STREAM HABITAT RESTORATION GUIDELINES
CHAPTER 3

STREAM HABITAT ASSESSMENT

****This Chapter is a draft version and the Aquatic Habitat Guidelines Program will be working to finalize it in the future****

Stream habitat is created and maintained by the dynamic interaction of multiple physical, chemical and biological processes that function at a range of spatial and temporal scales (Chapter 2 of this document). Historically, restoration efforts were primarily quick fix, in-channel engineering efforts that were implemented without adequate knowledge of watershed and ecosystem processes and characteristics. These restoration efforts were often conducted at inappropriate locations or inappropriate spatial and temporal scales and did not address the processes that were limiting the production of habitat or species. Therefore, structural and functional failures were common. Appropriate habitat assessments could have prevented many of these failures.

The purpose of a habitat assessment is to characterize the present (and/or historic) state of habitat and the processes that create and maintain it so that problems and appropriate restoration options and obstacles can be identified and prioritized. It provides the technical basis for making decisions concerning land management as well as restoration and mitigation policy, planning, and project development. In light of the limited resources available to put towards restoration efforts, the risk of project failure, and the risk of unintended detrimental habitat and infrastructure impacts when watershed processes and conditions are not well understood, some degree of assessment should be conducted for all projects in order to maximize their long-term success. Assessment costs should be considered part of the cost of project implementation and should therefore be included in a project budget. It is usually more cost effective to adequately assess watershed conditions before project implementation rather than after a project has failed to meet expectations, especially if more than one project can benefit from the endeavor.

The objectives of this chapter are to:

- Describe types of information to be gained through expanding scales of assessment,
- Describe typical components of an assessment,
- Provide tips on selecting an appropriate scale of assessment,
- Identify references concerning various assessment methodologies, and
- Identify available resources to help in your assessment.

Because the goals of assessment and the depth and scale of analysis vary with the problem(s) being addressed, specific instructions on how to conduct an assessment are not addressed below.

3.1 Role of Assessment

Stream habitat assessments are typically conducted at three scales: 1) watershed, 2) reach, and 3) site, because the processes responsible for creating, maintaining, and connecting stream habitat operate on multiple spatial and temporal scales. For instance, sediment found at a particular site may be derived from adjacent bank erosion (site-scale process), upstream channel incision (reach-scale process), or mass wasting events in the watershed (watershed-scale process). The other reason is that the impacts of activities within the watershed are cumulative and propagate downstream (e.g., water quality impairment), upstream (e.g., channel incision), and laterally (e.g., channel migration). Hence, what's going on elsewhere in the watershed may influence the effectiveness of your restoration project. Similarly, the effects of an individual or series of restoration project may extend beyond the project area.

3.1.1 Watershed Assessment

Watershed assessments provide the context for evaluating the spatial and temporal variability of watershed inputs (water, sediment, organic material, energy, and solutes), their effects on watershed -, reach-, and site -level habitat conditions and species populations, and their relationship with past, current, and future land management. Understanding this relationship may allow one to determine cause and affect relationships and to differentiate between anthropogenic and natural shifts in habitat and population conditions. Identifying the root cause(s) of habitat degradation is necessary to successfully restore stream ecosystems. Projects that address only the symptom of a problem, rather than its cause, will provide only short-term localized benefit.

Reid (1998)[1] lists the following questions as examples of what watershed assessments can best address:

- "What areas are important for fish [and wildlife], and why?
- Where has habitat been impaired?
- What aspects of the habitat have changed?
- What caused those changes?
- What is the relative importance of the various habitat changes to fish [and wildlife]?
- What is the present trend of changes in the system?
- Which changes are reversible?
- What is the expected effectiveness of the potential remedies?
- What are the effects of those remedies on other land uses, [infrastructure], and ecosystem components?
- What are the relative costs of the potential remedies over the long term?"

Watershed assessments may also assist in:

- Identifying watershed-wide constraints and opportunities for habitat restoration, enhancement, and preservation (Habitat restoration is of little long-term value in a watershed incapable of supporting the processes that create and maintain habitat conditions),
- Integrating planning efforts to avoid the problems and inefficiencies that result from multiple actions within a basin performed in isolation of each other,
- Developing prioritized restoration strategies that target projects and drainages that offer the greatest potential for collectively achieving long-term restoration goals at the lowest cost,
- Determining the appropriate scale at which to implement restoration, rehabilitation, enhancement, and preservation efforts, and
- Developing monitoring strategies and objectives to determine the individual or collective effectiveness of restoration measures conducted throughout the watershed. Such measure

is necessary to monitor and adaptively manage the watershed's overall restoration strategy.

3.1.2 Reach Assessment

A reach assessment addresses conditions found within a specific length of stream. It may be limited to the stream channel itself, or it may extend laterally to adjacent contributing areas. Channel reaches are typically many channel widths in length and exhibit similar geomorphic characteristics throughout, such as channel pattern, slope, confinement, or sediment size[2].

