RAI 02.04.12-38, Revision 1

QUESTION:

To meet the requirements of 52.79(a) and assist staff in its analysis, additional information concerning the groundwater modeling is required. Aquifer pump test data and data reduction to mean values are inconsistent between the ER and FSAR (which are consistent), and the groundwater model document. Provide a consistent presentation of the hydraulic conductivity data and mean values, and, if necessary, provide amendments to the ER, FSAR and/or groundwater model document. Differences exist in the number of data presented and the data values, see ER Table 2.3.1-15, FSAR Table 2.4S.12-10, Groundwater Model document Section 2.7.1 (page 19, Table 4).

RESPONSE:

This response replaces the initial response to RAI 02.04.12-38 (STPNOC Letter U7-C-STP-NRC-100107, dated May 17, 2010). This response evaluates the inconsistency of data presented in FSAR Table 2.4S.12-10, ER Table 2.3.1-15 and the Groundwater Model Report (Reference 1) Table 4 and presents additional information on whether the MCR was filled or partially-filled during the MCR relief well pumping tests.

Dataset Sources:

The differences in datasets presented in FSAR Table 2.4S.12-10 and ER Table 2.3.1-15 and the dataset presented in Table 4 of the Groundwater Model Report (Reference 1) are a result of two factors. First, Table 4 of the Groundwater Model Report (Reference 1) includes the results from the MCR relief well pumping tests conducted in the Upper Shallow Aquifer during May 1984 while the other tables did not. Secondly, the Groundwater Model Report (Reference 1) only used historical site-specific pumping test results from the Shallow Aquifer because the modeling effort only includes the Shallow Aquifer in contrast to FSAR Table 2.4S.12-10 and ER Table 2.3.1-15 that summarize site-specific Shallow Aquifer and Deep Aquifer pumping test results to present site-scale values.

Long-duration aquifer pumping tests (with a pumping period between 1.9 and 12 days) were conducted at the STP site in the Shallow Aquifer prior to the construction and filling of the MCR (FSAR Reference 2.4S.12-7). Representative aquifer parameters from these pumping tests for the Shallow Aquifer were presented in the STP Units 3 & 4 FSAR and ER groundwater sections. Five short duration aquifer pumping tests (with a pumping period between 6 and 8 hours) were also conducted in MCR relief wells during the construction and filling of the MCR. These tests, due to their short duration and the proximity of the wells to the MCR as it was being filled were not described or used in the groundwater evaluations performed for the STP Units 3 & 4 FSAR groundwater discussion. However, the results of the short-duration tests were considered indicative of the specific hydrogeologic conditions at the MCR during construction and filling activities.

The groundwater flow model was developed to supplement the groundwater discussion presented in the STP Units 3 & 4 FSAR. A summary of the STP Units 1 & 2 MCR relief well aquifer pumping tests results was included as part of the site background information used for the Groundwater Model Report (Reference 1). Table 4 in Reference 1 provided a summary of the historical, Shallow Aquifer pumping tests performed at STP. Similarly, Table 5 provided the hydraulic conductivity values obtained from site slug tests and Table 6 provided the hydraulic conductivity values obtained from site laboratory tests (Reference 1). Section 3.3.4 of the Groundwater Model Report (Reference 1) states that the horizontal hydraulic conductivity value used in the model for the sand strata was assumed to be 3 x 10^{-2} cm/sec. The value selected is within the typical range for sand-sized material and is within the range of hydraulic conductivity values obtained from the site pumping tests.

MCR Relief Well Aquifer Pumping Test Evaluation:

MCR relief well aquifer pumping tests were conducted in May 1984. When the MCR relief well aquifer pumping tests were performed the MCR was undergoing filling and was filled to an average elevation of approximately 26 ft MSL. Based on the hydrostratigraphic evaluation made during the tests and the known depths of penetration of the MCR borrow pits, it is highly likely that the water in the MCR and the Upper Shallow Aquifer were in hydraulic communication during the tests. Since the MCR relief wells penetrate the Upper Shallow Aquifer the MCR could act as a constant source of water to the relief wells during the pumping tests. An interpretation of the test results indicate that recharge boundary conditions were encountered during both the pumping and the recovery phases of the tests.

Effects from a recharge boundary (the MCR) are evident in the data from all five tests. Analysis of the data was complicated by this boundary effect causing much of the data to be discarded during the analysis of the tests. In addition, variation in pumping rates (specifically for tests W110 and W559) are outside of the range considered suitable for a constant rate test and thus further complicates the analysis. Corrections for surface water influence were applied to W559 due to fluctuations in the level of the adjacent Little Robbins Slough. No other corrections of drawdown or recovery data were made for surface water influence.

The analytical methods used to solve for transmissivity were the Theis and the Jacob methods. Both are non-equilibrium techniques applied to homogenous and isotropic confined aquifers of infinite aerial extent and constant thickness with a fully penetrating pumping well. Therefore, influences from boundary conditions, such as surface water recharge or leakage require analysis with other methods. The relief well pumping test results likely over estimate transmissivity because correction for the encountered recharge boundary (the MCR) was not made. Based on the results of this evaluation, the test results from the short-duration MCR pumping tests provide information on the Upper Aquifer System as the MCR was being filled, but do not provide representative information on the aquifer parameters for the Upper Shallow Aquifer at the STP site.

Aquifer Parameter Inconsistencies due to Rounding and Selection of Time Response for Well WW-4:

Rounding:

The transmissivity value from Well WW-1 and the hydraulic conductivity values from Wells WW-2 and WW-4 differ between Table 4 of the Groundwater Model Report and FSAR Table 2.4S.12-10 and ER Table 2.3.1-15. The differences in values for Wells WW-1 and WW-2 between FSAR Table 2.4S.12-10 and ER Table 2.3.1-15, and Table 4 of the Groundwater Model Report are due to rounding the values obtained from FSAR Reference 2.4S.12-7.

Selection of Time Response for Well WW-4:

For Well WW-4, FSAR Reference 2.4S.12-7 presents aquifer property values calculated from the multi-well aquifer pumping test. The hydraulic conductivity value derived for WW-4 presented in Table 4 of the Groundwater Model Report is from the late time period in the aquifer pumping test, whereas the value presented in FSAR Table 2.4S.12-10 and ER Table 2.3.1-15 is derived from the early time period of the aquifer pumping test. Interpretation of WW-4 test data (Reference 2.4S.12-7) indicates that during the late-time readings, leakage was observed. The stated impact of the leakage was to increase the transmissivity and hence the hydraulic conductivity of the aquifer. Since the leakage induced effect is not representative of the aquifer properties, the early time transmissivity value should be used to compute the hydraulic conductivity as presented in FSAR Table 2.4S.12-10 and ER Table 2.3.1-15. This value agrees with the value presented in STP Units 1 & 2, USFAR Table 2.4.13-3.

The geometric mean values presented in FSAR Table 2.4S.12-10 and ER Table 2.3.1-15 differ from that presented in the Groundwater Model Report Table 4 because they were derived from the differing values described above. However, even if the MCR relief well aquifer pumping tests and the WW-4 late time analysis in Table 4 of the Groundwater Model Report are considered, the difference in the geometric mean values are not significant compared to the values presented in FSAR Table 2.4S.12-10 and ER Table 2.3.1-15.

Summary:

The information in Table 4 of the Groundwater Model Report was provided as background information and was used as one of the data sources considered to select the initial aquifer parameters used to build model Run 201. The horizontal hydraulic conductivity value used in the model for the sand strata was assumed to be 3×10^{-2} cm/sec (Reference 1).

Table 4 of the Groundwater Model Report will be revised in a future revision to be consistent with the results for the Shallow Aquifer in Table 2.4S.12-10 and ER Table 2.3.1-15.
A discussion of the MCR relief well pumping tests will be added in a future revision of the Groundwater Model Report and to FSAR Subsection 2.4S.12.2.4.1 and ER Subsection 2.3.1.2.3.6 as shown below.

The following paragraph will be added to FSAR Subsection 2.4S.12.2.4.1, between the first and second paragraphs, and to ER Subsection 2.3.1.2.3.6, between the sixth and seventh paragraphs:

> Additionally, five short duration aquifer pumping tests (with a 6 to 8 hour pumping period) were conducted in the Upper Shallow Aquifer in five MCR relief wells during the construction and filling of the MCR. These tests, due to their short duration and the boundary influences of MCR filling, were not presented or used in the groundwater evaluations because they do not provide representative properties of the Upper Shallow Aquifer.

<u>Reference</u>:

1. STPNOC Letter U7-C-STP-NRC-090206, dated November 30, 2009, Attachment 2, "Groundwater Model Development and Analysis for STP Units 3 & 4."

RAI 02.04.12-39

QUESTION:

To meet the requirements of 52.79(a) and assist staff in its analysis, additional information concerning the groundwater modeling is required. Evaluate simulated upward or neutral gradients at Kelly Lake with respect to the field data and hydrogeochemical characteristics of the groundwater as acknowledged in the Groundwater Model document. Note that Strata C and E do not exhibit discharge to Kelly Lake in the post-construction setting. (See Groundwater Model document, page 27 of 177, Figure 82 {calibrated model discharge}, Figures 84, 85, 93, 94 {post-construction model pathlines}).

RESPONSE:

Stratum C (Upper Shallow Aquifer) does exhibit discharge to Kelly Lake in both post-construction model settings (with and without slurry wall) as evident by the potentiometric surface configurations shown in Figures 84 and 93 of the Groundwater Model report (Reference 1) and by water budget analysis of post-construction conditions in the groundwater model. Post-construction water budget analysis uses the same budget zones as the pre-construction water budget analysis presented in Table 15 of Reference 1. In the model budget analysis (both post- and pre-construction conditions), Kelly Lake is represented by budget zone 27. Model outflow to zone 27 is about 345 gallons per minute (gpm) for post-construction conditions, which is slightly more than the 302 gpm outflow shown in Table 15 (Reference 1) for the pre-construction simulation. Post-construction scenarios show slightly greater discharge to Kelly Lake due to the higher MCR stage used in the post-construction scenarios (49 ft MSL for post-construction versus 42 ft MSL for pre-construction). Model sensitivity runs were performed in the spring and summer of 2010 to further evaluate the groundwater model to represent site conditions (Run 301). Based on these subsequent runs, the post-construction model outflow to Kelly Lake is approximately 373 gpm compared to a pre-construction outflow of approximately 298 gpm. Sensitivity runs are further discussed in the Response to RAI 02.04.12-40.

The post-construction particle tracking, shown in Figure 84 (no slurry wall) and Figure 93 (with slurry wall), does not show particle pathlines terminating at Kelly Lake because the particles released in Stratum C (Upper Shallow Aquifer) at STP 3 & 4 travel down through the permeable backfill into the Stratum E (Lower Shallow Aquifer) due to the downward vertical gradient (Figure 87 of Reference 1). Similarly, the pre-construction calibrated scenario illustrated by Figure 77 (Reference 1) shows the particles released in Stratum C in the proposed area of STP 3 & 4 travel to the area of STP 1 & 2, then down through the permeable backfill and east to the Colorado River within Stratum E (Lower Shallow Aquifer). Consequently, the particles released in the Upper Shallow Aquifer shown in these figures do not discharge to Kelly Lake because they are intercepted by the permeable backfill at STP 3 & 4 in the post-construction scenarios and STP 1 & 2 in the pre-construction scenario and travel to Stratum E of the Lower Shallow Aquifer.

Conceptually, Stratum E (Lower Shallow Aquifer) is not expected to exhibit discharge to Kelly Lake because the intervening, low-permeable Stratum D confines flow in the Lower Shallow Aquifer at the site and prevents upward discharge to Kelly Lake. The groundwater model shows a potential downward vertical gradient across Stratum D at Kelly Lake and that discharge from the Lower Shallow Aquifer (Stratum E) to Kelly Lake does not occur. Consequently, the post-construction pathlines in Stratum E illustrated in Figures 85 and 94 (Reference 1) terminate to the east at the Colorado River and not at Kelly Lake.

The pathlines of particles released at STP 3 & 4 in Stratum H of the Lower Shallow Aquifer travel southeast beneath the MCR to the Colorado River. Although these particle pathlines appear to travel "through" Kelly Lake in map view on Figures 84, 85, 93 and 94 of Reference 1, they are actually about 80 ft beneath the lake bottom, separated from the lake bottom by two intervening low-permeable confining units (Strata D and F). These particle pathlines are best viewed in cross-section in Figures 87, 88, 89, 96, 97, and 98 (Reference 1).

At the west end of Kelly Lake, the simulated head in the Upper Shallow Aquifer is about elevation 12 ft MSL (Figure 70 of Reference 1) and in the Lower Shallow Aquifer is about elevation 9.5 ft MSL (Figure 74 of Reference 1), indicating a 2.5-foot head differential and a potential downward vertical gradient between the two aquifers in the model. Water levels measured in the field on September 22, 2008 (Reference 2) indicate a slight upward vertical gradient (0.21 ft and 0.56 ft head differential) between the Upper Shallow Aquifer and the Lower Shallow Aquifer at two of the three well clusters (OW-959U/L and OW-961U/L) installed around Kelly Lake. Considering that well cluster OW-959U/L is located about 1,000 ft west of Kelly Lake, the 0.21 ft head differential which provides an upward gradient there is unlikely associated with discharge to Kelly Lake from the Lower Shallow Aquifer. Well cluster OW-961U/L is located within 100 ft of the northwest arm of Kelly Lake. The upward head differential (0.56 ft) at this well cluster shows the potential for discharge to Kelly Lake from Stratum E. The third well cluster (OW-960U/L) shows a 2.91-ft greater head in the Upper Shallow Aquifer suggesting a downward vertical gradient. The well cluster is situated nearest to Kelly Lake, to the southeast.

Water levels measured on December 15, 2008 (Reference 2) indicate all three well clusters installed around Kelly Lake show water levels to be 1.72 ft to 3.77 ft higher in the Upper Shallow Aquifer than those measured in the Lower Shallow Aquifer, indicating that seasonal fluctuations may account for the variation in gradient direction. The recorded groundwater levels within the Lower Shallow Aquifer remained relatively steady over this period compared to the water level fluctuations exhibited within the Upper Shallow Aquifer and appear to indicate that the Upper Shallow Aquifer is susceptible to climatic and seasonal fluctuations. The Lower Shallow Aquifer does not appear to be as susceptible as the Upper Shallow Aquifer to climatic and seasonal changes. This different response can be interpreted as an indication that the two aquifers are not hydraulically connected and that discharge from the Lower Shallow Aquifer to Kelly Lake is unlikely.

Although the model does not simulate upward flow from the Lower Shallow Aquifer to Kelly Lake, the model overall does correspond to groundwater level measurements at Kelly Lake with the exception of the slight upward gradient that may be attributable to seasonal fluctuations. The model does not predict seasonal fluctuations because it is a steady-state model.

Hydrogeochemical characterization discussed in FSAR Subsection 2.4S.12.2.5 suggests indirect evidence of hydraulic communication between the Upper Shallow Aquifer and the Lower Shallow Aquifer at two well clusters, OW-332U/L at STP 3 and OW-930U/L located approximately one mile upgradient (northwest) of Kelly Lake. Based on this analysis, the change in chemistry of water in the Lower Shallow Aquifer to that of the Upper Shallow Aquifer at these two locations may indicate downward vertical flow. However, results from three of the four site aquifer tests indicate that no significant hydraulic communication between the Upper Shallow Aquifer and the Lower Shallow Aquifer is evident around Kelly Lake (FSAR Reference 2.4S.12-7). The fourth aquifer test indicates hydraulic connection between the Upper Shallow Aquifer and the Lower Shallow Aquifer southwest of the MCR over two miles from Kelly Lake. The other three tests, being much closer to Kelly Lake, are likely more representative of the hydrogeology at that portion of the site. The aquifer test results provide evidence of the degree of communication between the Upper Shallow and Lower Shallow Aquifers. Analysis of the degree of communication using the hydrogeochemical characterization requires additional inference and is indirect in comparison to the analysis provided by the aquifer tests.

No COLA revision is required as a result of this RAI response.

References:

1) South Texas Project Letter No. U7-C-STP-NRC-090206, "Supplemental Response to Requests for Additional Information," dated November 30, 2009, Attachment 2, "Groundwater Model Development and Analysis for STP Units 3&4".

2) STPNOC Letter U7-C-STP-NRC-090205, "Supplemental Response to Requests for Additional Information," (RAI 02.04.12-28, Supplement 1), dated November 23, 2009.

RAI 02.04.12-40

QUESTION:

To meet the requirements of 52.79(a) and assist staff in its analysis, additional information concerning the groundwater modeling is required. The calibrated model was used to simulate an MCR surface water level of 49 ft MSL. Provide quantification of the predicted MCR seepage into the groundwater aquifer, and groundwater capture by the system of relief wells and sand drains. For example, provide a water budget for the post-construction simulation of the MCR surface water level at 49 ft MSL similar to that shown for the calibrated model (run 201) in Figure 82. To help evaluate the model as a tool for post-construction predictions, please also discuss whether calibrated model results have been compared against the 47 ft MCR level and the corresponding piezometric heads in FSAR Table 2.4S.12-18.

RESPONSE:

This response is presented in two parts to provide individual responses to the following two questions in this RAI:

- Part 1: Quantification of MCR Seepage into the Groundwater System.
- Part 2: Calibration Results for an MCR Stage Elevation of 47 feet MSL

To provide an understanding of the process used to address this and other groundwater RAIs, it is important to understand the approach and sensitivity analyses that were performed for Phase I or that will be performed during Phase II to address the entire series of groundwater modeling RAIs contained in the NRC Request for Additional Information Letter No. 333, dated April 16, 2010. Therefore, the specific response to this RAI is preceded by two summaries, as follows:

- The approach used to address the groundwater modeling RAIs contained in the NRC Request for Additional Information Letter No. 333, dated April 16, 2010; and,
- The groundwater model sensitivity analyses that provide the basis for these responses.

