Category	Synopsis	#	Recommendation	Workshop Input	Implementation Recommended	Compliance-oriented	Fiscally-feasible	Feasible	Implementation Strategy	Comments
Ecological Model Scenario Testing HYDRO ECO MONITORING APPLIED RESEARCH M&M MEASURES	There are several different scenarios and/or issues that should be investigated using the ecological model.	**101**	To explore how submerged aquatic vegetation habitat affects FD, the timing of the existing maps could be switched within simulations to determine whether simulated FD population dynamics are sensitive to sub-regional scale and interannual variability in the observed submerged aquatic vegetation (habitat) record.	· Low flow and spring flow protection measures should be simulated; • Catastrophic simulation would be a useful exercise for refugia planning (e.g., to model reintroduction and population growth); • Eco model should look at a range of flows, not just extremes; • It would be useful to use a wider lens to apply eco model to a variety of different questions (not just darter populations); • The eco model can be used to simulate conditions to approximate different climate change scenarios, and should be used for this purpose—planning for climate change should begin sooner, rather than later, to begin building new data to support the renewal of the ITP; • Eco model should be used to verify darter density per submerged aquatic vegetation metrics; • High flows, such as flooding, should be simulated; • Streambed morphology should be examined with a view to identifying whether velocity shelters would be appropriate to situate in the river channel to provide additional protection to Covered Species, such as the darter; • Eco model should be used to identify what environmental factors are most critical for influencing darter populations (e.g. under low flows, are certain parameters most critical to manage for?); • Eco model should include impacts of runoff on water quality; • The general orientation towards the model should be one of maximizing its usefulness to answer a variety of ecological questions relevant for management, not just a strict, narrow "compliance focus"	Only to the extent it is part of the Phase II process	No	No	Yes	None	1. The Ecological Model was designed specifically for the Phase II process to ensure that the fountain darter would recover after a repeat of the DOR mitigated by the bottom up package.; 2. Currently, the Ecological Model contract has expired and there are no remaining dedicated resources to do further development on the Ecological Model or run additional scenarios; 3. Exploratory modeling is not part of the EAHCP; However, is possible that modeling could be conducted after Phase II and used to evaluate aspects of Conservation Measures. 4. Any one scenario requires significant time and investment in resources; does not simply entail twirling a dial on the model and hitting "run."
		102	A scenario could be run to force FD population reductions (simply remove individuals on a day in certain areas) and determine the time period that the population remains below a threshold and the subsequent rate of recovery of the population to a healthier value.			No	No	Yes	None	
		103	Running the model under low flows and for flow protection measures to evaluate the impact on predicted submerged aquatic vegetation is a critical question for the FD model.			No	No	Yes	None	
		104	Pushing the model to catastrophic scenarios – for example where submerged aquatic vegetation is only present in refugia – might reveal some insights regarding recovery following such an event.			No	No	Yes	None	
		105	Examining simulated maps of submerged aquatic vegetation representative of "good" and "bad" years in various virtual time series should be done in a dynamic submerged aquatic vegetation model.			No	No	Yes	None	
		106	A possible useful application of the model would be to better understand the degree of long-term maintenance that might be required to eradicate non-native species.			No	No	Yes	None	
		107	The EAA should explore the diagnostic abilities of this mechanistic model to better understand the environmental forcings that influence vegetation, and to identify future applied research questions that might best serve management goals.			No	No	Yes	None	
		108	An additional scenario could be designed to examine whether there are measurable thresholds of submerged aquatic vegetation acreage in a given reach that result in dramatic increases or declines in FD abundance.			No	No	Yes	None	

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		109	Historical flows outside of the calibration and validation time periods should be used to assess FD responses under a wider range of previously observed historical flow conditions.			No	No	Yes	None	
		110	The effects of the EAA's so-called "bottom-up package" of flow protection measures should be imposed in the model and compared to FD population dynamics without the package.			No	No	Yes	None	
		111	A specific set of flow scenarios should be designed to determine what conditions of low flows lead to high risk for FD.			No	No	Yes	None	
		112	A scenario could be designed that varies the growth, mortality, reproduction, and movement rates of the individual FD within the model under a suite of flows and other environmental conditions.			No	No	No	None	
		113	Factors like low dissolved oxygen, sediment removal, algal blooms, gill parasites, and shifts in prey and predator composition can all be examined with the FD model.			No	No	No	None	

