Puget Sound Technical Recovery Team Technical Comments: Combined Template and Probabilistic network Analysis

Puyallup and White River Chinook Populations

Technical Feedback

The attached technical feedback has three components:

- Brief summary of results of our review concerning certainty, and discussion and recommendations of factors we believe are critical to address in order to improve certainty of your plan;
- Consolidation of technical reviewers' composite and detailed comments on your June 30th draft; and
- A description of the methods by which we performed the certainty analysis (i.e., the probabilistic network analysis).

The "near-term steps" suggested in Section 1 of the feedback should occur by April 30th, because they will help you finalize your draft chapter. The "long-term steps" should generally occur as you implement your adaptive management program.

I. SUMMARY OF CERTAINTY ANALYSIS

The content of this section summarizes the results of our probabilistic network analysis (for description of the approach, see *Section III* of this document.) We view using this certainty analysis in an iterative fashion, to help you in guiding plan revisions. This analysis also will help us strategically track the elements of your plans and how information at each step affects the overall certainty that the proposed actions in your plan will contribute to population and ESU recovery. This section is divided into separate discussions of the certainty in habitat, hatchery and harvest management elements of your plan. You will notice that several questions within each "H" encourage us to check how well the habitat, hatchery and harvest strategies are integrated in the plan. We fully expect that the certainty in your plan's outcomes can be increased by providing more information and documentation—we have highlighted areas we think would be particularly fruitful to focus on in near-term revisions in each section below.

Habitat strategy

Key Issues to Improve Certainty

The most important ways, in the near-term, to improve the certainty of an effective habitat strategy in an integrated Puyallup watershed recovery plan are to:

- Better document the data, assumptions, and models used as they relate to population VSP characteristics.
- Provide a summary of any available empirical support that can be used to relate ecological processes, land use, flow management regime, habitat conditions, and all four VSP responses in a recovery planning context to strengthen the analytical support for a recovery plan.
- Provide documentation of the watershed data regarding the relationships among ecological processes, land use, flow management, habitat conditions, and the resulting responses in the viability characteristics of the chinook populations.
- Identify and adopt interim recovery goals, develop a recovery hypothesis and a recovery strategy. Integrate the habitat strategy with hatchery and harvest management strategies in the planning area.
- Develop an adaptive management plan for a habitat recovery strategy explicitly relating the recovery targets to interactions among flow management regime, land use, habitat forming processes, habitat conditions and the resulting population VSP responses.
- Provide any available empirical data on the effectiveness of the protection actions described or assumed.
- Develop better empirical and analytical support for relationships among specific protection and restoration actions, a recovery hypothesis, a recovery strategy, and specific VSP characteristics or ESU persistence.

Based on our analysis, developing and implemented the key items above would increase the current moderate likelihood of a "high" level of certainty by approximately 20 fold.

Did the analysis use one or multiple independent models to understand potential fish status and responses?

One. The submittal reports results from a two phased, detailed EDT based assessment of actions to restore the watershed.

How well supported is the understanding of the links between habitat actions and population viability (VSP) characteristics used in the planning (Analytical Support)?

The analytical support was moderate.

- It appears that demonstration of this support could be substantially increased by better documenting in a more transparent manner what has been accomplished and by highlighting how the multiple, independent lines of evidence can be used to support recovery hypotheses and strategies regarding the interactions among land use, habitat forming processes, habitat conditions, and specific population VSP responses. For example, the qualitative Limiting factors analysis (LFA) for the watershed considered the affects of habitat conditions on some

of the population VSP characteristics and could be used as a qualitative model addressing the above interactions.

- The EDT method was used to quantitatively model restoration actions and resulting population VSP characteristics responses. However, the reported results did not explicitly discuss the population spatial structure characteristic responses available in the EDT results. Reviewers found it very hard to track down assumptions in the material provided. There is little information on the justification for assumptions of project effects on habitat conditions. The level of documentation and support for the assumptions on land use changes due to projects or management actions is also poor. It is noted that documentation for the restoration is complicated because the analysis bundles projects into classes and locations, and those effects are estimated on the group of projects. An example of the need to document and provide support for the assumptions is the historical baseline assumed for the lower White River. The alternative assumptions on the historical channel route and configuration and on productivity of that channel could lead to significantly different model results. That suggests that further analytical work is needed to reduce the uncertainty in the analytical support. Documentation summarizing the key assumptions for habitat and VSP would make the supporting evidence more readily available and transparent to various users. Similarly, a synthesis of the empirical support applied in the assessment would strengthen the analytical support for a recovery plan.
- No sensitivity analysis of the EDT model is apparent, so it is unclear how the modeled effects of habitat projects on environmental conditions would change under differing assumptions. Similarly, no analysis has been undertaken to explore the sensitivity of the model's population results (VSP) to differing assumptions about habitat conditions in the future.
- Apparently, no empirical test was performed on the model although one could have been conducted for abundance and productivity using observed R/S data. Similarly, there is no apparent documentation of any calibration of the model rules and relationships to current habitat conditions in the Puyallup and White River watersheds or for chinook abundance and productivity. Likewise, is not known whether calibration occurred to fit the model's assumptions to empirical effects of habitat actions or for the VSP parameters of diversity and spatial structure.
- No validation of the model was provided or proposed.
- The EDT model did not incorporate quantitative estimates linking habitat-forming processes (e.g., sediment dynamics, riparian dynamics, nutrient and contaminant loadings, hydrologic and floodplain dynamics) and land use to habitat conditions and population characteristics. The EDT reports reference sources of evidence regarding processes such as sediment dynamics, riparian dynamics, nutrient and contaminant loadings, hydrologic and floodplain dynamics. Specific linkages of the above processes to life history stages and VSP characteristic responses would significantly strengthen the overall analytical support for a recovery plan. These linkages can be qualitative or even conceptual. However, application of SHIRAZ results that are complete for the White River would add greatly to the certainty of the analytical model support.

Near-term steps to improve certainty:

- Better document the data, assumptions, and models used as they relate to population VSP characteristics;

- Provide any available empirical support that can be used to relate ecological processes, land use, flow management, habitat conditions, and all four VSP in a recovery planning context to strengthen the analytical support for a recovery plan.

Long-term steps to improve certainty:
- Further develop explicit life stage specific relationships among ecological processes, land use, flow management, habitat conditions, and resulting responses in population viability characteristics;
- Conduct sensitivity analyses;
- Conduct empirical tests and validation testing.

How well supported is the recovery hypotheses with watershed specific data? (Watershed Data Quality)

Support for the recovery hypothesis using watershed specific data was low.

- Support can be readily improved in the near-term by documenting the local habitat information supporting a recovery hypothesis.
- This question asks if the watershed has data that has been used to independently support the results of the qualitative analysis. The hypothesis is "if these projects are implemented, the resulting VSP will be x." (The hypothesis assumes a status quo baseline is maintained, in the face of human population growth and development, by protection actions) This was rated as low since expert opinion is primary support for hypothesis. The extent of local habitat information supporting the hypothesis could be better than is evident and should be documented. There is information in the documents submitted and referenced that could be turned into hypotheses regarding the primary habitat problems and the major life stages limiting population recovery. EDT documentation includes a discussion of how EDT is used to construct working hypotheses and what those are for the assessment. A synopsis of the hypotheses relating the inputs and results to VSP could help formulate a recovery logic that would be readily transparent, and, therefore, much more useful to reviewers, users, and other external parties.

Near-term steps to improve certainty:
- Provide documentation of the watershed data regarding the relationships among ecological processes, land use, flow management, habitat conditions, and the resulting responses in the viability characteristics of the chinook populations.

Long-term steps to improve certainty:
- Develop more explicit and quantitative life stage specific model(s) with watershed specific data relating the interactions among ecological processes, land use, flow management, habitat forming processes, habitat conditions and potential population VSP responses.

Is the recovery strategy consistent with the recovery hypothesis? (Consistent with Hypothesis)

No.
- No goals have been adopted and no habitat strategy for recovery is explicitly stated. Good integration of all-H strategies to hypotheses is not provided. The co-managers' White River recovery plan would serve as a readily adaptable source for guidance on interim recovery

goals, development of a recovery hypothesis and recovery strategy, and on an integrated approach.

Near-term steps to improve certainty:

- In collaboration with the co-managers, identify and adopt interim recovery goals, develop a recovery hypothesis and a recovery strategy; and 2) integrate the habitat strategy with hatchery and harvest management strategies in the planning area.

Is the recovery strategy robust by preserving options for recovery? (Preserves Options)

No.

- Preserving options requires an adaptive management plan to respond to changes and uncertainty as they occur. No goals have been goals adopted and no habitat strategy for recovery is explicitly stated. It is not clear how VSP can be recovered in the future, given that the list of actions is not related to any recovery objectives.

Near-term steps to improve certainty:

- Develop an adaptive management plan for a habitat recovery strategy explicitly relating the recovery targets to interactions among flow management regime, land use, habitat forming processes, habitat conditions and the resulting population VSP responses.

Long-term steps to improve certainty:

- Implement an adaptive management plan which includes and addresses more explicit detailed qualitative and quantitative interactions among flow management regime, land use, habitat forming processes, habitat conditions and population responses for specific protection and restoration action plans.

How well have the recovery actions been shown to work? (Empirical Support)

Support for the proposed actions is moderate.

- For the protection and restoration actions in the watershed, the evidence suggests that actions may work, although there are some conflicting results and uncertainty. Areas that are especially uncertain are 1) the effectiveness of regulatory protection programs, and 2) validation that the habitat actions to restore, rehabilitate, or enhance floodplain, estuary, and nearshore habitats actually support chinook life stages as predicted. Empirical support for protection measures is weak. The relationships between the regulations, their implementation, and resulting effects on habitat process, habitat conditions and population responses is unknown and appears to not be predictable.

Near-term steps to improve certainty:

- Provide any available empirical data on the effectiveness of the protection actions described or assumed.

