Peer Review of the Edward aquifer Recovery Implementation Program's Science Subcommittee's "k" Charge Recommendations

SUSTAINABLE ECOSYSTEMS INSTITUTE

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INTRODUCTION

Sustainable Ecosystems Institute (SEI) is a public benefit, non-profit organization, founded in 1992. The goal of the Institute is to provide impartial scientific support for conservation decisions; the Institute is non-partisan, and seeks science-based, cooperative solutions to environmental issues. The organization has previously carried out extensive work on resource conservation and management, and has developed the use of peer review in such situations (Brosnan 2000).

The Edwards Aquifer Recovery Implementation Program (EARIP) contracted with SEI to conduct a peer review of the EARIP's Science Subcommittee recommendations of the "'k' charges" described in the Request for Proposal and Statement of Work provided to SEI by the EARIP (appended as appendices 1,2) (SSC report hereafter).

The specific charges to SEI included:

- To scope the review and, based on SEI's experience with other reviews and the materials to be considered, to determine the size, composition and academic specialties of reviewers.

- To select the reviewers best suited to the review, and to contract with them to carry out the review. SEI was also charged with maintaining the scientific integrity of the process, by allowing EARIP to observe the process, but not to influence the selection of reviewers.

- To set up a wiki site, and to make all relevant materials (provided by EARIP) available to reviewers, and to ensure that reviewers carry out a timely and well prepared review.

- To provide a written report that summarizes the opinions of individual reviewers, and of the review group as a whole, including any rebuttal or changes to reviews following comments received from EARIP.

The overall goal of this review then is to provide a comprehensive, and critical evaluation of relevant information regarding the k charges and important science issues discussed by EARIP. Ultimately, this evaluation may be used by EARIP, USGS and partner agencies in making science and management decisions. These are appropriately the responsibility of the various agencies. SEI's process is designed to provide an impartial scientific evaluation. It is not our role to provide advice on management decisions, and reviewers were instructed to avoid such comments. Our approach is restricted to summarizing, critiquing, analyzing, and synthesizing scientific materials.

The process we adopted was to set up a panel of experts drawn from a range of different academic backgrounds relevant to the review. These experts read the materials that were available or that were developed. Overall project lead was Dr. Steven Courtney, Vice-President of SEI, who has expertise in endangered species research and management, and in the application of peer review processes to natural resource management issues.

Panel members and their particular expertise in the review were:

• Dr. Mark Bain	Cornell	Ecology
• Dr. Alan Fryar	U Kentucky	Karst hydrology
• Dr. Tom Dunne	Tulane	Karst hydrology
• Dr. Carol Wicks	Louisiana SU	Karst hydrology

Dr. Bain was selected for several reasons. He is an icthyologist and ecologist of national standing, and has previously visited the Edwards Aquifer region, so that he is familiar with organisms discussed in the review. He has also previously worked with SEI on other reviews where the hydrology/ecology interface was relevant, and he has a strong quantitative background.

Dr. Fryar is a nationally recognized hydrologist, who carries out field-based studies and mathematical modeling of ground-water flow, mass transport, and reactions in the subsurface. He has extensive experience with recharge issues, and has very strong quantitative and modeling experience.

Dr. Toran is chair in Environmental Geology at Tulane University, and is an expert in karst hydrology in the eastern US. She also has published extensively on ground-water/ surface interactions in general.

Dr. Wicks is a nationally recognized expert on karst hydrology, with an interest in interaction with organisms, as well as the factors affecting recharge in large systems. She also has expertise in modeling of such systems.

SEI was asked to select 4 to 5 reviews, the exact number to be determined by SEI, on the basis of covering all the necessary academic disciplines, and with adequate relevant experience. In the event, SEI elected to employ just 4 reviewers. Our rationale was that 1. We were asked to provide at least one reviewer with karst experience – in fact all three hydrologists are karst experts, and the ecologist also has relevant experience; 2. We were asked to provide a review with quantitative strengths – in fact all four reviewers have such strengths, and several carry out modeling of aquifer systems. Hence we decided that it was unnecessary to expend additional resources to augment the panel, since the four reviewers were so well

qualified to carry out the review (this will result in cost-savings to the EARIP program).

The four reviewers were selected using standard SEI approaches. We consulted our database of experts who have already committed to carrying out reviews for management-relevant science. This resulted in a large list of potential reviewers, including hydrologists, but no karst or recharge modelers. Ultimately Dr. Bain was the only reviewer we selected on the basis of our first search. We then sought the opinion of experts who have previously worked with SEI on hydrology issues (e.g. Everglades flow, fluvial modeling). These suggestions provided a larger group of hydrologists, but ultimately did not provide us with appropriate experts who were of sufficiently high academic standing. We also carried out research of our own into identifying which scientists had well-established reputations in karst hydrology. Ultimately it was this approach that allowed us to identify and select the three hydrological reviewers.

In addition to the four reviewers selected, we also approached and interviewed several other potential reviewers. We asked one of these, Dr Jean Bahr of U Wisconsin, to serve as a reviewer, but she declined due to extensive prior commitments.

REVIEWS

Given the varying expertise of the reviewers we elected not to provide a single list of questions, but instructed each reviewer to consider the report of the EARIP science subcommittee (and relevant background materials) on the basis of her or his own area of expertise. In the event, most of the comments made were positive, with some suggestions for additions or better documentation.

The sections that follow first present an overview of the reviews received, followed by the individual reviews of the four panelists. The written responses and verbal comments of the science subcommittee were also discussed with the panelists, and we provide a summary of the final conclusions reached on the important points of discussion between reviewers and the SSC.

Overview of reviews

In general, all four reviewers felt that the SSC report was well conceived, well written, and did a good job of justifying its conclusions. No major problems were identified with the report or with the conclusions it reached, and the reviewers unanimously felt that the SSC report represented good science. This overall high standard indicates that the SSC report will be a useful scientific document on

which to base management decisions, and that decision-makers can have high confidence in the scientific quality of the document. Based on SEI's experience elsewhere, it is unusual to have such positive reviews, and the SSC appears to have done an exemplary job of synthesizing and analyzing materials.

Each reviewer did identify some areas that were poorly explained, in need of further clarification, or where the reviewer had slightly different opinions than the SSC. In part, these reviewer comments reflected genuine scientific differences of opinion. During the group discussion following the written reviews and SSC responses, the SSC acknowledged the need to make some corrections or clarifications to address these comments. However on some points, reviewers asked for material to be included in the report that is best reported elsewhere, or addressed issues that will be the subject of future SSC reports. In these cases, the reviewers and SEI agree that it is not necessary for the SSC to make corrections and additions.

In general then, the SEI reviewers were supportive of the analyses and conclusions described by the SSC report. Many of the reviews addressed technical details rather than overall conclusions. As noted by Toran in her review, and other reviewers in discussion, the reviewers did not feel that SSC needs to change any of its conclusions, and they offered minor critiques that are likely only to affect details of presentation etc.

Review by Mark Bain

General Assessment

My review of this report focused on task 2 which heavily considers the environmental requirements of the threatened and endangered species. My background is aquatic ecology, fish and invertebrate biology, and environmental analysis methods. I have visited the Edwards Aquifer area, both Comal and San
Marcos Springs, and been thoroughly oriented to the endangered species and water management issues of the aquifer. I found the conclusions of the Edwards Aquifer Area Expert Science Subcommittee well founded using the available local information. I do not disagree with the main conclusions reported.
While the basic findings are acceptable, I found shortcomings in the analyses and reporting. The information used to support the findings are almost entirely of local origin. Also, the analyses were direct and simple, and there was a lack of quantification on many topics normally presented in numeric terms (water volumes, habitat values, population size, etc). Inconsistencies were limited in scope. I found that more thorough review and analyses would be possible. Finally, the scope of the report was very constrained although this may be appropriate under the assignment to the Subcommittee. Overall, I found this report well reasoned, prepared with simple and direct analyses, and complete with local information.