RAI Response Approach:

The analyses performed to address this RAI are interconnected with other groundwater model related RAIs in NRC Request for Additional Information Letter No. 333, dated April 16, 2010. These RAIs can generally be subdivided into two groups of sensitivity analyses. The first group consists of RAIs that relate to whether specified changes in the groundwater model would produce desirable refinements in the model. This group also includes changes to the model to incorporate changes to the STP Units 3 & 4 site configuration that have occurred since the original model was developed, such as the addition of crane foundation retaining walls (CFRW). The second group consists of analyses to examine the effects of postulated conditions ("what-if scenarios") on the model results.

During the NRC audit of the groundwater model held on May 25, 2010 and a follow-up conference call with the NRC Staff on June 2, 2010, a phased approach was established to respond to groundwater model-related questions in Request for Additional Information Letter No. 333. Phase I involves model boundary condition sensitivity analyses and model validation before running subsequent postulated condition scenarios during Phase II.

Phase I involves model sensitivity analyses to address dry cells and flooded cells present in pre- and post-construction models, to examine the influences of the boundary conditions to the post-construction model predictive simulation, and to incorporate design changes to STP Units 3 & 4 subsurface site configuration since the model was developed. A model validation was also performed to a groundwater level measurement data set corresponding to an MCR water level stage 5 feet higher than the data set used in the calibrated model. The Phase I sensitivity analysis effort was completed in August, 2010.

Subsequent Phase II sensitivity analyses will be performed to address the perceived bias in the model calibration and to evaluate the hydraulic properties of the STP Units 3 & 4 excavation backfill and cover. Phase II responses will be submitted no later than December 15, 2010.

Groundwater Modeling Process Used to Address Phase I Sensitivity Analyses:

The following groundwater modeling process, common to all groundwater model-related RAIs discussed above, is described in this section and incorporated by reference in other RAI responses. The basis for this analysis is the groundwater model described in the Groundwater Model Summary Report (Reference 1). This groundwater model is referred to as the "base model" and is designated "Run 201." The base model was evaluated and modified to perform the following sensitivity analyses:

- Evaluate the dry cells and the flooded cells to establish their cause(s);
- Evaluate the general head boundaries (GHB);
- Evaluate the drain boundaries (DRN) representing canals and ditches;
- Perform a series of model sensitivity runs that include using alternate conceptual models that pertain to the development of the GHB and the DRN conditions;
- Import a revised topography using refined interpolation methods for a more accurate portrayal of the land surface in the model; and
- Compare results to the model calibration of Run 201.

After running a series of sensitivity analyses to address the GHB and DRN boundary conditions, the scenarios that either improved or least impacted the model calibration relative to Run 201 were chosen to formulate a revised model run (pre-construction Run 301). The findings of the sensitivity analyses suggest that the presence of dry cells and flooded cells have very minimal affect on the results and conclusions made in the Groundwater Model Summary Report (Reference 1). Regardless, model changes (i.e., topography and boundary conditions) were incorporated to eliminate or reduce the number of dry and flooded cells in the model domain. The other change made in the model for validation purposes involved altering the river and constant head boundaries that represent the MCR.

Run 301 was validated by evaluating February and March 2003 groundwater level measurement data sets for the STP site (MCR elevation level of 47 ft MSL) and comparing it to the results of

Run 201 (MCR elevation level of 42 ft MSL). The groundwater head distribution of Run 301 was compared to that of the Run 201 calibrated model. The simulated groundwater head distribution and the groundwater budget of Run 301 matched very closely with that of Run 201.

To incorporate changes to the STP Units 3 & 4 site configuration that have occurred since the model was developed, a post-construction model (Run 301PC) was created from the pre-construction Run 301 model by first splitting layer 2 (part of Stratum A/B) into two layers, splitting layer 4 (Stratum D) into two layers, and splitting layer 6 (Stratum F) into two layers. This 10 layer model was created to facilitate incorporating representations of the proposed plant structures, excavations, and placement of structure backfill. The revised 10 layer, pre-construction 301 model run (prior to incorporation of the proposed plant structures and excavations) was evaluated to determine if the heads and flow were similar to the 7 layer pre-construction 301 model. The 10 layer model was found to be suitable for use from which to build the post-construction model.

The Run 301PC post-construction model incorporated the following changes:

- Refinements to the STP Units 3 & 4 structures and structural fill locations and elevations;
- Refinement to the finished grade and backfill cap;
- Refinements to the slurry wall based on power block configuration changes;
- Addition of two below grade Crane Foundation Retaining Walls (CFRWs);
- Relocation of a portion of the Main Drainage Channel; and
- An MCR stage elevation of 49.5 ft MSL, based on the spillway elevation (representing an upper bound condition, 0.5 ft above the normal maximum operating MCR stage elevation of 49 ft).

Post-construction simulations using Run 301PC were, in general, similar to calibrated Run 201. Particles released within the Unit 3 & 4 power block travel east or southeast to the site boundary. Simulated post-construction groundwater levels were more than 10 ft below the finished grade of STP Units 3 & 4. In addition, MCR relief well failure scenarios were performed based on the post-construction Run 301PC model. The failure of all relief wells did not have a significant impact on the predicted maximum water level beneath the Units 3 & 4 power block. The role of the relief wells is discussed in more detail in the response to RAI 02.04.12-48.

Part 1: Quantification of MCR Seepage into the Groundwater System

Quantification of the post-construction predicted MCR seepage into the Shallow Aquifer and groundwater capture by the system of relief wells and sand drains from simulated post-construction activities was accomplished by performing a water budget analysis similar to the one completed for the base model (Run 201). The sensitivity analyses evaluation was performed on the updated post-construction model (Run 301PC), which incorporates the model refinements and site configuration changes described above.

This evaluation simulated an MCR elevation at 49.5 ft MSL, which is the MCR spillway elevation (FSAR Subsection 2.4S.8.2.2). The MCR spillway elevation represents the maximum

MCR stage during post-construction operation and is higher than the normal maximum operating elevation level of 49 ft MSL.

Table 1 provides the water balance with MCR operation at an elevation level of 49.5 ft MSL (Run 301PC). When compared to the MCR discharge in the base model Run 201 (Reference 1, Table 15) and Run 301 (Table 4), which use data taken with the MCR at levels of 42 ft and 47 ft MSL respectively, this table shows an increase in the discharge from the MCR as would be expected with the higher MCR stage of 49.5 ft MSL.

Figure 1 shows the groundwater budget analysis for post-construction Run 301PC. This figure is similar to the Run 201 pre-construction groundwater budget analysis (Figure 82 of Reference 1). As indicated by a comparison of Figure 82 (Reference 1) and Figure 1, a greater MCR seepage into the groundwater aquifer, and groundwater capture by the system of relief wells and sand drains occurs for this post-construction scenario, as would be expected for the different MCR conditions (Run 301PC).

Part 2: Calibration Results for an MCR Stage Elevation of 47 feet MSL

As described above, the updated pre-construction model Run 301 was validated using the February-March 2003 observed piezometric data set with MCR elevation at 47 ft MSL. In addition, Run 301, which also simulated an MCR elevation of 42 ft MSL, matched closely with the groundwater heads of the pre-construction model Run 201. A total of 169 observed groundwater levels, presented in FSAR Table 2.4S.12-18, were used for the validation, including measurements from piezometers located within the MCR embankment. The MCR piezometers are grouped by their elevations along the embankment: Level A, top of reservoir; Level B, mid-height of reservoir; Level C, toe of reservoir; Level D, away from reservoir; Level S, furthest away from reservoir.

The calibration statistics for the validation on Run 301 for the entire model are shown graphically in Figure 2. These statistics are compared to the calibration Run 201 model statistics in Table 2. Specifically, Table 2 shows a correlation coefficient of 0.78 for Run 301 when all of the 169 observed groundwater levels were used in the validation (denoted as Scenario 1). This is lower than the correlation coefficient of 0.95 for Run 201, the calibration of which was based on 73 observed data points. The disparity between the two correlation coefficients is attributed to the use of two different sets of observed water level data. Scenario 1 includes data from the piezometers near the MCR embankment whereas the data set for the Run 201 calibration comes spatially farther away from the MCR embankment. Furthermore, in Scenario 1 of Run 301, the observed heads from about half of Level A and a few of Level B MCR embankment piezometers are higher than the corresponding calculated heads (negative residuals) in model layer 3. These piezometers are positioned near the mid-section of the MCR embankment where the hydraulic gradient is steep and cannot be accurately predicted by the model due to the 50 ft by 50 ft grid size in that location. MODFLOW uses a node-centered grid to calculate head within a cell, which in some cases is too far from the data point to accurately simulate that level due to the steep hydraulic gradient. The maximum residual (R_{max}) of -20.68 ft is at Piezometer P-38, which is located in the extreme southwest corner of the cell away from the center of the grid cell.

Validation of Run 301 was further evaluated without considering the Level A and B piezometers, and it was denoted as Scenario 2. Scenario 2 reduces the total number of calibration targets from 169 to 108. However, Scenario 2 still has more calibration targets than Run 201 (73 targets). Scenario 2 was then run to obtain the suite of calibration statistics directly from the model. Figure 3 graphically illustrates these statistics and Table 2 compares these statistics against the statistics from the previous validation run (Scenario 1) and the Run 201. The maximum residual is reduced from -20.68 ft in Scenario 1 to -6.80 ft in Scenario 2, which is slightly more than the maximum residual from Run 201 (-6.59 ft). Table 2 also shows that the correlation coefficient improved between the two scenarios from 0.78 for Scenario 1 to 0.87 for Scenario 2, and that the root mean square (RMS) error and the normalized RMS also improve.

Based on the calibration criteria, Scenario 2 achieves similar calibration standards as Run 201 (Table 3) even with the addition of 35 more calibration targets in Run 301. Table 3 includes both the groundwater level calibration criteria and the groundwater flow calibration criteria described in Reference 1. Table 3 shows that Scenario 1 of Run 301 does not meet three of the groundwater level calibration criteria and one of the groundwater flow criteria. This is attributed again to the model grid spacing being too coarse to adequately simulate the steep hydraulic gradient within the Upper Shallow Aquifer from the MCR to the model domain. The steep hydraulic gradients occur within the vicinity of the Level A and B piezometers in the MCR embankment. Thus, the model simulated and observed heads do not match closely at the MCR embankment.

Under this circumstance, omission of these Level A and B piezometer targets is reasonable. The groundwater flow results for Scenario 1 and Scenario 2 are obtained from a water balance analysis provided in Table 4. Note that both scenarios are simulating the same physical system (only the number of calibration targets are different); and, thus, the water balance for both scenarios is identical.

In conclusion, Table 3 shows that Run 301 (as Scenario 2) can simulate groundwater levels that match a set of known data without the need for recalibration. This analysis indicates that either model Run 201 or model Run 301 is suitable for post-construction predictions.

No COLA revision is required as a result of this RAI response.

References:

1. South Texas Project Letter No. U7-C-STP-NRC-090206, "Supplemental Response to Requests for Additional Information," dated November 30, 2009, Attachment 2, "Groundwater Model Development and Analysis for STP Units 3&4".

Table 1. Water Balance for the Run 301PC Post-Construction Model.

Description	Run 301PC MCR stage at 49.5 ft MSL (MCR Spillway Elevation)	
	Inflows (gpm)	**Outflows (gpm)**
MCR Discharge Total	5030.9	0.0
Through Sand Pits	3498.5	0.0
Through Remaining Portion of MCR	1532.4	0.0
Precipitation/Recharge	2.0	0.0
ECP	1.5	0.0
Stratum C GHB	211.7	257.1
Stratum E GHB	209.1	103.4
Stratum H GHB	175.8	94.7
Levee-Bound Irrigation Canals	147.7	4.1
Livestock Well	0.0	0.4
Colorado River	0.2	715.6
Canals and Ditches in Stratum A/B	0.0	666.7
Little Robbins Slough and Plant Area Drainage Ditches in Stratum C	0.0	935.7
Kelly Lake	0.0	372.6
MCR Relief Wells and Sand Drains from MCR	0.0	2606.1
MCR Relief Wells and Sand Drains from other Sources	0.0	23.0
TOTALS	**5778.9**	**5779.4**
PERCENT DISCREPANCY	**-0.009**	

Table 2: Comparison of Calibration Statistics between Calibration Model Run 201 and Run 301.

Calibration		Manual Calibration	All Piezometers Scenario 1	No Level A & B MCR Piezometers Scenario 2
Run Label		**201**	**301 Validation Runs**	
MCR Stage		42 ft MSL	47 ft MSL	47 ft MSL
Mass Balance Discrepancy, M_d (%)		-0.01	-0.01	-0.01
Stratum	Model Layers	3,5,7	3,5,7	3,5,7
All	Largest Residual (ft)	-6.59	-20.68	-6.80
	Largest Residual Location	437	P-038	P-052
	Smallest Residual (ft)	0.03	0.01	0.01
	Smallest Residual Location	OW-954U	P-266	P-266
	Residual Mean (ft)	0.22	-2.3	-0.79
	Abs. Residual Mean (ft)	1.04	3.17	2.09
	Standard Error of Estimate	0.17	0.28	0.23
	Root Mean Squared (RMS) Error (ft)	1.46	4.29	2.5
	Normalized RMS (%)	7.80	11.37	9.36
	Correlation Coefficient	0.95	0.78	0.87
	Number of Data Points	73	169	108
Stratum C	Model Layer	3	3	3
	Largest Residual (ft)	-3.59	-20.68	-6.80
	Largest Residual Location	P131	P-038	P-052
	Smallest Residual (ft)	0.03	0.01	0.01
	Smallest Residual Location	OW-954U	P-266	P-266
	Residual Mean (ft)	0.34	-2.61	-0.80
	Abs. Residual Mean (ft)	1.02	3.51	2.30
	Standard Error of Estimate	0.20	0.32	0.29
	Root Mean Squared (RMS) Error (ft)	1.34	4.63	2.69
	Normalized RMS (%)	7.15	17.4	17.34
	Correlation Coefficient	0.96	0.7	0.81
	Number of Data Points	44	141	80

Table 2: Comparison of Calibration Statistics between Calibration Model Run 201 and Run 301 (continued).

Calibration		Manual Calibration	All Piezometers Scenario 1	No Level A & B MCR Piezometers Scenario 2
Run Label		201	301 Validation Runs	
Stratum E	Model Layer	5	5	5
	Largest Residual (ft)	-6.59	-4.14	-4.14
	Largest Residual Location	437	446	446
	Smallest Residual (ft)	0.05	-0.33	-0.33
	Smallest Residual Location	OW-933L	201	201
	Residual Mean (ft)	-0.15	-0.85	-0.85
	Abs. Residual Mean (ft)	1.15	1.66	1.66
	Standard Error of Estimate	0.49	0.39	0.39
	Root Mean Squared (RMS) Error (ft)	1.90	2	2
	Normalized RMS (%)	45.27	9.83	9.83
	Correlation Coefficient	0.62	0.9	0.9
	Number of Data Points	16	23	23
Stratum H	Model Layer	7	7	7
	Largest Residual (ft)	2.79	-1.46	-1.46
	Largest Residual Location	OW-928L	417	417
	Smallest Residual (ft)	0.18	0.27	0.27
	Smallest Residual Location	OW-951L	415	415
	Residual Mean (ft)	0.23	-0.25	-0.25
	Abs. Residual Mean (ft)	0.99	0.72	0.72
	Standard Error of Estimate	0.34	0.61	0.61
	Root Mean Squared (RMS) Error (ft)	1.20	0.89	0.89
	Normalized RMS (%)	25.21	23.34	23.34
	Correlation Coefficient	0.97	0.92	0.92
	Number of Data Points	13	3	3

Table 3: Calibration Criteria Comparison.

Calibration Criteria[1/]	Criteria Value[1/]	Manual Calibration Run 201[1/]	Run 301 Validation – Scenario 1	Run 301 Validation – Scenario 2
Maximum absolute residual (R_{max})	<6 feet	-6.59 feet	-20.68 feet	-6.80 feet
Root mean squared error (*RMS*)	<3 feet	1.46 feet	4.29 feet	2.5 feet
Normalized root mean squared (*NRMS*)	<10 percent	7.80%	11.37%	9.36%
Mass balance discrepancy (M_d)	< 0.1 percent	-0.01%	-0.01%	-0.01%
Absence of areal bias of largest residuals [2/]	Highest residuals are not clustered	Highest residuals not clustered[3/]	Level A & B piezometers have largest residuals	Highest residuals not clustered[3/]
Calculated groundwater discharge rate to Colorado River	> 20 gpm/mi (0.8 cfs)	690.7 gpm or 40.6 gpm/mi	689 gpm or 40.5 gpm/mi	689 gpm or 40.5 gpm/mi
Calculated discharge from MCR to groundwater approximately equal to total MCR seepage	3,530 gpm	3,550 gpm	4,192 gpm[5/]	4,192 gpm[5/]
Calculated MCR seepage captured by the relief well system	Within bounds of relief well discharge and 68 percent of total MCR seepage[4/]	1,716 gpm	2,079 gpm[5/]	2,079 gpm[5/]

Notes:
[1/] Reference 1
[2/] Not used as a calibration criteria in Reference 1.
[3/] Clustered positive residuals along the north and northeast of the MCR and negative residuals around the MCR are small compared to the residual calibration criteria.
[4/] Reference 1 indicates this range to be between 1,665 gpm and 2,400 gpm.
[5/] Table 4
Shaded cells indicate values outside of calibration criteria.

cfs = cubic feet per second.
gpm = gallons per minute.
gpm/mi = gallons per minute per mile.