Long-term steps to improve certainty:

- Further document assumptions for floodplain, estuary, and nearshore habitat protection and restoration actions by type to increase the strength of the empirical support;
- Strengthen the empirical support for each type of protection and restoration action by testing for the effectiveness and by validation that the actions result in the predicted responses.

Are the recovery actions consistent with the recovery strategy? (Consistent with Strategy)

No. There is no habitat recovery strategy.

Near term steps to improve certainty:

- Develop better empirical and analytical support for relationships among specific protection and restoration actions, a recovery hypothesis, a recovery strategy, and specific VSP characteristics or ESU persistence.

Hatchery strategy—Puyallup population

Key Issues to Improve Certainty

The most important ways to improve the certainty of an effective hatchery strategy in an integrated Puyallup watershed recovery plan include:

- Developing a recovery hypothesis for the effects of hatchery production that considers the status and functioning of the habitat;
- Developing a strategy for achieving watershed goals based on the recovery hypothesis and integrating across all management sectors (habitat, harvest, and hatcheries);
- Developing an adaptive management plan.

Based on analysis, by developing and implementing the key issues identified above, the likelihood of a "high" level of certainty for biological effectiveness would increase nearly 18-fold.

How well supported is the understanding of the links between hatchery actions and population viability (VSP) characteristics used in the planning (Analytical Support)?

The analytical support was moderate.

- The co-managers used a qualitative model (e.g. the Benefit-Risk Assessment Procedure cited in co-managers' resource management plan) to understand the potential affects of hatchery actions on populations. The model addressed all VSP criteria. Documentation is available for the basic model structure but not for how local watershed data (as opposed to general information from the scientific literature and expert guesses) were used to calibrate the assessment for the Puyallup River populations. Most of the analyses were based on weak inferences because the assessment did not utilize local watershed data.

Near term steps to improve certainty:

- Utilize better local information to assess the effects of hatchery actions and to develop models that will allow managers to understand how different factors affect the certainty of the results from hatchery management decisions (e.g. through a sensitivity analysis).

How well supported is the recovery hypotheses with watershed specific data? (Watershed Data Quality)

Support for the recovery hypothesis using watershed specific data for was low.

- This question asks if the watershed has data that has been used to independently support the results of the qualitative analysis. The implicit hypothesis in this watershed is that the hatchery programs, which are intended to provide harvest, will not interfere with recovery. However, the plan lacked recovery goals that could be tied to an explicit recovery hypothesis. Some demographic data are available from South Prairie Creek, but these may not be good indicators for the whole watershed. Nor were they explicitly used to support a recovery hypothesis for the effects of hatchery actions on VSP characteristics of the population. Background data provided in "Hatchery Element" of the plan are based on old documents and are no longer accurate.

Near term steps to improve certainty:
- Provide explicit recovery hypotheses for the possible effects of hatchery production in the recovery of Puyallup River Chinook salmon.

Long term steps to improve certainty:
- Focus on getting better estimates of abundance, contribution of hatchery fish to natural spawning, productivity, spatial distribution, and diversity to test the hypotheses.

Is the recovery strategy consistent with the recovery hypothesis? (Consistent with Hypothesis)

No.
- The TRT did not find a clearly stated recovery hypothesis or a recovery strategy based on the hypothesis.

Near term steps to improve certainty:
- The key action for this question is to develop a recovery strategy for hatcheries that integrates hatchery actions across management sectors (habitat, harvest, and hatcheries) to achieve the recovery goals for the population.

Is the recovery strategy robust by preserving options for recovery? (Preserves Options)

No
- The lack of a recovery strategy and an adaptive management plan strongly suggested that current actions for recovering Puyallup Chinook salmon are unlikely to preserve options for recovery.

Near term step to improve certainty:
- The key action for this question is to develop an adaptive management plan that helps reduce uncertainty of the recovery strategy.

Are the recovery actions consistent with the recovery strategy? (Consistent with Strategy)

No
- A number of actions currently being taken in the watershed, such as reintroductions above Electron Dam, appear to be consistent with recovery. In addition, the plan identified recommendations of the Hatchery Scientific Review Group (HSRG) as actions. Although some of these actions may be appropriate, they are not based on recovery goals or a recovery strategy integrated across management sectors (habitat, harvest, and hatcheries).

Near term steps to improve certainty:
- The key action for this question is to develop an integrated recovery strategy.

How well have the recovery actions been shown to work? (Empirical Support)

Empirical support for the proposed actions is moderate.

- The plan identified actions based on the HSRG review and other actions detailed in hatchery and genetic management plans (HGMPs). There is some empirical evidence that these actions may be effective if they are part of an appropriate strategy; however, neither of these reviews incorporated uncertainty.

Near term steps to improve certainty:

- The key action for this question is to develop an integrated recovery strategy.

Hatchery strategy—White River population

Key Issues to Improve Certainty

The most important ways to improve the certainty of an effective hatchery strategy in an integrated Puyallup watershed recovery plan include:

- Developing a recovery hypothesis for the effects of hatchery production that considers the status and functioning of the habitat.
- Developing a strategy for achieving watershed goals based on the recovery hypothesis and integrating across all management sectors (habitat, harvest, and hatcheries).
- Developing an adaptive management plan.

Based on our analysis, by developing and implementing the key issues identified above, the likelihood of a "high" level of certainty for biological effectiveness would increase nearly 24-fold.

How well supported is the understanding of the links between hatchery actions and population viability (VSP) characteristics used in the planning (Analytical Support)?

The analytical support was moderate.

- The co-managers used a qualitative model (e.g. the Benefit-Risk Assessment Procedure cited in co-managers' resource management plan) to understand the potential affects of hatchery actions on populations. The model addressed all VSP criteria. Documentation is available for the basic model structure but not for how local watershed data (as opposed to general information from the scientific literature and expert guesses) were used to calibrate the assessment for the Puyallup River populations. Demographic and genetic data exist for the White River hatchery programs in the White River and at Hupps Springs and these data were used to calibrate some parts of the assessment. Most of the analyses were based on weak inference because the assessment did not use local watershed data.
- *Key actions for this question* are to use better local information to assess the effects of hatchery actions and to develop and apply models that will allow managers to understand how different factors affect the certainty of the results from hatchery management decisions (e.g. through a sensitivity analysis).

How well supported is the recovery hypotheses with watershed specific data? (Watershed Data Quality)

Support for the recovery hypothesis using watershed specific data for was low.

- This question asks if the watershed has data that has been used to independently support the results of the hypothesis(es) generated by the qualitative analyses. Local watershed data do support the hypothesis that the risk of extinction of population could be lowered by intensive hatchery intervention. This is not the same as recovery to a viable status, however, and the TRT concluded the support was low because the plan did not identify an explicit recovery hypothesis and it did not use the available information on existing hatchery programs and stocks to look at all four VSP characteristics.
- *The key action for this question* is to develop a recovery hypothesis for the effects of hatcheries on recovery in the watershed. One possible way of doing this might be to start with the existing White River Plan developed by the co-managers and improve it by addressing all four VSP criteria in the context of results from EDT or SHIRAZ habitat model analyses.

Is the recovery strategy consistent with the recovery hypothesis? (Consistent with Hypothesis)

No.

- The TRT did not find a clearly stated recovery hypothesis or a recovery strategy for hatcheries that was based on integration across all management sectors (habitat, harvest, and hatcheries).
- *The key action for this question* is to develop a recovery strategy. This will require a recovery hypotheses (see recommendation above) and recovery goals to integrate hatchery actions across management sectors (habitat, harvest, and hatcheries).

Is the recovery strategy robust by preserving options for recovery? (Preserves Options)

No

- The lack of a recovery strategy and an adaptive management plan strongly suggested that current actions for recovering White River Chinook salmon are unlikely to preserve options for recovery.
- *The key action for this question* is to develop an adaptive management plan that helps reduce the uncertainty of the recovery strategy.

Are the recovery actions consistent with the recovery strategy? (Consistent with Strategy)

No

- Many of the actions taken by the Tribes and the Washington Department of Fish and Wildlife to maintain the White River population are consistent with initial efforts at recovery. Although some of these actions may be continue to be appropriate, they are not based on recovery goals or a recovery strategy integrated across management sectors (habitat, harvest and hatcheries). Nor is there evidence that they are based on potential changing status of the habitat or population. Consequently, the TRT concluded that these actions were not consistent with a recovery strategy.
- *The key actions for this question* are to develop an integrated recovery strategy and actions to implement it.

How well have the recovery actions been shown to work? (Empirical Support)

Empirical support for the proposed actions is low. However, this could readily be rated as moderate if the available information were applied in a recovery plan per the TRT's Technical Guidance document.

- The plan failed to identify suites of actions for hatchery programs that would lead to viability and recovery of the White River population. .
- *The key actions for this question* are to develop an integrated recovery strategy and actions to implement it. Empirical support exists for many of the suites of actions that might be possible under an integrated recovery strategy, although the results will continue to vary based on individual watershed conditions and chance.

Harvest strategy— Puyallup population

NOTE: This evaluation is based on the Puyallup Management Unit profile, pages 165-167 of the *Comanagers' Puget Sound Chinook Harvest Management Plan*.

Key improvements to development of the harvest management portion of an integrated Puyallup watershed recovery plan include

- Developing exploitation rate guidelines based on local data and an updated assessment of the expected responses in VSP characteristics of the population (i.e. relationships to abundance, productivity, and considerations for potential effects on diversity and spatial structure);
- Developing some qualitative discussion of the potential effects of harvest management on diversity and spatial structure;
- Analyzing how recent population assessment data supports, or suggests modifications to, the EDT modeling as it relates to predictions of the effects of harvest on VSP characteristics;
- Developing an integrated recovery adaptive management plan which includes and addresses harvest strategies to reduce weaknesses in the current escapement and productivity data to test whether the exploitation rate guidelines are effective (i.e. can be sustained under current conditions and allow for population growth with improved habitat conditions);
- Developing a harvest management strategy for achieving watershed goals that explicitly follows from a recovery hypothesis relating harvest management, integrated with the harvest and hatcheries sectors, to responses in all four population VSP characteristics.