Task 1 - A San Marcos Pool?

The review of relations between well elevations and spring discharges is done on a well by well basis. Figure 13 plots four well elevations and the discharge of San Marcos Springs. This plot suggests to me that a multivariate statistical model that combines data across wells may be much more effective in predicting spring flows. I am familiar with multivariate statistical methods and I am aware of that groundwater modelers have other tools for integrating well data. Consideration should be made of multi-source analyses such those used by Ritzi et al. (1993) and Stetzenbach et al. (1999).

The relationship between Comal and Sam Marcos Springs appears unrelated in Figure 14 however accounting for aquifer levels at multiple wells could provide relations that results in a time series of discharges shown. The discussion of flows and levels across the aquifer could be captured using water elevations in multiple wells together. The hydrologists on this review panel would be better for advice on this point.

Task 2 - Minimum Spring Flows

Flow Regime and Minimum Flows

The primary conclusion by the Science Subcommittee for task 2 is that minimum spring flows are required. My judgement is that this conclusion is proper and supported by the information presented. However, no information is provided on the magnitude of minimum flows. Also, the conclusion is embedded in a broader concept that a flow regime is needed for maintenance and recovery of the threatened and endangered species.

The conclusion that a minimum flow is necessary is not very informative without some scale of quantification. Clearly no flow or zero spring discharge would very likely

eliminate some threatened and endangered species. This was observed when Comal Springs experienced a lack of spring flow (no minimum flow, no flow) in 1956. Therefore, the need for a minimum flow has been demonstrated at the aquifer spring sites.

The primary conclusion and task 2 discussion includes the concept of a flow regime or mix of low, 'normal', and high flows. I was part of the group (Poff et al. 1997) that published the primary paper on the importance of flow regimes for conservation of river biota. The logic supporting our argument was that flowing water species are adapted to environments with different flows through an annual cycle, and that they depend on the habitats created by different flows. In the case of spring environments, the biota may be especially dependent on flow constancy and a very limited range of environmental conditions. The report makes this argument in many parts of Task 2 and in the description of the biology of some threatened and endangered species. In general, the constancy of spring and groundwater dominated streams has been recognized as supporting species poor, specialized, and unique communities (Ward and Stanford 1983), and this is a natural although rare situation. I conclude from the information reported and familiarity with constant flow environments outside Texas, that there is not a strong case for a regime of flow variability for the aquifer spring environments or their unique biota.

While I conclude the argument for a flow regime is not well supported, there is some information presented that suggests some variation in flows could be important to a few species. Texas wild-rice uses different modes of reproduction and expansion depending on current velocity and possibly water depths. This finding suggests variable flows may be important for population recovery of this species. Note that Texas wild-rice appears least obligate to the highly specialized conditions of the springs because its distribution can be well removed from the immediate spring outlets. The San Marcos salamander also appears to require rock substrates that may need periodic high flushing flows for maintaining clean coarse substrate. Again, this species is found outside the immediate influence of the springs. Overall then, I suggest that the discussion and conclusions about the need for flow regimes is currently speculative and will need further support to be accepted with confidence as a general finding for all spring dependent species.

Assemblage Scale Assessment

The report reviews the biology and dependency of the eight threatened and endangered species found in the Comal and San Marcos springs ecosystems. The primary environmental variables defining the habitat of the surface species are: water clarity, velocity, temperature, and carbon dioxide level. In some cases (e. g., fountain darter, San Marcos salamander) the species depend on secondary conditions (e. g., aquatic vegetation, rock substrate) linked to the primary environmental variables. On page 48, the report comments that most species associated with the springs are endemic but not ESA-listed since enough species are already listed to protect the spring dependent community. All this makes a case for considering the community in a more comprehensive manner with the species level assessments provided in the report now.

Bearing directly on the assigned tasks, a consolidation of environmental requirements

would help identify the need for spring flow and habitat conditions. I recommend a chart or series of charts showing the range of values required by each species on a gradient from immediate spring conditions to beyond all the species needs. For example, plot each species on a gradient spanning temperatures at the point of spring flow discharge (at or very near 69.8oF) to temperatures considerably above the most high temperature tolerant species. In this way, one could easily visualize the conditions that are required to maintain the community. The spatial scale associated with these gradients could be approximated to convey the scale of habitat area. This charting and synthesis form of reporting would summarize effectively the needs by species and the spring dependent community.

Good scale maps of the systems would be helpful. Locations are discussed that only those familiar with the spring sites would know. Also, the potential range of the species could be shown.

Finally, non-native species are a real threat to the threatened and endangered species. A similar analysis showing tolerances of non-native species could indicate the extent of threat and the need for conditions providing refuge from non-native species.

Fountain Darters

On page 39 there is a lengthy discussion of population fluctuations of fountain darters in response to high flow events and changes in aquatic vegetation. This information is valuable in considering spring flows and habitat conditions. However, no numbers are reported for darters, flows, or vegetated area. To make the case, some level of quantification should be reported. The current lack of numbers makes this discussion much less valuable than it could be. Also, sources for population data are not clear in this text.

Flushing Flows

High flows for shaping habitats, cleaning substrates, and possibly reducing non-native species is invoked at different points in the report. On page 46 the comment is made that no research exists for the magnitude of these flushing flows. I agree there is probably no empirical field studies at the spring sites on this topic. However, methods to estimate flows needed to shape channels and move fine sediment are well established. Some examples are: Dunne and Leopold (1978), Gordon et al. (1992), Carling (1996).

While the waterways associated with the springs are far from natural channels, it would be possible to estimate flows that would accomplish some habitat maintenance objectives.

Habitat Manipulations

The assigned tasks focus on spring flow needs for the species listed under the federal Endangered Species Act. The Science Subcommittee recommendation on page 52 states the belief that no alternatives exist to minimum flows. I agree if only water volumes are to be considered. The report does raise surface water habitat modification at a few points as well as spring flow alternatives like flow augmentation and recirculation. Further, the

discussion of in-situ refuge approximates habitat enhancement and states that this orientation should be evaluated and has potential merit. Much more could be done on this. The Science Subcommittee states in page 56 that restoration of the San Marcos ecosystem has not been attempted but should be considered. The current surface waters at both San Marcos and Comal Springs are highly artificial and engineered. I believe reengineering the surface waters to maximize use of spring flow to promote space meeting species requirements has much merit. The report introduces the topic in a subtle fashion while suggesting significant potential.

Artificial Rearing and Holding Capability

Off-site propagation conclusion well discussed and sound. Propagation is one conservation technique commonly used for endangered species but sometimes seen as a solution on its own. The report makes a good case for not adopting this perspective.

Miscellaneous

Both 'springflow' and 'spring flow' are used throughout the report. One form should be selected.

Task 3 - Trigger Levels for San Marcos Springs

This short discussion of changes to trigger levels may benefit from a more thorough analysis as I suggested under task 1 above. Several of the plots and triggers are shown for well J-17 which is described by the Science Subcommittee as not related to San Marcos Springs discharge (page 21). This inconsistency draws into question the analyses in this section.

