Subbasin Assessment Template for the Northwest Power Planning Council's Fish and Wildlife Program

This document describes a template (or guidelines) for the assessment of conditions in subbasins of the Columbia River Basin. Assessments at the subbasin scale (generally, 4th-field HUC but sometimes 3rd-field HUC) are intended to contribute to the development of regional and subbasin plans that detail priorities and actions to rebuild fish and wildlife and restore the Columbia River ecosystem. This assessment has been developed for the Northwest Power Planning Council's (NWPPC) Fish and Wildlife Program with coordination of other assessment and funding activities throughout the Pacific Northwest.

There are many assessment and planning efforts underway at different spatial scales in the Columbia Basin. These efforts have a variety of purposes, but all are intended to restore fish, wildlife, clean water, and other ecosystem resources to the Columbia Basin. Program managers, including the NWPPC, the federal land management agencies, state governments and Indian Tribes, have explicitly recognized that assessment and planning at the subbasin scale[1] is important for fish and wildlife and clean water program decisions. The subbasin scale is also important for developing and implementing recovery plans for certain threatened and endangered species. Further, the agencies have begun working on strategies to integrate Clean Water Act (CWA) Total Maximum Daily Load (TMDL) and Endangered Species Act (ESA) processes and requirements and a subbasin context may be relevant to this effort. Science-based assessments are useful precedents for subbasin planning because assessments provide an objective and clearly stated scientific foundation for planning decisions. Subbasin assessments that are consistent and repeatable across land ownerships and programs are most useful at larger geographic scales. Consistency assists program managers and stakeholders in collectively assessing present fish and wildlife capability, coordinating priority actions, and measuring progress.

Subbasin assessments provide technical information upon which subbasin plans and other planning activities are based. Assessments and subbasin plans contribute to the overall planning effort but are separate and distinct technical exercises. Assessments help to estimate the resource potential of each subbasin and identify risks and opportunities for recovery. The template proposed here is an outline that suggests the types, spatial and temporal scales, and sources of information most useful for subbasin and regional fish and wildlife planning. It further recommends types of analytical procedures and protocols appropriate for interpreting the data. Subbasin assessment will be an evolving science. Therefore, this document should be viewed as dynamic with improvements incorporated into the process, as they become available.

1. Background and Introduction (establish purpose)

1.1. Purpose of the Assessment

Subbasin assessment establishes the context for assessment at finer geographic scales. It provides an understanding of the core problems within the subbasin and establishes an understanding of the comparative potential of each watershed within the subbasin to contribute to recovery efforts. Subbasin assessment provides the technical information needed by policy decision-makers to prioritize watersheds for more detailed assessment at the watershed scale. The value of subbasin scale assessment lies in its ability to direct more detailed, finer scale assessment to a few key watersheds rather than assessing all. Subbasin assessment characterizes habitat condition and ecosystem processes within a subbasin, provides estimates of relative production and diversity of fish and wildlife, characterizes water quality, and identifies risks and opportunities for ecosystem protection and restoration in preparation for subbasin planning. In the short term, it should use available information. In the long term, assessments will be refined with data collection and further analyses. Consistent application of a subbasin assessment will also allow comparison of conditions between subbasins.

- 1.1.1. Provide a technical foundation for the development of habitat restoration and protection efforts; identify key scientific questions and ecological processes
- 1.1.2. Provide a spatially explicit estimate of the biological potential within the subbasin
- 1.1.3. Provide indication of those parameters of greatest value in finer-scale assessments
- 1.1.4. Provide a general indication of those factors likely to be responsible for limiting habitat recovery in a subbasin

1.2. Describe the utility of the assessment at the subbasin scale and how the analysis relates to efforts at other spatial scales (e.g. Columbia Basin, province, ESU, and watershed, Table 1)

1.3. Indicate the relationship to existing programs and/or assessments (e.g. OWEB, ICBEMP, WSRO, TMDL,etc.) and ongoing decision support tools (e.g. EDT, CRI, PATH and other tools)
1.4. Identify potential participants in the process, data sources, and analytical methods used the subbasin assessments (focused team working w/ local experts) and assessment tools
1.5. Assessments at Finer Spatial Scales (Table 2)

One of the key uses of Subbasin Assessment is to guide more detailed analyses to locations where benefits to focal species are likely to be greatest

1.5.1. Watershed level assessment (5^{th} or 6^{th} field HUC)

Watershed assessment examines the relationship between human activities and habitat for specific watersheds identified as high priority by the Subbasin Assessment. Watershed assessment provides the detailed technical information needed to identify appropriate restoration or protection action within a watershed. Analyses of ecological processes are key to watershed assessments for long term action plans.