Based on our analysis, by developing and implementing the key issues identified above, the likelihood of a "high" level of certainty for biological effectiveness would increase approximately 14-fold.

Was the analysis based on one or many models?

One**.**

-a qualitative assessment of abundance and productivity and quantitative assessment of exploitation rates using a South Sound indicator conglomerate, as none is available for the Puyallup; however, no relationship between ER and escapement is made.

Analytical support for model:
Low.

- The harvest management plan appears to be based on the hypothesis that if exploitation rates are reduced from levels previously observed, VSP parameters will improve for the naturally-spawning population. Harvest management will be constrained by an upper limit overall exploitation rate of 50%, but it is not clear how this number was derived.
- There is no qualitative discussion of the effects of harvest on diversity and spatial structure.

Near term steps to improve certainty:

Develop exploitation rate guidelines based on an updated assessment of the population's abundance, productivity, and other VSP characteristics. This could probably be accomplished for interim purposes for abundance and productivity using the Puyallup watershed EDT habitat-based model adjusted for the recent hatchery stray rate information.

Develop and provide qualitative discussion of the potential effects of harvest management on diversity and spatial structure.

Quality of data used to support recovery hypothesis:
Low.

- The support for the recovery hypothesis is highly uncertain because there is no attempt to relate the conceptual harvest hypothesis to an overall recovery hypothesis or to use local information and discuss how it supports a hypothesis. It is not clear whether South Prairie Creek is a useful indicator of the population's abundance. An amalgamation of South Puget Sound coded-wire tag groups is used as an exploitation rate indicator, and it is not clear whether this amalgamation has any correlation with exploitation rates on the Puyallup population.
- It appears that the detailed EDT assessment for the watershed could be used, perhaps in conjunction with other data, for deriving harvest management objectives. (See above)
- Development of a means for quantifying the population's abundance and exploitation rates, such as establishing a local CWT indicator group, could markedly increase the certainty of effectiveness in implementation of harvest actions.

Near-term steps to improve certainty:

- Analyze how recent population assessment data supports or suggests modifications to the EDT modeling as it relates to predictions of the effects of harvest on VSP characteristics.

Long-term steps to improve certainty:

- Determine a means for quantifying the population's abundance and exploitation rates and implement the appropriate actions.

Recovery strategy preserves future options:
No.

- It is not clear whether the population has sufficient productivity to sustain the exploitation rate. The need for documentation of the basis for a strategy that is integrated with an overall recovery strategy is addressed above. Once an explicit integrated strategy is developed, an adaptive management plan, including harvest strategies, can further reduce uncertainties.

Near-term steps to improve certainty:

- Develop an integrated recovery adaptive management plan, including harvest strategies, to reduce weaknesses in the current escapement and productivity data and to test whether the exploitation rate guidelines are effective (i.e. can be sustained under current conditions and allow for population growth with improved habitat conditions).

Recovery strategy is consistent with recovery hypothesis:

No

- The harvest management strategy is not clearly related to a hypothesis relating harvest management to VSP characteristics.
- It is not clear whether the intrinsic productivity of naturally-spawning Puyallup Chinook will be sufficient to support the likely exploitation rates. Naturally-spawning Puyallup Chinook will be much more likely to support exploitation rates derived from a harvest management strategy that is better linked to a hypothesis and analytical support for the abundance and intrinsic productivity of the population.
- Development of an expanded hypothesis explicitly including the relationships between harvest actions and expected diversity and spatial structure responses of the population will further improve the likelihood that the strategy will be consistent.

Near-term steps to improve certainty:

- Develop a harvest management strategy for achieving watershed goals that explicitly follows from a recovery hypothesis relating harvest management, integrated with the harvest and hatcheries sectors, to responses in all four population VSP characteristics.

How certain is the empirical support for the effectiveness of the recovery actions?

Low

- The effects of the harvest plan on diversity and spatial structure have not been evaluated. The general evidence suggests that that reducing harvest rates could improve VSP characteristics. There is weak local evidence that exploitation rates on NORs have been reduced or that escapements are responsive to the harvest actions. Apparent exploitation rates in last seven years, although on average lower than in earlier years, seem quite variable with no trend, while escapement has been decreasing (although variable) during that time. The exploitation rate evidence is confounded by hatchery straying, which has recently been demonstrated to be potentially high (only one year of data), and by lack of NOR outmigrant production data corresponding with escapements. Escapement was relatively high in 1989 and decreasing since then, with no reliable quantitative estimates of NORs. Apparent exploitation rates were reduced in 1995 but escapement has not shown an increasing trend.

Key actions provided for the other questions will improve the empirical support for the harvest recovery actions.

Are the harvest management recovery actions consistent with the plan's all-H recovery strategy?

No.

- Actions are determined to be potentially consistent with a hypothetical integrated recovery strategy based on EDT modeling. As in the habitat section, the strength of the empirical and modeling evidence demonstrated for the effectiveness of the proposed actions will have a significant influence on the implementation certainty of a recovery plan. In this case the weakness of escapement data current precludes the ability to implement the intended action correctly.

- *Key actions* provided for the other questions will improve the empirical support for the harvest recovery actions, thereby enabling implementation of harvest recovery actions that are consistent with all-H recovery strategy.

Harvest strategy—White River population

NOTE: This evaluation is based on the White River Management Unit profile, pages 162-164 of the *Comanagers' Puget Sound Chinook Harvest Management Plan*.

Key improvements to development of the harvest management portion of an integrated Puyallup watershed recovery plan include:

- Developing exploitation rate guidelines based on local data and an updated assessment of the expected responses in VSP characteristics of the population (i.e. relationships to abundance, productivity, and considerations for potential effects on diversity and spatial structure).
- Developing some qualitative discussion of the potential effects of harvest management on diversity and spatial structure.
- Utilizing existing local data to develop an updated harvest management strategy that explicitly follows from a recovery hypothesis relating harvest management, integrated with the habitat and hatcheries sectors, to responses in all four population VSP characteristics.
- Developing an integrated recovery adaptive management plan, including harvest strategies, to reduce weaknesses in the current escapement and productivity data and to test whether the exploitation rate guidelines are effective (i.e. can be sustained under current conditions and allow for population growth with improved habitat conditions).
- Developing a harvest management strategy for achieving watershed recovery goals that explicitly follows from a recovery hypothesis relating harvest management, integrated with the harvest and hatcheries sectors, to responses in all four population VSP characteristics.

Based on our analysis, by developing and implementing the key issues identified above, the likelihood of a "high" level of certainty for biological effectiveness would increase approximately 11-fold.

Was the analysis based on one or many models? One.

Analytical support for model: Low.

- The harvest management plan is apparently based on the hypothesis that maintaining the overall exploitation rate below 20% will not impede the ability of the population to respond positively to habitat and hatchery actions to promote recovery. However, this hypothesis is not clearly stated in a plan.

- There is no qualitative discussion of the effects of harvest on diversity and spatial structure.
- Development of exploitation rate guidelines based on local data and an updated assessment of the expected responses in VSP characteristics of the population (i.e. relationships to abundance, productivity, and considerations for potential effects on diversity and spatial structure) could significantly reduce this uncertainty.

Near-term steps to improve certainty:
- Develop exploitation rate guidelines based on local data and assessments of the population's abundance, productivity, and other VSP characteristics (i.e. relationships to abundance, productivity, and considerations for potential effects on diversity and spatial structure) and 2) develop some qualitative discussion of the potential effects of harvest management on diversity and spatial structure.

Quality of data used to support recovery hypothesis:
Low.
- The support is highly uncertain because there is no explicit discussion relating how a harvest hypothesis supports an overall recovery hypothesis. Although reasonably good exploitation rate estimates are available, accurate escapement estimates for the populations and hatchery returns are hard to obtain. Thus, management for an exploitation rate target is a good idea, but this has to somehow be related to the populations' productivity and other VSP characteristics. In addition, resolution of the remaining uncertainties on the population structure of Chinook in the White River, as identified in the habitat section and the consolidated comments, will be necessary to reduce the harvest management uncertainties discussed here.
- The exploitation rate guideline, based on an assessment of the population's VSP characteristics, could probably be accomplished using the SHIRAZ or EDT habitat-based models and the available fishery, escapement, and genetic data. An update of the co-managers' White River Recovery plan, synthesizing the recent genetic stock identification results with other analyses and data, is one potential approach that has been discussed.

Near-term steps to improve certainty:
- Utilize existing local data to develop an updated harvest management strategy that explicitly follows from a recovery hypothesis relating harvest management, integrated with the habitat and hatcheries sectors, to responses in all four population VSP characteristics.

Recovery strategy preserves future options:
No.
- It is not clear whether the population has sufficient productivity to sustain the exploitation rate. The need for documentation of the basis for a strategy that is integrated with an overall recovery strategy is addressed above. Once an explicit integrated strategy is developed, an adaptive management plan, including harvest strategies, can further reduce uncertainties.

Near-term steps to improve certainty:
- Develop an integrated recovery adaptive management plan, including harvest strategies, to reduce weaknesses in the current escapement and productivity data and to test whether the

exploitation rate guidelines are effective (i.e. can be sustained under current conditions and allow for population growth with improved habitat conditions).

Recovery strategy is consistent with recovery hypothesis:
No.

- The harvest management strategy is not clearly related to either a recovery hypothesis or the VSP characteristics of the population. It is not clear if the intrinsic productivity of naturally-spawning White River Chinook will be sufficient to support the current exploitation rates. Naturally-spawning White River Chinook will be much more likely to support exploitation rates derived from a harvest management strategy that is better linked to a hypothesis and analytical support for the abundance, intrinsic productivity, diversity, and spatial structure of the population.
- Development of an expanded hypothesis explicitly including the relationships between harvest actions and expected diversity and spatial structure responses of the population will further improve the likelihood that the strategy will be consistent.

