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

Lake Washington/Cedar/Sammamish (WRIA 8)
Chinook Salmon Conservation Draft Plan submitted June 30, 2004

This 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

1. *Did the analysis use one or multiple independent models to understand potential fish responses to habitat actions? What is the nature of the analytical support for the model*

linking population status to changes in habitat-forming processes and in-stream habitat conditions?

A single model (EDT) was used to describe and evaluate the relationship of habitat conditions to population response (VSP parameters) for both populations. However, spatial structure did not appear to be included as an output for this analysis. A second, qualitative model was used to describe a set of watershed conditions but this model was not linked through habitat-forming processes to the EDT model. Some logic-based links could have been developed; instead, it was used to create "tiers" by which actions could later be prioritized and sorted. There is discussion of "process-based" restoration, but this concept was not carried through the analysis and linked to VSP parameters.

There are no quantitative predictions for the effects of restoration actions on habitat conditions or VSP parameters; the diagnostic phase of EDT analysis was the only one carried out, in order to establish recovery (habitat) hypotheses. There is reasonably good documentation of the habitat conditions that form the inputs to the EDT model for both populations but it could be improved for flow conditions in the Cedar River by discussing the assumptions made in the Cedar River HCP.

Analytical support for the model is considered moderate based on the lack of some documentation elements and on the lack of a sensitivity analysis and empirical support.
There is little discussion of the assumptions for the effects of project actions or classes of actions in habitat conditions or on VSP parameters; little discussion of the assumptions for protection of current habitat conditions; and virtually no discussion of the effects of the current path of land use on process and habitat conditions.

No sensitivity analysis of the model has been done, so the effects of varying input assumptions on the model results cannot be determined. No independent empirical comparison of the model output with watershed data has been done, and no calibration of the rules and relationships to local conditions has been done.

Near-term steps to increase certainty:

- Highlight, if applicable, where multiple lines of evidence are used to support the general analytical model linking land use, habitat forming processes and habitat condition to population response for both populations;
- Create a logic-driven qualitative model between the land use conditions in both watersheds and the habitat-forming processes that could be used to bridge the conceptual gap between watershed condition and EDT inputs;
- Discuss the assumptions for current path land use on the protection of existing habitat conditions and VSP parameters;
- Include a discussion of the flow: habitat assumptions from the Cedar River HCP.

Long-term steps to increase certainty:

- Use EDT to evaluate the restoration actions proposed in the plan. Document the assumptions used to set the input parameters for this work and compare with the projects derived from the diagnostic phase;
- Conduct a sensitivity analysis of the EDT model so that the relative importance of the assumptions and inputs can be understood.

2. *How well supported are the hypotheses for (1) the VSP parameters most limiting recovery and (2) the habitat-forming processes or conditions that are limiting the population response? What is the nature of the watershed-specific data used to support (either of) these hypotheses?*

This rates a moderate from the TRT. The hypothesis that increasingly intense land uses have led to habitat decline and thus to a decline in VSP attributes is poorly stated and appears to be based mainly on expert opinion. Little direct empirical evidence linking land use to changes in VSP parameters is provided in the plan, although much circumstantial evidence is presented. The watershed condition model is helpful here but requires evidence linking the attributes to habitat condition and then to VSP. Juvenile life stages are assumed to be the most directly affected, particularly productivity and diversity for the fry stage. There is some juvenile survival data for movement through the Hiram Chittenden Locks. There are, however, few other data about juvenile productivity for either population. The habitat data supporting the hypothesis is more robust and there may be more available that would support the hypothesis more strongly, but it must be documented. There seems to be information in the plan (and in the EDT work) that could provide life stage and habitat-specific hypotheses that would be quite useful as links to habitat projects and recovery actions.

There is little information about the potential effects of the Cedar River sockeye program on Chinook in that system. Is this program considered to have insignificant effects on the Chinook population?

