Hydrologic Modeling Recommendations

Topic	Recommendation	Details
Modeling for Phase 2 Decisions	MODFLOW should be used to help develop strategic decisions associated with adaptive management and revisions to minimization and mitigation measures.	Developing a more refined framework that incorporates modeling into the decision criteria for triggers rather than relying on triggers based on measured groundwater elevations at specific wells should be considered in planning for Phase 2 of the HCP.
		A decision support system (DSS) should be developed to be used in Phase 2 of the HCP in order to apply the model to short-term decisions (e.g., a one-month time frame) related to determining springflow protection triggers.
		A DSS would clearly direct these decisions on the basis of different model outcomes. A good DSS is developed and applied with the understanding that model predictions, although uncertain, represent the best available science on which to base management decisions.
		MODFLOW should be used to evaluate scenarios that help understand what processes are important in the system. Examples would include applying the model for testing concepts, parameters, and system conditions, not just producing predictions, which can be highly uncertain.
Modeling Scenarios	Optimizing the bottom-up package of the four spring flow protection measures (scenario to test hydrologic model).	Testing a variety of scenarios will not only improve the confidence in the model itself but also will help develop strategic decisions associated with adaptive management and revisions to minimization and mitigation measures.
		There is currently no information on any attempt to optimize the combination of measures including the magnitude and spatial implementation of each or the order in which they might be implemented. In such an analysis, the objective function could be formulated to minimize the deviations of the spring flow and water level targets.
		From this exercise a different combination of measures with different magnitudes may emerge as the optimal combination which minimizes the deviations from the spring flow targets or cost of implementation.

Italicized text indicates recommendations repeated from Report 1

		An optimization modeling exercise should be conducted using pumping sensitivity analysis results to determine the combination of wells and wellfields that would be most effective in achieving the hydrologic goals of the HCP. A comprehensive analysis of this could provide useful information for developing various options for implementing flow protection measures during future droughts. This scenario can answer the question "Which wells have the greatest influence on index wells or discharges from the springs?"
Concept/Scenario Testing	MODFLOW should be used to test a variety of scenarios to improve the confidence in the model itself once current improvements to the model are complete.	The groundwater model should be tested against the 2011 to 2015 period. This period, which includes both very dry and wet years, offers a remarkable opportunity to validate the model and enhance confidence in the model for future applications.
		Past droughts of shorter duration with more or less intensity are also of interest in understanding the effectiveness of flow protection measures and to test the model's accuracy. Testing how well the model can predict responses during such lesser extremes may demonstrate its applicability to a variety of climatic conditions and further enhance the confidence in the model for adaptive management and for other applications in Phase 2 of the HCP.
		A hydrologic scenario that simulates climatic and socioeconomic conditions more severe than the DOR should be designed to test the model. Performance of the system under a variety of drought conditions. The DOR may not represent the true worst-case scenario as the baseline for hydrological modeling (Report 1).
		The use of paleo data (e.g., tree rings) and possibly stochastic modeling of rainfall patterns should be explored for the development of extreme modeling scenarios.
		Climate scenarios should be designed considering the results of climate-model predictions available from regional climate models that are nested within general circulation models.