Near-term steps to improve certainty:

- Develop a harvest management strategy for achieving watershed recovery goals that explicitly follows from a recovery hypothesis relating harvest management, integrated with the harvest and hatcheries sectors, to responses in all four population VSP characteristics.

- **How certain is the empirical support for the effectiveness of the recovery actions?:** Moderate

- The effects of the harvest plan on diversity and spatial structure have not been evaluated. There is no evidence that reduction in exploitation rates in recent years has resulted in increased escapements, as escapements have been quite variable with no significant trend. Both exploitation rates and escapement were higher in the early nineties than now.

- **Are the harvest management recovery actions consistent with the plan's all-H recovery strategy?**

No.

- Actions are determined to be potentially consistent with a hypothetical integrated recovery strategy based on EDT modeling results provided. As in the habitat section, the strength of the empirical and modeling evidence demonstrated for the effectiveness of the proposed actions will have a significant influence on the implementation certainty of a recovery plan. *The key actions* identified above will also improve the certainty that harvest management recovery actions are consistent with the all-H recovery strategy as intended.
- *Key actions* listed for the other questions will improve the empirical support for the harvest recovery actions, thereby enabling implementation of harvest recovery actions that are consistent with all-H recovery strategy.

II. CONSOLIDATED COMMENTS ON TECHNICAL REVIEW TEMPLATE

REVIEW TEMPLATE FOR TECHNICAL REVIEW OF DRAFT WATERSHED PLANS

Reviewer's Name: **Puget Sound TRT & Technical Reviewers**

Watershed Plan: **Salmon Habitat Restoration and Protection Efforts in WRIA 10 and 12**

Populations or ESUs considered: **White River Chinook**
Puyallup Chinook

Summary

Overview of Shared Strategy questions and how well the watershed plans address the technical aspects of those questions. In particular, what is the watershed's technical basis to the answer to the questions from the Shared Strategy: (1) what are the major physical and biological changes necessary to meet the population planning targets? And (2) What are the expected changes in H's and fish population responses over the next 5-10 years?

Review of Plan--Overview

Overall summary of approach, scope of plan (geography, species, populations, ESUs, included), stated goals, participants in plan development, etc.

The Muckleshoot Tribe is currently not participating in development of a recovery plan for this watershed. It will be important to consider the co-managers' White River Chinook recovery plan and how results reported there might affect the strategies or actions identified in this document. Incorporation of the results of an independent watershed assessment conducted for the Muckleshoot Tribe would also substantially strengthen the technical basis for a recovery plan for this watershed.

The Pierce County submittal provides executive summary style answers to the six questions and a key relating the questions and associated issues to materials provided in the attached appendices. The submittal is not a plan per se. It is a summary of the results of a multi-species watershed assessment for salmon habitat restoration and recovery planning in WRIAs 10 and 12 using the EDT method, the Pierce County salmon restoration strategy report to the SRFB, and a report to Pierce County on the effectiveness of county environmental protection ordinances relative to salmon habitat. The summary outlines the assessment work that Pierce County has conducted to build a technical basis for engaging in salmon conservation efforts and environmental protection forums. It does not integrate that work with reports from the co-managers on other efforts they have undertaken to assesses the effects of their actions and potential actions in the various sectors [the H's] relating to managing for recovery.

The summary of EDT results presents changes in the habitat by major grouping of action types and area and uses the predicted responses of the two populations of chinook and of coho stocks to establish priorities for the actions and major groupings. The priority physical changes in habitat needed to support natural chinook and coho salmon production are diagnostically driven results from the EDT assessment of projected responses of chinook and coho salmon to a comprehensive menu of potential restoration projects and assumed protections.

This review focuses on the submittal materials provided for the Puyallup Watershed. The TRT considered the materials provided by Pierce County for WRIA 12 and nearshore areas as part of the South Sound Chapter review and is providing feedback accordingly.

Brief narrative of how well the plan addresses the following; including strengths and weaknesses:

1. **What biological and physical changes does the plan state are required for the population(s) in the watershed to achieve their targets?**
   For watersheds without targets, what biological and physical changes are needed for the habitat to be considered functioning for anadromous fish?

This question is not answered in the documentation provided. The submittal reports results from a two phased, detailed EDT based watershed restoration assessment. Watershed conditions were inventoried and diagnosed in the first phase. An extensive set of major habitat restoration actions, identified by the Technical Advisory Group, were then modeled, and the predicted population level responses were reported. The resulting VSP characteristics for the two Chinook populations were reported to be below "desired levels"—i.e., desired levels of fish are not attainable in the short term, However, it was not clear what those "desired levels" were. The submittal did not define what additional measures in any of the H's would be needed to achieve some higher levels for VSP characteristics.

It is not clear from the materials provided whether there is any intent to adopt or establish population goals. The summary stated the target for Puyallup Chinook and the predicted potential abundance from a series of actions (a scenario). The expected long-term average abundance given the status of the habitat at the 75th year mark (assuming protections and actions effectiveness) fell within the target range. The associated productivity and diversity outputs from the EDT assessment were not provided in the submittal or discussed to provide an evaluation of how the habitat changes relate to achieving the population targets. There was no further discussion elaborating on the implications of this predicted abundance; the reader was left to interpret, if he/she chose, the implications of the information presented.

There were no targets stated, adopted, or proposed for the White River chinook population. The submittal noted this and then stated the interim escapement goals reported by the co-managers as of 1996. The submittal provided a predicted average number of natural origin spawning Chinook expected if a series of actions were taken both with and without the White River hydroelectric project operations. Here a discussion of the historic, present and expected future productivity of Chinook in the White River was provided to make the point that predicted very low productivity would be a driving consideration of recovery planning for the foreseeable future. Based upon the EDT results indicating very low productivity, the summary went on to conclude that hatchery supplementation was believed to be necessary for the foreseeable future to avoid extinction of the population. No further discussion of the other VSP characteristics of viable populations or relationships to the changes was provided.

While the EDT assessment did provide a basis for discussion of the alternative question above *"For watersheds without targets"*, the submittal did not synthesize the protection and restoration provided or referred to into a complete discussion answering the question *"what biological and physical changes are needed for the habitat to be considered functioning for anadromous fish?"*.

The submittal provided a well executed use of EDT to identify the priority threats to functions of habitats necessary to supporting natural chinook and coho salmon production in the watershed and the predicted responses of chinook and coho salmon stocks to specific habitat changes. The EDT assessment provided information on the rankings of the projects and action groupings based upon three of the VSP characteristics. Thorough review of the EDT assessment inputs and assumptions would be required to fully understand the complete list of protections and actions that were embedded in, or implied by the EDT assessment. The details of the EDT analysis and the supporting documents could provide the basis for a thorough discussion of the threats by geographic and action groupings, as they relate to all four VSP criteria, if they were applied in a recovery plan.

2. **What biological goals does the plan aim to achieve (in 5-10 years and over longer term). What are fish-based and habitat, hatchery or harvest management-based goals?**

The stated goal was to "improve the performance of target stocks." All 4 VSP parameters were mentioned, but no specific numeric or narrative goals were provided. The planning targets set forth by the co-managers for the Puyallup River population were discussed, but it is not clear whether there were any intent to adopt these or alternatives as long-term recovery goals. The co-managers' goals stated in the White River Chinook Recovery Plan (1996) also were mentioned, but nothing more was stated in regard to how these or alternatives could be used in a recovery plan.

There was not a clear description of how short-term actions may relate to any recovery goals. The submittal stated that a short-term goal was to develop strategic benchmarks and to use accomplishments of restoration projects as measurable objectives and as a surrogate to any biological recovery goals for the 5 -10 year timeframe. There was no mention of measures of fish population response as part of their short-term goal assessment. Also, none of the co-managers' past or current fish based-goals for the Puyallup and White River Chinook populations were noted, though they appeared to be presumed (e.g. Fish access to upper Puyallup and White River watersheds, fish handling protocols, etc.).

The biological goals for harvest and hatchery were not stated in sufficient detail to assess how they may relate to current or future VSP. The submittal included a summary description of the Puget Sound Comprehensive Chinook Management Plan (PSCCMP) and the specific management objectives within that plan for the Puyallup and White River Chinook populations. The overall objective of the PSCCMP is to constrain harvest to the extent necessary to enable rebuilding of natural chinook populations in the ESU, provided that habitat capacity and productivity are protected and restored. Additional specific objectives for the Puyallup chinook population included a total exploitation rate not to exceed 50%, and other actions triggered at critical low abundances, to assure that a viable natural spawning population is perpetuated. There were similar additional specific objectives for the chinook population, with a total exploitation rate not to exceed 20%. No information was provided to demonstrate how these exploitation rates were derived or to justify why they are appropriate.

The submittal included summary descriptions of hatchery production of Chinook in the Puyallup River watershed and operational guidance for hatcheries in South Puget Sound, including specific HSRG recommendations for the South Sound area and for the Puyallup fall Chinook stock production facilities. The submittal neither included existing recommendations for the White River Chinook stock facilitiesn or explained why they were not included.

3. **What is the biological RATIONALE for identified actions in all of the H's (i.e., is the "hypothesis-strategy-action" logic presented in the watershed guidance document used?).**

   (a) What is the population's current status for all 4 VSP (this should come out under the hypotheses)?

The primary method underpinning the design of the submittal was to use EDT results to develop an initial set of priorities and a range of potential actions (Phase I), and then develop an "actions-up" approach to identify and evaluate a set of actions that were considered to be feasible by the technical team (Phase II). Actions were bundled into scenarios by Mobrand before analysis. The results of Phase II were summarized with regard to the predicted responses of the target salmon stocks to the action scenarios.