Reach assessments can be used to collect information essential to project planning, development, and implementation. Reach assessments can identify, quantify, and evaluate the condition of species and the abundance and quality of habitat contained within. They can describe the relationship between species inhabiting the area, existing habitat conditions, and the habitat-forming processes acting within that reach. They can identify restoration constraints and opportunities within the reach. And they may identify limiting factors to the health and abundance of species that spend their entire life cycle within that reach. But their limited scope may not allow one to assess limiting factors to migratory species that spend some part of their life cycle outside the study reach. Their limited extent may also prevent the cause of any habitat deficiency from being revealed if the cause lies outside the study reach. As a result, treatment may only partially address the problem or be limited to addressing the symptom of a problem rather than the cause. Because reach assessments, by definition, cover a larger area than site assessments, they are better able to predict the impacts a project might have on upstream, downstream, and adjacent habitat and infrastructure. But their limited scope leaves them incapable of evaluating the cumulative watershed effects that lie outside the study area.

3.1.3 Site Assessment

Sound project design requires knowledge of the condition and layout of the project site. For instance, riparian planting projects require knowledge of soil type and condition; light and moisture availability; the extent, frequency, duration, and depth of flooding; land management; and wildlife use of the area, among other variables. Such knowledge enables the designer, to select appropriate plant species and site preparation and maintenance techniques. In addition to being a necessary design tool, site assessments are capable of identifying, quantifying, and evaluating the condition of species and the abundance and quality of habitat at that particular site. They can explore the spatial relationship among various in-channel habitat components, such as the proximity of cover to spawning habitat, or the connectivity of off-channel and in-channel habitat. And they can identify site-based restoration constraints and opportunities.

But site assessments are inadequate for identifying limiting factors to species health and abundance unless the species spends its entire life cycle within that particular site (e.g., vegetation, certain macroinvertebrates). They are also incapable of identifying the cause of any problems that originate from outside the site. For instance, although plants are stationary, their health, species composition, distribution, and extent are influenced by the availability of light, water, and nutrients, patterns of sedimentation and inundation, and the type, magnitude and frequency of disturbance. Each of these factors are controlled by site, reach and watershed-scale processes. Likewise, site-scale assessment may be inadequate to predict how an individual project may influence upstream, downstream, and adjacent habitat, infrastructure, and channel stability. Hence, well-intentioned projects implemented to enhance habitat may inadvertently damage or impair other habitat or biota, destabilize the channel bed or banks, or put nearby infrastructure at risk.

3.2 Conducting Assessments

Humans can alter habitat and habitat availability within the stream corridor directly through channelization, bank armoring, stream cleaning, and levee construction activities, among others, or indirectly through landuse activities within the watershed. The cumulative impact of land use activities may cause a series of channel and watershed responses that destabilize the stream or degrade habitat conditions, water quality, or fish and wildlife productivity. Degraded conditions may also result from natural disturbance (e.g., floods, landslides, fire, or debris torrents). Because the issues and cause and effect relationships vary both within and between watersheds, every assessment is unique, even if the reasons for conducting the analysis are the same. Assessments must be tailored to address the specific topics of interest and objectives of those conducting the analysis.

3.2.1 Assessment Topics

Stream habitat assessment includes the reconnaissance, measurement, and documentation of existing conditions, historic conditions, and predicted future conditions as they relate to fish and wildlife species population and distribution, and the processes that influence and determine stream habitat. The habitat of an organism is defined by its physical (e.g., velocity, depth, substrate), chemical (e.g., dissolved oxygen, nutrient, and contaminant levels), and biological (e.g., predator-prey, competitive, and symbiotic relationships) characteristics[3]. Hence, an assessment of the value, distribution, abundance, and accessibility of stream habitat may include physical, chemical, and/or biological surveys. Which components are evaluated and to what extent depends on project and restoration objectives, site, reach, and watershed conditions, and the scale(s) of analysis. Note that it may be very difficult to collect historical data and its proper use is often problematic. For example, how far back in history do we have to go to get a look at natural habitat, and is that information still relevant to the species given the possibilities for restoration?

Landuse throughout the watershed directly and indirectly influences habitat conditions, and it may disturb (e.g., noise, artificial light), limit migration (e.g., dams, culverts, levees, tide gates), or create dangerous situations (e.g., roads) for fish and wildlife. Thus, habitat assessments are often done in conjunction with landuse, land management, landowner, and infrastructure assessments. It is important to note that it can be difficult to establish clear causality between cumulative land use activities, especially with regards to biological response (establishing a link between watershed activities and physical channel response may be more clear). Lag time between action and response can be years or decades, and the greater the lag time, the more opportunity for additional influences to come in to play. For example, it may take decades for sediment inputs associated with logging to accumulate in downstream sites[4].

3.2.1.1 <u>Physical Habitat Assessment</u>

A physical habitat assessment describes the structure and composition of a landscape. Physical habitat assessment may consist of:

- Documenting physical characteristics of the land and stream such as topography, feature dimensions, soils, stream bed and bank characteristics, channel characteristics (entrenchment, sinuosity, channel migration zone), vegetation, and drainage basin boundaries, size, and shape.

- Evaluating channel stability. Is the channel actively aggrading or incising?
- Evaluating the abundance, distribution, proximity, condition, and accessibility of various types of habitat. Is there potentially productive habitat that is currently inaccessible because it lies behind levees or upstream of impassible culverts, tide gates, dams, or other stream or floodplain obstructions?
- Documenting landuse, land cover, and infrastructure, including those that place constraints on the channel, floodplain, or habitat-forming processes.
- Documenting the extent, type, and location of direct stream and floodplain modifications (e.g., channel straightening, dredging, diking, armoring, or cleaning; dams; floodplain fill) that have occurred.
- Identifying barriers and constraints to fish and wildlife passage between critical habitats (e.g., culverts, roads, levees, high flow velocities, low flow depths). Are they temporary, partial, or complete barriers?
- Determining physical habitat deficiencies (limiting factors) that limit fish, wildlife, and plant productivity within the stream corridor.
- Identifying potential constraints to ecosystem recovery and restoration.

