneficial effect.

4.2.1.3 Monitoring Questions

1. Are watershed conditions in the Chehalis Basin improving, remaining the same, or declining over time?
2. Does the process-based restoration and protection approach of the ASRP attenuate human and climate change stressors to watershed processes?

4.2.1.4 Scale

Sampling may occur at the overall basin level and be stratified by selected watershed habitat categories or hydrologic unit codes (e.g., HUC 10), to be further described in the full M&AM Plan. Sampling and reporting by ecological region may occur depending on specific data needs and the patterns of restoration implementation.

4.2.2 Aquatic Species Diversity Monitoring

Aquatic species include both native and invasive fishes, amphibians, and plants as well as semiaquatic species that use aquatic habitats for a portion of their life cycle. Sampling for aquatic species diversity could provide baseline information on less-studied species and non-salmonid indicator species that can help provide context for reach- or project-level results. Aquatic species in the Chehalis Basin occur in a wide variety of habitat types. Different habitat types (strata), whether lotic (flowing) or lentic (stillwater), require varied sampling methods to evaluate their distinctive aquatic and semiaquatic species diversities (composition, richness evenness), although within a habitat type, methods and metrics would be consistent. Primary comparisons would be made within the same stratum, rather than across strata. Diversity metrics (alpha, beta, gamma, composition, richness, evenness) would be used to evaluate the health of the habitat and associated populations in each stratum.

4.2.3 Salmon and Steelhead Population Monitoring

The ongoing status and trends monitoring of salmon and steelhead populations is already providing useful information for interpreting fish responses at multiple scales. Salmon and steelhead population monitoring provides annual trends in salmon and steelhead abundance and harvest, describes a suite of viable salmonid population (VSP) metrics, and identifies whether trends in abundance are associated with changes in freshwater productivity. VSP metrics include spatial distribution, diversity, and productivity. Together, the VSP and freshwater productivity metrics can be used to interpret abundance trends and guide future restoration actions. Annual trends in salmon and steelhead abundance are the basic information used to evaluate fish responses to restoration and management practices. Sustained trends may trigger an adaptive response, specifically whether to stay the course (positive trends), make immediate changes (negative trends), or continue to evaluate (inconclusive trends). Harvest is an important indicator of long-term success of the ASRP, and the contributions of wild and hatchery production to harvest should be tracked over time. Additions to the sampling network for salmon and steelhead populations could be made in the 2019–2021 biennium, and the program would continue as part of the status and trends evaluation of populations at the watershed scale.

5 HYPOTHESIS TESTING AND DATA GAPS

An essential element of the M&AM Plan is to test key hypotheses to reduce uncertainty, otherwise known as validation monitoring. The M&AM Team identified an initial list of hypotheses, which was further refined into five categories deemed to have a large potential effect on the implementation and evaluation of the ASRP. Within these categories, the SRT identified multiple hypotheses that either underpin benefits of restoration that are assumed but need validation (uncertainty is relatively high) or represent fundamental questions where knowledge is needed. Validation is recommended to ensure that factors limiting the productivity of native species in the Chehalis Basin are clearly identified and restoration actions can be designed to effectively address them.

To address key hypotheses, the SRT developed a spreadsheet containing approximately 20 hypotheses linked to the ASRP Initial Document's vision statement (ASRP SC 2017), the Scientific Foundation, and Phase 1 approach and expected outcomes. Next, the SRT reviewed and ranked the hypotheses within the spreadsheet, which resulted in the following general categories of hypotheses being identified and prioritized:

1. Water Temperature
2. Wood
3. Off-Channel Habitat/Floodplains
4. Invasive Species
5. Poorly Acknowledged Factors Controlling Production (e.g., food)

Within each general category, several hypotheses were identified and reviewed, including the following:

1. **Water Temperature:** Can engineered logjams alter hyporheic flows and reduce water temperatures to the levels needed when combined with improving riparian shade?
2. **Wood:** Can engineered logjams adequately hold and maintain spawning gravels?
3. **Off-Channel Habitat/Floodplains:** Will the protection and creation of thermally suitable habitat, including localized cool-water refugia, result in the intended species assemblages and benefits (e.g., support summer rearing habitat for salmon and steelhead)?
4. **Invasive Species:** To what extent does the presence of predatory and competing fishes (invasive and native) in off-channel habitats limit their use by salmonids and other native aquatic species, or the survival of the latter?
5. **Poorly Acknowledged Factors Controlling Production (e.g., food):** Are actions available to increase food production in stream and off-channel habitats?

The SRT has not developed a finalized list of testable hypotheses. This will require additional discussion in the 2019–2021 biennium. However, the categories listed in this section (such as Water Temperature and Wood) provide an initial framework upon which to develop the key hypotheses component of the M&AM Plan.

Sampling methods for key hypotheses that are prioritized and selected for monitoring are anticipated to be case-specific to the habitats and species addressed in those studies. Some may be possible to address with the sampling programs or protocols previously described. The approach and effort for addressing the monitoring issues identified in these hypotheses would be designed to support the precision and accuracy needed for the results.

6 CONCLUSIONS

Collectively, programs included in the M&AM Framework provide a comprehensive basis from which to evaluate and enhance the ASRP effectiveness through the process of adaptive management. Project effectiveness monitoring will provide insight into physical changes that occur at the restoration sites themselves. Status and trends monitoring will provide information about watershed-scale changes that are occurring more generally throughout the basin for aquatic populations and their habitats. Given the diversity of the Chehalis Basin, the status and trends monitoring will focus on three key areas of watershed health—watershed conditions (physical chemical, and biotic), native species diversity, and salmon and steelhead populations. Finally, hypothesis testing would provide strategic information needed to adaptively manage the ASRP over time.

This document was developed through a collective and collaborative process across agencies, tribes, and other entities that will continue as the framework is refined and the M&AM Plan is developed and finalized. Continued work by the M&AM Team and input from the SRT and Steering Committee are expected in the 2019–2021 biennium. Next steps include additional detail development, prioritization of program elements for implementation, cost estimation, and full plan development in 2020.

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