1.5.2. Sites/Reach level planning

Site level planning and design is used to implement the actions identified during the watershed assessment.

Products:

- Clear statement of the scope of the assessment within the spatial context of the subbasin, province, ESU and basin levels
- Description of how the assessment relates to and utilizes previously completed or ongoing landscape analyses
- General explanation of the assessment tools that will be employed

2. Subbasin Description (establish landscape context)

The subbasin description characterizes the general environmental conditions across the subbasin (3^{rd} or 4^{th} HUC) and provides information on factors outside the subbasin that could be affecting biological features within the subbasin. This information provides a more broadly based context for interpreting information collected at finer spatial scales (5^{th} or 6^{th} HUC) and facilitates comparisons with assessments of other subbasins.

2.1. Province/ESU context
2.2. Basin-scale (HUC-2) context
  2.2.1. Hydroelectric/project operations
  2.2.2. Out of subbasin harvest
  2.2.3. Climate trends
  2.2.4. Ocean and/or Estuary conditions
2.3. Subbasin characteristics
  2.3.1. Location and general environment (subbasin scale)

Location within the Columbia River Basin and relative to jurisdictional boundaries; counties within subbasin. Size of subbasin (km^2). Climate, geology, and geomorphology of the subbasin. Historic disturbance regime (e.g. frequency and severity of flooding, fire, drought, and insect outbreaks) and how these have been changed by human activities.

    2.3.1.1. Watersheds within the subbasin
    2.3.1.2. Geology
    2.3.1.3. Geomorphology
    2.3.1.4. Climate/weather
    2.3.1.5. Vegetation type
    2.3.1.6. Land cover
    2.3.1.7. Disturbance regimes – change from historic patterns
  2.3.2. Water resources (subbasin scale)

For each major watershed within the subbasin: primary mechanisms for generation of flow in the watershed [e.g., spring snowmelt, rain-dominated, mixed rain and snow]; dominant storage features [e.g., soil water, groundwater, snowpack, wetlands, lakes, artificial storage]; changes from historic conditions in storage features and effects on the stream system/riparian system [aquatic habitat]; runoff timing and quantity; changes in runoff patterns caused by human use and effects on the stream/riparian system [aquatic habitat]; the primary sources for stream flows, lakes and wetlands; description of how the sources have been altered by human activity; description of annual flow variation for primary streams.

    2.3.2.1. Hydrography (map of channel network)

2.3.2.2. Hydrologic regime (runoff pattern, historical and present)
2.3.2.3. Water use (seasonal patterns)
2.3.2.4. Water quality

Products:

- Description of the biophysical environment of the subbasin
- Indication of out-of-subbasin factors potentially impacting within-subbasin biological resources
- Description of changes to the biophysical environment

3. Subbasin Level Characterization of Ecological Conditions and Processes (compile/collect data)

Much of the currently available ecological data for the Columbia Basin have been compiled at the 6th HUC level. For this reason, we propose that data for Subbasin Assessment be organized at this scale, when possible. The scale will be determined by the parameters being measured. Coarser-scale analyses can be accomplished by aggregating information collected at the 6th HUC level. These data will not be used to evaluate ecological characteristics or processes at the watershed scale but will be used in aggregate to describe patterns in conditions across the subbasin. Data necessary for Subbasin Assessment includes information on the physical attributes of the 6th HUCs, the inferred ecological processes responsible for creating and maintaining these features and information on the biological resources. This information provides the basis for comparing conditions across the subbasin, relative sensitivities to land use and, with the biological information, facilitates prioritization of areas for protection and restoration during the planning process. The data categories listed below are intended as examples of the types of information useful in conducting an assessment, but they may be modified as local conditions dictate.