Consider current conditions as well as how each of these characteristics has been altered from historic conditions and how they will change over time if current landuse activities, regulations, and trends continue. Many characteristics vary over time and space in response to variations in climate, geology, vegetation, the frequency, magnitude, type, and proximity of disturbance, and site-, reach-, and watershed-scale processes. Therefore, evaluation of the processes that determine the physical characteristics of an area is an integral component of physical habitat assessment. Principal processes that influence channel morphology and physical habitat conditions include the delivery and routing of[5 6 7]:

Sediment: Evaluation may include identifying, locating and determining the relative dominance of current sediment sources to the stream (e.g., mass wasting events, channel incision, bank erosion, surface erosion), predicting where future erosion is likely to occur, evaluating whether individual sources are temporary or long-term, sediment size distribution, suspended sediment concentrations, or the rate of sediment transport to and from the site, reach, or watershed (sediment budget). Consider also how these have been altered from historic conditions and how they will change over time. What are the natural and human causes of changes between historic and current conditions? How is the supply of sediment affected by other controls and processes (e.g., surface runoff, vegetation, stream discharge)? How does the supply of sediment affect other processes (e.g., wood recruitment) and channel stability? Assessments concerning sediment supply and erosion may include inventories of landslides, roads that present a landslide hazard, and surface erosion hazards (e.g., unvegetated or disturbed soil areas), calculations of road density, or identification of dams, reservoirs, and instream detention basins that prevent downstream sediment transport. Refer to Chapter 4.5.1, *Restoring Sediment Supply*, of this document for information on the function and value of sediment in a stream, potential human impacts to sediment supply and transport, and potential techniques to address those impacts. Refer to the *Sediment Transport Appendix* for further information on evaluating sediment transport. [8]

Water: Evaluation may include determining the rate and timing of discharge to and from (water withdrawals) the stream, the frequency, depth, duration, and extent of floodplain inundation, and the routing and storage of water within the watershed, determining peak flows, dominant flows, and minimum flows, and locating special hydrologic features such as springs and groundwater recharge areas. Is the flow comprised dominantly of surface water or groundwater? Is the watershed subject to rain-on-snow events? Consider also how these have been altered from historic conditions and how they will change over time. What are the natural and human causes of changes between historic and current conditions? How is discharge affected by other controls and processes (e.g., vegetation, fire, floodplain connectivity, channel roughness)? How does discharge affect other processes (e.g., species migration, channel migration, sediment delivery) and channel stability? Assessments concerning stream flow regime may include an evaluation of how the flow regime has been affected by dams, water withdrawals, stormwater drainage networks, wetland drainage and fill, floodplain drainage and fill, land cover changes, stream channel and floodplain modifications, and by increasing amounts of impervious surface in the watershed. Or it may include an assessment of the connectivity of stream channels, floodplains, wetlands, side channels, and other off-channel habitats. How much of the floodplain is no longer accessible to overbank flows? Refer to Chapter 4.5.2, *Restoring Stream Flow Regime*, of this document for information on the function and value of water in a stream, potential human impacts to water supply and transport, and potential techniques to address those impacts. Refer to the *Hydrology Appendix* for more information on evaluating watershed hydrology.[5 6]

Organic material (large wood and detritus): Evaluation may include the age, extent, species composition, and distribution of riparian and upland plant communities, or the distribution, abundance, species, and size of large wood in the stream. Consider also how these have been altered from historic conditions and how they will change over time. What are the natural and human causes of changes between historic and current conditions? How is the organic material supplied to the stream affected by other controls and processes (e.g., fire, wind throw, mass wasting, flooding, vegetation)? How does it affect other processes (e.g., sediment storage, scour, channel migration, primary productivity, disturbance, species migration) and channel roughness, gradient, and stability? Assessments concerning organic inputs to the stream may include riparian vegetation and in or near-stream large wood surveys, the history of fire, fire suppression, landslides, bank erosion, flooding, blow down, and other recruitment mechanisms for large wood, the history of stream cleaning, timber harvest, and land cover changes, and inventories of obstructions to large wood transport (e.g., culverts, bridges, dams). Refer to the *Large Wood and Log Jams* technique and the *Riparian Restoration and Management* technique for further information on instream wood and riparian habitat, respectively.[5 6 8]

Energy (light and heat): Evaluation may include the degree of shade provided to the stream, or the turbidity (as turbidity increases, light penetration decreases), temperature, and flow of the stream, its tributaries, and other natural or artificial discharges to the stream. Consider also how these have been altered from historic conditions and how they will change over time. Is the dominant source of water to the stream groundwater or surface water? What are the natural and human causes of changes between historic and current conditions? How is the energy supplied to the stream affected by other controls and processes (e.g., vegetation, discharge, hyporheic flow, sediment supply)? How does it affect other processes (e.g., biotic productivity, dissolved oxygen content)? Assessments concerning energy inputs to the stream may include inventories of the temperature, turbidity, and flow regime of the stream and natural and artificial discharges to the stream, the rate and timing of water withdrawals (shallow water heats up faster than deep water), the extent and nature of modified channels (over-wide and flat bottomed channels will have relatively shallow flow), direct measurements of shade or indirect measurements based on the height, extent, species composition, and canopy cover of nearby vegetation that provide shade to the stream. It may also include an inventory of natural and artificial impoundments that allow water to heat up. Does the water released from those impoundments come from the surface of the reservoir (where it will be warmest) or from lower down?