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		114	To explore how submerged aquatic vegetation habitat affects FD, observed submerged aquatic vegetation habitat maps could be retained in simulations, but adjust growth, mortality, or reproduction of the FD individuals to reflect when they are in the areas where submerged aquatic vegetation is expected to respond to the management actions.		Done	No	No	Yes	None	
		115	To explore how submerged aquatic vegetation habitat affects FD, existing submerged aquatic vegetation habitat maps could be used, and manipulated to reflect expected changes based on the management actions.		Done	No	No	Yes	None	
		116	A first effort to evaluate the impact of changed coverage by native versus non-native submerged aquatic vegetation species on FD populations could be useful given recent submerged aquatic vegetation AMP.		No	No	No	Yes	None	
		117	The focus on using the FD model to predict the responses of FD abundance to alternative HCP flow control packages is useful, but there are other uses of such mechanistic models that should be considered.		Done	No	No	Yes	None	
		118	The conceptual and predictive ecological models should be used to evaluate the minimization and mitigation (M&M) measures, both in terms of appropriateness and efficacy.		Only to the extent it is part of the Phase II process	No	No	Yes	None	
		119	Scenario analysis should be used as part of a broader iterative process inherent in all ecological modeling.			No	No	Yes	None	
		120	Scenarios should be defined based on the management needs, to advance our understanding, and to identify critical data gaps.			No	No	Yes	None	
Definitions, Clarity, and Nomenclature in Ecological Modeling	Definitions of terms, clarity and transparency of model assumptions, and standardized language should be used in the ecological modeling program.	**121**	All scenario questions should be well defined.	• “Low flows” should be defined; • Uncertainty associated with model predictions must be provided; • The model is not “done” and care must be taken representing it as such (might instead be described as HCP’s “task” being done; the model itself is inherently iterative); • Once uncertainly has been quantified, then you could call the model “done”	Yes	No	Yes	Yes		
		122	The conditions under which the model was developed should be compared to the conditions for which the model will be used in scenarios, in order to determine the degree to which the model is within in its domain of applicability		Yes	No	Yes	Yes		

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		123	There should be an explanation of the expected effects of a scenario on and what and how these effects are represented in the model (either explicitly or implicitly).		Done - in model report for scenarios run	No	Yes	Yes		
		124	There should be confirmation that the major effects are represented in a reasonable way for each scenario.		Done in model report	No	Yes	Yes		
		125	Sources of stochasticity represented in each scenario should be identified and acknowledged to account for expected variability.		Staff agree	No	Yes	Yes		
		126	Dimensions of uncertainty in each scenario should be tracked and acknowledged to account for variability.		Staff agree in principle; no	No	No	No	Currently there is no additional uncertainty analysis planned for the EcoModel.	
		127	The baseline conditions and dimensions of the predictions (temporal and spatial scales; absolute or relative terms) should be clearly stated as part of specifying each scenario.		Yes; can be implemented going forward.	No	Yes	Yes		
		128	Predictions for scenarios should include, at some level, model-based explanations of why the predicted response occurred.		Yes	No	Yes	Yes		
Administrative/Logistical Considerations Associated with the Ecological Model	There are some overarching logistical and/or administrative considerations that must be taken into account to ensure the mode is used appropriately.	**129**	General information regarding sensitivity analyses that should be used to inform the limits and expectations for model runs should be made available.	· Model runs and outcomes need to be communicated to stakeholders and the public; • There should be a public process for vetting the benchmarking of acceptable levels of risk/ uncertainty; • It's important to put into perspective what the decision context is when adjudicating what level(s) of uncertainty is/are acceptable; • Care should be taken in interpreting results around extremes (e.g. low flows); • We need to meet again to revisit the eco model once it's operational and once uncertainty is quantified, to have a more informed and timely discussion	Done - to the extent that sensitivity analysis was performed, it is in interim report.	No	Yes	Yes		
		130	A simple one-time transfer of the models from the developers to the EAA should be avoided because this can result in inefficient, and even possibly erroneous, use of the FD and submerged aquatic vegetation models.		Agreed - in progress	No	Yes	Yes		The EcoModeling team will take approximately a month to work with EAA staff on training.
		131	The temporal and spatial scales of the submerged aquatic vegetation and FD models are reasonable but the representativeness of selected reaches and the variance properties associated with the use of QUAL2E outputs as model inputs should be clearly documented.		Done - in model report	No	Yes	Yes		