3.1. Environmental Conditions
3.1.1. Land Cover
3.1.1.1. Vegetation type and age; plant communities
3.1.1.2. Successional processes
3.1.1.3. Disturbance types and frequency
3.1.2. Geologic characteristics
3.1.2.1. Channel type distribution
3.1.2.2. Channel gradient and confinement
3.1.2.3. Valley forms and topographic features
Include flood plain condition and connectivity
3.1.2.4. Erosion potential/known sediment production areas
3.1.3. Hydrologic characteristics
3.1.3.1. Hydrologic regime
3.1.3.2. Flood magnitude and frequency
3.1.3.3. Low flow discharge
3.1.3.4. Water diversions and activities that could influence groundwater levels
3.1.3.5. Dams influencing hydrology at the 5th/6th HUC level
3.1.4. Water quality
3.1.4.1. Streams classified as water quality impaired; presumptive causes
3.1.4.2. Nutrient concentrations
3.1.4.3. Temperature
3.1.4.4. Other water quality data
3.1.5. Riparian condition
3.1.5.1. Vegetative cover
3.1.5.2. Riparian landform
3.1.6. Wetlands
3.1.6.1. Location and type of wetlands
3.1.6.2. Proximity and connection to streams
3.1.7. Land ownership and land use

What is the existing ownership pattern? Describe the major categories of use within the subbasin (e.g. forestry; ranching; agriculture; mining; municipal). What percentage of the subbasin does each category cover? What is the trend for each category?

3.1.7.1. Protected areas

What are the major protected areas within the subbasin (e.g. wilderness areas; refugia; wild and scenic rivers; BLM conservation areas; national and state parks, wildlife acquisitions)? Where are they located? What percentage of the subbasin and available habitat types does each category of protected area cover? Additional designations anticipated in the near future? For each protected area identified, discuss the level of conservation and use.

3.1.7.2. Proportion of federal, state and local or private ownership
3.1.7.3. Proportion of area in agriculture, forest, or other land use types
3.1.7.4. Road density, urban/industrial areas, land use zoning
3.1.7.5. Streamside buffers and other riparian management considerations

3.2. Biological Information (presence/absence; abundance, life history traits, etc.)

Population information summarized at the level that matches the scale at which information on habitat is compiled. The scale at which the data is summarized should reflect the population distribution and structure within the subbasin.

3.2.1. Population structure

Indicate the life history patterns present, genetic characteristics, relationships to other populations in the subbasin. Include historic patterns. What are the demographically independent populations of salmonids within the region, and what is the population substructure (McElhany et al 2000).

3.2.2. Existing species list and distribution for fish, wildlife and vegetation
3.2.3. Information for species of interest (focal species)

At a minimum, the species list should include any species listed as threatened or endangered by a state or federal agency.

3.2.4. Population abundance and productivity

What are the current and historical population characteristics for fish abundance, productivity, and habitat capacity? For each focal species, describe the current and historical population abundance, productivity, and habitat capacity. Estimates of abundance and productivity must include naturally produced, naturally spawning individuals. This will involve subtracting out the contributions of hatchery produced fish to natural escapements and productivity. Often, abundance information is not available. For anadromous fishes, spawner abundance often is the only comprehensive data type that is available at the subbasin scale. Other measures of abundance (smolt production, fry density) are more sensitive to freshwater habitat conditions and should be used to support spawner counts whenever possible. Some key questions to be addressed with distribution and abundance data include: What was the historical (pre-development) geographic distribution and its relationship to available habitats? What is the population trend over the past 20-50 years? 10 years? What is the most recent trend?

3.2.5. Population Diversity

What are the current and historical history, morphological, physiological, and genetic diversity for each population?

3.2.6. Limiting Life Stages

What is the timing of the various life-stages? What are the primary sources of mortality of at each life stage? What life stage mortality has the greatest effect on the population growth rate?

3.2.7. Habitat use by species/population and life stage function.

Describe habitat and water quality preferences by life stage for focal species in that subbasin. For each species of interest, what life stages appear to be most dependent on specific habitat types?