Physical habitat inventories may be conducted at a watershed-, reach-, or site scale. However, evaluation of the processes that create, maintain, and connect those habitats will likely need to occur on a watershed-scale.

3.2.1.2 Chemical Habitat Assessment

The concentration of solutes (substances capable of dissolving in water) in a stream is a major factor in determining the quality of habitat for aquatic organisms and for terrestrial and avian species that drink the water or prey on aquatic species. Some solutes may be beneficial or necessary to support life within a certain range of concentrations (e.g., dissolved oxygen, nutrients) while others have only detrimental impacts above a certain threshold concentration. Where water quality is impaired, restoration of physical habitat in the absence of water quality improvement measures will provide minimal benefit, if any.

Chemical habitat assessment may include :

- Monitoring water quality. Are the surface water quality standards described in WAC173-201A being met? If not, how often and under what conditions are they out of compliance?
- Identifying the source, fate, and transport pathways for solutes of interest. As solutes are derived from numerous natural and anthropogenic sources, evaluation of land use activities within the watershed may be a necessary component of chemical habitat assessment. How have changes in land cover, land use, hydromodification, stream and floodplain modifications, and legal and illegal effluent discharges to the stream altered the source, fate, and transport of pollutants? Documenting current and historic escapement levels of anadromous fish may be necessary in streams deficient in marine-derived nutrients supplied by anadromous fish carcasses.
- Monitoring streamflow, which directly influences the concentration of solutes in the stream.

- Defining any associations between water quality and the present condition of species in an area. Is water quality a limiting factor to fish, wildlife, and plant productivity within the stream corridor?
- Determining how water quality is affected by other controls and ecosystem processes (e.g., mass wasting, flooding, stream flow, shade, vegetation, soils)?
- Identifying beneficial uses that are dependent on water quality (e.g., fish and wildlife species that dwell in or drink from the stream, near-shore, or marine environment; fish, wildlife, and people that consume fish and wildlife that dwell in or drink from the stream, near-shore, or marine environment; drinking water; irrigation water, swimming).

Consider current conditions as well as how each of these characteristics has been altered from historic conditions and how they will change over time if current landuse activities, regulations, and trends continue. Refer to Chapter 4.5.4, *Restoring Water Quality*, of this document for information on potential human impacts to water quality, and potential techniques to address those impacts.

Chemical assessment can be conducted at the watershed, reach, or site scale. Because water quality varies with flow and with processes that influence the supply, transport, and fate of solutes in a stream, the frequency and timing of measurement is one of the biggest determinants of the value of the data, no matter what scale of assessment is conducted.

3.2.1.3 Biological assessment

Biological assessment may encompass any and all life within the stream corridor, though it's scope is often limited to a particular species, group of species, or type of life form (e.g., vegetation, birds, reptiles, amphibians, fish, invertebrates). Biological habitat assessment may include [9]:

- Determining the relative abundance and distribution of species present in, or dependent upon, the stream corridor, including identification of threatened or endangered species, native and non-native species, resident and migratory species.
- Identifying species that have been extirpated.
- Identifying biotic invaders that may impede or prevent recovery
- Measuring the age, size, growth rate, and condition of species present. Condition may refer to physical ailments or abnormalities, the presence of parasites or pathogens, or to the genetic integrity of stocks. What factors are responsible for this condition?
- Documenting the life histories of species, including how and when they use different parts of a stream network (the needs of the individual species may vary from season to season and from year to year).
- Determining interactions among species present, including dependency (e.g., predator/prey, parasitic, or symbiotic relationships) and competition among species for available habitat or resources.
- Documenting harvest and harvest management over time

Consider current conditions as well as how each of these characteristics has been altered from historic conditions and how they will change over time if current landuse activities, regulations, and trends continue. Because people, pets, and livestock also make up part of the biological community, their proximity and role as predator, prey, and disturber of fish and wildlife, may also be evaluated as part of a biological assessment.

Biological assessment can be conducted at the watershed-, reach-, or site-scale, depending on the assessment goals. Certain objectives require large-scale analysis. For instance, the scale of assessment necessary to conduct population and limiting factors studies must equal the range of migration for the species of interest. Such analysis may go beyond the watershed to encompass entire flyways (e.g., migratory birds) or marine and near-shore environments (e.g., anadromous fish).

3.2.2 Determining the Scale of Assessment

Information gleaned from an assessment varies with the scale of analysis. Information from multiple scales complements one another. Habitat assessment at a site or reach scale may reveal the effects of impacts to watershed-scale processes. Similarly, limitations to habitat potential at the site or reach scale may identify watershed assessment needs. For instance, a decrease in the abundance of pool and cover habitat within a particular stream reach may trigger an assessment of instream wood, riparian vegetation, and sediment supply to determine the root cause of the change. Broader scales of analysis allow individual sites, issues, and concerns to be viewed in a larger context, increasing the likelihood of identifying and addressing core problems and fully assessing how a potential project will impact, respond to, and function within the landscape. Unless a problem, its cause, and its potential treatment impacts are clearly limited to a specific site (e.g., water quality degradation immediately downstream of an industrial discharge pipe), focus on restoration of individual sites is only appropriate after developing some understanding of how those sites fit within the broader landscape. An overview watershed analysis that identifies broader ecosystem problems is recommended prior to initiating isolated restoration activities. Note that such an analyses does not necessarily need to be extremely detailed or costly.]