Review by Alan Fryar

I have read this report to the EARIP Steering Committee, including attachments, and I generally agree with the methodology and conclusions. I am a hydrogeologist who studies karst systems and I have lived in central Texas, but I have not conducted research on the Edwards aquifer. The subcommittee members seem to have done a thorough job compiling the existing literature and addressing the specified tasks, including considering stakeholder input. In particular, the section on Task 1 ("Are the data sufficient to designate a San Marcos Pool?") is clearly written. My relatively minor critiques (including edits) are as follows:

p. vii, ¶ 4: "data was" should be "data were", and "this data" should be "these data"
p. 6, ¶ 1: "addition information" should be "additional information"
p. 8: For the bulleted list in Task 1.3, hydraulic correlation analyses should precede water chemistry analyses, since the sections fall in that order.
p. 8, ¶ 3: "in the case" should be "in this case"
p. 11, ¶ 1: "in large parts the Hueco Springs Fault Block" should be "in large parts of the Hueco Springs Fault Block"
p. 20, ¶ 2: Should Schindel and Johnson (2008) be Johnson and Schindel (2008)?
If rivers are largely spring-fed, I would expect river stage to depend on spring discharge, rather than vice versa. To what extent do "rivers act as recharge to groundwater feeding the springs"?
p. 21: Inclusion of a map showing locations of springs and key index wells would be helpful.
Fig. 11 shows that hydraulic heads in well 68-23-302 "have a strong correlation with Comal Springs discharge" above a threshold of 619 ft MSL (italics mine).
Fig. 13 shows correlations between hydraulic head and San Marcos Springs for four wells. Because the correlation for well 68-16-701 is the weakest of the four ($r2 = 0.32$), I think "strongly correlate" should just be "correlate" (or one of the other wells should be highlighted).
p. 24: In the caption for Fig. 12, I think well 67-09-110 should be Southwest Texas Farms Well, not "Landa Park or Panther Canyon well" (based on p. 21).
p. 27-28: The section on water chemistry is too brief. What are the differences in chemistry between the two groups of springs at San Marcos Springs? Are they consistent with differences in residence time and/or lithology? See Musgrove, M., Fahlquist, L.S., and Houston, N.A., 2008, An overview of the geochemistry of Edwards aquifer ground water in south-central Texas, in Kuniansky, E.L. (ed.), U.S. Geological Survey Karst Interest Group Proceedings, Bowling Green, Kentucky, May 27–29, 2008: USGS Scientific Investigations Report 2008-5023, p. 67.
p. 28, ¶ 4: What does "the most fundamental projections of future conditions" mean?
p. 29, ¶ 3: The sentence "Some interchange of ground water of the aquifer that includes a storage unit and a zone in which water is transmitted from this storage unit to major points of discharge" should be deleted.
p. 33: Where is Fern Bank Springs?

The MODFLOW conduit-flow model of Lindgren and others (2004) should be rerun with MODFLOW-2005 Conduit Flow Process. See Shoemaker, W.B., Kuniansky, E.L., Birk, S., Bauer, S., and Swain, E.D., 2008, Documentation of a Conduit Flow Process (CFP) for MODFLOW-2005: USGS Techniques and Methods, Book 6, Chapter A24, 50 p.

p. 38, ¶ 1: Although water quality is integral to maintenance of threatened and endangered species at Comal and San Marcos springs, water quality was not explicitly part of Task 2.

p. 39, ¶ 1: What are temperature ranges in the springs? What are examples of fountain darter predators?

p. 42, ¶ 3: "Experimentation…and observation has shown" should be "Experimentation…and observation have shown".

p. 43, ¶ 2: "moderate temperate water" should be "moderate temperature water"

p. 44, ¶ 2: The sentence "All these non-native species occur at least in part in habitats that could be occupied by Texas wild-rice" is redundant and can be deleted.

p. 46, ¶ 3: "affect" should be "effect"

p. 47, ¶ 3: Are riparian areas intact around Comal and San Marcos springs?

p. 56, ¶ 2: Is the study of planting Texas wild-rice seeds in degradable cloth bags still in progress? If completed, what were the results?

p. 61, ¶ 4: Rating curves are commonly limited by a lack of high-flow measurements. Are "additional measurements in the upper portions of the rating curve" practicable?

p. 63–67: Relative to Tasks 1 and 2, the section on Task 3 is overly brief. For readers like me who are not intimately familiar with the Edwards aquifer, provide background information on what actions are taken when the triggers are exceeded. What do stages I–IV represent?

p. 68: "U.S. Fish & Wildlife Department" should be "U.S. Fish & Wildlife Service"

p. 77: I didn't see Taylor (1904) cited in the text.

p. 79: "an individual could also nominate themselves" should be "individuals could also nominate themselves"

Review by Laura Toran

TOPIC 1: Evaluate designating a San Marcos Pool

The conclusion of the committee is that it is not appropriate at this time to designate a San Marcos Pool. This conclusion is supported by the data presented and by most of the comments in the position papers (Appendix F).

Nonetheless, some of the supporting information could be strengthened. In the executive summary (and repeated on p 32), lack of hydrologic information is cited as the reason the SM pool cannot be separated: "a more complete understanding is required of the various elements of the hydrogeologic framework". This phrasing is so general that it could be applied to any problem at any time and it is especially true in karst systems where many doubt we will ever have "complete" understanding. I think the phrasing could be more specific. There is a much more pointed statement on p 32: "aquifer levels, recharge, and pumpage in Comal and Bexar counties have sufficient effects on San Marcos Springs that management of a fully separate San Marcos Pool would be an administrative action rather than a scientifically-based decision." This statement makes clear that flow comes from multiple directions that overlap with the existing pool, and it should be the emphasis in the executive summary. Furthermore, evidence from geochemical data supports the conclusion.

Given the importance of flow paths to the interpretation, I would like to see clarification of the flow path discussion around pp 15-16. The sources of information are referenced, but the methods aren't discussed much. How much of the information on flow direction is from tracer tests, how much from water levels in wells and springs, how much from geologic consideration of permeabilities and likely barriers? One of the final recommendations is to do "more" tracer tests, but the reader doesn't have a sense of what has already been done. Tritium dating is mentioned later but seems likely to help the flow path interpretation since the dates suggest different sources for northern (local) and southern (regional) springs at San Marcos. This information could be discussed earlier to tie together different lines of evidence for the flow paths.

One specific example using water levels to interpret flow paths is the drought story from the 1950s (p 15). Although this is a good example of methods, I'm concerned about citing 1950's data for interpretation. Land use has undoubtedly changed since then. Couldn't that affect flow paths? It would help to have a description of current land use and any significant changes.

Sometimes the flow path descriptions were hard to follow. Fig 2 shows water from the upthrown to downthrown block while Fig 6 shows prominent arrows with water from downthrown to upthrown sides. Fig 4 doesn't show either of these flow arrows, although maybe it is at a different scale that doesn't include this detail. A reader scrutinizing the figures could use some help to decide how each one relates to the text and the interpretation.

A sentence or two describing Puente's "traditional recharge estimate" is needed, especially since this source isn't readily available. EPA has published a method that sounds similar (Ginsberg and Palmer 2002) and it might be helpful to compare the methods since the EPA method is thoroughly described in the referenced (readily available) report.

The summary comparison of the spring and river discharges (p 20) was very useful to the interpretation of source areas. The water balance estimates point out that multiple recharge areas contribute to the SM spring discharge. This summary is based on estimates used in Fig 8 -- does that mean Fig 7 could be omitted? There were some confusing statements in the recharge section preceding (used to set up the water balance discussion.) For example "Recent studies (HDR Engineering, Inc., 2002, LBG-Guyton Associates 2005) suggest that recharge occurring in the primary streambed is variable…" What is recharge occurring in the streambed? Is this a losing stream? Or was the text supposed to read discharge? The sentence goes on … "and may be less than half of the calculated total recharge for some basins." I don't see why a streambed would be compared to a basin unless it is discharge in the stream compared to recharge in the basin. The relevance of this discussion needs to be made clear. A lot of HDR reports with different dates are cited here and it was hard to follow which is the most recent or whether the dates of the report indicate which is most up to date. The reports are summarized thus: "While overall estimates of long-term average recharge were quite similar", but then the following sentence says recharge was greater. Maybe the sentence was supposed to say the recharge AREA was greater? These statements aren't clear. It was a bit odd to say on p 19 that the HSPF model was completed in 2002, then on p 20 say the HSPF model is being refined. I think the point is that it has been revisited but maybe different wording should be used on p 19.