Near-term steps to increase certainty:

- If there is direct evidence linking land use intensity and changes in habitat condition to any or all VSP parameters, it should be brought into the plan and documented;
- Present any habitat or population data that supports the hypotheses independent of the EDT results;
- Without investing in the EDT treatment phase, use the diagnostic information to derive some life stage-specific hypotheses for VSP parameters and habitat conditions;
- Develop an explicit hypothesis about the effects of the sockeye program on chinook VSP in the Cedar River.

Long-term steps to improve certainty:

- Calibrate and run the “treatment” phase of the EDT model for the populations;

- Begin collecting juvenile survival data for different habitat types used by the populations;
- Using the watershed evaluation model as a start, develop an evaluation model that links land use to habitat forming processes (hydrology, erosion, etc) and then to habitat condition;
- Use the model to monitor and evaluate suspected mechanisms between land use, processes and habitat conditions.

3. *Is the recovery strategy consistent with the recovery hypotheses for population status and key habitat factors limiting recovery?*

The habitat recovery strategy is not consistent with the recovery hypotheses. First, because there are no long term recovery goals adopted for this draft plan, there is no explicit long-term strategy for achieving recovery. Short-term goals are discussed, but these are not embedded in an overall strategy for achieving population viability. Second, land use effects are held as a primary cause for habitat degradation, and it would seem that any strategy should be directed toward alleviating these effects. The draft plan however, does not address a widespread, coordinated strategy for addressing land use effects. Third, there is no integration of the habitat work and evaluation with either hatchery or harvest strategies. There is no clear discussion of the harvest and hatchery assumptions and their implication for a habitat strategy. This is particularly important for understanding the effects of the sockeye program in the Cedar on Chinook viability and habitat recovery actions.

Near-term steps to increase certainty:

- Develop recovery goals—even interim ones—for both populations;
- Given the recovery hypotheses in the plan, develop an explicit strategy following the guidance in the PSTRT Watershed Guidance document;
- Obtain the hatchery and harvest management programs for these populations from the co-managers and examine the assumptions of each. Discuss the implications for the habitat strategies in the respective watersheds;
- Examine and discuss the implications of the sockeye hatchery program for the habitat strategy in the Cedar River.

4. *Does the habitat recovery strategy preserve options for recovery of all four VSP parameters across all Hs?*

The weak habitat recovery strategy does not consider all four VSP parameters (spatial structure is largely absent) and is not integrated with either hatchery or harvest strategies for the populations. Because the habitat strategy is not informed by assumptions or actions in the other Hs, it does not, by definition, preserve options for recovery. It is unclear how VSP attributes will be recovered.

Although there is an excellent discussion and framework for adaptive management, the decision support system and the monitoring and evaluation program that supports it is not developed explicitly enough to evaluate the program’s ability to respond to information and make corrections in management direction or in program objectives. This is not unique to the Cedar and Sammamish recovery plans, however. Many plans lack even the framework for adaptive management that this draft plan describes so well.

Near-term steps to improve certainty:

- Obtain the harvest and hatchery assumptions for the populations and for other hatchery programs that affect these populations and clarify the assumptions for effects on the VSP parameters. Use these assumptions to evaluate the interaction of the habitat strategy with the other H strategies.

Long-term steps to improve certainty:

- Develop the monitoring and evaluation elements for the adaptive management program. These elements should be included: decision model, criteria for decision points, metrics, monitoring protocols, data required, management alternatives at decision points.

5. *Are the habitat recovery actions consistent with the recovery strategy?*

The version of the draft plan reviewed by the PSTRT contained no explicit recovery actions. This element was judged to be "No". This could become a "yes" with the inclusion of strategic recovery actions as the plan progresses.

6. *How well have the habitat actions been shown to work?*

Without explicit recovery actions, this cannot be determined. However, proposed protection measures that rely on current regulatory pathways have poor empirical support; the relationship between regulations, their implementation and their outcomes to support recovery is unpredictable. This element was judged to be low due to the lack of empirical evidence and poor predictability. This could improve as further analysis on regulatory protections is done and other recovery actions are included in subsequent drafts of the plan.