3.2.8. Artificial propagation and harvest

Describe, by species, all artificial production programs within the subbasin. What is the management intent? What is the source of the brood stock over time? What is the annual production over time? Where and when are the releases and at what life stage do they occur? Who operates the facility? For fishes, at what stage are they released? Volitional release? Incubation and rearing densities? Spawning protocols? Hatchery water source? For anadromous fishes, what is the trend in escapement to the hatchery? Who operates the facility?

3.2.9. Potential for interaction with introduced or managed species
3.2.10. Level of in-subbasin harvest

What has been the level of harvest on each population through time? Are there effects on life history characteristics (e.g., size) attributable to harvest?

3.2.11. Pathogens

Products:

- Description of status and trends in aquatic and terrestrial habitats and water quality
- Comprehensive (to the extent possible) description of fish and wildlife resources in the subbasin

4. Analyze key parameters (narrative descriptions coupled with maps indicating locations of habitat areas used by species of interest. Analyses are displayed at the spatial scale matched to the species or assemblage being evaluated (e.g., resident – fish 6th HUC; anadromous fish - 5th HUC))

4.1. Coarse-scale association of habitat characteristics and population attributes of species of interest (Figure 2)

One of the primary products of subbasin assessment is identification of those watersheds within a subbasin that are ecologically important to focal species or communities. Identification of these watersheds will assist planners in allocating resources in the most efficacious manner. Multiple methods are available to achieve this goal, and more than one can be used to inform the planning process. These analytical techniques compare habitat attributes at a site to information on species presence or abundance at the site, so that associations between populations and habitat characteristics can be developed. The habitat-population associations can be used to predict the distribution and abundance of a species or a species assemblage for specific locations or watersheds within the subbasin based on assessment of current conditions (and assuming the locations are physically accessible). The predicted distribution information can be used to help focus management actions on watersheds with the greatest potential to support species of concern.

4.1.1. Examine the relationship between habitat attributes and biological information

Several methods are available for associating habitat characteristics with population information. Habitat attributes important to various wildlife communities have been identified for the Columbia Basin. The information collected during the subbasin assessment can be used to verify and refine these associations for each subbasin. Similar approaches have been developed for relating habitat to abundance of fish populations. The simplest methods rely on the opinions of local fish managers and other technical specialists to identify those watersheds within the subbasin that have the greatest potential to support species of interest and identify the factors most likely impacting productive potential. Such an analysis is shown for the Walla Walla subbasin (Table 2). This type of approach is all that is possible in cases where information on population status is very poor or nonexistent. However, in situations where data are more complete, quantitative techniques should be employed. These approaches use available information on abundance of the fish species of interest and relate abundance with habitat characteristics. The ICBEMP analyses utilized a classification regression tree method (CART) to identify relative strength of salmonid populations at a 6th code HUC level across the entire interior Columbia Basin (Rieman et al. 1997; Thurow et al. 1997). This technique identifies watershed variables showing the strongest influence on population abundance. The NMFS' habitat research program is using a similar approach but employing a different statistical technique, Hierarchical Linear Modeling, to determine habitat-population abundance associations for the Salmon River and Willamette River. This method regresses all habitat variables against normalized population abundance values for each year in the data record. As with the CART analysis, this approaches enables the identification of those habitat variables that consistently exhibit a significant relationship to fish abundance. Both of these methods produce a list of watershed and habitat attributes associated with sites that support high densities of key species. With this information, the potential for all watersheds within the subbasin to support species of interest can be predicted, regardless of whether or not information on population status is available. Information on historic conditions can be used to better understand the extent of habitat alteration in an area, and identify watersheds that might be restored to conditions favorable to focal species. Comparison of current and historic conditions also provides a spatially explicit reference to factors responsible for degradation of habitat. However, identifying specific actions to restore habitat in areas with the potential to support focal species will usually require additional analysis at the watershed scale. The subbasin assessment indicates where these finer-scale analyses would be most profitable.

