APPENDIX D PEER REVIEW FINAL REPORT

June 12, 1999

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Subject: Peer Review Panel Report On SSA Study on Seepage And Subsurface Inflows To Salton Sea And Adjacent Wetlands

Dear Tom:

We have reviewed the May 26, 1999 report entitled: "75% submittal - A Study on Seepage and Subsurface Inflows to Salton Sea and Adjacent Wetlands" prepared for the Salton Sea Authority. As part of the peer review process, we reviewed relevant documents and reports and attended two technical workshops (28-Apr-99 and 3-Jun-99) with representatives from Tetra Tech, HSI Geotrans, Coachella Valley Water District, and the Imperial Irrigation District. In addition, the peer review panel met separately on 7-Jun-99. The comments and recommendations contained herein represent the joint effort of the peer review panel members.

In summary, the model is conceptually sound, provides reasonable values, and can be used for the intended purpose of the seepage and underflow estimates. Predictions made using the model are also reasonable within the limits of the data provided. Our comments focus on the following three areas:

- Conceptual Models - Ground Water And Water Balance
- Suitability Of The Ground Water Model To Quantify The Reduction In Seepage And Subsurface Inflows To The Salton Sea
- Recommendations For Improvements And Future Work

Conceptual Models - Ground Water And Water Balance

In general, the ground water model is conceptually sound. That is, the model's three layers, overall area of interest, boundary conditions, and related MODFLOW packages are appropriate for the geologic and hydrologic conditions encountered in the area and the intended purpose of the model. The model is calibrated against the 1979 observed water balance as well as the ground water level history in a number of wells. Based on the information available, the model appears to reasonably replicate the water supply and disposal items in the balance as well as the ground water level history in most model areas.

The conceptual model generally describes flows associated with surface features based on existing data, but does not include an error budget. Thus the numbers presented probably appear more certain than they really are. Ground water flow calculations are less well described. Inadequate descriptions are noted relating to the ground water flow calculations. However, the order of magnitude of the numbers appears reasonable.

The vegetation water balance, although simple in concept, assumes a constant evapotranspiration rate. The actual rate used in the calculations is not indicated in Section 8 of the report. However, earlier in the report, reference is made to 4 and 5 feet per year as given by the US Bureau of Reclamation. Since this is 20% uncertainty, and the total is a large fraction of the water balance, uncertainty in this number will directly affect the calculations. In reality, this number may be expected to increase in dry years and decrease in wet years. It may also depend on the maturity of the vegetation, and such events as rangeland fires. The calculations indicate four or five significant digits; this should be rounded to reflect the actual uncertainty in this number.

The following findings are consistent with the models. The geology of the northeast shore of the Salton Sea precludes any significant subsurface flow to the Salton Sea. The low-permeability lake clays preclude subsurface flow and restrict infiltration of surface water. Other than the active and formerly active channels of Salt Creek, little subsurface flow could be reasonably expected. As a result, the major portion of available water supply is consumed by native vegetation with little or no subsurface flow to the Salton Sea.

The conceptual model for ground water discharge summarizes total flows calculated in sections 3, 4, and 5 of the report. Ground water flows are constrained by two major features of the ground water basin between the All-American Canal and the Salton Sea. First, the ground water basin is essentially full from a few miles north of the AAC to the Salton Sea, and second, the tile drain network prevents heads from rising above the levels of the tile drain except during floods. Thus, the effects of head changes caused by lining the canals is restricted to a small part of the area modeled.

The conclusion that the change in discharge attributable to the mound beneath the canal cannot be calculated is not entirely justified. The hydraulic gradient is fixed by such features as the elevations of the base of the East Highline canal, the tile drain network and the Salton Sea. Therefore, all northbound ground water originating in the mound formed beneath the AAC is intercepted by the drainage features before it reaches the Salton Sea. The flow volume to the drainage features is proportional to the height of the mound. The volume of water is limited by the hydraulic conductivity, which changes very little by collapsing the mound. Collapsing the mound will approximately halve the gradient, and, assuming the water levels revert to 1939 levels beneath the mound, the ground water flow rate contribution to the drains will be approximately half. A hand calculation of this would provide a way to check the reasonableness of the computer model.

A related problem with the conceptual model of the ground water balance is that it does not attempt to identify the current contribution of the seepage mound to flow rates in the drains. Although this is discussed to some extent elsewhere in the text, it is also relevant here.