Near-term steps to improve certainty:

- A thorough analysis of the regulatory framework that reveals gaps in protection and evaluates effectiveness should be carried out for these watersheds;
- Develop a list of strategic recovery actions to be included in the plan;
- Provide empirical evidence of the actions' effectiveness for improving habitat conditions and VSP attributes.

Long-term steps to improve certainty:

- Include the evaluation of the regulatory and non-regulatory actions in the adaptive management plan.

Note: Because hatchery and harvest strategies were not included as part of this plan, a PN analysis for harvest and hatchery could not be carried out. The PSTRT will carry out a PNA when these elements are received.

II. Consolidated Comments on Technical Review Template

REVIEW TEMPLATE FOR TECHNICAL REVIEW OF DRAFT WATERSHED PLANS

Reviewer's Name: **PSTRT and Adjunct Reviewers**

Watershed Plan: **Sammamish-Cedar**

Populations or ESUs considered: **Cedar; Sammamish**

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 plan covers the greater Lake Washington watershed including the Cedar River, Lakes Washington and Sammamish, Issaquah Creek, and the North Lake Washington (Sammamish) tributaries: Bear Creek, Little Bear Creek, North, and Swamp Creeks. It addresses two TRT populations: the Cedar River Population and the Sammamish (NLW) population, and adds a third—the Issaquah hatchery population—to the analysis and action. The plan seems to have a good understanding of the habitat factors that have caused degradation in the Chinook population. Although the plan relies on an ecological approach, it addresses only Chinook.

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?

No targets have been provided for these populations. However, the plan developers have proposed short-term goals and objectives for VSP attributes in most cases, and some long-term objectives for 3 of 4 VSP parameters (omitting abundance). These can be found in chapter 4. The Technical Committee has identified several options for consideration: a percentage of PFC as proposed in WRIA 7; a modified PFC for urban areas; a percentage improvement in key habitat attributes.
Overall, the plan points out the necessity for considerable restoration, moving toward PFC by advancing conditions through a shorter term objective of Best Prevailing Conditions that defines

the best conditions in the watershed for the PFC attributes. In terms of VSP, the plan calls for improvements in all parameters as necessary for viability; the plan calls for increases in LWD, riparian attributes and in-stream habitat complexity as necessary to support viability. The plan is centered around VSP as an organizing framework, using EDT for linking habitat actions and conditions to VSP attributes, and employing a Watershed Analysis to set the EDT (and VSP) information in context.
There are no goals for the nearshore or for Lake Washington habitats, however. Page 63 has several actions but their origin is unknown.

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?

For productivity, the plan suggests a 2X increase in juvenile survival at all juvenile life history stages but gives no absolute productivity objective; for spatial structure, the plan calls for the transformation of a satellite area (for each population, I assume) to be transformed into a core area; for diversity, the plan proposes an increase in the in-stream rearing juvenile stage from 25% of the population to between 30 and 40%.; for abundance, the plan adopts the objective of 1250 NOR spawners in the Cedar and 350 in Bear and Cottage Creeks.
Over the long term, productivity objectives are for a S/S ration of at least 1; for spatial structure, re-establish the historic spatial structure; for diversity, increase the in-stream LHT to 50% of the out-migrant population. The following table summarizes the goals:

Characteristic	Short-term	Long-term
Abundance	Not established	Not established
Productivity	Double survival rates of juveniles	Not established
Spatial Distribution	Cedar convert satellite area to core Sammamish not specific	Restore historical spatial distribution
Diversity	Cedar 30-40% of trajectories (draft) Sammamish not established	Cedar 50% of trajectories Sammamish not established

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?**

The current status of the population is described relative to VSP in Chapter 3 using a variety of data sources. It is clear that abundance is very low. One reviewer notes that VSP attributes are considered only from a freshwater perspective, omitting the nearshore.