The historic and current status, to the extent known, were captured for each population as inputs and results of the EDT method assessment and described in supporting documents. EDT documentation included a discussion of how EDT was used to construct working hypotheses and what those were for the assessment. A synopsis of the hypotheses relating the inputs and results to VSP could help formulate

a recovery logic that would be readily transparent, therefore, much more useful to reviewers, users, and other external parties.

Estimates on status for the run components need to be stated and discussed as hypotheses to explicitly define the assumptions and use of evidence underlying the reported status. Reporting information, other than the EDT results, on current status (E.g., Shaklee and Young 2003, Ford et al. 2004, TRT database, Sanderson et al. in prep.) needs to be included and compared to strengthen the arguments presented. For example, there was not an adequate treatment of diversity and spatial structure status, especially as they pertain to comparison of historical and current spatial structure and diversity in the basin. Remaining uncertainties on historical population structure and life history, for the populations in the Puyallup watershed, were identified and discussed in the *Independent Populations of Chinook Salmon in Puget Sound*:

"The historical and current status of early-returning Chinook salmon that used the upper Puyallup River (Williams et al. 1975) are unknown. Nehlsen et al. (1991) considered this population extinct. The co-managers did not identify these as a distinct stock or describe their return timing as a part of the "summer/fall" stock (WDFW et al. 1993), which suggests that they were no longer present in significant numbers during that assessment. The TRT lacks information to determine whether these are either an independent population or part of a broader return timing of the historical population.

The origins of late-returning Chinook salmon in the White River are also uncertain. Genetic evidence indicates that the extant population is characteristic of Green River–origin Chinook salmon and genetically distinct from the early-returning White River population (Shaklee and Young 2003). These fish may represent

- a life history that was a distinct historical population,
- an extended return time that was once part of the historical White River population but was replaced by nonnative Chinook salmon,
- a part of the historical late-returning Puyallup population that used the lower White River, or
- recent establishment of the life history in the White River from introductions of Green River–origin hatchery fish.

The effects of disruptions to habitats and fisheries on the spatial and temporal distribution of salmon in the Puyallup basin were unclear. Alterations in flow, temperature, fish passage, and harvest management strategies probably altered utilization relative to historical distribution patterns. This makes reconstructing historical patterns difficult. However, the additional life history diversity within the Puyallup watershed may have contributed to broader geographic and temporal distribution of Chinook salmon from this watershed, both within the watershed and in marine environments, and may have been an important part of the viability of Chinook salmon in the watershed.

A Puyallup watershed recovery plan will need to address the above to reduce uncertainties as to the basis for and applications of the current and predicted status of the populations. "

(b) What is the population's predicted status for all 4 VSP over the short- and long-term?

No actual prediction of future status was provided. The predicted responses of the two Chinook populations and coho stocks to the EDT modeled scenarios of habitat restoration actions were provided in the EDT reports. Results included predictions for abundance, productivity, and life history diversity with an emphasis on abundance. Spatial structure was not analyzed or explicitly discussed. An

explanation of the rationale for this was provided in the documentation notes for the final EDT draft submittal to Pierce County by Mobrand Biometrics, Inc. The assumptions made for harvest and hatchery management, and how habitat conditions were translated into population effects were not provided, so it was not possible to evaluate the confidence in these results. The summarized EDT results predicted a potential abundance of 6,170 for the Puyallup and 2,280 to 3225 for the White River under a "specified set of habitat actions." Insufficient discussion was provided to determine how these estimates may relate to the Puyallup targets or the White River [interim rebuilding] goals. It appears that further integrative analyses will be needed to generate "real world" predicted outcomes for specific sets of all H actions.

(c) What are critical threats affecting the populations? Have all been identified and considered in the stated hypotheses? Are there potential threats that are missing from the plan? Be explicit about each threat or potential factor limiting recovery.

The submittal provided a well executed use of EDT to identify the priority threats to functions of habitats necessary to supporting natural chinook and coho salmon production in the watershed and the predicted responses of chinook and coho salmon stocks to specific habitat changes. The EDT assessment provided information on the rankings of the projects and action groupings based upon three of the VSP characteristics. Thorough review of the EDT assessment inputs and assumptions would be required to fully understand the complete list of protections and actions that were embedded in, or implied by the EDT assessment. The details of the EDT analysis and the supporting documents could provide the basis for a thorough discussion of the threats by geographic and action groupings, as they relate to all four VSP criteria, if they were applied in a recovery plan.

Discussion of basic uncertainties as to the meta-population structure for chinook spawning in the White River and stock management actions to address threats to population integrity and viability were neither included nor noted in the submittal. The final Puget Sound Chinook Population Identification document discussed remaining uncertainties as to the Chinook presently spawning in the White River. The co-managers are working to resolve these issues, as is discussed in the White River Recovery Plan (1996) and Shaklee and Young (2003). Incorporation of an updated treatment of these issues and a proposed course of actions to address them is an essential element to a Puyallup watershed Chinook recovery plan.

The potential habitat, hatchery and harvest problems (limiting factors) were stated as facts, rather than as hypotheses throughout the document. A recovery plan's treatment of certainty of what is known and its vision for implementation is improved by treating information on threats as hypotheses (see TRT Watershed Guidance document.) Phrasing H factors potentially limiting recovery as hypotheses acknowledges that such a judgment is based on best available (but imperfect) information, and also forces plan authors to treat H factors as potential effects on VSP that need to be monitored to that we can learn over time about the nature and magnitude of the actual effects.

Habitat

The rationale for the choice of the habitat factors as being the critical ones was not well stated in the submittal. Primary habitat threats needing improvement in the Puyallup River were described as a combination of loss of habitat diversity, channel instability, and sediment loss. Primary threats for the White River were listed as loss of habitat diversity, channel instability, sediment, reduction in habitat quantity and flow management regimes by the Mud Mountain Project and the PSE hydroelectric project. The rationale may be available in supporting documents, such as the LFA (in some cases it is discussed in detail). However, it was not provided in the submittal to demonstrate the strength of the rationale and other supporting evidence for a plan.

To answer the question of what are critical 'threats', a discussion of both current habitat conditions and processes is needed, and then in turn, what land use or other actions affect the state of the instream conditions or processes (e.g., is sediment a critical problem? Why? Temperature?)

There was no mention of how "other" factors potentially affecting Chinook (i.e., ocean conditions, predation, NIS, climate) are, or could be, considered.

Harvest

There was no rationale or reference provided for the reasoning underlying the harvest effects—either that past harvest rates likely contributed to declines or that present rates should allow for recovery. As for the habitat and hatchery factors, the potential effects of harvest should be stated as hypotheses for past and present effects on VSP of the White River and Puyallup populations. The statement that the magnitude of effect from non-harvest mortality is much greater than harvest sources was misleading and appeared to be confounding life stage-specific mortality rates and population-level impacts.

Hatchery

There was no rationale or reference provided for the reasoning underlying the hatchery effects—either that past practices likely contributed to declines or that the potential beneficial or detrimental effects of hatchery practices are not outlined. As for the other H factors, the potential effects of hatchery practices should be stated as hypotheses for past and present effects on VSP of the White River and Puyallup populations. The potential effects of hatchery practices were summarized as "significant straying" by hatchery fish throughout the basins and the statement that hatchery fish were masking the status of natural origin fish (to an unknown degree because of insufficient information, tagging, escapement estimates.) The submittal indicated that there are three hatchery complexes in the system. The HSRG review was mentioned, and some of the recommended changes were listed. The White River Chinook supplementation program was not discussed. Hatchery management practices and potential future changes were not discussed in sufficient detail to demonstrate the intent of future management direction.

(d) Is the strategy for H management changes consistent with the identified hypotheses for current population status, desired future population status, and primary threats? What elements of the strategy are missing? Be explicit about each threat or potential factor limiting recovery.

The H effects were described in the submittal except for the White River Chinook supplementation program.

The strategies were well expressed for addressing the primary habitat, hatchery and harvest factors. The rationales for the strategies were not linked to potential problems in population status (i.e., VSP) or the stated habitat factors limiting recovery.

The EDT assessment accounted for all known factors, but was limited in scope to an assumed "no net loss" baseline (i.e. The hypothesis assumes that a status quo baseline is maintained, in the face of human population growth and development, by protection actions) plus the habitat actions scenarios, with no harvest and some hatchery (e.g. fitness loss) effects. Further analysis and documentation is needed to generate "real world" strategies and predicted outcomes for specific sets of actions and conditions.

The strategies for addressing habitat factors listed for WRIA 10 were: protect South Prairie Creek mainstem and estuary, restore estuary, address diversion screens at Electron Dam, restore floodplain connectivity in lower Puyallup, White and Carbon, changes in flow management for Mud Mountain Dam and PSE bypass, removal and amelioration of migration barriers, and increase protection and restoration of currently highly productive tributaries. WRIA 12 strategies and resulting actions recommended were: restoring habitat diversity (via LWD projects, floodplain restoration and reconnection, riparian restoration), improvement in low flow conditions, and remove barriers.

Linkages between strategies and the list of priority actions were not clear. For example, high-priority actions were listed in the Table under the answer to question D. Why wasn't there an action listed there

that was associated with flow management changes at Mud Mountain Dam? Also, there were no actions that constitute protection for South Prairie Creek, even though that is listed as a key strategy. Strategy development is a key step in the recovery planning process where multiple lines of evidence can significantly improve certainty in recovery success (see uncertainty question.)

The plan stated that nearshore strategies are covered in the South Sound plan. It does not appear that any coordination with other nearshore areas has been done.

The hatchery strategy was stated as necessary to maintain runs in the 2 populations, and the need for reform measures was noted. A concise statement of how harvest levels or hatchery management practices are adjusted based on desired salmon population goals should be included in a Puyallup watershed recovery plan.

e) How are actions in the H's linked to fish population status? Both existing and future/planned H actions should be addressed. Are these links based on empirical or modeled estimates or both? Be explicit about each threat or potential factor limiting recovery.