I had mixed feelings about the correlation discussion that followed (bottom of p20 and after). The text states: "Correlations between river stage and spring discharge provide an indication of whether the rivers act as recharge to groundwater feeding the springs. Correlations between spring discharge hydrographs measure the hydraulic communication between the springs, either
in terms of sharing similar recharge zones or in terms of discharging from the same groundwater reservoir." This statement ignores some important concepts – it may be acceptable as a shortcut, but some cautions need to be included and a better description of the data analysis is needed for the reader to understand both the strengths and the limitations of this data.

First caution: The response of a well and a spring is not really expected to correlate. The spring has an obvious conduit pathway for at least part of the flow path. The well may intersect no conduits. For these reasons, we consider springs, wells, and streams to fall on an overlapping spectrum in terms of their response times and peaks. These differences have been quantified in various studies and are well recognized. In many cases wells are the only upgradient source of information, so they are a necessary part of the picture. However, lack of correlation doesn't mean the well isn't along the flow path

for the spring, as implied by the text. Instead, the well and spring lacking correlation may share some but not all of the flow paths. The text should include these cautions, while still comparing well and spring response. (Later I point out how the different responses of the well and spring may suggest conduit pathways in the well do exist.)

Second caution: The data analysis significantly affects the interpretation of the correlations. It is important that the sampling interval and time periods be the same when trying to compare the data. The correlation figures after don't give a time period for the data or a sampling interval. Questions arise such as: In Fig 13 the San Marcos discharge isn't the same for all of the lines – does this mean different times were used for the different plots? The time period can influence the results, so it needs to be stated. Was it a full year? More than one year? This is important to mention so the reader knows how seasonality might affect the data. Are the discharges peak flows or what interval? Is it the same interval for each data point? Answering these questions is also relevant to the discussion of drought triggers in section 3. Furthermore, it would help to have the wells all plotted on the same map with the springs. I couldn't find locations for some of the wells.

As long as these concepts can be clarified, the information presented in Figs 9-13 contributes to the discussion of source areas.

The modeling discussion raises some interesting questions. Perhaps they can't yet be answered, but it is worth posing them to better place the modeling in the context of determining the source areas. What is the implication of the predicted decline (dry up) in flow at San Marcos in the 1979 model? What does it imply about source area? About development? Did the model- predicted decline occur? What does that say about the source area? Does the moving groundwater divide between SM and Barton springs suggest the boundary is transient and thus any pool would be transient? Is this a reasonable conclusion? How does the possibility of transient recharge area complicate designation of a pool? The answers to these questions point to tasks that could be important follow on studies.

Section 1.3 ends with recommendation for follow on studies (p 33). These recommendations didn't seem to be linked closely with the previous text and several of them are too broad to be useful. Most of the tasks would further delineate overlapping pools; if that is the goal, it should be explicitly stated. One of the position papers stated this more bluntly (Guadalupe-Blanco River Authority): since there is NOT a separate pool, future studies should be geared to better prediction not to finding out if there is a separate pool. This may be stating things too strongly given the task assigned, but studying temporal changes in the pool and improving management strategies (suggested by San Antonio Water Authority) is within the stated task and would make a better focus for future work. I suggest rewriting the list of recommendations with this focus, and providing stronger justification and links to the previous discussion.

TOPIC 2: Evaluate the necessity of maintaining minimum spring flows.

The discussion of threats to the aquatic ecosystem and lack of alternatives to minimum flows was for the most part straightforward. There wasn't much ambiguity about the relationship between spring flow and ecosystem health: minimum spring flows are necessary for ecosystem health. Furthermore, the position papers in Appendix F were also in accord that there need to be minimum spring flows, although the definition could perhaps be better quantified.

The need for stable water chemistry and supply is stated clearly. The unique habitat of the springs (their stability) is also described. Species requirements are thoroughly discussed.
A few questions about the details are worth noting. Answering these questions might clarify the writing, but not change the outcome. I didn't understand the distinction between definitions of "required" and "necessary" in the opening paragraph on p 36. After this sentence, the rest of the paragraph made clear the importance of different definitions of minimum flows and how minimum springs flows could be used in different contexts.

I'm not sure how the discussion of non-native species competition fits in (p 40). I don't think spring flow can prevent invasion. A similar comment on p 44 implies spring flow control: "As discussed above, the natural timing, frequency, duration, and magnitude of springflows are important in controlling invasive and non-native species." It seems to be that because of variations in the needs of different species, whether native or not, there isn't one springflow rate or range of rates that is optimal. No flow is a problem, but I don't see information in this discussion that helps determine optimal flow.

The discussion of alternatives around pp 55-58 could include cost comparisons, for example the costs of reintroduction compared to costs of maintaining minimum flows. However, the cost of failure is perhaps incalculable, so perhaps no other costs matter?

The suggestions for future study seem reasonable. For instance, temperature and CO2 are important for evaluating flow diversion (p 59). Also, reassessing stage-discharge as low flow is approached (p 62) seems a reasonable suggestion. Wouldn't it be a good idea to reassess the relationship after flooding too, since that can alter stream morphology?

TOPIC 3: Evaluate whether adjustments to drought triggers for San Marcos Springs should be made

This section starts with a summary of the trigger levels on pp 63-64. This summary could be presented better with a table (see below). I didn't see an explanation for why San Marcos doesn't have trigger III, IV, but I assume it related to minimum flows. This should be clarified.
The SSC states that they can't recommend adjustment because of lack of scientific understanding of current trigger. The report summarizes current data. It could perhaps

go a bit further in interpreting the data. This interpretation would provide guidance on how one would go about adjusting the drought triggers if the conceptual model could be clarified. In other words, suggest a basis for adjustment; make more clear what the missing information is. I make a few suggestions below. Some of the data interpretation is provided under task 1, so it isn't clear whether these issues should be discussed in this section or the previous section.

Discuss the issue of timing for the triggers. Do plots (Fig 1, 14, 15 or other similar figures examined by the committee) show that triggers provide sufficient warning? Time period not clear on Fig 9-13, and number of periods not clear, which make it difficult to address this question.

Discuss how the response at SM compares to the other spring and wells. In Figure 1 SM is more muted except for June 05. Why is it more muted? Larger recharge area? Does this implied it has more sources (i.e. a larger pool). However, isn't an alternative explanation for muted response that SM has more matrix flow? Wells and springs overlap, which means that the spring doesn't have to be more responsive than the well! Answering these questions about likely flow paths would help to better interpret and set triggers. In other words, I recommend including a discussion of flow paths in the section on triggers.

Trigger	San Marcos Spring	Well J17	Comas spring
I	96 cfs	660 ft	225
II	80 cfs	650	200
III		640	150
IV		630	100

Overall Summary

For the most part, addressing my comments would change focus but not the conclusions of the report. One exception is the suggested future research direction on p 33, which I think could be improved by rethinking to address some of the questions raised in this review.

Reference on recharge calculation

Ginsberg and Palmer, 2002. Delineation of Source-water Protection Areas in Karst Aquifers of the Ridge and Valley and Appalachian Plateaus Physiographic Provinces: Rules of Thumb for Estimating the Capture Zones of Springs and Wells. (available at http://www.epa.gov/safewater/sourcewater/pubs/guide_karstaquifersrvapp_2002.pdf

Review by Carol Wicks

The clearly written report specifies three tasks that had to be addressed 1) to evaluate designating a San Marcos Pool, 2) to evaluate the necessity of maintaining minimum spring flows, and 3) to evaluate whether adjustments to drought triggers for San Macros Springs should be made. I have been asked to evaluate uncertainty, in general. Specifically, I will consider the following questions for each of the three tasks.