Even watershed assessments can be conducted at multiple scales. A watershed is any area of land that drains to a common point. A watershed-scale assessment extends from the mouth of the stream to the far reaches of its drainage basin. Because the watershed of a small tributary stream is nested within the watersheds of successive larger streams, watershed-scale assessment may mean different things to different people. Its focus may be limited to the tributary or it may encompass the entire river basin including the main-stem and all tributaries. The size of watershed included in an assessment varies with the study objectives, topics to be addressed, and the physical, biological, and social complexity of the system. A site or reach-specific problem, such as water quality concerns or insufficient instream cover or pool habitat for resident aquatic species, requires an assessment only of the local watershed to determine the cause of the problem, though risks and benefits to habitat and infrastructure associated with proposed treatments should also be considered as the effects of individual projects may extend up- or down-stream. Other topics, such as fish and wildlife population studies, or limiting factors for the productivity of migratory fish and wildlife species (e.g., migratory waterfowl, anadromous fish species) require assessment at larger scales, and may include the marine and nearshore environments.

Reid provides a comprehensive description and evaluation of a number of approaches and procedures for watershed assessment, ranging from "ad hoc" approaches that focus on specific issues in specific areas to broad watershed analyses that seek to understand watershed conditions and identify issues of concern. She describes two of the most widely accepted and implemented watershed assessment procedures that are applied in Washington State:

> *Ecosystem Analysis at the Watershed Scale: Federal Guide for Watershed Analysis*. This guide was completed under the direction of the Regional Interagency Executive Committee and the Intergovernmental Advisory Committee, representing multiple federal agencies. It describes a 6-step process that focuses on seven core analysis topics (erosion processes, hydrology, vegetation, stream channel, water quality, species and habitats, and human uses) as well as specific problems or concerns identified in the watershed. Analysis teams identify and describe ecological processes of greatest concern, establish how well or poorly those processes are functioning, and determine the conditions under which management activities, including restoration, should and should not take place. The analysis itself is not prescriptive, but it provides the objective background information from which later management decisions and environmental impact assessments can be based. This analysis has a broad scope, capable of providing information to evaluate a range of land use issues.
>
> *Standard Methodology for Conducting Watershed Analysis Manual, Version 4.0*[10]. This method was developed by a multitude of state agencies, tribes, members of the forest products industry, small private landowners, and environmental groups who were participating or otherwise involved in the Timber, Fish, and Wildlife Agreement. The assessment method presented is stepped and iterative, consisting of two parts—resource assessment and management prescription. A series of key questions provides a framework to develop information and interpret the condition and sensitivity of public resources within the watershed, including fish habitat (salmonid emphasis), water quality, water supply, and public works. These findings then feed into a prescription process where local land managers and agencies develop a tailored forest management plan for the watershed that responds to the identified resource concerns. The manual also includes modules that describe how to evaluate mass wasting, surface erosion, hydrologic change, riparian function, fish habitat, water quality, and public capital improvements. The procedure currently focuses on impacts to aquatic habitat. Terrestrial habitat may be addressed at a later date.

Two watershed assessment methodologies developed in Washington State since Reid's publication include:

> *State of Washington Guidance on Watershed Assessment for Salmon*. The Joint Natural Resources Cabinet, representing multiple state and tribal agencies and planning councils, developed this document. The guidance provided is oriented towards identifying problems and issues in salmon recovery for specific watersheds. It presents three stages of watershed assessment: 1) Habitat Conditions--what habitat conditions are limiting salmon production? 2) Causes of Conditions--what processes or land uses are causing the habitat conditions?, and 3) Salmon Response to Conditions--what linkages exist between salmon and

habitat conditions? Successive stages of assessment build on one another and support increasingly complex issues and decisions with regards to habitat preservation and restoration. Though the focus of the document is on salmon habitat, products may have broader application. The guidance does not explain how to assess various parameters, however, it contains an appendix that lists the various types of assessment that may be necessary and their relation to existing statewide information sources.

Enhancing Transportation Project Delivery Through Watershed Characterization: Methods and SR522 Case Study. Review Draft Report to the Transportation Permit Efficiency and Accountability Committee. The Watershed-Based Mitigation Subcommittee, created by Washington's Environmental Permit Streamlining Act in 2001, developed this report. It summarizes a scientific framework and set of procedures being developed at multiple watershed scales to identify and prioritize sites having potential to mitigate for transportation impacts. The framework consists of three parts: 1) Project site assessment –understanding the transportation project's potential environmental impacts, 2) Watershed characterization and cumulative impact assessment – characterizing effects of land use on ecological processes and aquatic and terrestrial resources, and 3) Identify and assess potential sites – ranking potential mitigation sites and selecting the preferred mitigation site. Each part includes a series of generalized steps that form the scientific framework for watershed characterization. Recovery efforts focus on recovery of ecosystem processes that create and maintain habitat in order to maximize the environmental benefit and longevity of mitigation activities.

The following is not a watershed assessment. However, when applied at a watershed scale, it can be used to rapidly identify stream reaches that appear to be functioning well and are candidates for protection and preservation, and those that are functioning poorly and require further review and assessment to reveal the cause of impairment and identify potential remedies.