4.1.1.1. Wildlife habitat associations (use tables developed by Multi-Species Framework effort or comparable method)

4.1.1.2. Aquatic species-habitat associations (Multiple techniques are possible. Use the one best suited to the species being examined and the quality of the available data (e.g., CART, NMFS H-VSP))

4.1.1.2.1. Use species-habitat associations to define productive habitat types and identify where they occur in the subbasin for each species of interest

4.1.1.2.2. Use the associations to identify areas of potentially productive habitats that are currently impaired – these areas may have high restoration potential

4.1.1.3. Evaluate connectivity (proximity to areas currently supporting high levels of the focal species and barriers to movement)

4.1.1.3.1. Migration barriers

4.1.1.3.2. Water quality barriers
4.1.1.3.3. Isolation of channels from floodplains (bank hardening)
4.1.1.3.4. Risk of extirpation due to catastrophic disturbance events
4.1.1.4. Use the map of productive and potentially productive habitats, and information on connectivity, to produce list of candidate watersheds for protection and restoration; discuss the risks and benefits of different restoration strategies (Table 3)

4.2. Estimation of viability of species of interest if available (e.g., CRI method for ESA-listed anadromous species, PATH analyses)

For each population, what are the population characteristics (abundance, productivity, diversity, spatial structure) that are needed for it to be self-sustaining(i.e., viable)?

4.2.1. Extinction risk and viability given current habitat quality and distribution
4.2.2. Genetic implications
4.2.3. Life history stage survival most influencing overall population growth rate
4.2.4. Factors for decline

What are the primary factors for decline (integrated over the whole salmon life cycle) limiting population growth rates in the ESU?

4.3. Assessment of current and potential biological performance and management options (e.g. EDT; ICBEMP Bayesian Belief Network Model, PATH analyses, CRITFC Cohort Model).
4.3.1. Capacity
4.3.2. Productivity
4.3.3. Life history diversity
4.3.4. Population status

4.4. Influence of Land Use on Watershed Processes

Ecological processes are the physical agents of landscape pattern formation and maintenance. They are the landscape scale features that create and maintain aquatic structural complexity that provides habitat for fish and wildlife. An assessment of ecological processes suggests the relative risk human land and water uses pose to ecological processes within each watershed.

4.4.1. Influences on water routing and yield.
4.4.2. Influences on sediment production and routing
4.4.3. Influences on organic matter and wood production and routing
4.4.4. Influences on changes in nutrient delivery
4.4.5. Influences on toxic chemical inputs
4.4.6. Influences on the type and frequency of disturbance events

Summary:
Analytical approaches used for subbasin assessment provide different types of information. All can be useful for managers during the Subbasin Planning effort. The coarse-scale habitat assessment provides the current spatial distribution of areas of differing habitat quality across the subbasin for those species or assemblages of interest, and identifies those watersheds where restoration efforts are likely to be effective. This analysis provides planners with a basis for prioritizing protection and restoration efforts across the subbasin in a manner that will be effective for the resources of interest. This analysis will also help to identify those watershed parameters of significance to the focal species. This information can be used to focus data collection during watershed and subwatershed level assessments. The relative risk of extinction of a species or stock is also a factor of key importance in allocating restoration resources. Analytical tools such as CRI that predict population or ESU viability or risk of extinction through changes in population levels over time can also be used in conjunction with the coarse-scale habitat characterization to prioritize management decisions at the subbasin level. The response of a population or assemblage to management actions depends on characteristics within the subbasin as well as factors outside of the subbasin. Several expert-system approaches have been developed to predict likely population responses to changes in various characteristics within and outside the subbasin being assessed. Three of these approaches are EDT, CRITFC Cohort Modeland the ICBEMP Bayesian Belief Network (BBN). The EDT process has recently been applied to 7 management strategies for the Columbia Basin. The ICBEMP BBN was employed to evaluate 3 alternative land management strategies for federal lands within the interior Columbia Basin. In combination, the three types of analytical approaches will provide subbasin planners with an indication of where efforts for habitat improvement could be focused, how those efforts relate to populations at greatest risk of extirpation, and the future status of populations under alternative management scenarios.