Table 4: Run 301 Validation Water Balance.

Model	**Run 301 Validation MCR stage at 47 ft MSL (February - March 2003)**	
Boundary Description	**Water Budget**	
	Inflows (gpm)	**Outflows (gpm)**
MCR Discharge Total	4191.8	0.0
Through Sand Pits	3306.1	0.0
Through Remaining Portion of MCR	885.6	0.0
Precipitation/Recharge	2.0	0.0
ECP	0.8	0.0
Stratum C GHB	212.7	249.8
Stratum E GHB	214.5	101.4
Stratum H GHB	180.7	92.6
Levee-Bound Irrigation Canals	147.6	3.6
Livestock Well	0.0	0.4
Colorado River	0.2	689.4
Canals and Ditches in Stratum A	0.0	606.1
Little Robbins Slough and Plant Area Drainage Ditches in Stratum C	0.0	782.8
Kelly Lake	0.0	335.8
MCR Relief Wells and Sand Drains from MCR	0.0	2079.4
MCR Relief Wells and Sand Drains from other Sources	0.0	9.2
TOTALS	**4950.3**	**4950.6**
PERCENT DISCREPANCY	**-0.006**	

Figure 1: Zone Budget Analysis for Run 301PC.

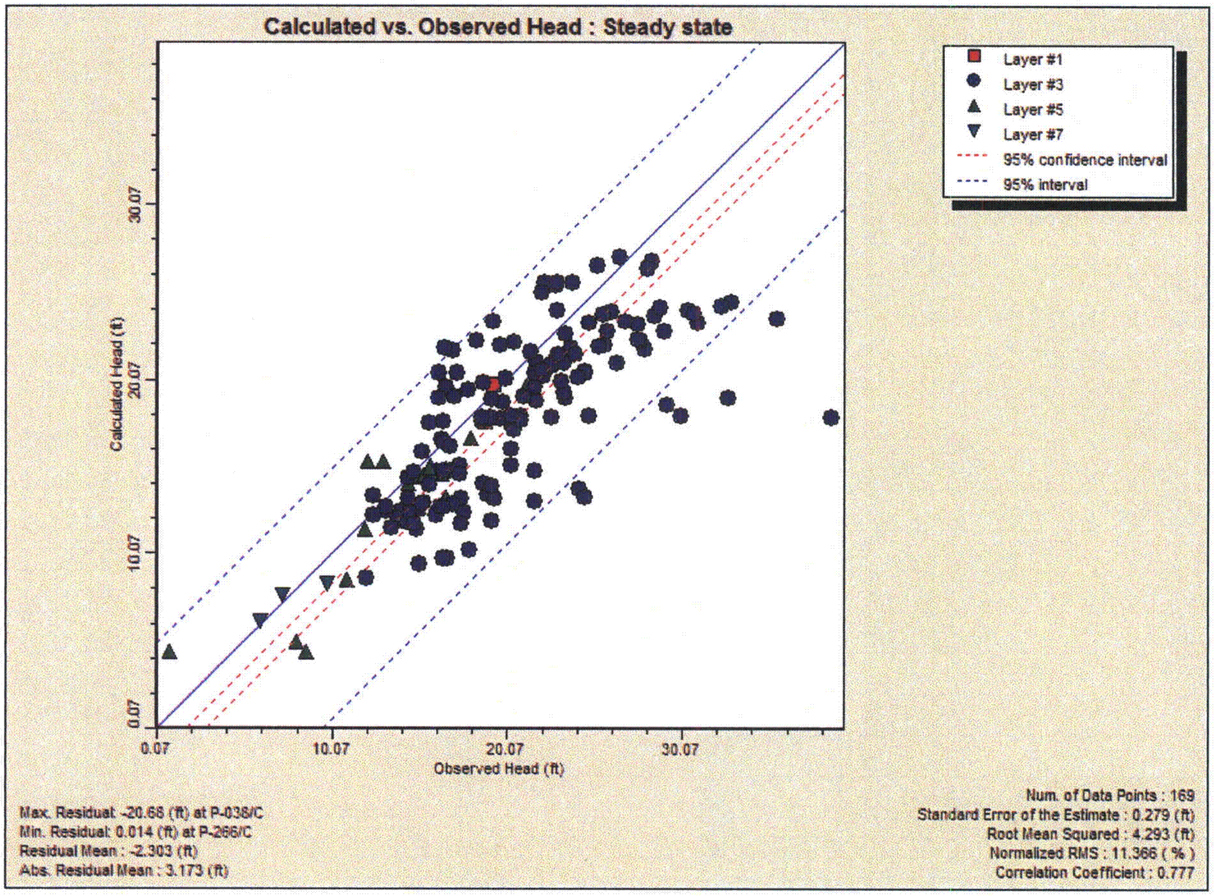


Figure 2: Scenario 1 Calibration Statistics – All Layers and All Piezometer Data.

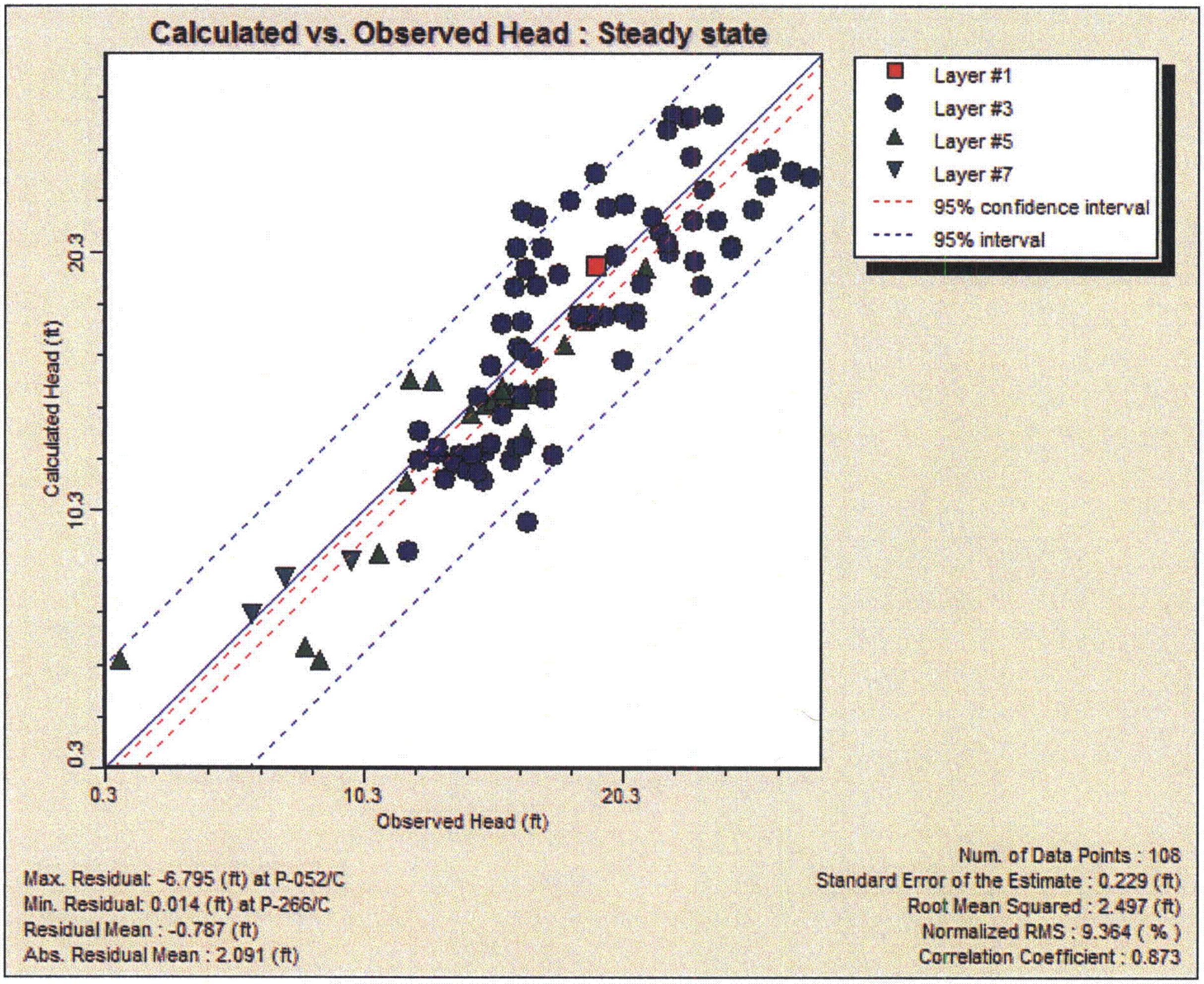


Figure 3: Scenario 2 Calibration Statistics – All Layers No Level A and B Piezometer Data.

RAI 02.04.12-42

QUESTION:

To meet the requirements of 52.79(a) and assist staff in its analysis, additional information concerning the groundwater piezometric surfaces in the vicinity of the filled excavation is required.

a. Consistent with the groundwater model results (Figure 71), provide field data from STP Units 1&2 in Stratum C, the Upper Shallow Aquifer, supporting the simulated depression of the water table. Figure 71 would seem to indicate a predicted depression on the order of 4 to 5 ft. Is this depression reflected in observed water levels? If so, provide field data from STP Units 1&2 in Stratum E of the Lower Shallow Aquifer, supporting the simulated mounding of the piezometric surface. Such a mound would be consistent with the groundwater model results of Figures 91 and 100 that indicate 3 to 3.5 ft of mounding at STP Units 3&4 in the future. (See Groundwater Model document, pages 40 and 41 (discussion of Scenarios 1 and 2), and Figures 71, 90, 91, 99 and 100.)
b. Review of the model grid in the vicinity of structures indicates irregular grid geometry, (i.e., matching geologic or engineered structures) that results in plunging and rising verticals. Describe the extent to which model results in the vicinity of structures could be an artifact of the grid? What MODFLOW alternatives exist to simulating this region and its transmissivity, and were these alternatives evaluated for impacts on simulated results?

RESPONSE:

a. Simulated Water Table Depression and Piezometric Mounding at Power Blocks:

Groundwater levels at STP 1 & 2 and the Essential Cooling Pond (ECP) were measured from a network of piezometers installed to monitor water levels during and after construction of STP Units 1 & 2 (Reference 1). Groundwater elevation data as measured on May 1, 2006 is presented in Table 1. These measurements support the depression and mounding simulated by the groundwater model at STP Units 1 & 2. This dataset shows a depression centered at piezometer 221C in the Upper Shallow Aquifer (Stratum C) and a mound centered near piezometer 222E in the Lower Shallow Aquifer (Stratum E).

The May 1, 2006 Upper Shallow Aquifer groundwater elevations are depicted on the potentiometric surface map presented in Figure 1. This potentiometric map indicates a depression with a low elevation of 15.06 ft MSL at Piezometer 221C that is centered between STP Units 1 & 2. These elevations increase to an elevation of 20.29 ft MSL at piezometer 263C located at the ECP. Figure 1 suggests a depression of 3 to 5 ft was present in the Upper Shallow Aquifer at STP Units 1 & 2. This configuration is similar to Figure 71 of the Groundwater Model Report (Reference 2), which shows a simulated depression on the order of 4 to 5 ft with the lowest contoured level at 15.0 ft MSL. Similarly, the May 1, 2006 data for the Lower Shallow Aquifer were used to prepare the potentiometric surface map in Figure 2. This potentiometric surface shows evidence of mounding in the Lower Shallow Aquifer centered between STP Units 1 & 2 near piezometer 222E where the potentiometric surface elevation was 14.77 ft MSL. Outlying piezometers indicate a uniform southeasterly flow that is interrupted at Piezometer 222E where this anomalously high elevation is recorded.

Figures 1 and 2 illustrate the measured May 2006 groundwater levels as contoured groundwater elevations for the Upper Shallow Aquifer and the Lower Shallow Aquifer at STP Units 1 & 2. Figure 1 supports the model simulation of the depression in the Upper Shallow Aquifer as illustrated by Figure 71 of Reference 2. Additionally, the mounding in the Lower Shallow Aquifer predicted by the model (Figure 73 of Reference 2) is supported by the May 2006 data as shown in Figure 2. Conceptually, the depression and mounding features are a result of the equilibration of the vertical head differential between the Upper Shallow Aquifer and the Lower Shallow Aquifer through the permeable backfill that connect Strata A through E. The consistency between the measured piezometer data and the model simulations of the Upper and the Lower Shallow Aquifers indicates that the model represents the physical hydrogeologic conditions at STP Units 1 & 2 and can be used for predicting post-construction scenarios at STP Units 3 & 4.

b. Irregular Grid Geometry:

The horizontal grid dimensions in the immediate area of the STP Units 1 & 2 and STP Units 3 & 4 power blocks are 20 ft by 20 ft in east-west and north-south directions providing regular horizontal grid dimensions. In the vertical dimension, the model grid is irregular due to the model site hydrostratigraphy and the geometry of the power block engineered structures.

The MODFLOW-2000 User Guide states that "as in earlier MODFOW versions, the finite-difference grid in MODFLOW-2000 is assumed to be rectangular horizontally, while the grid can be distorted vertically" (Reference 3). The vertical gridding of the power block area for the Units 3 & 4 groundwater model was developed in accordance with the MODFLOW-2000 User Guide and is considered acceptable.

Visual MODFLOW (Reference 4) requires that all model layers extend across the entire simulation domain. The engineered structures in the power block region are represented with the same number of layers required to represent hydrostratigraphy in the model. Examples of the modifications to layer elevations that were employed in model Run 201 (Reference 2) to represent engineered structures at STP Units 3 & 4 include:

- The bottom of model layer 2 within the excavation footprint is adjusted to represent the elevation of the floor of the Radwaste Buildings.
- The bottom of model layer 3 below the Radwaste Buildings is adjusted so that layer 3 portrays the base of the concrete foundation that will be placed below the floor of these buildings.
- The bottom of model layer 4, in the region of the Radwaste Buildings, was adjusted to represent the bottom of the power block excavation. Model layer 4 is composed of

structural fill material that will be placed at the bottom of the excavation between native soils and the concrete foundations of the Radwaste Buildings.

- Similarly, the bottom of model layer 5 dips further down to include the bottom of Reactor Buildings and the Control Buildings as these foundations will be lower in elevation relative to the foundations of the Radwaste Buildings.
- Beneath the Reactor Buildings, model layer 6 geometry is locally adjusted to represent the base of the concrete foundation specified for these buildings.

The vertical model layers are irregular in geometry in order to represent the structures in the power blocks. Within the power block excavation, different transmissivity values are used to represent structural fill, concrete building foundations and natural soil that make up the aquifer and confining unit materials. For example, the transmissivity for the concrete is approximately 5.7×10^{-5} ft^2/day, whereas the transmissivity for the same layer just outside the Radwaste Building is orders of magnitude higher. Similarly, the transmissivity for the concrete below the Reactor Building and the Control Building is approximately 2.8×10^{-4} ft^2/day, where the transmissivity is orders of magnitude higher just outside the building area in the same model layer. The groundwater model depicts the variation of transmissivity for different units/materials within the same layer in the power block areas.

The irregular portions of the vertical model grid, the plunging and rising verticals of engineered structures within the power blocks, occur mostly in model layer 3 (under the Radwaste Building) and in model layer 6 (Reactor Building and the Control Building). This irregularity occurs as a result of using the same number of layers to represent the engineered structure foundations and site hydrostratigraphy. The elevations of hydrostratigraphy layers are locally modified to represent the elevations of the floors, foundations, and excavations for these structures at STP Units 3 & 4.

An alternative grid representation in the power block areas using refined horizontal grid spacing and additional layers to the model would allow a more accurate representation of the foundations of the engineered structures. However, a refined grid would not produce significantly different head distributions in the power block region because the abrupt variations in transmissivity related to the engineered structures would still be present.

The current model accounts for the transmissivity distribution expected from the placement of concrete fill and structural fill material as part of the construction of STP Units 3 & 4. The hydraulic heads depicted in the vicinity of the structures are due to the variation in transmissivity between model cells representing concrete, structural backfill, and the aquifer materials. The MODFLOW-2000 User Guide documents that the vertical grid geometry can be distorted; and, as a result, the hydraulic head results are not considered an artifact of the vertical grid in the immediate vicinity of the structures but are due to variations in transmissivity between the cells.

No COLA revision is required as a result of this RAI response.

References:

1. STPEGS Updated Final Safety Analysis Report, Units 1 and 2, Revision 13.

2. STPNOC Letter No. U7-C-STP-NRC-090206, Attachment 2, "Groundwater Model Development and Analysis for STP Units 3 & 4", dated November 30, 2009.

3. Harbaugh, A.W., Banta, E.R., Hill, M.C., and McDonald, M.G. MODFLOW-2000. The U.S. Geological Survey Modular Ground-Water Model – User Guide to Modularization Concepts and the Ground-Water Flow Process. U.S. Geological Survey, Open-File Report 00-92. Pages 1-130.

4. Schlumberger Water Services. Visual MODFLOW Premium v.4.3, User's Manual, 2009.

Table 1. Shallow Aquifer Groundwater Elevations at STP Units 1 & 2.