Process for Assessing Proper Functioning Condition (PFC)[11]. PFC was first developed by the Bureau of Land management, and adopted by all other federal land management agencies. It is a qualitative assessment system used to evaluate how the stream is handling the energy flowing through it. Assessment is based on hydrology and geomorphology, riparian vegetation, and soils. It results in a classification of streams, reach by reach, as exhibiting "proper functioning condition", "functional, but at risk", "nonfunctional", or "unknown". Non-functional stream reaches are those that lack adequate vegetation, landform, or large wood to dissipate stream energy, indicative that the channel itself or the processes that create, maintain, and connect habitat within such reaches have likely been altered from historic conditions. PFC's strength lies in its relatively rapid application.

Each of the watershed assessment methods described above was developed with specific objectives in mind. Despite their differences, they share a common philosophy that:

1. General patterns exhibited through a watershed are more important to consider than specific details.
2. Understanding of interactions among watershed components and processes is more important than understanding of the individual components.
3. Qualitative descriptions and order-of-magnitude estimates are often of greater value than precise numbers.

The choice of which watershed analysis to use depends on the problems being addressed and the objectives of those conducting the assessment. Planners are encouraged to review the inherent assumptions, potential application, limitations, and required time, cost, and expertise of a procedure, as well as the utility and credibility of its results prior to making a selection.

Conducting an assessment costs time and money, both of which increase with the number of parameters studied, the level of detail required to describe each parameter (e.g., quantitative vs. qualitative analysis), and the geographic extent of the study. Limited resources may limit the scope and scale of assessment. But the cost and time associated with assessment must be weighed against the amount and type of data necessary to provide meaningful results. The success of an assessment is measured by its utility to decision makers and resource specialists applying the results.

Where available time and funding for watershed assessment is limited, it may be appropriate to limit its scope to that necessary to plan, design, and implement low risk restoration activities that offer a high likelihood of success. Roni et al.[5] reviewed the effectiveness of various restoration methods for improving salmonid habitat. Results, summarized in **Table 3.1**, suggest the highest likelihood of success is associated with preserving high quality habitat; reconnecting isolated high quality instream, floodplain, and estuary habitats that are currently inaccessible as a result of barrier culverts, dams, levees, or other artificial structures; and restoring ecosystem processes and controls through projects such as road abandonment and improvement, and riparian restoration. With that in mind, if a full culvert assessment has not been done in a low gradient watershed, a culvert assessment might be a good place to start. In watersheds with a history of mass wasting and identified sedimentation concerns, consider conducting a mass wasting assessment. In an area subject to urban growth, identification and assessment of undeveloped riparian zones and floodplains that can be acquired represents important opportunities that may soon be lost. Information from similar watersheds, in conjunction with the help of professional scientists and resource managers with previous experience in the region can play an important role in prioritizing watershed assessment efforts, when prioritization in necessary. Areas with similar geology, geography, landuse, and climate often have similar needs for restoration.

Table 3.1. Typical response time, duration (plus sign means it could extend beyond the indicated duration), variability in success, and probability of success (low = L, moderate = M, high = H) of common restoration techniques.

[Insert table 6 from Roni et al (2002)—need copyright permission]

Where sustained long-term funding is available, assessments may be incremental, with efforts focusing on new sub-basins within a watershed, or issues and effects not previously assessed.

However, it is important to integrate incremental assessments with previous information to get a better handle on the cumulative effects and cause and effect relationships between physical, chemical, and biotic processes operating in watersheds.

It is recommended that the following considerations be made when determining the necessary scope and scale of assessment for restoration and project planning:

Restoration Planning:

- What are your assessment goals? Is there a particular issue you are trying to address (e.g., elevated nitrogen and low dissolved oxygen concentrations in the nearshore environment) or is your objective to identify and prioritize issues and restoration/management initiatives in the watershed? Is your objective restricted to project-specific reconnaissance?
- How much is already known about the stream, its watershed, and the fish and wildlife that it supports? Have other studies been conducted such that the proposed assessment is unnecessary or its scope can be limited to avoid redundancy of effort? Can the current assessment fill critical data gaps identified in previous analyses?
- Are other restoration projects likely to occur in the watershed that can benefit from the assessment? Encourage and pursue opportunities for coordinated and cooperative analysis efforts. Because watershed analysis promotes the long-term viability of an overall restoration strategy, it may be practical to pursue cost sharing of assessment among numerous smaller projects.
- What is the spatial and temporal scale of the problem? Is it localized or system-wide?
- What is the spatial and temporal scale of the cause of the problem? Keep in mind that limitations to habitat potential at the site or reach scale may sometimes be explained only by assessing watershed-scale processes. The scale of assessment much match the scale of the underlying cause of the problem if it is to be correctly identified and addressed. For instance, sedimentation of spawning gravels resulting from watershed-wide land use impacts will require watershed assessment to identify dominant sources and prioritize potential remedies.
- What funds are available to conduct an assessment? Could the cost be shared among multiple projects and stakeholders? Could the scope or scale of assessment be modified to attract more funding?

Project Planning:

- What factors and conditions will influence the success or failure of the project?
- What are the nature and scale of impacts associated with the proposed project? What are the possible impacts (including unintentional impacts) to habitat, infrastructure, and fish, wildlife, and human life? How far reaching will those impacts be? What is the likelihood of their occurrence?
- What is the risk of, and associated with, project failure? What is the nature and scale of impacts to habitat, infrastructure, and fish, wildlife, and human life if the project should fail? What is the likelihood of project failure? Many projects have a high risk of failure when the watershed processes and conditions are not well understood. Higher risk projects warrant higher levels of assessment.