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		Spatial variability in rainfall within the Edwards Aquifer region should also be explored in scenario investigations.
		A scenario with projected land use changes and likely change in climate (but no change in water withdrawals by well pumping) over the next two to three decades should be simulated to answer the question "How would a changes in recharge amount due to changing land use impact spring flows?"
		Use telescoping grids in hydrologic model. Modeling smaller areas can address some of the RRWGs concerns about cost and feasibility in testing conceptual models because there is no need to reconceptualize the entire HCP model.
Recharge Methods	A recharge estimation ensemble should be created using as many different recharge estimation methods as feasible, and varied uncertain recharge parameters within these methods.	The ensemble will provide a range of possible outcomes for spring flows, and this range can be examined for calibration periods, validation periods, and most importantly for future scenarios predicted by the model.
		Daymet data should be considered for recharge estimation instead of NEXRAD. Daymet data contains gridded weather parameters for the United States at a 1-km resolution for 1980 to the present.
		USGS' soil-water-balance (SWB) model should be used to enhance the ensemble for estimating recharge. This model estimates spatially distributed daily recharge on the basis of gridded weather and soils data.
EAA Five-year Modeling Plan	The Five-Year plan should provide more details about what updates are going to be incorporated.	Providing more specifics about what updates will occur enhances communication.
		The Five-Year plan needs to show an iterative approach between data collection and model updates; it does not do so now.
		It may be necessary to update the Five-Year plan more frequently than every five years (e.g., every two to three years) if new information becomes available and the original plan becomes outdated.
		A decision support system should be included in the Five-Year plan.

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Interactions between Modeling & Monitoring	There should be a modeling team member who communicates regularly with the monitoring team about how current research can be incorporated into the model.	A formal versioning system should be used, consisting of a model archive and peer-reviewed report identified by a unique version number, with a model update occurring about every five years. Once the model moves from the development and calibration stage to operational mode, it should be formally documented as a public record at a high level of transparency.
Additional Data	*The importance of collecting additional field data to improve the groundwater model was discussed in some detail in Report 1.*	*Data associated with characterizing conduits and evaluating Trinity-Edwards hydraulic connections should be incorporated to improve the groundwater model.*
		All available pumping data should be incorporated to improve the groundwater model.
		Rainfall variation data from the past few years should be high priority for incorporation in the groundwater model.
		Conduit and barrier features in the MODFLOW model were adjusted based on FEFLOW modeling, but additional evaluation of these features could be considered.
Sensitivity Analysis	*Use additional calibration and validation metrics.*	It is essential that the EAA strives to improve the predictive skills of the model for the anticipated refinements to the flow protection measures that may be necessary in Phase 2. The MODFLOW model is expected to continue to be the primary groundwater modeling tool for the HCP.
		The EAA should conduct a sensitivity analysis involves field tests using a set of wells thought to have the highest sensitivity to water levels at index wells and flows at springs. Pumping at these wells could be increased by some percentage for a certain length of time (e.g., one-two months).
		Conduct more explicit sensitivity analysis. Technique(s) to quantitatively assess model uncertainty, that should be used and presented in formal EAA documents.
		Public misunderstanding about uncertainty analysis should not be used as an excuse to limit best practices in modeling. Moreover, techniques should be applied to improve model design and data collection that decrease uncertainty.
		One of the 5 methods of uncertainty analysis recommended in Report 1. There was no indication that other conceptual-model parameters, boundary conditions, or other assumptions will be included in an ensemble approach for uncertainty analysis.

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Uncertainty Analysis	*An ensemble approach should be used to analyze sensitivity to help quantify uncertainty.*	Recharge estimates from the HSPF method should be included in the ensemble approach being used for uncertainty analysis.
		No new progress on HSPF modeling since the first Committee meeting (February 2014) has been presented. The EAA spent considerable time developing recharge estimates using HSPF.
		Using PEST predictive uncertainty analysis. One of the 5 methods of uncertainty analysis recommended in Report 1. The RRWG identified uncertainty analysis in the Five-Year plan, but only the ensemble approach is mentioned.
		Show error bars on spring-flow and water-level predictions. One of the 5 methods of uncertainty analysis recommended in Report 1….the Five-Year plan does not mention error bars, and modeling results shown at the committee meeting on February 2, 2016 did not incorporate them.
Single Model	*Single model would incorporate the best concepts from existing models, rather than two "competing" models.*	FEFLOW stratigraphic data should be incorporated into the current MODFLOW model.
		Lessons learned from incorporating the contributing zone in FEFLOW should be articulated so that they can be used to inform the current MODFLOW model.
		Devote future resources to a single model.

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