Units 1 & 2 and ECP Piezometer No.	North Coordinate	East Coordinate	Date Measured (m/d/yyyy)	Water Table Elevation (ft MSL)
201C	361,335.21	2,945,778.68	5/1/2006	No Data
201E	361,340.53	2,945,778.28	5/1/2006	13.70
203C	361,820.47	2,945,592.67	5/1/2006	15.46
203E	361,815.71	2,945,596.25	5/1/2006	14.59
218C	361,191.28	2,945,310.35	5/1/2006	16.30
218E	361,191.65	2,945,304.97	5/1/2006	14.17
220C	361,779.81	2,945,135.96	5/1/2006	15.30
220E	361,785.75	2,945,134.54	5/1/2006	14.75
221C	361,569.65	2,945,134.97	5/1/2006	15.06
221E	361,565.31	2,945,135.20	5/1/2006	14.74
222C	361,417.33	2,945,135.81	5/1/2006	15.19
222E	361,406.30	2,945,136.70	5/1/2006	14.77
223C	361,187.78	2,945,140.77	5/1/2006	16.32
223E	361,188.88	2,945,135.14	5/1/2006	14.49
225C	361,811.49	2,944,983.16	5/1/2006	15.42
225E	361,824.99	2,944,990.62	5/1/2006	14.78
230C	361,195.13	2,944,980.07	5/1/2006	15.71
230E	361,195.15	2,944,980.15	5/1/2006	14.55
241C	361,121.96	2,944,720.52	5/1/2006	17.46
241E	361,121.77	2,944,725.38	5/1/2006	14.50
243C	361,846.60	2,944,499.78	5/1/2006	17.03
243E	361,852.16	2,944,499.09	5/1/2006	15.22
244C	361,557.55	2,944,488.46	5/1/2006	15.62
244E	361,570.23	2,944,476.73	5/1/2006	14.87
245C	361,295.73	2,944,483.71	5/1/2006	15.76
245E	361,307.05	2,944,483.73	5/1/2006	14.33
263C	*362,835*	*2,946,000*	5/1/2006	20.29
265	*361,615*	*2,946,626*	5/1/2006	18.89
266	*361,358*	*2,946,973*	5/1/2006	18.44
267	*361,350*	*2,947,459*	5/1/2006	18.06
274C	*362,459*	*2,946,928*	5/1/2006	19.28

(shaded)	Upper Shallow aquifer (Stratum C)
(unshaded)	Lower Shallow aquifer (Stratum E)

Note: ECP piezometer coordinates estimated using STP 1 & 2 UFSAR Figure 2.5.6-12 (Reference 1) are italics. Coordinate system: Texas South Central State Plane, NAD 1927 (ft).

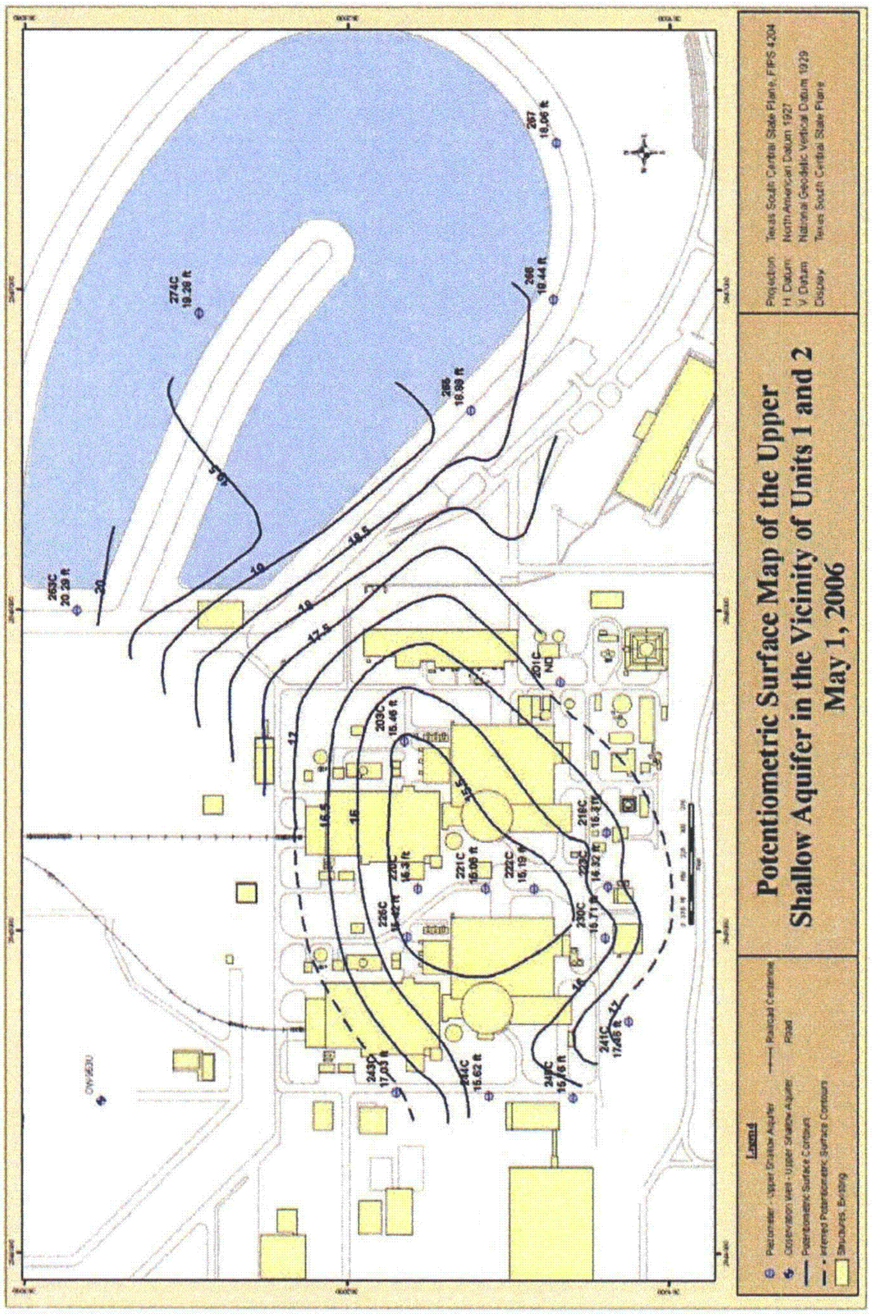


Figure 1. Potentiometric Surface Map of the Upper Shallow Aquifer, STP Units 1 & 2.

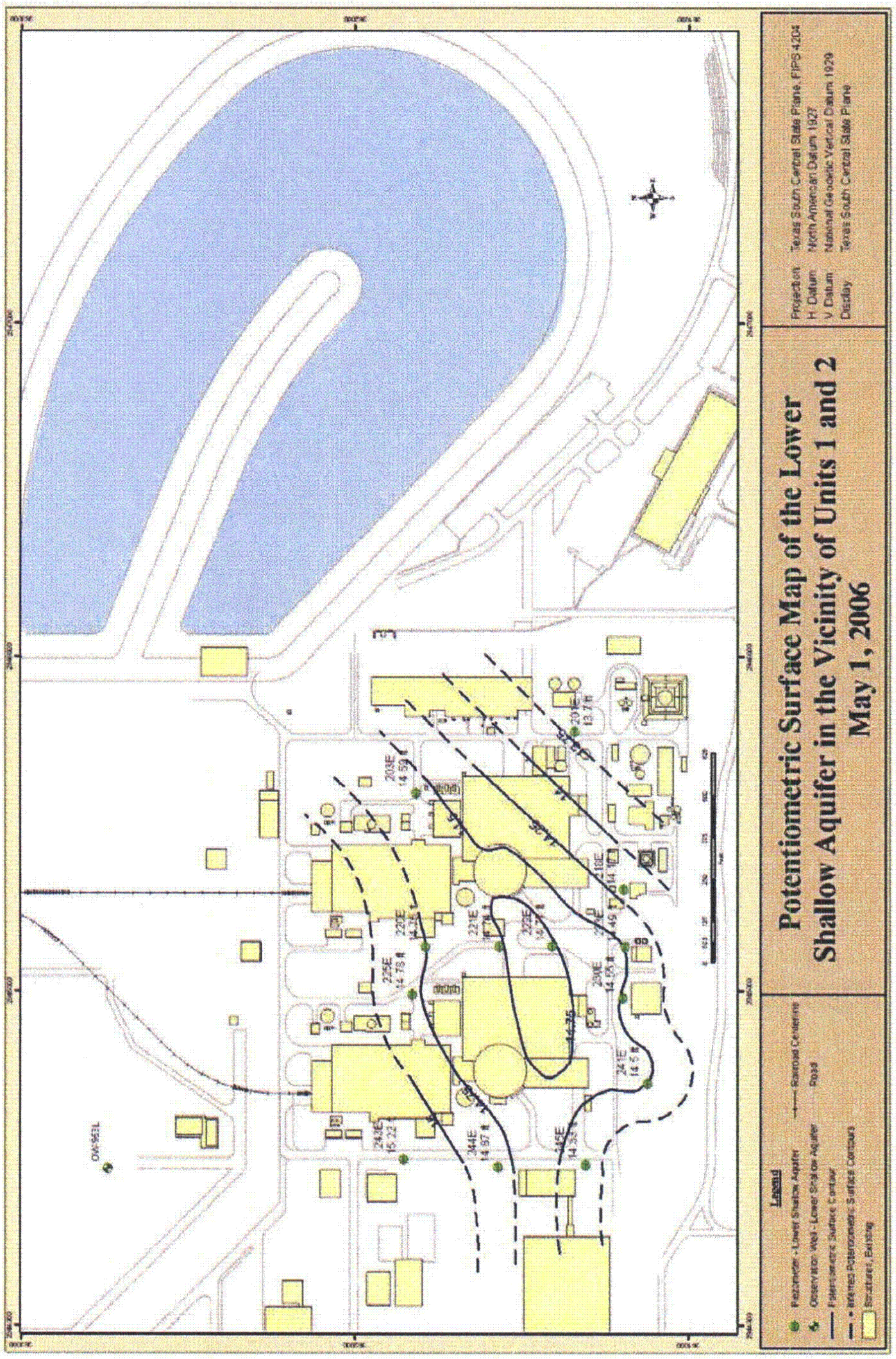


Figure 2. Potentiometric Surface Map of the Lower Shallow Aquifer, STP Units 1 & 2.

RAI 02.04.12-43

QUESTION:

To meet the requirements of 52.79(a) and assist staff in its analysis, additional information concerning the groundwater model results and the influence of the dry cells is required. Describe the potential influence of dry cells in model results. The manually calibrated model (run 201) presents large areas in the northeast quadrant of Layer 1 and around the MCR as dry cells. Was defining the top layer of dry cells as inactive cells attempted? In the current model, describe the impact on recharge through those cells that appear as "dry" in the solution. Are heads imported from prior simulations to start or restart simulations? If heads for dry cells are imported from a previous run are used as initial conditions, what is the impact on the new or restarted simulation?

RESPONSE:

Model layer 1 of the groundwater model represents only a portion of the thickness of stratum A/B in Run 201 because layer 1 from the Run 101 model was split to improve the representation of the STP Units 1 & 2 foundations and structural fill in Run 201 (Reference 1). This caused model layer 1 to become thin along the northeast portion of the current model. Although groundwater level data for stratum A/B were not collected as part of the site investigation, drilling logs indicate saturated conditions are not typically encountered within stratum A/B.

The cells in model layer 1 around the MCR essentially represent the top of the embankment. The cause of the dry cells in the embankment surrounding the MCR is due to the bottom elevation of layer 1 emulating the topography. At the MCR embankment, the bottom elevation of layer 1 is above the simulated groundwater level, forming dry cells.

As a result of these factors; it is conceptually acceptable to have dry cells in layer 1. However, dry cells can affect the groundwater model results if recharge is only applied in layer 1. In this case, some portion of recharge is prevented from entering the model. This was the case of manual calibration Run 201; hence some flow from recharge was prevented from entering the current model. The implication of this has been investigated through a series of sensitivity analyses described below.

For this evaluation, the current groundwater model (Run 201) was run with all recharge applied to model layer 3 – the Upper Shallow Aquifer (stratum C) – to compare the zone budget of this run with results presented in Reference 1. As in the current model, net infiltration of 0.001 inches per year (in/yr) is used and is the amount of infiltration hypothesized to reach the Upper Shallow Aquifer (Reference 1). Based on this analysis, flow into the model from this recharge increases from 344 ft^3/day (or about 2 gpm as presented in Table 15 of Reference 1) to 393 ft^3/day when applied directly to layer 3. The water balance for this run is shown in Table 1 for comparison to Table 15 of Reference 1. Table 2 shows that applying recharge directly to layer 3 has no significant effect on the percent of the model area that contains dry cells. Consequently, the impact on the solution when recharge is applied to the dry cells in layer 1 appears to be minimal. To determine the impact of dry cells on the groundwater model results, a sensitivity analysis with three runs was conducted to demonstrate that dry cells in layer 1 of the model do not significantly impact the model solution. The goal of this analysis was to demonstrate that changes to layer 1 do not adversely change the model calibration statistics or the model water budget, and also to demonstrate that heads imported from a previous run (which had dry cell conditions) as the initial conditions, did not have any impact on the new simulations.

Prior to executing these runs, modifications that minimize or eliminate the potential influence of the flooded cells and the potential boundary constraints (that might prevent an accurate prediction of groundwater elevations beneath STP 3 & 4 and the formation of a southwest pathway in the Lower Shallow Aquifer) were incorporated into the current model (Run 201) as "Run 301." A summary of the objectives and development of Run 301 is described in the response to RAI 02.04.12-40. Further modifications incorporated as a result of sensitivity analyses to address flooded cells are discussed in the responses to RAI 02.04.12-44 and to RAI 02.04.12-45, Supplement 1. The modifications incorporated as the result of these sensitivity analyses to address boundary conditions are also discussed in the response to RAI 02.04.12-47.

The three runs that were completed for the analysis were:

1. Run 301PrevH: This run is similar to Run 301, except that the initial conditions (i.e., the heads) for the run were imported from the previous run (Run 301).
2. Run 301TopInactive: For this run the entire layer 1 of Run 301 was set to inactive.
3. Run 301TopInactiveDL2: For this run the entire layer 1 of Run 301 was set to inactive with drains from layer 1 copied to layer 2 (to represent small streams and ditches in the model domain of layer 2) so that there is surface drainage from stratum A/B in the model even though layer 1 is inactive.

Simulated heads, calibration statistics, and groundwater budgets generated from these runs were then compared to those generated from the current model as discussed below.

In the current model (Run 201), the initial heads are set at a specified elevation of 41.02839 ft and are not imported from prior simulations to start or restart subsequent simulations. The specified starting head elevation is the highest topographic elevation used to define the model surface in the current model (Run 201). This setting is preserved during this analysis except in one run ("Run 301PrevH") executed to evaluate the effect of an alternate initial head setting on the model solution.

The second sensitivity analysis involved inactivating all of the cells defining layer 1, referred to as "Run 301TopInactive." This run also inactivated all of the drain cells within layer 1, which represent small streams and ditches that provide surface drainage from stratum A/B.

The final, third sensitivity analysis was similar to Run 301TopInactive, except that drain cells from layer 1 were copied to layer 2. This run was named "Run 301TopInactiveDL2."

Table 3 provides the calibration statistics for the sensitivity runs used to analyze the impact of dry cells on the model solution. This table demonstrates that there is essentially no difference among the three dry cell sensitivity runs and Run 301 in terms of the model solution in the vicinity of the STP Units 3 & 4 power blocks. Table 4 gives a summary of the water balance among the boundary conditions in the model and shows negligible differences among the model runs.

Head differences between Run 201 and Run 301 for layers 3, 5 and 7 are presented in Figures 1, 2, and 3, respectively. The areas where the head differences are positive are due to lower heads simulated by Run 301 compared to the heads simulated by Run 201. These differences are due primarily to the changes made to the general head boundary along the west model domain to alleviate the presence of flooded cells in that area. The head differences are less than 1 ft in the study area. Figures 1, 2, and 3 show that heads at the northeast quadrant of the model domain and along most of the perimeter of the MCR and are not affected, indicating the dry cells play no significant part in model results between Runs 201 and 301.

Simulated heads and head differences between Run 301PrevH and Run 301 are presented graphically in the top three model layers in Figure 4, Figure 5, and Figure 6, respectively. Equivalent plots are provided in Figure 7, Figure 8, Figure 9, and Figure 10 for Runs 301TopInactive and 301TopInactiveDL, respectively. Results from layer 1 are not provided for Runs 301TopInactive and 301TopInactiveDL because layer 1 was inactive in those two runs. Figures 5 to 10 show that negligible differences between model solutions occur where dry cells occur. The differences in model solutions are also apparent south and southwest of the MCR as depicted in Figures 7 to 10. These differences occur because drainage from the groundwater model is reduced in these areas when layer 1 was set to inactive.

Based on the above sensitivity analysis, it can be concluded that the dry cells in layer 1 are conceptually acceptable and by inactivating layer 1, no appreciable change to the calibration statistics and groundwater budget occur compared to Run 201. Considering that all the recharge was applied to layer 3 in Run 301, there is no impact to recharge due to dry cell conditions in layer 1. These dry cells do not adversely impact the model solution as demonstrated from the comparison of the Run 301 groundwater model results with the three dry cell sensitivity run model results. Also, the results from Run 301PrevH show that both calibration statistics and groundwater budget results are identical to Run 301 when using heads from a previous run (which is Run 301) as the initial heads.

No COLA revision is required as a result of this RAI response.

<u>Reference</u>:

1. South Texas Project Letter No. U7-C-STP-NRC-090206, "Supplemental Response to Requests for Additional Information," dated November 30, 2009, Attachment 2, "Groundwater Model Development and Analysis for STP Units 3&4".

Table 1: Run 201 with Recharge Applied Directly to Model Layer 3.