- What are the risks associated with a delay of project implementation during the time necessary to conduct an assessment (e.g., further habitat degradation or species extinction)? Studies may take years to accomplish effectively, during which time valuable resources may be lost.

**** NOTE: THE REMAINDER OF THIS CHAPTER IS INCOMPLETE AT THIS TIME ****

[Discuss risk assessment as it relates to geomorphic condition of landscape (e.g., steep channels, entrenched channels, unstable channels (aggrading, incising, alluvial fans), urban watershed]

3.2.3 Necessary Level of Expertise for Conducting Assessments

3.2.4 Limitations of Assessments

Assessment, on any scale, can provide valuable insight into the conditions and issues of concern in a watershed and the underlying cause of those conditions. However, the ability of an assessment to accurately and fully reveal an understanding of what's going on in the watershed, and to provide meaningful results can be limited by any of the following:

- Property ownership and access may limit the area of study.
- The type and resolution of data collected may be limited by time, money, or the limited objectives of those conducting the assessment.
- Scientific understanding of watershed processes is limited and comprehensive and reliable techniques for evaluating watersheds are lacking[12].
- Impacts to environmental resources are influenced by multiple factors and can accumulate through space and time, a fact that complicates the determination of cause and effect relationships and the evaluation of potential future impacts.
- No single discipline covers the many influencing variables, and thus, a study must involve an interdisciplinary team of professionals. This requires coordination and cooperation among the individuals involved.
- Rare events that occurred in the past or elsewhere in the watershed may influence sites a considerable distance downstream, many years or even decades later. Consequently, the temporal and spatial scope of analysis may be insufficient to identify remote or historic causes.
- Lack of historical records may limit our understanding of past conditions.
- The quality, accuracy, and precision of data are dependent upon the knowledge and skill of those collecting and interpreting the data. Training is essential to minimize human error and ensure consistent application of data collection methods.
- The quality, accuracy, and resolution of data are influenced by the tools and methods employed for data collection.

Consider these limitations when evaluating the level of confidence inherent to a study.

3.3 Assessment Methodologies

There is no single resource for the State of Washington that provides comprehensive guidance and instruction in how to conduct an assessment for stream habitat restoration.

3.3.1 Published Reviews of Assessment Methodologies

3.3.2 Published Assessment Methodologies

List the most common methodologies. Note that the list is not exhaustive, nor is it meant to limit the reader. For each, we will provide a citation and a brief description of the type of information to be gained.

Consider WDNR (1995)[13], Skagit Watershed Council (1999)[14], and Watershed Professionals Network (1999)[15].

3.3.2.1 <u>Physical Habitat Assessment</u>

3.3.2.2 <u>Chemical Habitat Assessment</u>

3.3.2.3 <u>Biological Habitat Assessment</u>

> Limiting Factors Analysis- if some sort of standardized protocol exists, need to get a reference and describe what it tells you—check with Conservation Commission--limitation is that it is very species specific

3.3.3 Suggested Sources of Data and Information

When conducting an assessment, always start with existing information and previous watershed assessments and inventories to avoid duplicating efforts. Most watersheds in Washington State have undergone previous assessment and restoration planning. However, the scope, scale, or quality of the assessment may be inadequate for some purposes. There may be considerable data available for many components of the assessment. Other components may require considerable original field data collection and data from remote sources. Be aware that the scale and scope of assessment is greatly influenced by the objectives of those conducting it. For instance, methods employed and data collected during a reach assessment that evaluates channel migration over time will differ from that collected during a reach assessment of available pool habitat, large wood, spawning redd counts, or dissolved oxygen levels. Assessments conducted at a site level will likely be highly project specific as site assessment is conducted primarily for the purpose of implementing a project.

In addition to published assessments, there is a wealth of publicly available information that may be useful. [This list needs to be expanded. Can refer reader to Section 2.1 of Rapp and Abbe[16], in press, for more information, if appropriate.]

- Air photos
- GIS maps
- Satellite photos
- Historic records

- USGS stream gage and water quality data
- Literature search
- Priority habitat species maps (available from WDFW)
- Anecdotal information. Speak with local city, county, and agency experts (biologists, geomorphologists, historians, etc) and landowners

The quality of information directly influences its utility. Therefore, those conducting an assessment should consider the following factors before using such information:

- Is the data relevant to the assessment question or issue being addressed?
- Is it compatible with other relevant analyses?
- Is it of an appropriate age?

Is it of sufficient quality? Consider its accuracy, completeness, data collection, handling, and analysis methods.

The reader is encouraged to make the results of their assessment publicly available so that others may benefit and build upon it.

3.4 References

3.4.1 Additional Reading

Abbe, T. B. and D. R. Montgomery. 1996. Large woody debris jams, channel hydraulics and habitat formation in large rivers. Regulated Rivers: Research & Management 12:201-221.

Bilby, R. E. and J. W. Ward. 1989. Changes in characteristics and function of woody debris with increasing size of streams in western Washington. Transactions of the American Fisheries Society 118:368-378.

Church, M. 1992. Channel Morphology and Typology. *In*: The Rivers Handbook, Vol. 1, Blackwell Scientific Publications, P. Calow and G. E. Petts (Editors). Oxford, England.