How would I evaluate the use of scientific information in the document? Is there a clear and consistent use of relevant data and facts? Are management or other decision clearly linked to objective evaluations of fact?

Task One – excellent, yes, yes
Task Two – excellent, yes, yes
Task three – excellent, yes, yes
Was all available and relevant information used? If not, what available data are missing? Could these omissions have affected the decisions made?
Task one – very good, the work of a few authors is missing, likely NOT.
Task two – excellent, none missing
Task three – excellent, none missing
Does the document make explicit discussion of uncertainty? If not, please indicate any areas where such uncertainties might influence management decisions.
Task one – very good
Task two – diffuse, but included and very good
Task three – clear, very good

Task One: to evaluate designating a San Marcos Pool

How would I evaluate the use of scientific information in the document? Is there a clear and consistent use of relevant data and facts? Are management or other decision clearly linked to objective evaluations of fact? My evaluation of the use of scientific information is very good. The authors have compiled and reviewed relevant data and facts and have used the data consistently. The decisions the authors made are clearly based on these data and facts.

Was all available and relevant information used? If not, what available data are missing? Could these omissions have affected the decisions made?
Nearly all relevant data were used.

Reports and papers by the research groups of Jack Sharp (UT-Austin), Bridgette Scanlon (Bureau of Economic Geology), and George Veni (NCKRI) are missing from the otherwise extensive list of works used

Sharp's work deals with recharge to the Edwards Aquifer. His findings are associated with the impact of urbanization on recharge. The lack of this work probably does not impact the findings. Scanlon's work is a large-scale numerical model of the Edwards. The EARIP report is based on a smaller scale, however Scanlon's work places uncertainty in a more regional context. Given the role of uncertainty in these management decisions, Scanlon's work should be included. George Veni's work is field-based basin and flowpath delineation. I am uncertain if Veni completed any studies in this segment of the Edwards; if Veni did, then these studies should be included.

Does the document make explicit discussion of uncertainty? If not, please indicate any areas where such uncertainties might influence management decisions.
The uncertainty of the structural (geologic) control on flowpaths and hydrogeologic conceptualization is made very clear. The two major studies (Guyton; Maclay and Land) that are extensively reviewed and relied upon are clearly presented; the differences in the findings are pointed. These differences lead to uncertainty and that is pointed out. Scanlon's work might provide an overall assessment of uncertainty of using numerical models in general

In general the flowpaths are to northeast. The uncertainty associated with direction is clearly stated by including the work of Otero (2007) who finds flowpaths through a portion of the aquifer to be toward the southwest. The uncertainty is clearly documented.

The recharge assessments are more consistent in quantity, although there are spatial differences. These differences in spatial patterns are clearly outlined. In addition, there are several methods that can be used to estimate recharge and those methods are presented.

The uncertainty associated with the water balance estimates is clearly stated.

I think the authors need to make clear that correlation is not necessarily cause and effect. There probably is cause and effect underlying these relations, however correlation analyses does not address cause and effect. Correlation analyses are a good first step and should more clearly be stated in that light.

Spatial and temporal changes in chemistry of water are difficult to understand when the flowpaths are well known. In this case, these changes are very difficult to understand given the uncertainty associated with the flowpaths. The authors were correct in limiting water chemistry to a short section that highlights these complexities.

Task Two: to evaluate the necessity of maintaining minimum spring flows
How would I evaluate the use of scientific information in the document? Is there a clear and consistent use of relevant data and facts? Are management or other decision clearly linked to objective evaluations of fact?

This section of the report is exceptional. The clearly presented data are used consistently and all relevant data have compiled. The decision is clearly based on objective assessment of the data and the uncertainty associated with that data.

Was all available and relevant information used? If not, what available data are missing? Could these omissions have affected the decisions made?
The authors have pulled together a massive literature base for each species of concern. They also relied on scientific literature related to ecohydrology in general. The report is based on the current understanding of ecohydrology and the role of disturbances and on current scientific research for each species. All relevant and available information was used.

Does the document make explicit discussion of uncertainty? If not, please indicate any areas where such uncertainties might influence management decisions.
The uncertainty is discussed for each species, which make the uncertainty discussion appear diffuse, which it is, but that discussion is explicit in each subsection.

Task Three: to evaluate whether adjustments to drought triggers for San Macros Springs should be made

How would I evaluate the use of scientific information in the document? Is there a clear and consistent use of relevant data and facts? Are management or other decision clearly linked to objective evaluations of fact?

The relevant data and facts were clearly presented and consistently used. Management decisions are linked to objective evaluations of the data.

Was all available and relevant information used? If not, what available data are missing? Could these omissions have affected the decisions made? This task is quite focused on one issue and the authors relied on the best data available – records of spring discharge and water levels in wells collected over a nearly thirty year period. These are the best data to use to assess this task.

Does the document make explicit discussion of uncertainty? If not, please indicate any areas where such uncertainties might influence management decisions. The uncertainties

associated with measuring spring discharge are clearly presented within the report as a whole. The records of water levels are known with a high degree of certainty. Finally, the analyses of trigger level against flow is appropriate for assessing this task.

FINAL CONCLUSIONS FOLLOWING DISCUSSIONS

The reviewers raised several issues in their comments. Some of these were important scientific concerns, but inappropriate for the task at hand (k charges) and will be addressed in future reports of SSC. SEI (as the final arbiter of the review process) agrees with SSC that it is not necessary to address such issues further in their current report. Some other issues raised were minor technical points, suggestions for improving clarity, adding scientific literature, etc. These were adequately discussed in the SSC responses to reviewers (often by simple statements that the points were accepted), and in the teleconference, and do not need further elaboration here.

This section concerns those areas where there was substantive scientific discussion between the reviewers and the SSC, and documents the conclusions reached by the group.

Comprehensiveness of review
As indicated above, there was extensive discussion by reviewers of whether all topics were adequately covered. It is important to note that reviewers were often seeking to understand the background and context for conclusions, rather than critiquing the report itself. Some of the issues which the panelists ultimately accepted as beyond the scope of the report included large analyses of water chemistry, or further literature review of the biology of the organisms affected. On other issues the SSC felt there was inadequate information to make strong statements, but the panelists persisted in asking for whatever information was available so that the context could be better understood (such as population ballpark estimates, or the results of dye studies).

As noted by Wicks on the conference call, the reviewers felt the SSC had done a very good job of developing a scientific report that addressed all the charges set forth by legislation.

Biological information
There was discussion, following the review by Bain, of the need for more information on the species assemblage. The SSC members articulated that there were limited data for many of the species, and that such a presentation would be of limited value. Bain and Wicks however persisted that such a summary table would be useful to help understand species' potential responses. Indeed, the lack of data on many topics is itself useful information, indicating the relative strengths of conclusions. However it may not be possible to provide any information at all for some species.

Bain also asked for information on population status and fluctuations, and pointed out that there was no way from the initial report to determine that there are hundreds of thousands of fountain darters. It was acknowledged by all that such data as exist are preliminary, and have high variance estimates. Fryar asked for similar data on temperature variation, which might have biological consequences.

Issues of flow

Although there was some discussion of quantification of minimal flow estimates, it was agreed that the current effort was sufficient for the task in hand, and that qualitative estimates of minimal flow were sufficient.