Hypotheses for how habitat factors affected (or are affecting) VSP parameters in the 2 populations are not documented, even though these hypotheses are formulated in the EDT modeling. A recovery plan needs to summarize an important missing link in the logic: what are the current and desired states of salmon population status, what habitat factors are most critical in limiting recovery to VSP goals, and what actions will effectively improve habitat factors so that VSP targets can be achieved?

EDT was used to evaluate the effects of 123 actions suggested by the TAG. The actions suggested were somehow bundled into scenarios by Mobrand before analysis—what were the scenarios explored? (This may be described in another document.) What are the bases for the assignment of "technical feasibility" and "certainty of outcome" for actions specified in EDT inputs in Appendix B?

The submittal includes sections on harvest and hatcheries action affects on the populations. However, the discussion in the answers to the questions does not appear to be related to the EDT assessment. For example, hatchery fitness effects, competition and predation affects are included in the EDT assessment, but are not presented and discussed in regard to predicted VSP responses. Potential hatchery and harvest effects on VSP are stated in very general terms—not specific to VSP parameters or magnitude of predicted effects.

(e)What are the plan's stated assumptions about existing habitat conditions or actions outside of the WRIA jurisdictional boundaries covered in the plan (freshwater and estuarine/nearshore)?

The plan stated that candidate actions for estuarine and bay areas were analyzed in EDT and are described in App. B. How were these developed, included with other EDT modeling results reported for freshwater?

The plan did not explicitly state these assumptions, except to note that they are covered in the South Sound plan. It was not clear how the nearshore policy group is related to planning in the White/Puyallup. Why are some documents from those meetings included in the documentation the TRT received as part of the plan?

(f) Are future options preserved in the proposed strategy-action links? How so? Be explicit about each threat or potential factor limiting recovery.

4. What is the empirical or modeled SUPPORT for the answers to question #3? How well do the Assessment data for the population status and the H's support the hypotheses proposed?

(a) What is the population's current status for all 4 VSP (this should come out under the hypotheses)?

The submittal provided some information on current status, specifically the discussion on low productivity. The population status reported was based solely on EDT results. More information is available in the EDT documentation. The TRT encourages the watershed to develop multiple lines of evidence arguments in a Puyallup watershed recovery plan using information such as in the harvest management plan, the co-manager recovery plan for White River Chinook, and the TRT abundance and productivity database to bolster their statements about current status. Since there were no explicitly stated hypotheses for what VSP status is, it is not possible to tell how well the hypothesis was supported by data or models.

(b) What is the population's predicted status for all 4 VSP over the short- and long-term?

The submittal provided a cursory discussion on the predicted status. More details are available in the EDT documentation. The EDT model results suggested % or numerical improvements in Abundance, Productivity, and Diversity for each population if the chosen habitat actions were implemented. As discussed above, the bases for the EDT results were difficult to decipher from the information presented.

The EDT assessment contained substantial information on the spatial distribution of habitat, actions, and predicted responses, but did not engage in any discussion of how that may affect population status over the short- and long-term.

(c) What are critical threats affecting the populations? Have all been identified and considered in the stated hypotheses? Are there potential threats that are missing from the plan? Be explicit about each threat or potential factor limiting recovery.

The various threats to the two populations were provided in the appendices; A, B, C, E. A large number of the threats were discussed and linked to the population status at the project and strategies levels through the restoration assessment (appendix A and B). Regulatory protection measures (e.g. water quality) and the Electron bypass reach flows were not included in that assessment.

The hypothesized effects of the main habitat factors considered were included in the results from EDT, though they were not reported explicitly in the main document. As for all H factors, these should be stated clearly as hypotheses, and their basis should be included. It is not clear how all of the potential habitat threats are prioritized in any order of importance in re: their effects on VSP characteristics.

No rationale or reference was provided for the reasoning underlying the harvest or hatchery effects—either that past harvest rates likely contributed to declines or that present rates should allow for recovery. Similarly, the potential beneficial or detrimental effects of hatchery practices were not outlined.

(d) Is the strategy for H management changes consistent with the identified hypotheses for current population status, desired future population status, and primary threats? What elements of the strategy are missing? Be explicit about each threat or potential factor limiting recovery.

The strategies aimed at addressing each habitat factor were developed based on results from EDT. It is very difficult to know how to consider the lists of existing and possible projects in specific areas within the Basin because the assumptions leading to their inclusion are not well described. It appears that these lists were made based on a combination of an analysis of "effectiveness", and "feasibility", and then those actions were included in EDT analyses. EDT results were used to prioritize actions—how was this done (using predicted effects on VSP, as in the Dungeness approach?) How were action effectiveness and feasibility determined so that actions to be included in EDT could be chosen?

The basin-specific habitat strategies were affected by key assumptions in EDT—one mentioned in several places is "normalizing for reach lengths". The implications of this assumption and how it affects results and decisions on priority strategies need to be explained. Furthermore, it appears that the prioritization

of actions with EDT focuses on currently productive Chinook areas, so the future potential (based on historical potential) was not considered, which seems to be a shortcoming of the overall strategy.

The basis for the hatchery and harvest management strategies isn't clear from the information provided in the plan. For example, what is the basis for exploitation rates of 50% and 20% in the Puyallup and White River populations, respectively? What are the bases for the juvenile hatchery fish release numbers in the White and Puyallup basins?

(e) How are actions in the H's linked to fish population status? Are these links based on empirical or modeled estimates or both? Be explicit about each threat or potential factor limiting recovery.

The summary outlined the priority changes in the habitat by major groupings of action types and area and the expected responses of the two populations. The EDT model was used to predict the VSP results from implementing subsets of the candidate habitat actions. The priority physical changes in habitat were diagnostically driven results from the EDT assessment of projected population level responses to a comprehensive menu of potential restoration projects and assumed protections. It is hard to evaluate the results with the information given. This is because assumptions made about how habitat actions translate into habitat conditions, how habitat conditions affect VSP, and what assumptions were made about harvest and hatchery management was not explained in the document. Thorough review of the EDT assessment inputs and assumptions would be required to fully understand the complete list of protections and actions that were embedded in, or implied by the EDT assessment. A Puyallup watershed restoration plan should clearly describe these linkages and characterize the potential effects of the assumptions on uncertainties in population status assessments so that the rationale and uncertainties can be readily evaluated (e.g. How were the candidate actions identified? How were the effects of those actions translated into EDT inputs? How were actions grouped into scenarios?).

It is important for users of EDT results to be aware of the explicit links between actions and habitat conditions that are missing, and to take those into account when interpreting results from EDT. For example, which actions are most likely (to least likely) to be successful in producing the predicted habitat condition or VSP results? (See discussion in Watershed Guidance Document regarding protection-restoration continuum). In addition, considering HOW a specific number of acres will be restored in different areas is important—what restoration technologies/techniques are fairly well established and known to work; which are more experimental and therefore uncertain in their outcomes? How likely are protected areas to function well, given their surrounding matrix of land and water conditions? Another important question for those interpreting EDT results to ask is what habitat conditions are assumed to occur in areas outside of project locations? (e.g., existing levels of protection in certain areas, regulation, effects of forest practices, rates of development, etc.?) Are certain assumptions more/less likely or risky?

For the above reasons, it is important for a recovery plan to explicitly acknowledge gaps in the component assessments and account for the remaining uncertainties. The strength of the empirical or modeling evidence demonstrated for the effectiveness of the proposed actions will have a significant influence on the implementation certainty of a recovery plan.

(f) What are the plan's stated assumptions about existing habitat conditions or actions outside of the WRIA jurisdictional boundaries covered in the plan (freshwater and estuarine/nearshore)?

None were given. Relationships between the Puyallup watershed plan and other elements of the Puget Sound recovery plan (e.g. the South Sound plan chapter) will need to be developed.

(g) Are future options preserved in the proposed strategy-action links? How so? Be explicit about each threat or potential factor limiting recovery.

The Puyallup watershed plan should include action strategies to identify and preserve future

opportunities for the priority restoration action groups that have been identified by the EDT assessment as essential for progress toward recovery. Demonstration of how future options are to be preserved in the proposed strategy-action links would reduce the uncertainty of implementation.

5. **How are the individual and interacting effects of the H's on the 4 VSP parameters considered for each population? How likely is it that the proposed suites of H actions will achieve the short- and longer-term stated goals? How certain are we in their translation into effects on salmon population VSP? Be sure to make note of the assumptions the plan makes about the effects of hatchery and harvest management, existing habitat actions, and survival in the nearshore/ocean, for ex**.

The EDT assessment accounted for all known factors, but was limited in scope to an assumed "no net loss" baseline (i.e. The hypothesis assumed a status quo baseline is maintained, in the face of human population growth and development, by protection actions) plus the actions scenarios with no harvest and some hatchery (e.g. fitness loss) affects.

It appears that further integrative analyses will be needed to generate "real world" predicted outcomes for specific sets of all H actions (e.g. Some assessment of projected build out effects for alternate effectiveness levels of protection actions, along with alternate hatchery and harvest scenarios would need to be added to habitat action scenarios).

A well documented integrated strategy where the interacting effects of the H's are considered in regard to their effects onVSP is a necessary element of a Puyallup watershed recovery plan.

6. **How does the plan acknowledge uncertainties and how are they factored into decisions, future actions**?

   (a) Uncertainties in data and information?

The assessment used alternative sets of habitat actions to explore possible VSP outcomes, which is a good feature. It is not clear how the alternatives were developed and evaluated to arrive at the reported results. A transparent explanation of the logical basis and analysis processes used to formulate the results, bought forward into a Puyallup watershed recovery plan, could serve as a useful framework for discussions of the various remaining uncertainties.

The assumptions made for harvest and hatchery management, and how habitat conditions were translated into population effects in the EDT modeling were not provided, so it is not possible to evaluate the confidence in these results. For example, EDT inputs included a categorization of data types/certainty, but it is not clear how these certainty levels affected subsequent use of the habitat conditions or ultimate decisions about actions.