Gordon, N. D., McMahon, T. A., and B. L. Finlayson. 1992. Stream Hydrology: An Introduction for Ecologists. John Wiley & Sons, England.

Knighton, D. 1998. Fluvial forms and processes: A New Perspective. Arnold, London, England.

Knighton, D. and G. C. Nanson. 1993. Anastomosis and the continuum of channel pattern. Earth Surface Processes and Landforms 18:613-625.

Leopold, L. B., Wolman, M. G., and J. P. Miller. 1964. Fluvial Processes in Geomorphology. Dover Publications, New York.

Makaske, B. 2001. Anastomosing rivers: a review of their classification, origin, and sedimentary products. Earth-Science Reviews 53:149-196.

Montgomery, D. R., G. Grant, and K. Sullivan. 1995. Watershed analysis as a framework for implementing ecosystem management. Water Resources Bulletin 31(3): 369-386.

Mount, J. F., 1995. California Rivers and Streams the Conflict between Fluvial Process and Land Use. University of California Press, Berkeley, California.

Moody, J. A. and B. M. Troutman. 2000. Quantitative model of the growth of floodplains by vertical accretion. Earth Surface processes and Landforms 25:115-113.

Naiman, R. and R. E. Bilby (Editors). 1998. River Ecology and Management: Lessons from the Pacific Coastal Ecoregion. Springer-Verlag, New York, New York.

Rapp, C. F and T. B. Abbe. In press. The Delineation of Channel Migration Zones: A Guidance Document for the State of Washington. Washington State Department of Ecology, Olympia, Washington.

3.4.2 Cited References

---

[1] Reid, L. M. 1998. Cumulative watershed effects and watershed analysis. Pages 476 to 501 *In*: Naiman, R. J. and R. E. Bilby (editors), River Ecology and Management – Lessons from the Pacific Coastal Ecoregion. Springer-Verlag, Inc., New York. 477 pp.

[2] Montgomery, D. R. and J. M. Buffington. 1998. Channel processes, classification, and response. Pages 13 to 42 *In*: Naiman, R.J. and R. E. Bilby (editors), River Ecology and Management – Lessons from the Pacific Coastal Ecoregion. Springer-Verlag, Inc., New York. 477 pp.

[3] Cowx, I. G. and R. L. Welcomme. 1998. Rehabilitation of Rivers for Fish. Published by arrangement with the Food and Agriculture Organization of the United Nations by Fishing News Books. Alden Press, Oxford and Northampton, Great Britain. 260 pp.

[4] Madej. M. A. and V. Ozaki. 1996. Channel response to sediment wave propagation and movement, Redwood Creek, California. Earth Surface Processes and Landforms 21:911-927.

[5] Roni. P., T. J. Beechie, R. E. Bilby, F. E. Leonetti, M. M. Pollock, and G. R. Pess. 2002. A Review of Stream Restoration Techniques and a Hierarchical Strategy for Prioritizing Restoration in Pacific Northwest Watersheds. North American Journal of Fisheries Management 22:1-20.

[6] Gersib, R. A., A. Wald, T. Hilliard, R. Schanz, L. Driscoll, A. Perez, J. Franklin, B. Aberle. 2003. Enhancing Transportation Project Delivery Through Watershed Characterization: Methods and SR522 Case Study. Review Draft Report to the Transportation Permit Efficiency and Accountability Committee. Washington Departments of Transportation and Ecology. Olympia, Washington. 104 pp.
Hwww.wsdot.wa.gov/environment/streamlineact/watershed.htmH

[7] Joint Natural Resources Cabinet. 2001. Guidance on Watershed Assessment for Salmon. Governor's Salmon Recovery Office, Olympia, Washington. 54 pp.

[8] Regional Ecosystem Office. 1995. Ecosystem Analysis at the Watershed Scale: Federal Guide for Watershed Analysis, Version 2.2. U.S. Government Printing Office, Portland, Oregon. 26 pp.

[9] Kauffman, J. B., R. L. Beschta, N. Otting, and D. Lytjen. 1997. An ecological perspective of riparian and stream restoration in the western United States. Fisheries 22(5):12-24.

[10] Washington Forest Practices Board. 1997. Standard Methodology for Conducting Watershed Analysis Manual, Version 4.0. Department of Natural Resources Forest Practices Division, Olympia, Washington.

[11] U.S. Department of the Interior, Bureau of Land Management. 1993. Riparian Area Management: Process for Assessing Proper Functioning Condition. Technical Reference 1737-9. Denver, Colorado. 51 pp.

[12] National Research Council, 1996. Upstream: Salmon and Society in the Pacific Northwest. National Academy Press, Washington D.C. 452 pp.

[13] WDNR. 1995. Standard methodology for conducting watershed analysis. Washington Forest Practices Board, Washington Department of Natural Resources, Olympia, Washington.

[14] Skagit Watershed Council. 1999. Application of the Skagit Watershed Council's strategy: river basin analysis of the Skagit and Samish basins – tools for salmon habitat restoration and protection. Skagit Watershed Council, Mount Vernon, Washington.

[15] Watershed Professionals Network. 1999. Oregon watershed assessment manual. Report to Governor's Watershed Enhancement Board, Salem, Oregon.

[16] Rapp, C. F and T. B. Abbe. In press. The Delineation of Channel Migration Zones: A Guidance Document for the State of Washington. Washington State Department of Ecology, Olympia, Washington.