There was more extensive discussion on the issue of whether the case had been made that variation was an important component of the flow regime. The group agreed that there was some natural variability in flow (but not chemistry), and there was further discussion on whether this variability was important to maintain the ecosystem and its component species. Brant and other members of the SSC stated their belief that variability might not be important on an annual basis – indeed very low or very high flows might have negative effects. Over the long term however, such variability could affect and enhance the evolutionary potential of the species. Bain and other panelists stated that the case for this view is not yet well articulated and supported for karst systems, as opposed to river systems, where it is well established that variability is needed for some species to complete their life cycle.. However no panelist felt that this view was incorrect – merely that the document as yet does not make a strong case for it. Toran and others pointed out that different species have different minimal (and probably optimal) flow levels, which implies the need for variability in order to maintain all component species.

Barker has prepared revisions to the SSC report that address the flow issues, and modeling aspects. Panelists were supportive of these revisions. Toran noted that some of the language used in the conference call was particularly useful and easy to understand, and might be considered for insertion.

Issues of recharge

Reviews and discussions made clear that there was a complex relation between rivers and pools, with some rivers contributing to recharge, and others being dependent on pools. It was also noted that some of the water contributing to recharge is derived from distal sources (inflow with rivers) on the plateau. It was agreed by all that this complexity needs to be better explained in the SSC document, and that Barker is addressing this need well by his additions. The reviewers thought it important that all relevant approaches to recharge (e.g. EPA) be at least referenced.

Connectivity
Several reviewers were surprised to learn of dye tracing results implying limited connectivity, and encouraged the SSC to include reference to them. Toran pointed out (in conversation with SEI) that such connectivity might vary temporally, and that spatial relations among rivers, pools and wells might therefore vary over time in a complex manner (as inputs from rain etc varied).

Correlation and causation
A persistent issue in reviewer's comments, and in the resulting discussions is the need for caution when evaluating correlations. As was acknowledged by both reviewers and the SSC, correlation does not imply causation, and there may be many factors in operation. This was raised in particular regarding the correlation between springs and wells. Nevertheless, Fryar was comfortable with the implied relationships (index use), although several reviewers pointed out that there may be threshold effects (e.g. above 619 feet, there may be a decoupling as physical limits are reached), and other non-linear interactions. The reviewers felt that the SSC were aware of the problem, and would address it in their final revision.

Discussion of water chemistry
Reviewers initially disagreed on the issue of water chemistry; Fryar asking for more discussion, while Wicks described the document as 'appropriately brief'. This apparent difference was resolved with the agreement that some more documentation is appropriate, but that an exhaustive analysis would be disproportionate to the benefit – a couple of paragraphs were thought to be sufficient.

Recommendations for future work
The SSC report makes reference to several possibilities for future research. While such prioritization issues may fall outside the scope of the review (as representing policy decisions), it is worth noting that reviewers felt that some topics would be more likely to fill perceived data gaps than would other topics. Toran in particular felt that the currently described future research topics were poorly justified at present, and that additional work would help to set better priorities. Reviewers also suggested that the SSC distinguish work that is possible in the future from work that is actually underway.

Potential research topics raised by reviewers including additional modflow modeling with conduit simulations; improving the accuracy of rating curves at high flow measurements; flushing flows; habitat manipulation; and the use of multi-variate statistical modeling. Although this latter topic has so far received little attention from karst hydrologists, it is clear that variables appear to not all be

independent, suggesting that multi-variate approaches may indeed have some value.

Use of literature

There was some discussion about the use of the scientific literature by the SSC. The reviewers suggested the inclusion of references to some omitted work (EPA recharge, Barton Springs studies). While the SSC did not initially agree that such references were necessary, arguing that there was a limit to the inferences that can be drawn from distant studies, or from exploratory work, the panel persisted in maintaining that well-recognized and cited work should be referenced – if only to explain why they are not relevant here.

Appendices

1. RFP
2. Scope of work
3. E-mails and notes regarding final review

Also provided to EARIP

1. mp3 of conference call with reviewers
2. wiki materials

1

REQUEST FOR PROPOSAL

The Edwards Aquifer Recovery Implementation Program ("EARIP") is a collaborative, consensus-based stakeholder process tasked with the development of a plan to protect the federally-listed species potentially affected by the management of the Edwards Aquifer and to contribute to these species' recovery. The stakeholders in the process include State of Texas agencies, local water resource authorities, water purveyors, environmental groups, municipalities, public utilities, and other individuals and groups interested in the Aquifer and the species residing in the Edwards Aquifer or in the springs and river systems fed by the springs.

See Attachment 1. The EARIP is seeking proposals for independent peer review of a study conducted by its Science Subcommittee.

BACKGROUND

Edwards Aquifer System

The Edwards Aquifer is a unique groundwater resource, extending 180 miles from Brackettville in Kinney County to Kyle in Hays County. It is the primary source of drinking water for over 2 million people in south central Texas and serves domestic, agricultural, industrial, and recreational needs of the area. The Edwards Aquifer is the source of the only two major springs remaining in Texas - the San Marcos and Comal springs. These springs feed the San Marcos and Comal rivers, which are tributaries to the Guadalupe River.

Eight species that depend directly on water in, or discharged from, the Edwards Aquifer system are federally-listed as threatened or endangered. These species include: fountain darter (*Etheostoma fonticola*), San Marcos salamander (*Eurycea nana*), San Marcos gambusia (*Gambusia georgi*), Texas blind salamander (*Eurycea rathbuni*), Peck's cave amphipod (*Stygobromus pecki*), Comal Springs dryopid beetle (*Stygoparnus comalensis*), Comal Springs riffle beetle (*Heterelemis comalensis*) and Texas wild rice (*Zizania texana*). The San Marcos gambusia has not been seen since 1983 and may be extinct.

The primary threat to the aquifer-dependent listed species is the intermittent loss of habitat from reduced springflows. Springflow loss is the combined result of naturally fluctuating rainfall patterns, regional intermittent pumping, and temporal drawdown of the aquifer. Other threats include invasive non-native species, recreational activities, predation, flood flows, and direct or

indirect habitat destruction or modification by humans and other factors that decrease water
quality (U.S. Fish and Wildlife Service 1996).
For more background information regarding the Edwards Aquifer see
http://www.edwardsaquifer.org/pages/eaaact.htm

The Edwards Aquifer Recovery Implementation Program

In 1991, the Sierra Club filed a lawsuit under the Federal Endangered Species Act that ultimately
resulted in the creation of the Edwards Aquifer Authority ("EAA"). The Texas Legislature
directed the EAA to regulate pumping from the aquifer, implement critical period management
restrictions, and pursue measures to ensure minimum continuous springflows of the Comal and
San Marcos springs are maintained to protect endangered and threatened species to the extent
required by Federal law. Today, competing water needs within the region continue to influence
2
management of the resource, and a workable comprehensive plan for the long-term protection for
the federally-listed species has yet to be adopted among the region's stakeholders.
As a result, in late 2006, the United States Fish and Wildlife Service ("FWS") brought together
stakeholders from throughout the region to participate in a unique collaborative process to
develop a plan to contribute to the recovery of federally-listed species dependent on the Edwards
Aquifer. This process is referred to as the Edwards Aquifer Recovery Implementation Program.
In May 2007, the Texas Legislature directed the EAA and certain other State and municipal
water agencies to participate in the EARIP and to prepare a FWS-approved plan by 2012 for
protecting the Edwards Aquifer-dependent listed species at Comal and San Marcos springs. The
Legislature directed that the plan must include recommendations regarding withdrawal
adjustments during critical periods (*i.e.*, droughts) that ensure that federally-listed species
associated with the Edwards Aquifer will be protected.
For more information regarding the EARIP see http://irnr.tamu.edu/earip

Science Subcommittee

The Texas Legislature required the EARIP to establish a Science Subcommittee of individuals
"with technical expertise regarding the Edwards Aquifer system, the threatened and endangered
species that inhabit that system, springflows, or the development of withdrawal

limitations." The
Legislature required the Science Subcommittee to prepare "initial recommendations by December 31, 2008, regarding:

• The option of designating a separate San Marcos pool, of how such a designation would affect existing pools, and of the need for an additional well to measure the San Marcos pool if designated

• The necessity to maintain minimum springflows, including a specific review of the necessity to maintain a flow to protect federally threatened and endangered species; and

• Whether adjustments in the trigger levels for the San Marcos Springs flow for the San Antonio pool should be made.