Suitability Of The Ground Water Model To Quantify The Reduction In Seepage And Subsurface Inflows To The Salton Sea

The ground water model's ability to predict the effects of management decisions is limited by several factors. Models have inherent limitations based on translation of the real system to mathematical terms, and they have other limitations based on the quality of the input. The appendix should include a short discussion of the assumptions used in the mathematical model, including features of the model, assumptions about lateral anisotropy, boundary conditions, mesh

size, time steps, which items change during time steps and which are constant, and other assumptions and generalizations used. Although some of these items are described, their limitations are not. The overall effect is to make the model seem more robust than it may really be.

This model did not involve generating any new data, instead, existing sources were relied on for all data used. Many of the water budget items have considerable uncertainty, and many of the largest items may have uncertainties of 20 percent or more. Items notorious for wide ranges in uncertainty include evapotranspiration, underflow, and rising water. The quality of data and the range of uncertainty for each item should be tabulated. The results of mathematical computer models may appear more certain than they really are. This problem is most apparent in the excessive significant digits carried by the model.

The magnitude of the seepage into the Salton Sea, around 7,000 acre-feet per year, is well within the uncertainty of many of the large water balance items. Therefore, any item with an uncertainty of this magnitude could affect the range of the seepage estimate. The results of sensitivity analyses for larger flow items should be included.

One effect tabulated but not discussed is the effect of mound collapse on leakage out of the East Highline canal.

The model is designed to model hydraulic heads in the horizontal plane. The observation wells that are constructed of open, 1-inch galvanized pipe may be influenced by vertical components of flow. This will introduce error into the model calibration when heads are considered. Vertical errors of several feet are possible, particularly near the canals. Other wells may be screened below the modeled aquifers, or across the aquitard (layer 2). Problems with the calibration wells may mean hydrographs at odds with the transient or steady-state calibrations, and several problems with wells are apparent. Where the causes of discrepancies is known or suspected, they should be noted either in the text or figures.

Evapotranspiration (EVT), as noted above, is a significant portion of the balance, yet has been calculated using a single value of a number that has a minimum 20% uncertainty. In addition, actual EVT may vary in years that are cooler or warmer or wetter or drier than normal. Because

both canal seepage and EVT are calculated, but their sum is constrained, any error in one makes an equal and opposite error in the other. In any flow-based model such as this one, the largest and most sensitive flows should receive the most effort to reduce uncertainty.

However, it should be recognized that each item of inflow and outflow is subject to a range of potential error. These errors can result in variations in the predictions of the water that may be lost to the Salton Sea and adjacent wetlands from the lining of the AAC and CB. For example, the combined estimated boundary underflow and drain flow of the La Mesa Drain is several times the predicted amount of water lost to the Salton Sea due to canal lining.

Recommendations For Improvements And Future Work

Some areas of the ground water model seem better calibrated than others. These areas need to be discussed as to how the difference between model generated ground water levels and historical levels impact the estimates of canal seepage and inflow to the Salton Sea. In general, more effort may be needed in model calibration if these "residuals" show an impact.

The ground water model reasonably duplicates steady flow conditions for the flows used. However, some of the flow items are less certain than they appear. The transient simulation extends the steady state assumptions to cover the recent past to the present. The projected changes due to the project are based on the transient calibration.

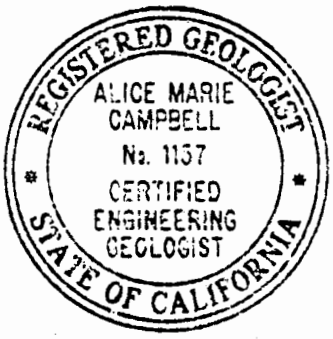
Although the mathematical model seems to be providing reasonable results, more sensitivity runs and error budget analysis may be warranted in the future, since the magnitude of the effects being sought are small in relation to the size of the input uncertainties.

It would be helpful to develop a table similar to Table 6-1 which would present an estimated error budget for each of the named features in the table.