Description	Inflows (cubic ft/day)	Outflows (cubic ft/day)
MCR Discharge Total	683365	0
Through Sand Pits	547620	0
Through Remaining Portion of MCR	135745	0
Precipitation/Recharge	393	0
ECP	159	0
Stratum C GHB	61542	9988
Stratum E GHB	40201	20084
Stratum H GHB	37698	17308
Levee-Bound Irrigation Canals	27798	610
Livestock Well	0	77
Colorado River	29	132940
Canals and Ditches in Stratum A/B	0	132545
Little Robbins Slough and Plant Area Drainage Ditches in Stratum C	0	146621
Kelly Lake	0	57444
MCR Relief Wells and Sand Drains from MCR	0	330570
MCR Relief Wells and Sand Drains from other Sources	0	3000
TOTALS	**851185**	**851187**
PERCENT DISCREPANCY	**-0.0002**	

All flow values in this table are rounded as shown from actual model output values.
The Percent Discrepancy reported in this table is rounded from actual model output and may not represent the rounded flow values presented in this table.

Table 2: Comparison of dry areas in the current model (Run 201) with recharge applied to Layer 1 and Layer 3.

Description	Run 201 with Recharge in Layer 1 (Ref. 1)	Run 201with Recharge in Layer 3
Area of Dry Cells (ft^2)	230,228,000	228,249,750
Percent of model area covered by dry cells	11.9	11.8

Table 3. Comparison of calibration statistics among dry cell sensitivity analysis model runs.

Layer	Run / Statistic	201*	301	301PrevH	301TopInactive	301TopInactiveDL2	MAX	MIN
All	RMS (ft)	1.458	1.453	1.453	1.448	1.450	1.458	1.448
	NRMS (%)	7.796	7.771	7.771	7.742	7.753	7.796	7.742
	Max. Residual (ft)	-6.590	-7.017	-7.017	-7.004	-7.038	-7.004	-6.590
	Location	437	437E	437E	437E	437E		
	Min. Residual (ft)	0.032	0.001	0.001	0.002	-0.009	0.032	-0.009
	Location	OW-954U	OW-956U	OW-956U	OW-956U	OW-956U		
	Residual Mean (ft)	0.216	-0.019	-0.019	-0.018	-0.023	0.216	-0.023
	ARM (ft)	1.041	1.013	1.013	1.013	1.014	1.041	1.013
	SEE (ft)	0.170	0.171	0.171	0.171	0.171	0.171	0.170
	CC	0.947	0.948	0.948	0.948	0.948	0.948	0.947
	Number of Points	73	73	73	73	73	73	73
3	RMS (ft)	1.338	1.307	1.307	1.297	1.296	1.338	1.296
	NRMS (%)	7.154	6.99	6.990	6.938	6.931	7.154	6.931
	Max. Residual (ft)	-3.588	-3.598	-3.598	-3.598	-3.598	-3.598	-3.588
	Location	P131	P131	P131	P131	P131		
	Min. Residual (ft)	0.032	0.001	0.001	0.002	-0.009	0.032	-0.009
	Location	OW-954U	OW-956U	OW-956U	OW-956U	OW-956U		
	Residual Mean (ft)	0.344	0.272	0.272	0.282	0.279	0.344	0.272
	ARM (ft)	1.018	1.000	1.000	0.998	0.997	1.018	0.997
	SEE (ft)	0.197	0.195	0.195	0.193	0.193	0.197	0.193
	CC	0.957	0.958	0.958	0.958	0.958	0.958	0.957
	Number of Points	44	44	44	44	44	44	44

Table 3. Comparison of calibration statistics among dry cell sensitivity analysis model runs (continued).

Layer	Run / Statistic	201*	301	301PrevH	301TopInactive	301TopInactiveDL2	MAX	MIN
5	RMS (ft)	1.901	1.939	1.939	1.938	1.946	1.946	1.901
	NRMS (%)	45.273	46.156	46.156	46.134	46.337	46.337	45.273
	Max. Residual (ft)	-6.590	-7.017	-7.017	-7.004	-7.038	-6.590	-7.038
	Location	437	437E	437E	437E	437E		
	Min. Residual (ft)	0.050	-0.008	-0.008	-0.034	-0.042	0.050	-0.042
	Location	OW-933L	OW-932L	OW-932L	OW-932L	OW-932L		
	Residual Mean (ft)	-0.147	-0.661	-0.661	-0.682	-0.691	-0.661	-0.147
	ARM (ft)	1.148	1.041	1.041	1.048	1.053	1.148	1.041
	SEE (ft)	0.489	0.471	0.471	0.468	0.470	0.489	0.468
	CC	0.616	0.608	0.608	0.609	0.608	0.616	0.608
	Number of Points	16	16	16	16	16	16	16
7	RMS (ft)	1.195	1.205	1.205	1.204	1.207	1.207	1.195
	NRMS (%)	25.207	25.417	25.417	25.410	25.456	25.456	25.207
	Max. Residual (ft)	2.790	2.379	2.379	2.376	2.371	2.790	2.371
	Location	OW-928L	OW-928L	OW-928L	OW-928L	OW-928L		
	Min. Residual (ft)	0.180	0.145	0.145	0.143	0.137	0.180	0.137
	Location	OW-951L	601A	601A	601A	601A		
	Residual Mean (ft)	0.226	-0.214	-0.214	-0.217	-0.223	0.226	-0.223
	ARM (ft)	0.987	1.024	1.024	1.023	1.025	1.025	0.987
	SEE (ft)	0.339	0.342	0.342	0.342	0.342	0.342	0.339
	CC	0.967	0.963	0.963	0.963	0.963	0.967	0.963
	Number of Points	13	13	13	13	13	13	13
Mass Discrepancy (%)		-0.01	0.000	-0.010	0.000	0.000	0.000	-0.010

* From Reference 1. RMS: Root Mean Squared NRMS: Normalized Root Mean Squared ARM: Absolute Residual Mean SEE: Standard Error of the Estimate
CC: Correlation Coefficient

Table 4. Comparison of water budgets among dry cell sensitivity analysis runs.

Description	Runs										Summary			
	201*		301		301PrevH		301TopInactive		301TopInactiveDL2		Inflows		Outflows(gpm)	
	Inflows	Outflows	Inflows	Outflows	Inflows	Outflows	Inflows	Outflows	Inflows	Outflows	Max	Min	Max	Min
MCR Discharge, Total	3550.0	0	3574.9	0	3574.9	0	3569.6	0	3570.2	0	3574.9	3550.0	0	0
Through Sand Pits	2844.9	0	2827.8	0	2827.8	0	2823.6	0	2824.1	0	2844.9	2823.6	0	0
Through Remaining Portion of MCR	704.9	0	747.1	0	747.1	0	746	0	746.2	0	747.1	704.9	0	0
Precipitation/Recharge	1.8	0	2	0	2	0	2	0	2	0	2	1.8	0	0
ECP	0.8	0	0.8	0	0.8	0	0.8	0	0.8	0	0.8	0.8	0	0
Stratum C GHB	319.7	51.9	213.2	244.8	213.2	244.8	213.1	247.5	213.3	242.3	319.7	213.1	247.5	51.9
Stratum E GHB	208.8	104.3	216.4	100	216.4	100	216.3	100.3	216.5	99.6	216.5	208.8	104.3	99.6
Stratum H GHB	195.8	89.9	182.1	91.4	182.1	91.4	182.1	91.5	182.2	91.3	195.8	182.1	91.5	89.9
Levee-Bound Irrigation Canals	144.4	0.0	148.2	3.1	148.2	3.1	147.8	3.1	148.1	3.1	148.2	144.4	3.1	0
Livestock Well	0	0.4	0	0.4	0	0.4	0	0.4	0	0.4	0	0	0.4	0.4
Colorado River	0	690.7	0.2	675.5	0.2	675.5	0.2	676	0.3	673.8	0	0	690.7	673.8
Canals and Ditches in Stratum A/B	0	689.1	0	542.5	0	542.8	0	499.8	0	520.1	0	0	689.1	499.8
Little Robbins Slough and Plant Area Drainage Ditches in Stratum C	0	761.6	0	671.6	0	671.6	0	681	0	677.7	0	0	761.6	671.6
Kelly Lake	0	301.5	0	298.5	0	298.5	0	298.5	0	298.3	0	0	301.5	298.3
MCR Relief Wells and Sand Drains from MCR	0	1715.8	0	1699.9	0	1699.9	0	1724	0	1716.1	0	0	1724.0	1699.9
MCR Relief Wells and Sand Drains from other Sources	0	16.9	0	10.3	0	10.3	0	10.1	0	10.6	0	0	16.9	10.1
TOTALS	4421.0	4422.0	4337.9	4338.1	4337.9	4338.3	4332	4332.2	4333.4	4333.4	4421.0	4332.0	4422.0	4332.2
PERCENT DISCREPANCY	-0.01		-0.01		-0.01		0		0					

* From Reference 1.
All flow values in this table are rounded as shown from the actual model output values.
The Percent Discrepancy reported in this table is rounded from actual model output and may not represent the rounded flow values presented in this table.

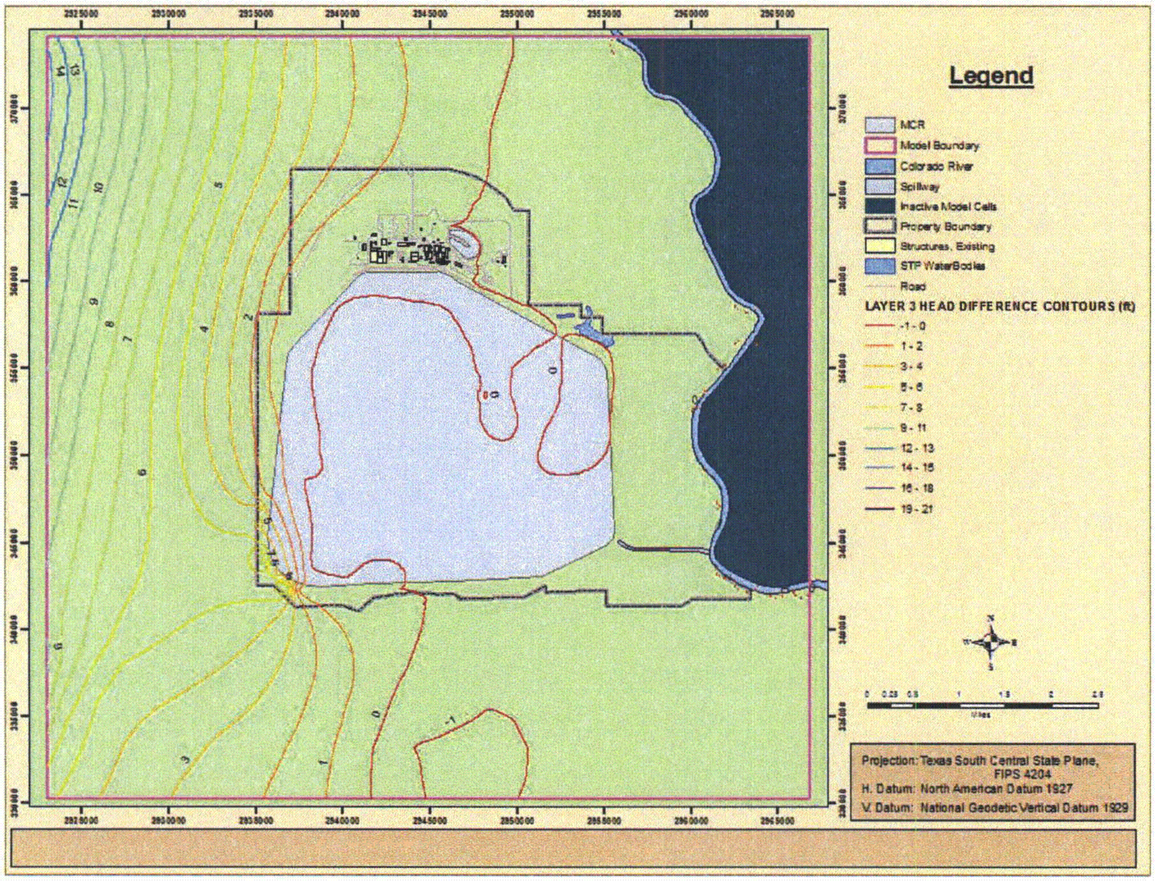


Figure 1. Head Difference between Runs 201 and 301 in Layer 3 – Stratum C.

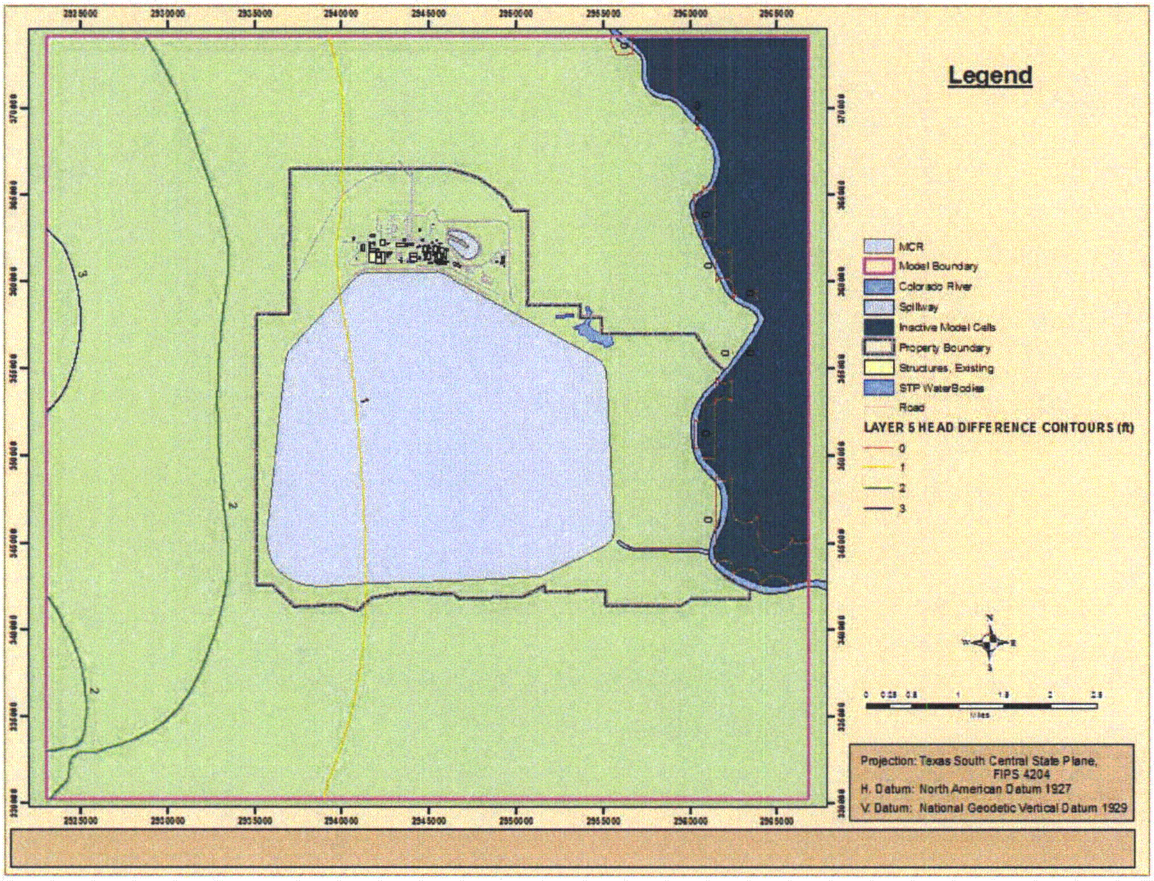


Figure 2. Head Difference between Runs 201 and 301 in Layer 5 – Stratum E.

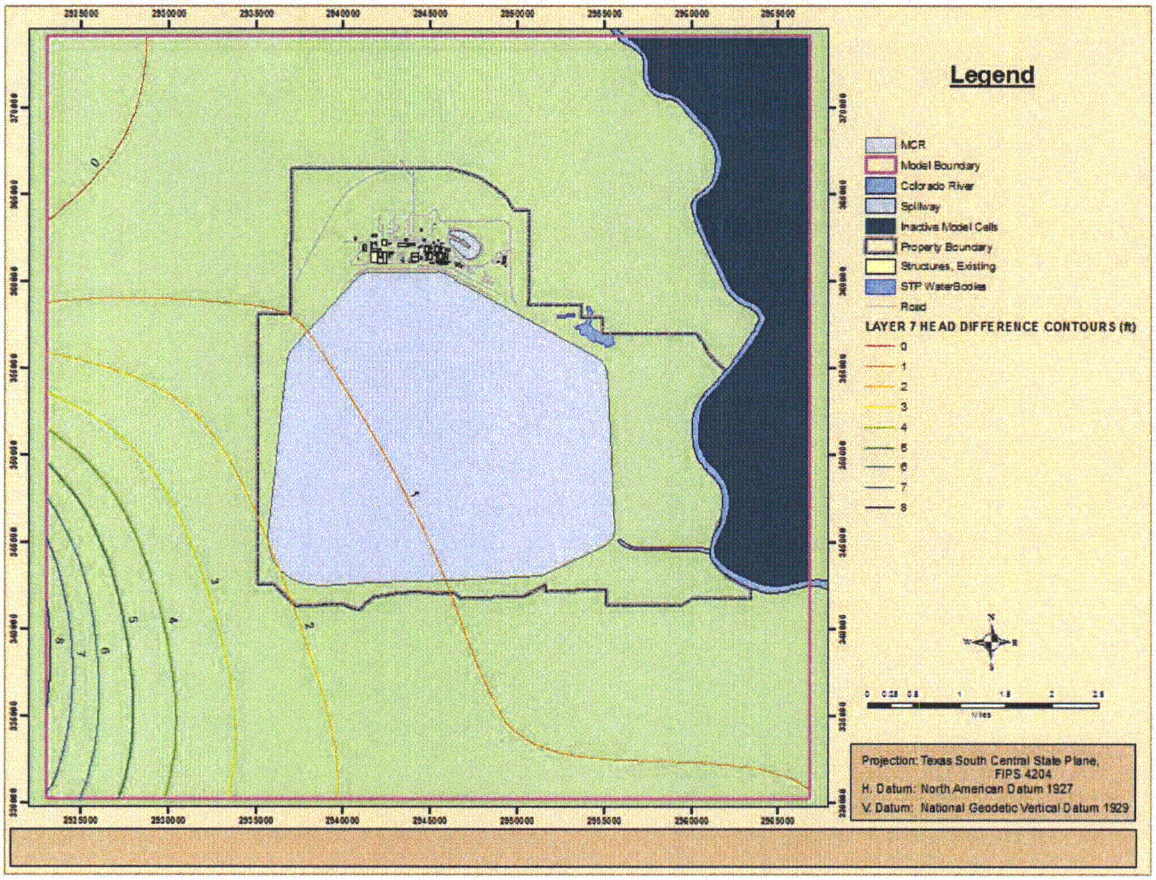


Figure 3. Head Difference between Runs 201 and 301 in Layer 7 – Stratum H.