In general, the assessment did employ a "multiple lines of evidence" approach. Bringing forward the multiple lines of evidence currently available in the Puyallup watershed to design recovery strategies could provide a very strong basis for decisions on recovery strategies and actions that would be best pursued in a recovery plan. (e.g., there are several different estimates of historical population abundance—EDT, Sanderson et al., numbers from the White River plan—why aren't these compared/contrasted and used to provide a rationale for choosing actions or predicting their effects?) A clear description of how uncertainties (in data, model/analysis interpretation) affected or will affect decisions about projects and where to prioritize effort is needed in a Puyallup watershed recovery plan.

The estimated current abundance for Puyallup and White River chinook was noted and briefly discussed under question 3 a. There should be an explicit statement about what assumptions were made in estimating fraction of historical abundance and a suggestion to strengthen the weight of evidence supporting them with other evidence. The following discussion addresses why documentation of

assumptions and addressing remaining uncertainties for a recovery plan separate from the component assessments it is important:

For example, the template conditions assumed to be appropriate for the EDT assessment of the lower White River were different from the actual historical conditions in the river prior to European settlement. The high degree to which the physical structure of the river in this sub-basin of the watershed has been altered from the historical template condition leaves a significant element of uncertainty embedded and unaddressed in the reported results [see the discussion in the Technical Guidance to watersheds]. This clearly demonstrates how clear documentation of assumptions and identification those cases where additional testing and/or independent supporting analyses are needed to reduce remaining uncertainties can strengthen the overall rationale for a recovery plan separate from the merits of the assessments it is based upon.

Another example of an assumption in the EDT assessment that left a significant element of uncertainty embedded and unaddressed in the reported results was "the alternative world views" assumption for the effects of estuarine habitat conditions on productivity, capacity, and diversity of the stocks assessed. Again, additional testing and/or independent supporting analyses are needed to reduce the uncertainties remaining the EDT assessment results associated with the assumption.

The submittal did not specifically address validation of the watershed assessment through either additional separate assessments or validation testing of the EDT method. The uncertainties regarding the strategic priorities and action scenarios presented could be reduced, perhaps significantly, if either of the above steps were taken to strengthen the weight evidence in support of their results. Additional separate assessments, using the existing data could reduce uncertainties within a recovery plan itself, whereas validation would be a course of action during implementation.

Pierce County has indicated they will maintain active participation in watershed assessment and recovery and will maintain the EDT method online. This is to include updates and refinements to the assessment as new information becomes available. This appears to be a good tool for implementation once a recovery plan is formulated and adopted and appears to be an important and useful step forward.

(b) Uncertainties in environmental conditions in the future?

Pierce County has indicated that by maintaining the EDT method online, they will be able to update and refine the assessment as new information becomes available. A clear statement of the intent for how this information would be applied within an adaptive management framework would be a useful element of a Puyallup watershed recovery plan for understanding specifically how this will address uncertainties in environmental conditions in the future.

(c) Uncertainties in effectiveness of actions?

Beyond a general recital of expected continuing Pierce County participation in multiple processes to gain and apply "best available science", there is no specific strategy for managing implementation of actions based upon some assessment of the relative risks of alternate courses of actions. Reference was made in the submittal to the use of the online EDT to enable Pierce County to develop and analyze new restoration scenarios. This could be interpreted as a generalized reference to use of adaptive management principles in implementation to test programmatically for effectiveness of the scenarios and make course corrections in the strategic priorities. The submittal only stated this as a capability.

Descriptions of how "technical feasibility" and "certainty of outcome" in EDT inputs (Appendix B) affect results for EDT or its interpretation in a Puyallup watershed recovery plan could provide a clear characterization of the areas of uncertainty regarding restoration of habitat functions. It is especially

important to address this issue in areas where uncertainty in VSP parameters or H factor problems exist, and what actions will address those problems (e.g., nearshore is very uncertain); the adaptive management plan should be clearly stated and specific.

7. **Reviewer: What is the estimated overall level of risk for the population(s) included in this plan, relative to low-risk (i.e., viable) population criteria? What is your rationale for this risk estimate? How certain are you in the estimation for each VSP parameter?**
   The probabilistic network analysis should help inform the answer to this question.

The probabilistic network analysis helps to frame an approach to inform discussions on the risks posed by a recovery plan. However, until a recovery plan is formulated for this watershed, it is premature to address this question.

8. **Make any suggestions for approaches or methods for addressing concerns mentioned above or reducing gaps in the plan.**

The co-managers recognize that a significant value exists in updating their White River Chinook rebuilding plan and have expressed a desire to proceed with such an update. Integration of this assessment with the Pierce County watershed assessment and other Hs in a Puyallup watershed recovery plan would provide the necessary linkages between the various actions and the expectations and predictability in population VSP characteristic responses as outlined in the TRT watershed technical guidance document. For example, remaining uncertainties on the population structure of Chinook spawning in the White River need to be resolved in the near-term to reduce risk of losing genetic integrity or diversity through numerous continuing and new actions across all 4Hs based upon erroneous information (Ruckelshaus et. al. in prep, Shaklee and Young. 2003). The TRT supports the parties' interests in pursuing an all Hs integrated approach to recovery planning.

The submittal included summary descriptions of hatchery chinook production programs in the Puyallup watershed and Operational guidance for hatcheries in South Sound, including reference to the draft Hatchery Genetic Management Plans (HGMPs) and a listing of specific HSRG recommendations for the South Sound area and for the Puyallup fall chinook stock production facilities. A comprehensive discussion of the White River Chinook supplementation program and issues needs to be added to the plan. An updated co-manager's White River Chinook rebuilding plan could provide the basis for discussion and form the basis for integration between the local habitat plan, the hatchery programs, and Federal management decisions for the Hydro system.

The watershed assessment has demonstrated that more normal flows from the Mud Mountain Project and restoration of flows to the White River Hydroelectric Project Bypass Reach are key actions. A comprehensive flow restoration initiative with all federal agencies fully participating as recovery implementation partners is needed to address this recovery plan element.

The EDT Phase 2 assessment materials acknowledged that sequencing of actions is an important matter and that the benefits of the priority actions could be improved by follow up analyses of logical sequencing scenarios.

The summary statement that Chinook in the Hylebos watershed are not presently sustainable under existing conditions does not reflect the role the area may play as laid out by applying the TRT guidance document. Areas such as the Hylebos can help to maintain population and ESU diversity and spatial structure characteristics that help increase long-term persistence of the ESU. This is expected to be the case even for areas that "do not consistently support Chinook" as these intermittently occupied areas facilitate population and ESU spatial structure processes important to ESU persistence. For example,

while it is unclear what the historical association of the chinook utilizing the Hylebos and its estuary had to the Puyallup watershed Chinook population structure, the close proximity suggests it did play an important role in spatial structure and diversity characteristics contributing to long-term persistence. Questions as to what role the Hylebos watershed will play in supporting the viability of the Chinook in the Puyallup watershed should be fully addressed in a recovery plan in terms of all four VSP characteristics.

Also see the answers of the individual questions and the summary of the probabilistic network analysis.

III. Analyzing Certainty of Biologically Effective Recovery Plans

All watersheds in the Puget Sound are unique. Not surprisingly, different watershed planning groups identify different long-term and short-term goals and propose different suits of actions to achieve those goals. The certainty that the actions in every watershed will be biologically effective in moving the populations towards recovery is a key factor in the recovery of the whole evolutionarily significant unit (ESU). Consequently, the Puget Sound Technical Recovery Team (TRT) has focused its analysis of watershed recovery plans on identifying ways to increase the certainty of the plans. The TRT hopes that these analyses will encourage watershed groups to improve the certainty of plans before the TRT does it analysis of the final plans next year.

To provide these analyses, the TRT used a probabilistic network (PN). A probabilistic network is a graphical model that shows how different states of the world of interest—in this case the scientific factors that provide certainty of biologically effective actions—are related (Figure 1). The basic approach is to assess certainty by applying conditional probabilities, which can be expressed as "Given event *b*, the likelihood of event *a* is *x*." In Figure 1, for example, the states of the variables in boxes that point to another variable (e.g. "Use of Independent Models" and "Analytical Support") are the events that condition the likelihood of the states for the latter variable (e.g. "High", "Moderate", and "Low" in the Certainty of the General Fish Response Model). Users provide evidence for the initial conditioning events (or diagnostic nodes); software for PNs use a set of sophisticated algorithms for recalculating the joint probability distributions for all the potentials based on tables of conditional probabilities provided by the analyst (Jensen 2001). Using a PN gave the TRT a rigorous, transparent, repeatable method of analyzing certainty across watershed plans and habitat, harvest, and hatchery management sectors.

Methods

The Puget Sound Technical Recovery Team (TRT) used the PN in Figure 1 to assess separately the certainty of biologically effective actions for each plan in four management sectors, 1) freshwater habitat, 2) nearshore habitat, 3) hatchery production, and 4) harvest. Each assessment also considered how well integrated actions were across categories and how the actions affected characteristics of viable salmonid populations (McElhany et al. 2003). The network graphically shows the logic of how different scientific variables affect the biological certainty of effective recovery plans. The model is based on the TRT's *Integrated Recovery Planning for Listed Salmonids: Technical Guidance for Watershed Groups in the Puget Sound* (http://www.sharedsalmonstrategy.org/files). The network shows that the overall biological certainty of an effective recovery plan depends on the certainty of the recovery strategy (Recovery Strategy), the robustness of the strategy (Preserves Options), and the expected effectiveness of actions chosen to implement the strategy. The certainty of the recovery strategy in turn is conditioned by the certainty of how well we understand the biological, physical, and chemical processes that affect the population (i.e. Recovery Hypothesis), which depends on well recognized sources of scientific uncertainty (Lemons 1996), such as model uncertainty (Use of Independent Models), framing uncertainty and stochasticity (Analytical Support), and empirical support for the hypothesis (Watershed Data Quality). After identifying the model structure, the TRT identified and defined different states of the variables (Tables 1-6).