Products:

- Assessment of watershed condition at a scale appropriate for species of interest
- Identification of those watersheds with potential to contribute to recovery of fish and wildlife within the subbasin
- Prediction of population performance under alternative habitat management or restoration options
- Hypotheses as to ecological processes limiting or affecting populations within the subbasin

5. Interpret and Synthesize Results

5.1. Potential risks and opportunities for restoration
  5.1.1. Identification of habitats or strategies that affect focal species or assemblages
  5.1.2. Evaluation of habitat restoration potential
    5.1.2.1. Ease of restoring habitat forming processes
    5.1.2.2. Estimated time for improvement using different strategies (Table 3)
      5.1.2.2.1. Upland watershed condition
      5.1.2.2.2. Current riparian condition
      5.1.2.2.3. Water quality and instream habitats
    5.1.2.3. Examination of alternative strategies

It is important to lay out alternative restoration strategies so that planners can select products that match their restoration goals. Matching an appropriate strategy to the degree of anthropogenic change and the potential for recovery is illustrated in Table 3.

- Identify key watersheds that have the highest recovery or protection potential for key species.

6. Assessment Validation and Monitoring

This section of the subbasin assessment focuses on the need for monitoring in support of the adaptive management process (assessment validation) and identifies important data gaps for which more information is needed in order to complete future assessment refinements.

6.1. Data weaknesses identified during the subbasin assessment
  6.1.1. Quality of existing information
  6.1.2. Biological information needs
  6.1.3. Habitat information needs
6.2. Monitoring
  6.2.1. Identification and evaluation of assumptions or rule sets used in the assessment procedures (including estimates of uncertainty)
  6.2.2. Identification of monitoring indices that can be effectively used to gauge progress towards habitat and population improvements
  6.2.3. Suggested organization and design of a monitoring program, including a scientific framework and rationale for monitoring
  6.2.4. Suggest a feedback loop to modify assessments and analyses based on monitoring results

Products:

- Identification and description of the conceptual framework for restoration monitoring that achieves information needs for planning and implementation
- Clear description of the process (decision support system, other prioritization procedures) used to assist planners in selecting of priority areas for restoration and protection within the subbasin
- Estimation of the cost, risks and benefits of restoration and protection options
- Discussion of how uncertainty was considered in assessing restoration and protection alternatives

7. Literature Cited

All literature should be readily available from common source. Hard copies of hard to find or limited circulation technical reports should be provided directly to a central library.

Table 1. Spatial Hierarchy of Assessments

Assessment Spatial Scale	Examples of Products	Examples of Data
Subbasin 3rd or 4th Code HUC	1) Prioritization for Watershed Analysis 2) Distribution of abundance by 5th and 6th code HUC. 3) Key factors influencing habitat quality and quantity	1) Fish counts by watershed 2) Land use 3) Vegetation 4) Climate 5) Geology
Watershed 5th or 6th Code HUC	1) Distribution of abundance within the watershed 2) Specific factors influencing habitat quality 3) Location of sites sensitive to land management	1) Fish counts by reach or subwatershed 2) Stand age distribution 3) Road density and location 4) Distribution of land uses
Reach or Subwatershed	1) Development and implementation of restoration plans	1) Pool frequency 2) Wood abundance 3) Riparian condition 4) Water quality

Table 2. Walla Walla Basin Habitat Protection and Enhancement Recommendations Indexed by Geographic Management Unit

GEOGRAPHIC MANAGEMENT UNIT (GMU)	SPECIES PRESENT	LIFE HISTORY STAGE	KEY FACTORS LIMITING PRODUCTION	PRIORITY STRONG-HOLD PROTECT-ION AREA	MANAGEMENT RECOMMEND-ATIONS	VALUE OF AREA TO SPECIES WITHIN BASIN (Action Priority)		MAJOR INFORMATION NEEDS (Data Gaps)	WATERSHED ASSESSMENT REFERENCE (Section or pages)
						Current	Potential		
Upper Walla Walla (53, 54)	Spring Chinook	Migration	None	Yes	Protect	High	High	Migration Behavior	
		Spawning	None	Yes	Protect	High	High	Spawning location	
		Rearing	None	Yes	Protect	High	High	Juvenile distribution	

Table 2. Walla Walla Basin Habitat Protection and Enhancement Recommendations Indexed by Species