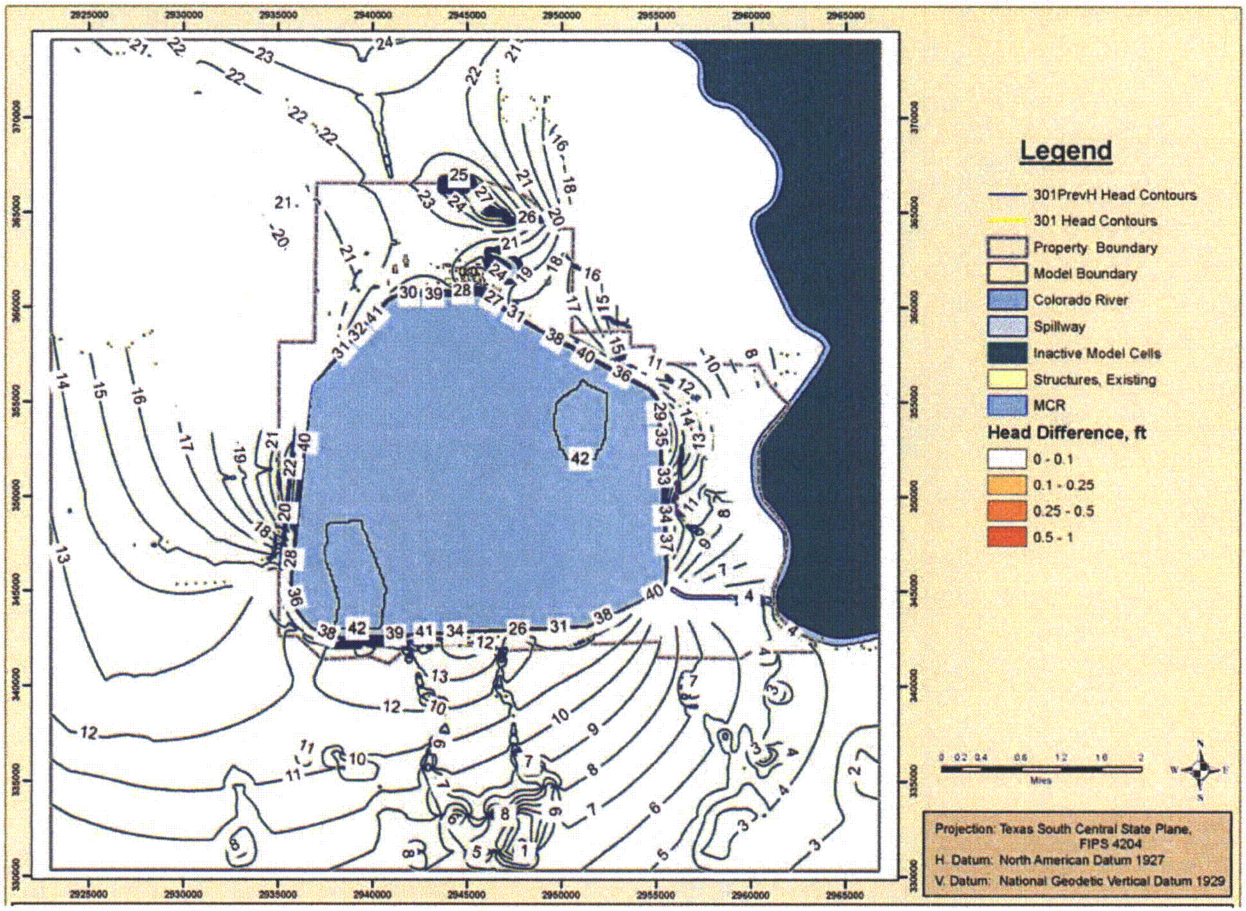


Figure 4. Head Difference between Run 301PrevH and Run 301 for Layer 1 - Stratum A/B.

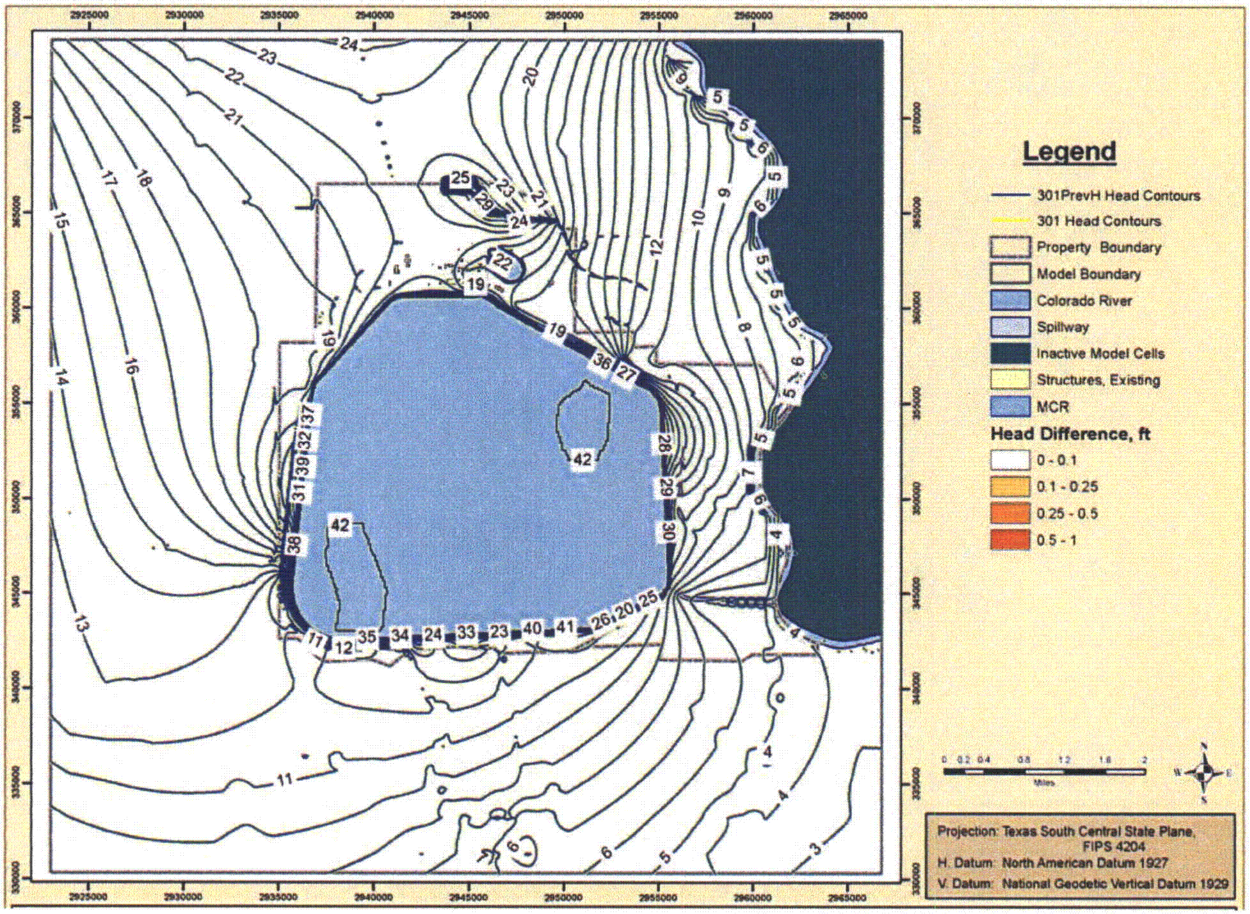


Figure 5. Head Difference between Run 301PrevH and Run 301 for Layer 2 - Stratum A/B.

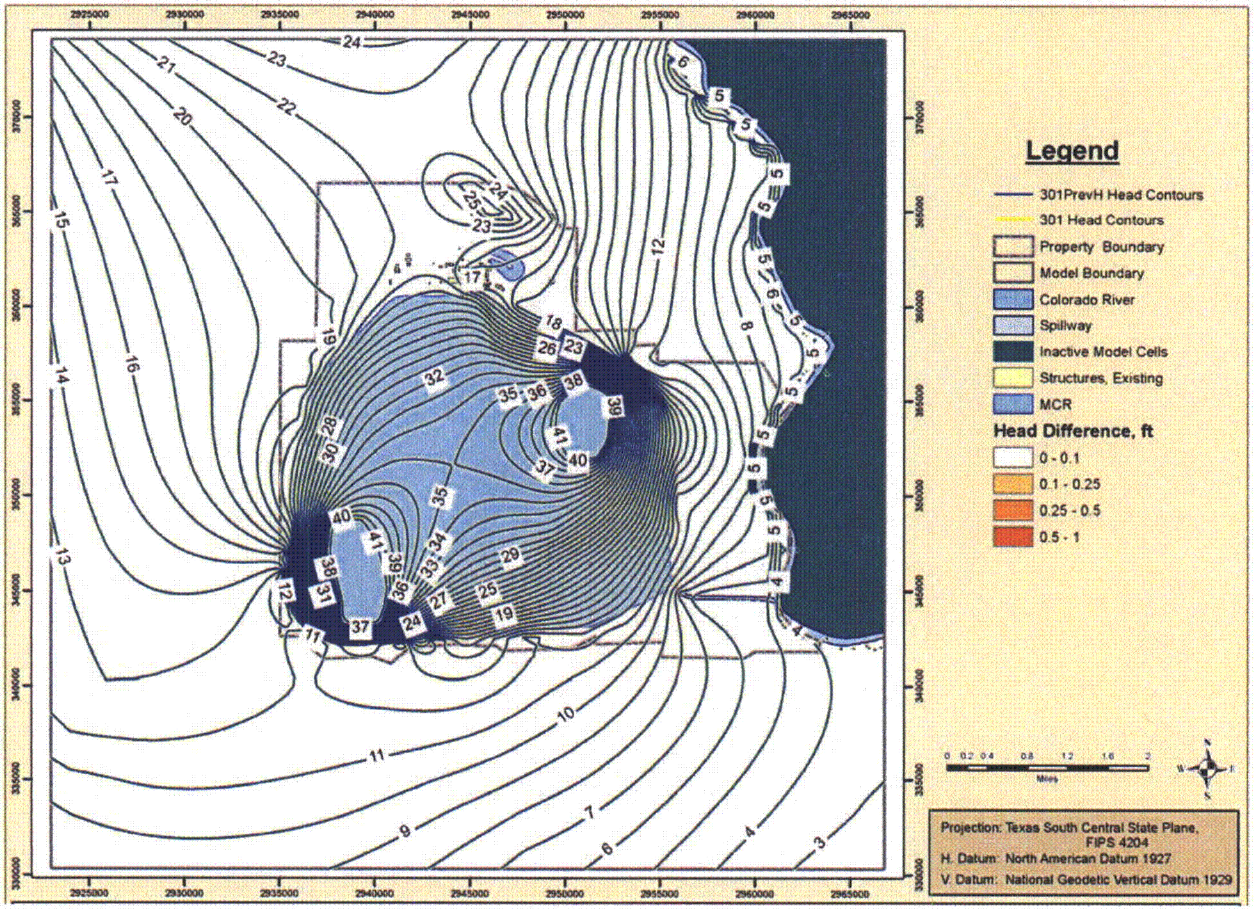


Figure 6. Head Difference between Run 301PrevH and Run 301 for Layer 3 - Stratum C.

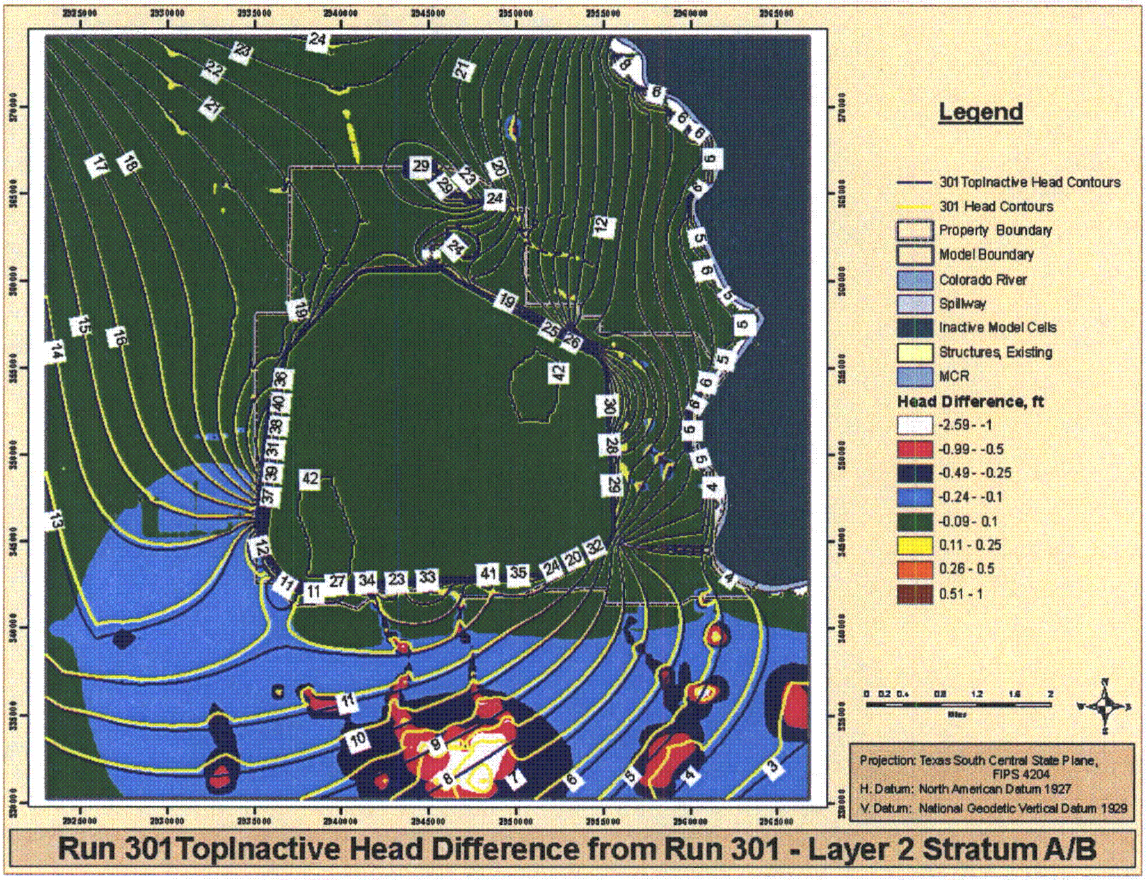


Figure 7. Head Difference between Run 301TopInactive and Run 301 for Layer 2 - Stratum A/B.

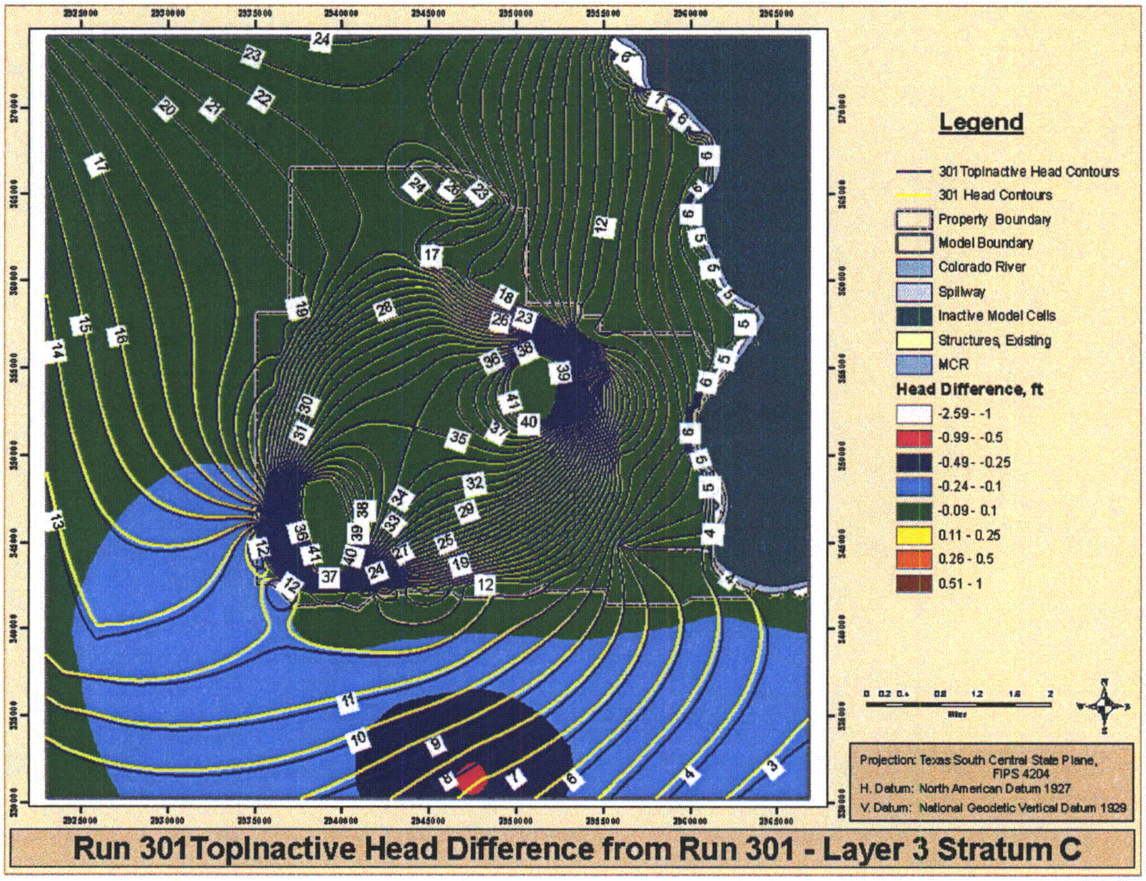


Figure 8. Head Difference between Run 301TopInactive and Run 301 for Layer 3 - Stratum C.