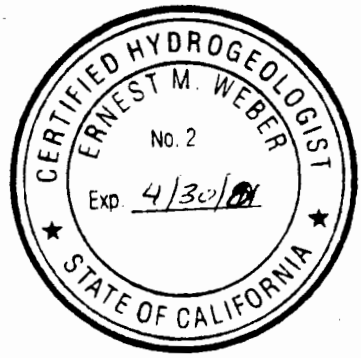
Because of the uncertainty of the accuracy of the water budget item, all values should be rounded to the nearest 1,000 acre feet. This is particularly true of the model predicted values.

Investigation on the suitability of the 1 in. galvanized pipes for use in model calibration should be justified with reference to the point and average head concept as discussed above.

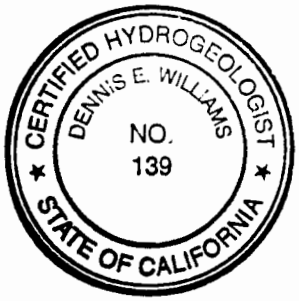
Sincerely,



Alice M. Campbell, R.G., C.E.G., C.H.G.
Project Manager
SCS Engineers



Ernest M. Weber, R.G., C.E.G., C.H.G.
Consulting Hydrogeologist



Dennis E. Williams, Ph.D., R.G., C.H.G.
President
GEOSCIENCE Support Services, Inc.

Tetra Techs' Response to Peer Review Panel Report
SSA Seepage Study

The following items summarize key points in the Peer Review Panel Report for the SSA Seepage Study and Tetra Techs' methodology for rectifying these points:

1) Page 2, 2nd Paragraph, Sentences 3 and 4.
Comment: *Ground water flow calculations are less well described. Inadequate descriptions are noted relating to the ground water flow calculations.*

Response: Most of these calculations were given in the AAC and CB EIR reports. Additional documentation will be added to this report in Appendix C on key items such as the canal seepage rates. More detailed cross-references to the AAC and CB EIR reports will also be added to Appendix C.

2) Page 2, 3rd Paragraph, Sentence 7.
Comment: *The calculations indicate four or five significant digits; this should be rounded to reflect the actual model uncertainty in this number.*

Response: The data from these tables are taken directly from the AAC and CB EIR reports and Tetra Tech is simply repeating the actual values as cited in the reference. The actual uncertainty in the EVT numbers will be qualified as discussed in the response to item number 6 below.

3) Page 3, 1st Paragraph, Last Sentence.
Comment: *Thus, the effects of head changes caused by lining the canal is restricted to a small /part of the area modeled.*

Response: The effects of head changes caused by lining the canal may be restricted to a small part of the area modeled, but the effects of flux changes caused by lining the canal, which is the primary focus of this study, is not restricted to a small part of the area modeled. Note that after canal lining, changes in flux are observed within the IID area drains as well as in the East Highline Canal.

4) Page 3, 2nd Paragraph, Sentence 6 and 7.
Comment: *Collapsing the mound will approximately halve the gradient and, assuming the water levels revert to 1939 levels beneath the mound, the groundwater flow rate contribution to the drains will be approximately half. A hand calculation of this would provide a way to check the reasonableness of the computer model.*

Response: The computer model predicts that the groundwater flow rate to the tile drains in 2026 if the AAC and CB canals remain unlined is about 21,770 afy. The model predicts that the steady-state flow rate after lining the canals is about 9,230 afy. Thus, the post-lining groundwater flow rate contribution to the drains is predicted to be just over 40 percent of the pre-lining value. This value is in good agreement with the expectation that the flow rate would be approximately half of the pre-lining value, considering that the one-half figure incorporates

several assumptions and/or approximations. Since the model agrees with the expectation, a hand calculation is not necessary. The text will be modified to remove the conclusion indicating that the change in discharge attributable to the mound cannot be calculated.

5) Page 3, Last Paragraph, Sentence 3.
Comment: *The appendix should include a short discussion of the assumptions used in the mathematical model, including features of the model, assumptions about lateral anisotropy, boundary conditions, mesh size, time steps, which items change during time steps and which are constant, and other assumptions and generalizations.*

Response: Text will be added to Appendix A expanding on model assumptions and limitations. Note that Section 6 of the 75% submittal discussed the assumptions regarding boundary conditions.