SPECIES PRESENT	LIFE HISTORY STAGE	KEY FACTORS LIMITING PRODUCTION	PRIORITY PROBLEM AREAS BY GEOGRAPHIC MANAGEMENT UNIT (GMU)	PRIORITY STRONG-HOLD PROTECT-ION AREAS	MANAGEMENT RECOMMEND-ATIONS	ACTION PRIORITY WITHIN WALLA WALLA BASIN	MAJOR INFORMATION NEEDS (Data Gaps)	WATERSHED ASSESSMENT REFERENCE (Section or pages)
Steelhead	Migration	Diversion structures and low flows	LWW (1,3) MWW (41, 42, 43) LT (4, 5)	WW (51-55) MC (56, 57) UT (22-30)	Passage improvements with ladders and screens; increased flows	High	Monitor passage, flow data	
	Spawning	Sedimentation and high temps	MT (12, 17-20) MWW (43) WW (50, 52)	WW (51-55) MC (56, 57) UT (22-30)	Reduce soil erosion and improve riparian areas	Medium	No major needs	
	Rearing	High temps and low flows	MT (12, 17-20) MWW (43) WW (50, 52, 55)	WW (51-55) MC (56, 57) UT (22-30)	Increase flow and improve riparian areas	High	Monitor flows	

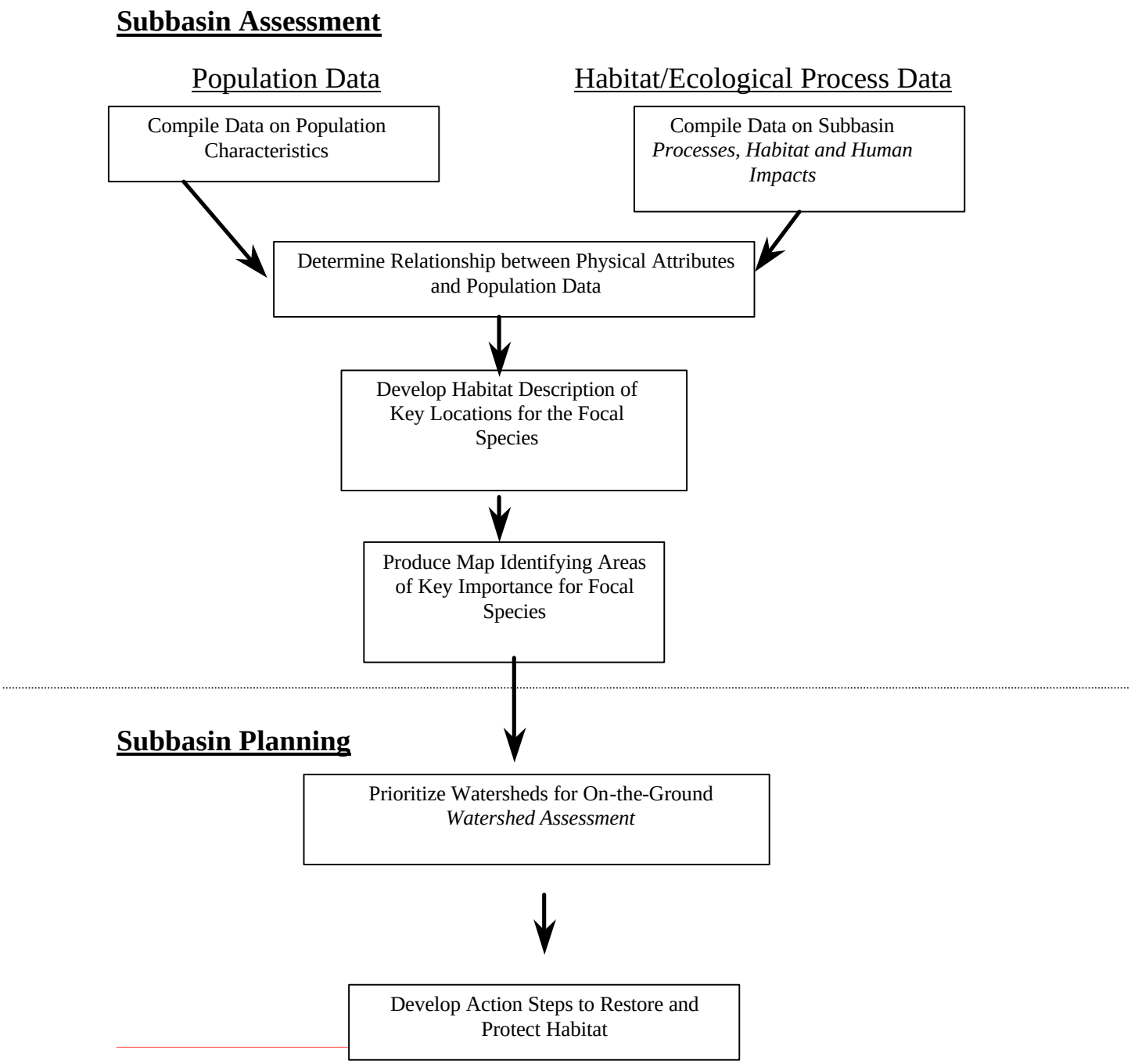
Table 2. Walla Walla Basin Habitat Protection and Enhancement Recommendations Indexed by Key Limiting Factors