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

All VSP attributes are at risk according to the plan. One reviewer suggests that the rationale for spatial structure in the Cedar River population is weak, however.

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

No quantitative predictions for the attributes of VSP have been made in the plan.

(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 critical threats are described at several levels of resolution. A general description in provided in Chapter 3.

Habitat loss seems to be the most significant threat facing the population. The threats are Listed: Altered hydrology, loss of flood plain connectivity, lack of riparian vegetation, disrupted sediment processes, loss of shoreline complexity, barriers to migration. Other threats discussed are water quality, effects of hatchery strays on natural origin recruits, and land use changes that seem to underlie habitat degradation. One reviewer suggests two other critical threats: the Cedar River sockeye hatchery, and the demographic threat posed by the low population size of the Cedar Chinook population.

(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.

Only habitat is covered in any detail but this strategy, and the identification of actions, uses a well-thought out integration of approaches based on watershed conditions, habitat-forming processes, and EDT. The discussion for hatcheries is restricted to a strong recommendation to implement the HSRG policies for Issaquah Creek. No harvest recommendations are made. One reviewer noted the absence of a land use strategy consistent with the hypothesis concerning land use effects. The strategy is not exactly absent but appears rather voluntary and opportunistic despite the importance attached to it in the plan. A further criticism is the absence of a specific flow strategy for the Cedar River despite the emphasis on altered hydrology in this system. If the tacit flow strategy is to accept the Cedar River HCP, then that should be stated. Another reviewer noted the apparent inconsistency between the approach take for Issaquah hatchery strays and the approach to strays in the Cedar.

(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.

Habitat actions are linked through the EDT model to VSP attributes. This work can be found in the EDT appendix. But, this is for the diagnostic phase of EDT only; the treatment phase of EDT has yet to be carried out so no predictions for VSP attributes or population status have been made.

(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)?

No explicit assumptions are made although the influence of outside conditions is acknowledged.

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

No. Because hatchery and harvest strategies and actions are not considered in this plan, it is difficult to see how options for recovery are being preserved. Moreover, there is no analysis of alternative actions (consistent with the strategy) in the face of uncertainty. The framework for an adaptive management program is well described but there is insufficient detail to understand how explicit uncertainty will be handled.

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

EDT is the basis for modeled support; some VSP attributes are not well-supported—productivity and diversity in particular, but abundance has a considerable record.
One reviewer note the emerging relationship between flow and fry survival from WDFW work that is not mentioned.

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

Current status is based mainly on EDT but some abundance data is present. The information from fry survival monitoring could be used here to evaluate productivity, as well.

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

No predictions have been made for any VSP parameters. The goals and objectives could be considered predictions of a kind but these would have to be tested by using the treatment phase of EDT to estimate VSP based on the proposed 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 Limiting Factors Analysis is the main source of information about threats to the population. This is complemented well by the EDT analysis. There is a considerable amount of information about these threats in the plan and more that could be pulled from a variety of other sources. This is especially true for land use data analysis to support changes in habitat-forming processes.

(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.

(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.

(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)?

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

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.

An analysis of the effects of interactions among the Hs is absent except for a brief discussion of the possible influence of straying of hatchery origin fish onto the spawning grounds of the NLW and Cedar pops—but even that is a bit weak. There is no discussion of harvest management assumptions or implications for either population. Without such an integration, there can be no confident determination of the likelihood of success of the proposed actions.

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

(a) Uncertainties in data and information?

(b) Uncertainties in environmental conditions in the future?

(c) Uncertainties in effectiveness of actions?

There is a useful discussion of uncertainty especially around EDT in the EDT appendix. However, no systematic evaluation of uncertainty has been done for this plan. There is no discussion of data uncertainty, future environmental conditions (this could be improved by bringing the Seattle Public Utilities work on future climate change into the discussion), and no analysis of the effectiveness of actions. This last item is especially important in so alterd a watershed as the Cedar-Sammamish.