The EARIP refers to these recommendations as the "k" charges. In making these recommendations, the Science Subcommittee is to "consider all reasonably available science"
and "base its recommendations solely on the best science available." The Subcommittee is
supposed to "operate on a consensus basis to the maximum extent possible."
The Steering Committee appointed 15 scientists to serve on the Science Subcommittee and one
non-voting member. A list of the members and their affiliations is included in Attachment 2.
Ms. Susan Aragon-Long from the United States Geological Survey chairs the Subcommittee.
More detailed information about the work of the Science Subcommittee on the "k" charges can
be found at http://earip.tamu.edu/SciComm.cfm

REQUESTED PROPOSAL

3
The EARIP is seeking a proposal for independent peer review of the Science Subcommittee
recommendations regarding the "k" charges. The recommendations will be available on or
before December 31, 2008. The recommendations will be in the form of a report that will be
approximately 75 pages in length. The work of the Science Subcommittee was based largely on
review of available literature, invited speakers, and discussions among the members. The work
did not involve new field work or the development of new hydrologic or biological models.
Because of the limited scope of the Science Subcommittee's work, the EARIP does not seek to
use the peer review process to "redo" the work of the Subcommittee. The EARIP does expect
that the reviewers will focus on the entirety of the referenced research and historic observations
used to support the Subcommittee's conclusions and recommendations and the extent to

which
the recommendations adequately address the Legislature's "k" charges. However, you should
feel free in your proposal to suggest a different scope of review.
Your proposal should be in the form of a brief scope of work and include:
• The number of reviewers proposed
• A description of how the reviewers will be selected
• A description of the deliverable including whether the individual reviewer's comments will be included
• Whether the Science Subcommittee will be able to comment on a draft report and/or respond to any questions the reviewers may have
• The length of time required for the review assuming that the recommendations are provided to you on December 31, 2008.
• A description of your group's experience in managing peer review processes
It is anticipated that the contract will be a time and actual expense contract with a not to exceed
amount. Your proposal should provide the hourly rates of the personnel and a proposed cap for
the contract. If the hourly rates of the reviewers are unknown at this time, an estimate of those
rates should be provided.
The objective of the EARIP is to ensure an unbiased, independent review. Accordingly, the
EARIP will not suggest or recommend reviewers. The EARIP, however, does believe that the
reviewers should be from outside of the region and not have directly worked on projects involving the Edwards Aquifer previously but may have expertise in ecohydrology, endangered
species, karst aquifer systems, and other appropriate disciplines.
Texas A&M University will serve as the contracting agent for the EARIP with respect to this
project. The project will be managed by Robert L. Gulley, the Program Manager for the EARIP.
All proposals and inquiries should be directed to:
Robert L. Gulley, Ph.D.
Program Manager
Edwards Aquifer Recovery Implementation Program
Texas A&M University
Institute of Renewable Natural Resources
4
3355 Cherry Ridge Dr., Suite 212
San Antonio, Texas 78230
210-467-6575, ext 232 (W)
210-930-1753(F)
RLGulley@ag.tamu.edu
Proposals should be received no later than October 10, 2008.

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ATTACHMENT 1
PARTICIPANTS IN THE EDWARDS AQUIFER RECOVERY IMPLEMENTATION PROGRAM

The following thirty-eight Stakeholders have executed the 2007 Memorandum of Agreement with the United States Fish and Wildlife Service regarding participation in the Edwards Aquifer Recovery Implementation Program:

Aquifer Guardians in Urban Areas
Alamo Cement Company
Bexar County
Bexar Metropolitan Water District
Carol G. Patterson
City of Garden Ridge
City of New Braunfels
City of San Marcos
City of Victoria
Comal County
CPS Energy
East Medina Special Utility District
Edwards Aquifer Authority
Gilleland Farms
Greater Edwards Aquifer Alliance
Greater San Antonio Chamber of Commerce
Guadalupe Basin Coalition
Guadalupe-Blanco River Authority
Guadalupe County Farm Bureau
John M. Donahue, Ph.D.
Larry Hoffman
Mary Q. Kelly
Nueces River Authority
New Braunfels Utilities
Regional Clean Air and Water Association
San Antonio River Authority
San Antonio Water System
San Marcos River Foundation
South Central Texas Water Advisory Committee
South Texas Farm and Ranch Club
Texas Bass Federation
Texas Commission on Environmental Quality
Texas Department of Agriculture
Texas Living Waters Project

Texas Parks and Wildlife Department
Texas Water Development Board
Texas Wildlife Association
6
Union Carbide Corporation
7

ATTACHMENT 2
Edwards Aquifer Recovery Implementation Program
Science Subcommittee Members

Members with biological or ecological expertise
Norman Boyd (Texas Parks and Wildlife Department)
Doyle Mosier (Texas Parks and Wildlife Department)
Jackie Poole (Texas Parks and Wildlife Department)
Michael Gonzales (San Antonio River Authority)
Tom Brandt (U.S. Fish and Wildlife)
Ed Oborny (Bio-West)
Glenn Longley (Texas State University)
Members with geological or hydrological expertise
Mary Musick (TCEQ – retired)
Rene Barker (Texas State University)
Alan Dutton (University of Texas at San Antonio)
Ron Green (Southwest Research Institute)
Robert Mace (Texas Water Development Board)
Sam Vaugh (HDR Engineering Inc.)
John Waugh (San Antonio Water System)
Susan Aragon-Long (U.S. Geological Survey)
Charlie Kreitler (non-voting member LBG-Guyton)

EXHIBIT B

Scope of Work For Peer Review of the Edward aquifer Recovery Implementation Program's Science Subcommittee's "k" Charge Recommendations

Sustainable Ecosystems Institute ("SEI") will conduct a peer review of the EARIP's Science Subcommittee recommendations of the "'k' charges" described in the Request for Proposal provided to SEI by the EARIP conformance with this Statement of Work ("SOW"), and SEI's Proposal for Peer Review ("Proposal") (attached hereto as Attachment 1). To the extent that there is a conflict between the RFP or Proposal and this SOW, the SOW will govern the conduct of the work.

After initial scoping and review of materials and questions, SEI will set up a process that will provide a clear, transparent peer review of the highest caliber. SEI will use a peer review process that is well-documented and which can be shown to be impartial. The following describes the specific tasks that will be used to meet these needs and provide a clear record.

Task 1: Scoping of review: Conclusions regarding documents to review and reviewer expertise

SEI will review the Science Subcommittee's recommendations and assemble a panel of four-to-five scientists. Based on the RFP, SEI has initially determined that panel of experts should focus primarily on hydrological issues but also include ecological or species specific expertise. Accordingly SEI intends to put together a panel comprised of three hydrologists (with at least one scientists with expertise in karst systems), a population biologist, and a quantitative expert. SEI's initial determination regarding the expertise on the panel may be refined after SEI reviews the Science Subcommittee's recommendations.

Task 2: Selection of reviewers

SEI will follow its normal procedures in selecting highly-qualified reviewers who are able to review the materials. SEI will solicit the names of possible reviewers from SEI board members, from previous SEI panelists, from other eminent scientists, and from SEI's standing panels of exerts in various fields. SEI will develop a file for each scientist considered as a reviewer, and the reasons for selecting (or not selecting) that scientist will be included in that file.