KEY FACTORS LIMITING PRODUCTION (Temps, flows, sediment & passage)	SPECIES PRESENT	LIFE HISTORY STAGE	PRIORITY PROBLEM AREAS BY GEOGRAPHIC MANAGEMENT UNIT (GMU)	PRIORITY STRONG-HOLD PROTECT-ION AREAS	MANAGEMENT RECOMMEND-ATIONS	ACTION PRIORITY WITHIN WALLA WALLA BASIN	MAJOR INFORMATION NEEDS (Data Gaps)	WATERSHED ASSESSMENT REFERENCE (Section or pages)
High temperature	Bull Trout	Migration	MT (11, 12) WW (50, 51) MWW (42, 43)	UT (25-30) MC (56, 57) UWW (52, 55)	Increase flows	Medium	Migration behavior	
		Spawning	UT (25-30)	MC (56, 57) UWW (52, 55)	Riparian enhancement	Medium	No major needs	
		Rearing	MT (17-20) UT (25-30)	MC (56, 57) UWW (52, 55)	Riparian enhancement	Medium	Rearing distribution	

Table 3. Aquatic and riparian habitat recovery options.

Strategy	Description
Protection	Preserve riparian areas that are ecologically intact and fully functional. Human activities that significantly impact aquatic and riparian ecological functions are restricted. The strategy is intended to protect aquatic and riparian ecosystems that are currently in good condition so that naturally regenerative processes can continue to operate.
Restoration	
A. Passive	Remove anthropogenic disturbances from altered aquatic and riparian ecosystems in order to allow natural processes to be the primary agents of recovery. Allow the natural disturbance regime to dictate the speed of recovery in areas that have a high probability of returning to a fully functional state without human intervention.
B. Active	Return functionally impaired aquatic-riparian ecosystems to a state that would occur naturally at the site by actively managing certain aspects of habitat recovery. Combine elements of natural recovery with management activities directed at accelerating development of self-sustaining, ecologically healthy riparian ecosystems. Many riparian restoration projects fall into this category.
Rehabilitation	Re-establish naturally self-sustaining riparian ecosystems to the extent possible, while acknowledging that irreversible changes such as dams, permanent channel changes due to urbanization and roads, stream channel incision, and floodplain and estuary development, permit only partial restoration of ecological functions. Combine natural and active management approaches where ecological self-sufficiency cannot occur.
Substitution	
A. Enhancement	Deliberately increase the abundance or functional importance of selected riparian characteristics as desired. Such modifications may be outside the range of conditions that would occur naturally at a site. The strategy involves technological intervention and substitution of artificial for natural habitat elements. There is some risk in using this strategy that enhancement may shift riparian ecosystems to another state in which neither restoration nor rehabilitation can be achieved.
B. Mitigation	Offset habitat losses by improving or creating riparian habitats somewhere else or by replacement of lost habitat onsite. The strategy involves extensive use of technological intervention and replacement of natural habitats with artificially created habitats, and is often employed in highly altered urban/industrial settings.

Figure 1. Synthesis of Subbasin Assessment Data



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