The framework for adaptive management should provide a useful mechanism for addressing some aspects of uncertainty but it will have to be developed in much greater detail. Even so, adaptive management should not be thought of a “see what works” approach to uncertainty; sources of uncertainty should be identified in the plan.

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.

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

1. Obtain the harvest and hatchery management plans from WDFW and review them for assumptions and goals relative to the VSP parameters. Use these assumptions to evaluate the habitat strategy and actions;
2. Develop the adaptive management plan in greater detail. Include objectives, metrics, decision points, etc.
3. A current and future path land use analysis would prove useful to understanding the relationship among habitat forming processes and habitat conditions.

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

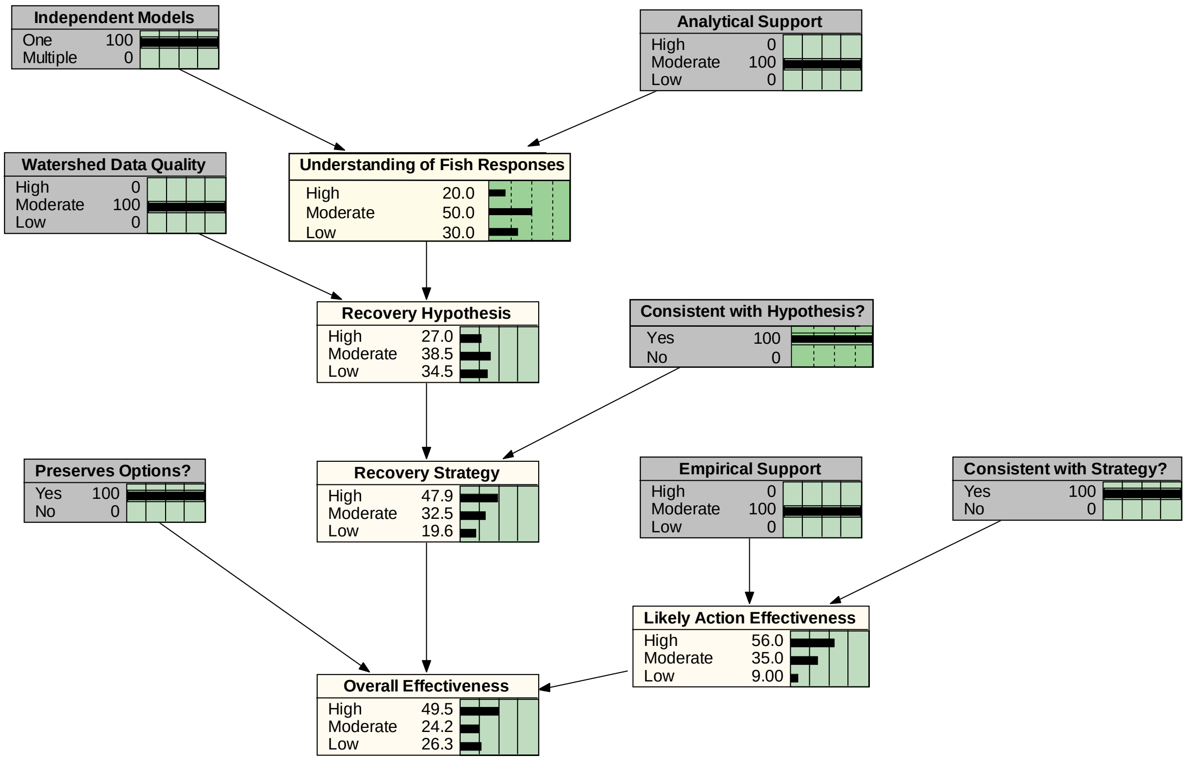

Figure 1. Probabilistic network for evaluating the biological certainty of effective recovery plans illustrating the results of a hypothetical review. Diagnostic nodes are shaded. Numbers at each node are the probabilities for each and the bars show the distribution of the results.

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, landuse, 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