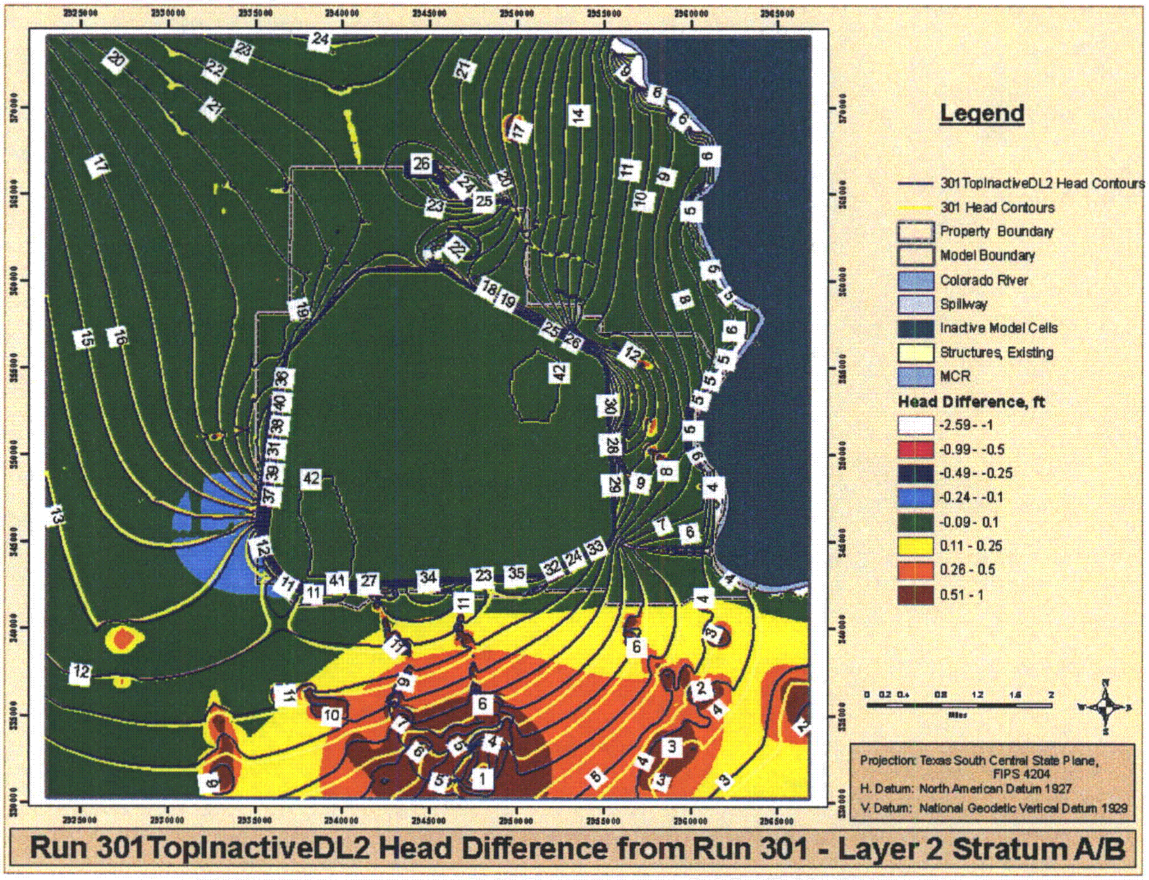


Figure 9. Head Difference between Run 301TopInactiveDL2 and Run 301 for Layer 2 - Stratum A/B.

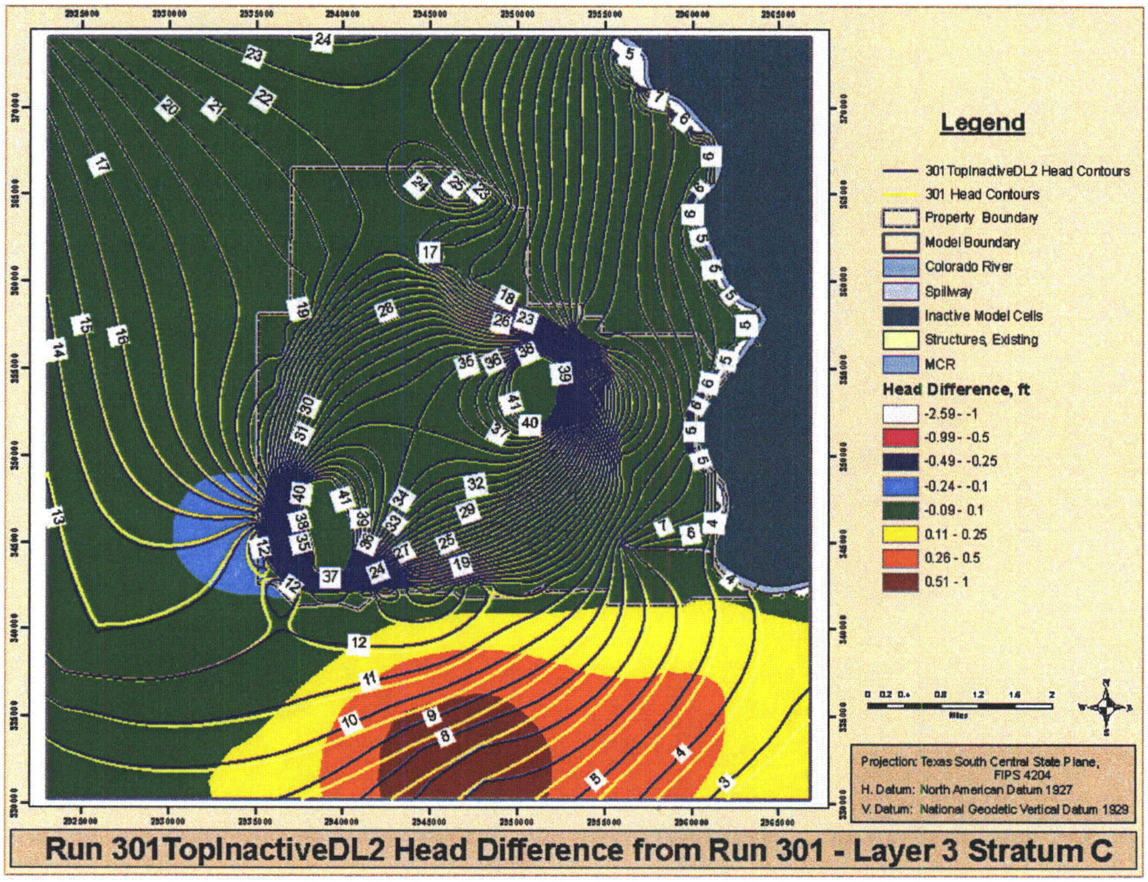


Figure 10. Head Difference between Run 301TopInactiveDL2 and Run 301 for Layer 3 - Stratum C.

RAI 02.04.12-44

QUESTION:

To meet the requirements of 52.79(a) and assist staff in its analysis, additional information concerning the groundwater modeling and the influence of the flooded cells is required. Describe the potential influence of flooded cells in model results. The manually calibrated model (run 201) presents relatively large areas in the western and southern side of the model exhibit flooding (hydraulic head above the specified land surface). Where flooding of cells is indicated, are the model results reasonable given the hydrologic system?

RESPONSE:

The manually calibrated model (Run 201) does exhibit relatively large areas where the simulated heads are above the model topography along the western and southern portions of the model (Figure 1). Although there is some swamp land in the south portion of the model, the presence of the majority of "flooded cells" is not believed to be representative of the given hydrologic system based on the Blessing SE, TX (Reference 1) and Palacios NE, TX (Reference 2) Quadrangle 7.5 minute series topographic maps. Given the information provided by these two maps, the topographic representation used in Run 201 outside of the STP site boundary was re-evaluated, resulting in refinement to the topography used in the groundwater model. Further re-evaluation of the western general head boundary (GHB) was conducted through a series of sensitivity analyses that resulted in eliminating the majority of the remaining flooded cells in the western part of the model domain.

In Run 201, the topography incorporated into the groundwater model for areas within the STP site boundary is based on LiDAR topographic data (Reference 3). The topography for the areas outside the STP site boundary is based on U.S. Geological Survey National Elevation Dataset (NED) data; and the topography for the area inside the MCR is based on digitized elevation contours from pre-site construction, U.S. Geological Survey topographic maps and adjusted for the estimated MCR borrow pit depths (Reference 3). Considering the flooded cells occur outside of the STP site boundaries, only the topographic representation obtained from the NED was further evaluated.

The NED data used to represent the topography outside of the STP boundary in Run 201 was 1/3 arc second (approximately ten-meter resolution). The NED currently has 1/9 arc second (approximately three-meter resolution) topography data for the Matagorda County area (Reference 4). This updated NED data has a greater resolution than the NED data used to represent the topography outside of the STP boundary in Run 201. The 1/9 arc second NED data, which was not available when the Run 201 groundwater model was developed, was used to refine the topographic representation of the areas outside of the STP site boundaries in the groundwater model.

The examination and refinement of the model topography were performed as part of a sensitivity analysis which is summarized in the response to RAI 02.04.12-40. The results of the sensitivity analyses performed and the evaluation of the updated model topography to evaluate the flooded cells in model Run 201 are discussed below.

The differences in surface elevation between the new topography (201NewTopo) and the old topography of Run 201 are displayed in Figure 2. Surface elevations between the two models are similar where the elevation differences are shown in white. However, areas across the model domain exist where the surface elevations are different in the two models as shown by the color gradations. These areas are attributed to the difference in the NED topography datasets. In addition, Figure 2 shows elevation differences within the boundary of the MCR and to the north of STP Units 1 & 2 and STP Units 3 & 4. During the sensitivity analysis it was discovered that the splitting of the Strata A/B model layer in Run 201 unintentionally shifted the model topography surface at these areas. This shift in the topography was corrected for all sensitivity evaluations.

Topographic elevations range from one to six feet higher across the north, west, and south sides of the model domain outside of the STP property boundary in the "new" topography. An area of relative decrease in topographic elevation is evident in the northeast corner of Figure 2. This relative decrease occurs because a cut-off oxbow is represented in the "new" topography that was not captured by the original topographic data used in the Run 201 model. Table 1 presents the change in flooding observed in the groundwater model as a result of changing topography. This refinement alone eliminated roughly two-thirds of the area of flooded cells outside of the MCR as presented in Table 1. The updated topography, which was found to have no significant impact on the model calibration, was incorporated into the model as 201NewTopo and was used in place of Run 201 for subsequent sensitivity analysis runs.

After updating the off-site topography using the updated NED data, some areas along the western model boundary remained flooded. This suggested that the general head boundaries (GHBs) along the western edge of the model domain likely contributed to the remainder of the flooded cells. Consequently, the GHBs were the focus for further evaluation in a series of additional sensitivity analyses performed.

Two different sets of GHB representations were used in the sensitivity analyses to determine which boundary configuration minimizes the remaining flooded cells while maintaining or improving the model calibration statistics (see responses to RAI 02.04.12-40, RAI 02.04.12-45, Supplement 1, and RAI 02.04.12-47 for further discussion). The first set uses the original GHBs as described in the Groundwater Model Report (Reference 3). The second set of GHBs was produced by altering the distance and elevation of the specified heads used in the GHBs. The two sets of GHB values were combined during intermediate runs because the original GHB values represent influences from local sources of recharge and discharge, whereas the values used by the alternative GHB scenario represent influences from the regional flow regime. From these two sets of GHB conditions, seven model runs were executed for this sensitivity analysis. The updated off-site topography and GHB values have been incorporated into an updated groundwater model, referred to as Run 301, as discussed in the responses to RAI 02.04.12-40, RAI 02.04.12-45, Supplement 1, and RAI 02.04.12-47.

Based on the progressive alterations made to the GHB values along the western edge of the model during the sensitivity analyses, the flooding issues identified in this portion of the groundwater model were eliminated as shown in Figure 3. The few areas of flooding that remained are located in areas defined by the Blessing SE, TX and Palacios, TX topographic maps (References 1 and 2) as either marsh or swamp or submerged marsh or swamp, and are believed to be reasonable given the hydrologic system within the vicinity of the STP site. The modified GHB values along the western boundary slightly improved the calibration statistics compared to those from Run 201 while having limited impact on the overall model water balance. Therefore, based on the results of the GHB sensitivity analysis, the flooded cells had no significant influence on the groundwater modeling results and simulations presented for STP Units 3 & 4 in Run 201.

No COLA revision is required as a result of this RAI response.

References:

1) U.S. Geological Survey (USGS), 1995. Blessing SE Quadrangle, Texas-Matagorda Co., 7.5 Minute Series (Topographic).

2) U.S. Geological Survey (USGS), 1995. Palacios NE Quadrangle, Texas-Matagorda Co., 7.5 Minute Series (Topographic).

3) STPNOC Letter No. U7-C-STP-NRC-090206, "Supplemental Response to Requests for Additional Information," dated November 30, 2009, Attachment 2, "Groundwater Model Development and Analysis for STP Units 3&4".

4) U.S. Geological Survey (USGS), 2009. "Jackson, Matagorda and Victoria Counties, Texas, 2007, 1/9-Arc Second National Elevation Dataset".

Table 1. Comparison of flooded areas between runs 201 and 201NewTopo

Description	201	201NewTopo
Area of Dry Cells (sq. ft.)	230,228,000	228,249,750
% of model area covered by dry cells	11.9	11.8
Area of flooded cells (sq. ft.)	597,070,700	410,754,250
% area covered by flooded cells	30.8	21.2
Area flooded outside of MCR (sq.ft.)	285,413,450	99,097,000
% of area outside of MCR covered by flooded cells	17.6	6.1

Notes:

The area of the dry cells are primarily along the MCR Embankment and the northeastern portion of the model domain (further explained in the response to RAI 02.04.12-43).

The area of flooding outside of the MCR includes the river cells.

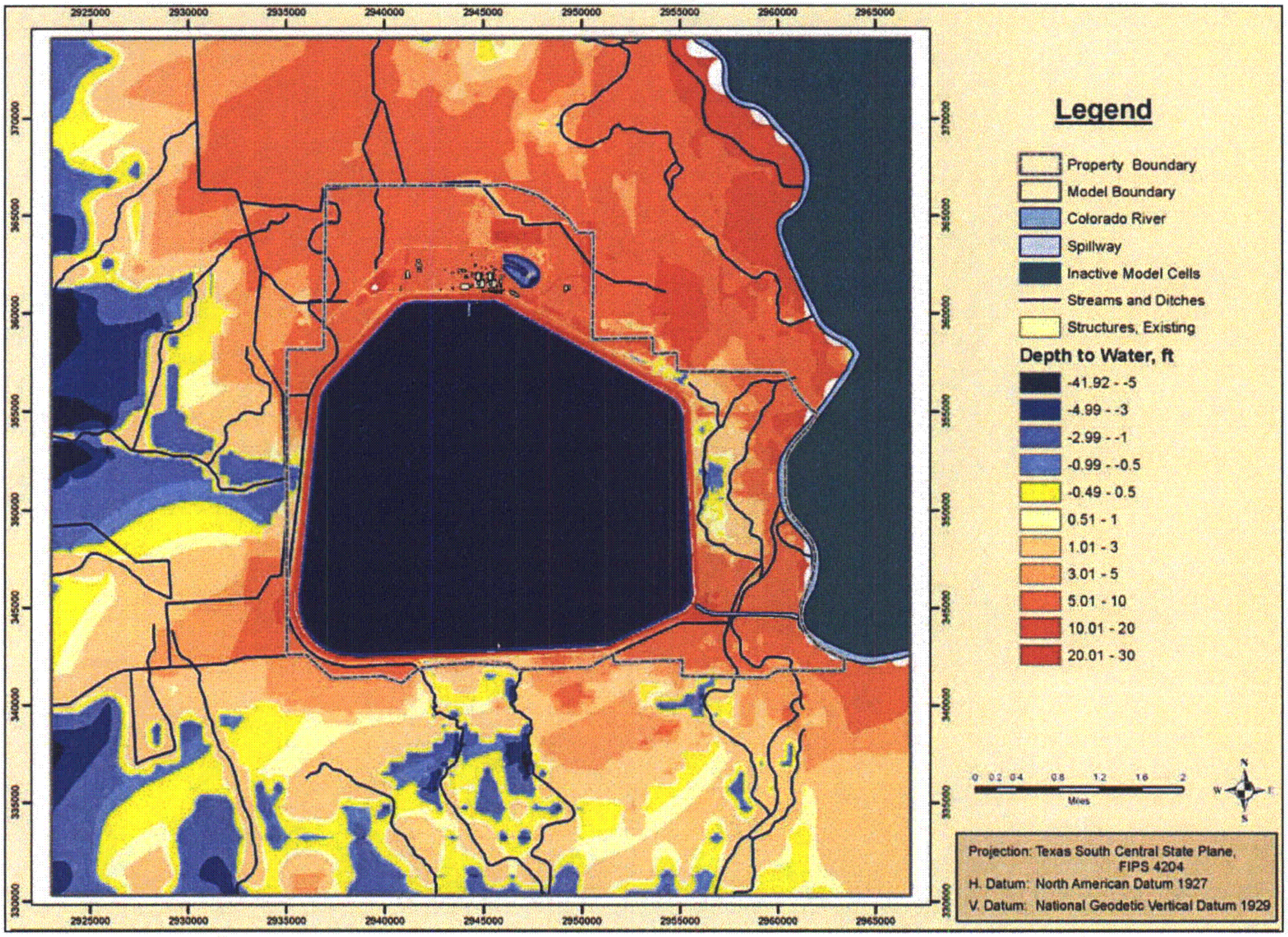


Figure 1: Run 201 areas of "flooded cells" shown by areas of negative depth to water. (Negative depth to water shown in blue to yellow color range.)