After considering the available pool of reviewers, SEI staff will select those reviewers who best meet the criteria of scientific eminence and experience, and who also pass all other criteria of independence and impartiality set out in the RFP. SEI will interview the

reviewers, record their responses, and ask them to sign statements attesting that they have no conflicts of interest (as per National Academy and SEI guidelines [*we should attach these guidelines*], and as in RFP).

To ensure that the review is independent of the stakeholders and interested parties, the EARIP, its Science Subcommittee or Program Manager will not control or be involved in the selection of the reviewers.

Task 3: Preparation of reviewers

After SEI has selected reviewers, panelists will be provided with background and other materials as soon as they become available, through SEI's dedicated wiki-site (see below). SEI will also set up conference calls with reviewers, and facilitate discussions ahead of the actual review. SEI staff will work with individual panelists to ensure that they understand the materials, the review requirements, and their individual tasks.

Task 4: Wiki site

SEI will maintain a clear record of all materials disseminated to the reviewers, the communications between SEI and the reviewers and among the reviewers, and individual panelist's responses using SEI's wiki. The individual and group reports will also be crafted on-line, so that there will be a complete record of any changes made to any document. SEI will ensure that the site is secure so that EARIP participants may watch the review unfold, but will not be able to comment on the reviews unless expressly allowed by SEI in the limited circumstances described below.

Task 5: Preparation of review

To obtain the individual opinions of panelists, SEI will require that each panelist provide written responses to a series of review questions. SEI will also allow panelists to discuss their responses, the issues involved, and to modify their written responses in light of such discussions. SEI will reflect any differences of opinion among the panelists in the final report.

After a draft final report has been completed, SEI will allow the Science Subcommittee to interact with the review panel under SEI supervision, by asking questions, or by providing additional material as requested by the reviewers. This will be accomplished either by allowing the Science Subcommittee access to the wiki or through a recorded conference call. SEI will work with Susan Aragon-Long, the chair of the Science Subcommittee, to set up the arrangements for the interactive process. At the close of the interactive process the panel will finalize the review.

Task 6: Deliverables

Draft and Final reviews of documents, including individual reviewers opinions.

A full Administrative Record (to include all e-mails, drafts, ancillary materials)

Timetable of events

By December 31, 2008	Set-up project specific wiki Select reviewers Load background materials to wiki Develop instructions for reviewers Conferences with reviewers regarding the review and their responsibilities
December 31, 2008	Delivery of Science Subcommittee Recommendations by EARIP Program Manager for review
January 26, 2009	Draft report completed and provided to Science Subcommittee
February 16, 2009	Discuss results with Science Subcommittee
March 2, 2009	Final Review completed and submitted to EARIP Program Manager
March 16, 2009	Administrative Record completed and submitted to EARIP Program Manager

Appendix 3
E-mails on final reviews and discussions

1.Bain

Steven P Courtney, Vice President
Sustainable Ecosystems Institute
PO Box 80605
Portland, Oregon 97280

30 March 2009

Dear Steven:

Prior to the response to the review and phone discussion, I had stated in my review that the findings of the reports were acceptable, well reasoned, and supported by local information and direct analyses. My concerns were on the limited information used, reliance on simple analyses, and lack of quantification for some findings. These were discussed on the conference call

Task 2 (minimum spring flows) was discussed relative to the need to have a minimum flow and all were in agreement that it is an obvious and established requirement. The team explained that there was a need to make the point in their report. I had a minor disagreement on flow regime for springs justified using facts from rivers. The inconsistency was acknowledged on the call and all agreed the regime requirements needed to be analyzed and presented in more detail. Again, the conclusions of the report on this topic were fine.

My recommendation to develop an assemblage-level justification for water needs was for enhancing the impact and use of reported information. This was discussed as a good idea that was not needed for this study but would be beneficial in other communications. Discussion on the call made clear the case it is beyond the study scope as assigned.

My question on the magnitude of the fountain darter population was answered by reporting the approximate range of numbers of darters. It was far larger than I expected and this made the point that putting even rough ranges in the report would help readers.

Habitat manipulations and flushing flows suggestions I made were seen as good ideas for future studies. Such work relies a lot on non-local

information and was beyond the scope of this study.

Other minor points were also discussed and some changes were made in the report text to respond.

Overall, I felt my review and suggestions were recognized by the study team and worked to introduce some new ideas and approaches for their future work. Our discussion provided answers for me on why they chose their approach to complete their assignment. This resolved my questions and some limited concerns on how study was conducted and reported. It was a concsturctibe review discussion and I think both sides gained insight on this hard conservation case.

Feel free to follow up further if more information is needed.

Sincerely,
Mark Bain

2. Fryar

Hi Steven,

I jotted down some notes during the conference call. My sense is that the rewrite and the discussion during the call addressed most of my concerns (including those of Laura Toran, who wasn't on the call). The remaining issues for the final version of the report were:

(1) note explicitly that groundwater-stream interactions vary up- and down-stream of San Marcos Springs;
(2) note the limits of correlation between hydraulic heads in wells and spring discharge;
(3) expand the section on water chemistry enough to explain the differences in chemistry between the 2 groups of springs at San Marcos Springs, and whether they're consistent with differences in residence time and/or lithology;
(4) discuss previous dye traces in the San Marcos Springs segment of the Edwards aquifer;
(5) provide background information in Section 3 on actions taken when triggers are exceeded, and note what stages I - IV represent;
(6) revise suggested future research directions to address questions raised during the review.

If you're satisfied that these issues have been or are being addressed, I don't need to see the final version of the report.

Regards--Alan

Alan E. Fryar, Associate Professor Department of Earth and Environmental Sciences University of Kentucky 101 Slone Building Lexington, KY 40506-0053 USA phone 1 859 257 4392 fax 1 859 323 1938 e-mail alan.fryar@uky.edu

3. Toran
Steven

Thanks for the opportunity to comment on the responses to the SSC review. I have read the responses and listened to the conference call.

I don't have anything new to add to the discussion in the conference call, but I would reiterate or amplify some points brought up in the call.

-The addition of the figure and text describing stream recharge was helpful.

-When using the word "correlation" it is important to qualify that we don't expect wells and springs to necessarily correlate, and that correlation doesn't mean causation. It sounded like this was going to be clarified in the next revision of the report, and this clarification will help keep the readers from misinterpreting data.

-The report provides a good basis for minimal flow. However, optimal flow is still a question. It would be helpful to specifically state that different species have different flow needs, so there may not be an optimal flow rate. This statement would not alter the conclusions.

-I wasn't clear how much tracer test information was going to be included in the final report. A short paragraph would be helpful to amplify the references cited. In particular, point out how much of the conclusions on flow direction is from tracer tests. The other reviewers supported this addition.

-There was an interesting statement in the conference call that I would recommend including in the report: "Temporal distribution of recharge is variable." This statement helps explain why the pools are difficult to sort out. The pools may be connected at some times and not at others. This may have already been stated, but I thought the linkage to temporal variability of recharge was interesting. This could provide a focus for one future study. (How does recharge are vary through time?)

-There were some other examples of future studies mentioned in the conference call and in the reviews. These could easily fit into section 1.3. Some modification of this section would be helpful.

-I agree with Alan that the point of citing the EPA report was not to do extra work but just to provide a more readily accessible reference to a method for estimating recharge. Explaining Puente's method better would suffice as well.

Again, no substantial changes are being suggested in my comments here.
- Hide quoted text -

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4. Wicks

Hello,

I am satisfied that my concerns were addressed. The recommendations the authors made were supported by the science presented and the science presented was clear. If the science had not yet advanced to answering a question, the authors noted that lack.

The correlation needs to be better explained, but if you (Steven) are satisfied, then I do not to see it again.

As I had a slightly different understanding of my role as a reviewer than the other reviewers had of their roles, my comments were easily for the authors to address.

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