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		132	The issues and recommendations described in NAS' interim eco model report should be adequately addressed prior to running the scenarios.	discussion	Done	No	Yes	Yes		The interim report was provided to the EcoModel team to allow for incorporation of appropriate recommendations.
		133	All model results should be carefully labeled according to the nomenclature described in Report 2.		Done	No	Yes	Yes		
Directions for Further Development of the Ecological Model	The ecological model program would benefit from additional work to refine the model.	**134**	Sexual and vegetative reproduction should be represented in the dynamic submerged aquatic vegetation model.	Scope creep is inevitable; therefore, it is important to keep an eye on budget and goals; • To expand and build model, it would be appropriate to involve other agencies; • The submerged aquatic vegetation component is critical to the eco model; • We need to draw a line on how far we go in responding to National Academy of Sciences input	Should resources become available for further model development, these recommendations will be utilized at that time.	No	No	No	None at this time.	Currently, the EcoModel contract has expired and there are no remaining dedicated resources to do further work on the EcoModel or run additional scenarios.
		135	The EAA should continue with the conceptualization of the overall ecosystem by building on the FD and submerged aquatic vegetation conceptual models.			No	No	No	None at this time.	
		136	The current habitat suitability analysis for TWR should be treated as a hypothesis and tested for robustness throughout the San Marcos River.			No	No	No	None at this time.	
		137	The EAA should return to Report 1 for a thorough evaluation and recommendations on their earlier approach and consider new methods that have evolved to address some of the issues with the classical habitat suitability approach if the suitability analyses are pursued in the future.			No	No	No	None at this time.	
		138	A better CSRB sampling approach is needed for determining ITP compliance, estimating the current CSRB population, and projecting future changes.			No	No	No	None at this time.	
		139	The EAA should be prepared to develop detailed monitoring plans for the other covered species if the CSRB is abandoned as an indicator species.			No	No	No	None at this time.	
		140	Explicit treatment of how actions directed at submerged aquatic vegetation would affect FD through the coupled models is recommended.			No	No	No	None at this time.	

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		141	The use of an individual-based approach imbedded within a 2-D spatial grid for full life-cycle simulations of FD population dynamics is a scientifically sound framework for the questions being asked, but there remain some important steps (related to how submerged aquatic vegetation) is represented) to link the FD dynamics to their habitat.			No	No	No	None at this time.	
		142	The representation of the processes of FD growth, mortality, reproduction, and movement presently in the model are well-founded but may be too simple and not sufficiently linked to changes in habitat and flow to answer some of the important management questions.			No	No	No	None at this time.	
		143	The submerged aquatic vegetation model is not yet far enough along in its development for detailed suggestions regarding scenarios.			No	No	No	None at this time.	
		144	The historical time period used for calibration had relatively similar environmental conditions from year-to-year, which limits the range of conditions of scenarios feasible for exploration by the model.			No	No	No	None at this time.	
		145	The representation of flow effects in the model seems too limited in potential effects due to reliance on having site-specific empirical evidence for the effects.			No	No	No	None at this time.	
		146	Thresholds in process representations should be used cautiously because they can erroneously create nonlinear population responses and unrealistic sensitivities to changes in habitat & flow.			No	No	No	None at this time.	
		147	The representation of density-dependence and how its effects on individuals manifest at the population level needs further evaluation.			No	No	No	None at this time.	
		148	Calibration and validation of the FD model to date shows the model can reproduce the historical abundances, but additional confidence is needed to most effectively use the model for management purposes.			No	No	No	None at this time.	
		149	*As a top priority the EAA should develop an ecosystem-based conceptual model, or a series of conceptual models of increasing resolution, that show how water quality and quantity, other biota, and restoration and mitigation activities are expected to interact with the indicator species, as well as with all covered species.*			No	No	No	None at this time.	

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		150	*The habitat suitability analyses done for the fountain darter should be used as a "back-up" to the individual-based modeling and provide additional quasi-independent results to support a weight-of-evidence approach for the fountain darter.*			No	No	No	None at this time.	
		151	*A much deeper understanding of the CSRB's natural history should be obtained in order to be able to include the CSRB in a mechanistic model.*			No	No	No	None at this time.	