6) Page 4, 2nd Paragraph, Sentence 4.
Comment: *The quality of data and the range of uncertainty for each item should be tabulated.*

Response: The water budget tables will be modified to indicate the range of uncertainty for each item. Note, however, that it may not be possible to define the exact level of uncertainty in all water budget items due to the varied sources referenced for the water budget. The scope of this study called for building upon the work of previous investigations to construct the SSA seepage model, and it was not possible within this study to independently verify all water budget components. Tetra Tech did, however, review all previous investigations and found that the data appeared reasonable and were from reliable sources such as the USGS.

In order to address the Peer Review Panel's concerns, Tetra Tech has modified the water budget table by adding a category with the relative level of uncertainty in each item. The level of uncertainty for each item will be established by a qualitative assessment of the type of data, the manner in which the data were estimated, and the degree to which independent investigations agree or disagree on each item.

7) Page 4, 4th Paragraph.
Comment: *One effect tabulated but not discussed is the effect of mound collapse on leakage out of the East Highline Canal.*

Response: Text will be added regarding the change in leakage out of the East Highline Canal.

8) Page 4, 5th Paragraph, Last Sentence.
Comment: *Where the causes of discrepancies is known or suspected, they should be noted either in the text or figures.*

Response: Text will be added regarding the causes of discrepancies.

9) Page 5, 1st Paragraph, Last Sentence.
Comment: *In any flow-based model such as this one, the largest and most sensitive flows should receive the most effort to reduce uncertainty.*

Response: Tetra Tech agrees in general with this statement, noting that for this very reason significant effort was devoted to matching the metered canal seepage looses. Uncertainty cannot always be reduced, however. For example, flows in Mexicali represent a large component of the water budget, but there was only limited data available which was of unknown quality.

Tetra Tech's scope of work did not call for conducting new field investigations to reduce uncertainty, and we were required to make use of the data currently available. Some key elements of the water budget, such as the amount of water flowing north into Imperial Valley and south into Mexico, were independently verified in this study, but data often were not available to independently verify all data used in this study.

10) Page 5, Last Two Paragraphs.
Comment: *Although the mathematical model seems to be providing reasonable results, more sensitivity runs and error budget analysis seems warranted since the magnitude of the effects being sought are small in relation to the size of the input uncertainties. It would be helpful to develop a table similar to Table 6-1 which could present an estimated error budget for each of the named features in the table.*

Response: Note that an error budget was given in Section 8 and the executive summary relating the overall model error to the model predictions. While additional analysis of uncertainty in the model predictions may be justified on technical grounds, Tetra Tech feels that it would require a level of effort well beyond the scope of this study. First, uncertainties in each of the principal components of the observed water budget would have to be quantified. We are prepared to perform only qualitative evaluations of this "input" uncertainty within our scope (see response to comments 6 and 9). Second, a multi-variate statistical analysis using an uncertainty technique such a Monte Carlo simulation would be necessary in order to truly define the relationship between the uncertainty in the model input parameters and uncertainty in the model output. This procedure would require hundreds of model runs and significant post-processing steps.

Such an investigation is well beyond the scope and schedule allocated for this study. While a Monte Carlo uncertainty analysis would be interesting, it is unlikely to change one of the key findings of this study: the change in flows to the Salton Sea and adjacent wetlands are a relatively small component of the overall water balance. Under any reasonable range of variations in the model input parameters and assumptions, changes in flows to the Salton Sea and adjacent wetlands are likely to still be a relatively small component of the overall water balance. Therefore, there may be relatively little to gain from this exercise which would be costly in terms of both time and resources.

11) Page 6, First Paragraph.
Comment: *Because of the uncertainty of the accuracy of the water budget item, the values should be rounded to the nearest 1,000 acre-feet. This is particularly true of the model predicted values.*

Response: The uncertainty in key items is noted in the executive summary and Section 8. Tables will also be modified indicating that the number of significant digits does not necessarily reflect the precision of the number; Tetra Tech prefers not to round the tabular values because the tables would lose the direct correlation with the model output, which has even more than four or five significant digits.

12) Page 6, Last Paragraph.
Comment: *Investigation on the suitability of the 1 in. galvanized pipes for use in model calibration should be justified with reference to the point and average head concept as discussed above.*

Response: Text will be added indicating that 1-inch galvanized pipes measure specific points rather than average aquifer heads, which may introduce measurement errors of several feet. However, since this model is regional in scope, and calibration seeks to match heads within 10 feet, the error associated with point rather than average aquifer head measurements should be reasonable for this investigation.