Conditional probabilities may be derived from frequencies from empirical data, simulation results, or subjective probabilities. When data are too few to parameterize simulation models, use of subjective probabilities is important (Bedford and Cooke 2001) and analysts have developed methods for estimating these (e.g. Ayyub 2001). Using experts to estimate subjective probabilities has inherent biases that can be difficult to control (Kahneman et al. 1982, Otway and von Winterfeldt 1992). Using estimates of conditional probabilities within a logical, transparent model such as a PN

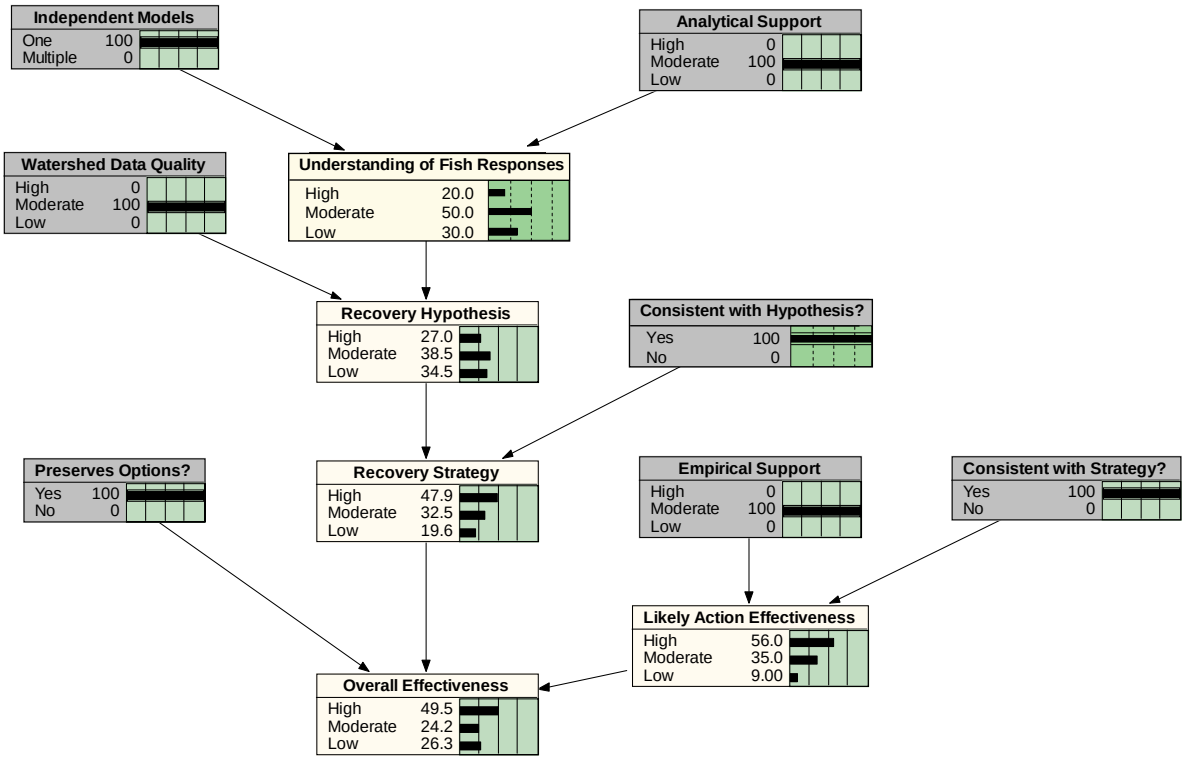

Figure 1. Probabilistic network for evaluating the biological certainty of effective recovery plans illustrating the results of a hypothetical review. Diagnostic nodes are shaded. Numbers at each node are the probabilities for each and the bars show the distribution of the results.

may reduce these problems compared to asking experts to provide absolute certainty estimates directly without a model. The TRT estimated conditional probabilities using a Delphi process (Helmer 1968, Ayyub 2001) in which TRT members iteratively estimated conditional probabilities individually; the distributions of the results were compiled and shared; and new estimates were generated. Sensitivity of the model was evaluated using the mutual information index (Pearl 1988) which measures the reduction in entropy of variable *A* due to a finding at *B*.

The TRT qualitatively assessed the states of seven diagnostic variables (box titles in parentheses) that address these questions:

1. Did the analysis use one or multiple independent models to understand potential fish responses to actions? (Independent Models)
2. How well supported is the model? (Analytical Support)
3. How well supported is the recovery hypotheses with watershed specific data? (Watershed Data Quality)
4. Is the recovery strategy robust by preserving options for recovery? (Preserves Options)
5. Is the recovery strategy consistent with the recovery hypothesis? (Consistent with Hypothesis)
6. Are the recovery actions consistent with the recovery strategy? (Consistent with Strategy)
7. How well have the recovery actions been shown to work? (Empirical Support)

The possible answers to these questions are in Tables 1-6. Reviewers usually choose one state, but if this is not possible because of uncertainty, reviewers could assign probabilities to different states (e.g., "Low" = 10%; "Moderate" = 90%). Analyses were performed using Netica (Norsys Software Corporation, Vancouver, BC; http://www.norsys.com).

Interpreting the Results

Even the best recovery plan is inherently uncertain because the future is so difficult to predict. Consequently, the quantitative estimates of certainty generated by the TRT are less important than the relative improvement that watershed planners need to make. For similar reasons, the quantitative estimates of certainty generated by the TRT are not relevant to analyses of certainty performed by regulatory agencies, which depend on a different interpretation and standard of certainty. Based on the TRT analyses, watershed planners may be able to increase the certainty of biological effectives several fold by focusing on several key factors. These are described in individual watershed analyses.

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Table 1. Attributes for different states of analytical support for models.

Analysis	Total Score	Attributes (Maximum Possible Score)
Habitat Models High Moderate Low	 0.60 -1.00 0.21 - 0.60 0 - 0.20	• Qualitative and/or quantitative description of the relationship landscape processes, land use, and habitat condition – (0.1 for each analysis) • Qualitative and/or quantitative description of the relationship between habitat condition and population viability (VSP) characteristics – (0.1 for each analysis; 025 for each VSP characteristic) • Model structures and parameters for each VSP characteristic documented; assumptions discussed and defended – (0.2) • Sensitivity of model to changes in parameters known – (0.2) • Model tested empirically and calibrated to watershed – (0.2)
Harvest Models High Moderate Low	 0.60 -1.00 0.21 - 0.60 0 - 0.20	• Qualitative and/or quantitative description of link between demographic processes, harvest effects, and population viability (VSP) characteristics– (0.2 for each analysis; 0.05 for each VSP characteristic) • Model structures and parameters for each VSP characteristic documented; assumptions discussed and defended – (0.2) • Sensitivity of model to changes in parameters known – (0.2) • Model tested empirically and calibrated to watershed – (0.2)
Harvest Models High Moderate Low	 0.60 -1.00 0.21 - 0.60 0 - 0.20	• Qualitative and/or quantitative description of link genetic and ecological processes, hatchery effects, and population viability (VSP) characteristics – (0.2 for each analysis; 0.05 for each VSP characteristic) • Model structures and parameters for each VSP characteristic documented; assumptions discussed and defended – (0.2) • Sensitivity of model to changes in parameters known – (0.2) • Model tested empirically and calibrated to watershed – (0.2)

Table 2. Attributes for different states of the quality of watershed data (support for hypotheses)

States	Attributes
High	• Used empirical population, habitat, and management data from the local watershed at multiple spatial scales to support hypotheses; sources clearly documented; assumptions explained
Moderate	• Used empirical population, habitat, and management data for watersheds or populations within the species' range OR used local watershed data but data highly uncertain or assumptions not well explained
Low	• Used theoretical support for hypothesis or expert opinion based on biological principles and local knowledge of the watershed

Table 3. Attributes for different states of consistency of recovery strategy with recovery hypothesis.

States	Attributes
Yes	Clear and logical relationship between the recovery hypothesis based on processes and conditions for habitat, harvest, and hatcheries and the recovery strategy as evidenced by • Main elements of strategy organized around dominant recovery hypotheses • Elements of strategy reflect spatial attributes of recovery hypotheses • Elements of strategy reflect temporal attributes and action sequencing of recovery hypotheses
No	No clear and logical relationship between recovery hypotheses and strategy; one or more of attributes listed above missing

Table 4. Attributes for different states of preservation of options in the recovery strategy

States	Attributes
Yes	• Strategy protects existing population viability (VSP) structure and opportunities for future improvement in habitat, harvest, and hatchery conditions; adaptive management & monitoring program maintains options for implementing strategy
No	• Strategy does not protect existing VSP structure or opportunities for future improvement in habitat, harvest, and hatchery conditions; adaptive management & monitoring program does not maintain options for implementing strategy

Table 5. Attributes for states of consistency of actions with recovery strategy.

States	Attributes
Yes	• Clear and logical relationship between the short-term and long-term actions and recovery strategy recovery hypothesis • Elements of strategy reflect spatial attributes of recovery hypotheses • Elements of strategy reflect temporal attributes and action sequencing of recovery hypotheses • No strong relationship between fish response models and recovery hypothesis
No	• Actions generally consistent with recovery strategy but major actions are missing or staging of major is inconsistent with recovery hypothesis • Little relationship between actions and strategy; major short-term and long-term actions do not follow from the recovery hypothesis and strategy

Table 6. Attributes of empirical support of recovery actions.

States	Attributes
High	• Evidence for effects of suites of actions (in habitat, harvest, or hatcheries) is clear and unambiguous; broad applications have been tested with similar results; uncertainty incorporated in assessments
Moderate	• Some empirical evidence of effectiveness in similar settings; few tested applications; some conflicting results; predictions of effect do not incorporate uncertainty
Low	• Little or no empirical evidence of the action being effective or appropriate