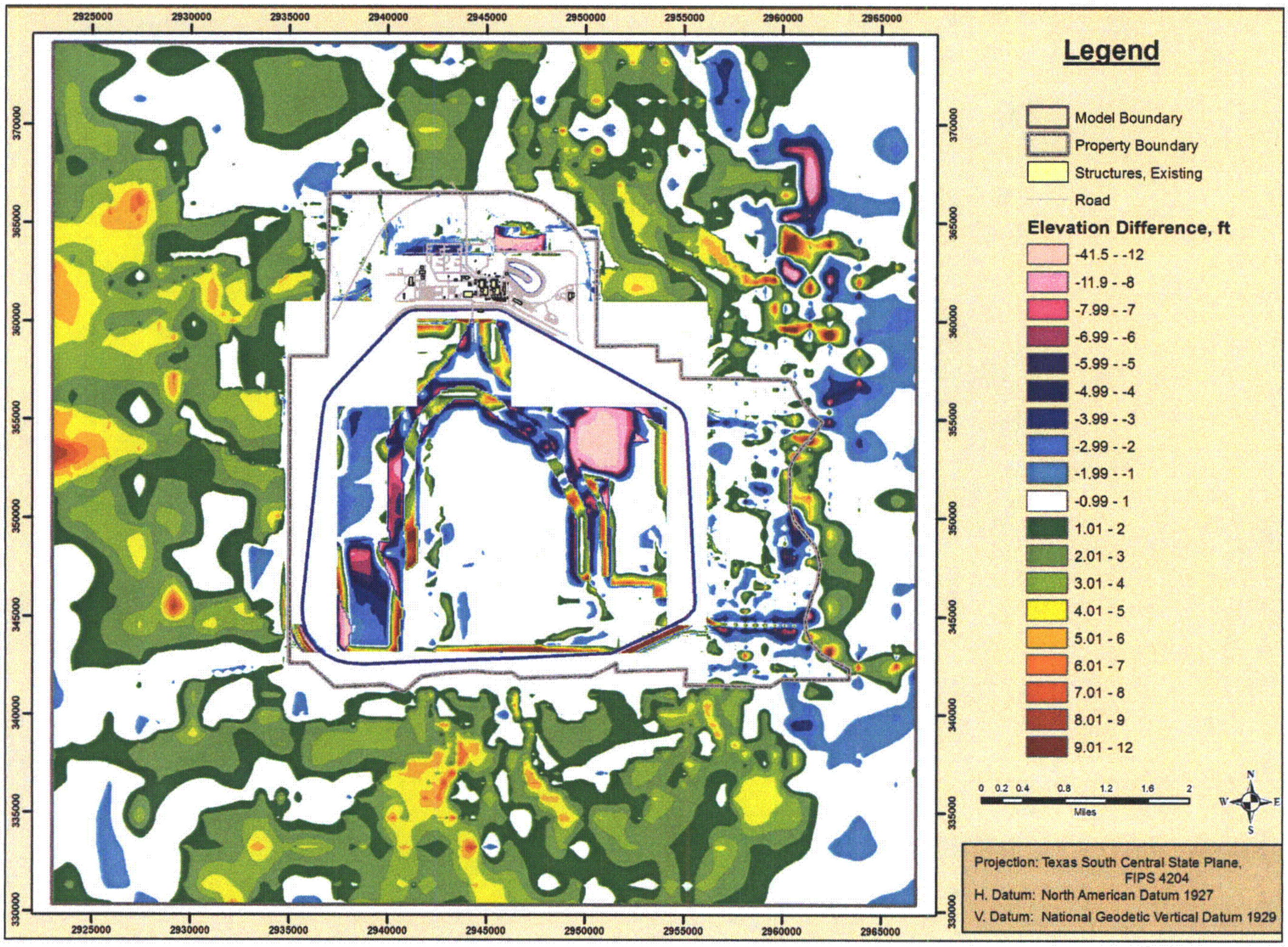


Figure 2. Difference in surface elevation between *Run 201* and *201NewTopo*.

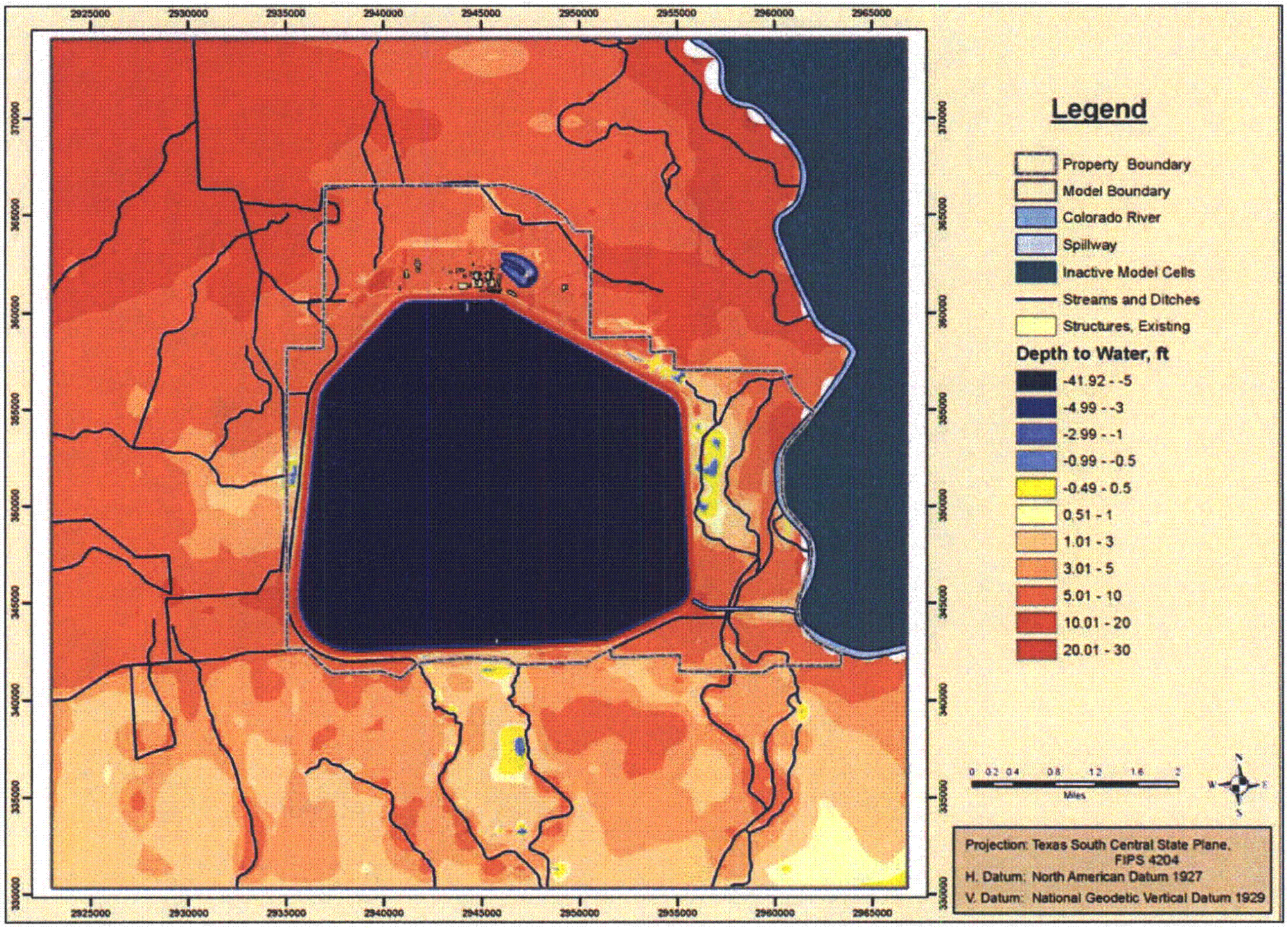


Figure 3. Depth to groundwater following refinements to model topography and general head boundary conditions.

Note: The few areas of flooding shown in Figure 3 are located in areas generally defined by the Blessing SE, TX and Palacios, TX topographic maps as either marsh or swamp or submerged marsh or swamp (References 1 and 2).

RAI 02.04.12-45, Supplement 1

QUESTION:

To meet the requirements of 52.79(a) and assist staff in its analysis, additional information concerning the groundwater modeling is required. Staff requests additional information for the groundwater model results and the bands of piezometric contours. The manually calibrated model (run 201) exhibits several rectangular bands of piezometric contours at locations on the south and west sides of the model domain in Layers 1&2. Describe whether these model results are reasonable, or whether they indicate model configuration issues with the drain boundary conditions (e.g., surface elevation, drain boundary conditions)?

RESPONSE:

This response supplements the initial response to RAI 02.04.12-45 (STPNOC Letter U7-C-STP-NRC-100107, dated May 17, 2010) to provide a further evaluation concerning the "several rectangular bands of piezometric contours" at locations on the south and west sides of the model domain in layer 1 and layer 2. The findings of this additional evaluation indicate that flooded cells found along the south and west sides of the model domain also contribute to the formation of the "rectangular bands of piezometric contours".

The initial response indicated that the "rectangular bands of piezometric contours" are produced by:

- Hydraulic head differentials between the assigned values of head in the drain boundary cells that simulate canals and ditches in model layers 1 and 2 and the computed head outside of the drain boundary cells;
- Relatively low horizontal hydraulic conductivity of model layers 1 and 2 that create steep hydraulic gradients; and
- Rectangular-shape grid cells.

The initial response stated that the drain boundaries that represent canals and ditches lower the simulated heads in adjacent cells in model layers 1 and 2 from 10 ft to about 3 ft and from 5 ft to about 0.3 ft along the south domain, and from 22.5 ft to about 13 ft along the west domain. Further analysis of these head differences reveals that flooded cells that occur along the west and south sides of the model domain (Figure 1) also play a role in the formation of the rectangular bands of piezometric contours. Figures 2 and 3 show the potentiometric surface of layer 1 and layer 2, respectively. Figure 1 shows the location of flooded cells where depth to groundwater is negative (blue to yellow color spectrum). Comparison of Figure 1 and Figure 2 shows the proximity of the flooded cells to the rectangular bands of piezometric contours.

A model sensitivity analysis was performed to assist in responding to the Groundwater Model RAIs received in RAI Letter No. 333. The process for development of the sensitivity analysis that supports this response is summarized in the response to RAI 02.04.12-40.

Evaluation of the cause of the flooded cells reveals that a coarsely-resolved model topography and the general head boundaries along the model limits of the base model (Run 201) contribute more significantly to the formation of the flooded cells. The original model surface outside of the STP site boundaries is represented by a low 30-meter resolution digital file downloaded from the USGS (Reference 1). This has now been replaced by a higher resolution USGS National Elevation Database (NED) 1/9 arc second (approximately three-meter resolution) digital file (Reference 2) to better represent the model topography outside of the STP site boundaries. The specified heads for the western general head boundaries in layer 3 (stratum C) were also reset to 6 ft MSL, which was lower than the prescribed head in the base model (Run 201), to eliminate or reduce the presence of flooded cells. This specified head value for the western-most general head boundary was obtained from the water surface elevation of the Tres Palacios River (a hydraulic boundary), located about 9,650 ft west of the model boundary. Drain cells representing the canals and ditches were also evaluated, but were found to play a less significant role in the formation and elimination of the flooded cells. These changes, along with others, were incorporated into a revision to the base model designated as Run 301. Run 301 was verified against the September, 2008 data and also against February and March, 2003 data. Calibration statistics and residuals for Run 301 were similar to that in Run 201.

After adjusting the above model input criteria, flooded cells were essentially eliminated. Figures 4 and 5 show the potentiometric surface of layer 1 and layer 2, respectively, as a result of the revision to the base model described above. Based on the evaluation of the flooded cells, the appearance of "rectangular bands" of piezometric contours is eliminated in certain areas and minimized in other areas. As a consequence of the readjustment of the model topography and refinement of the general head boundaries the model generated heads are now slightly lower in some areas than the drain elevations. In addition, the large gradient, which was observed in Run 201, that caused the "rectangular bands" around the drain cells are now minimal. Thus, the resulting potentiometric surface contour lines shown in Figures 4 and 5 are reasonable and appropriate for the conditions on which this model is based and do not indicate model configuration issues with the drain boundary conditions (e.g., surface elevation, drain boundary conditions). No further evaluations concerning the rectangular bands of piezometric contours are anticipated based on the findings from the flooded cell analysis.

No COLA revision is required as a result of this RAI response.

<u>References</u>:

1. STPNOC Letter No. U7-C-STP-NRC-090206, "Supplemental Response to Requests for Additional Information," dated November 30, 2009, Attachment 2, "Groundwater Model Development and Analysis for STP Units 3&4".

2. U.S. Geological Survey (USGS), 2009. "Jackson, Matagorda and Victoria Counties, Texas, 2007, 1/9-Arc Second National Elevation Dataset".

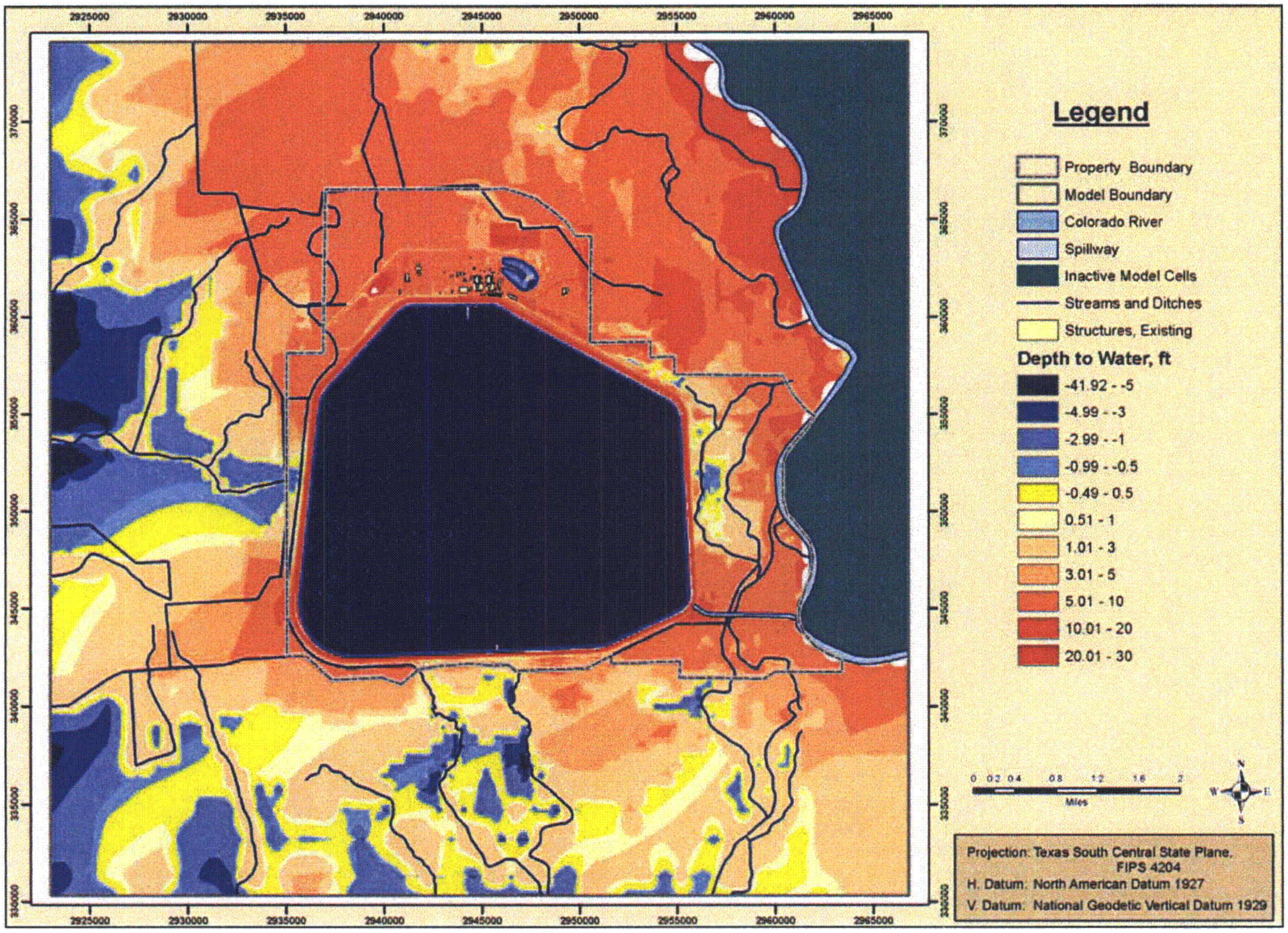
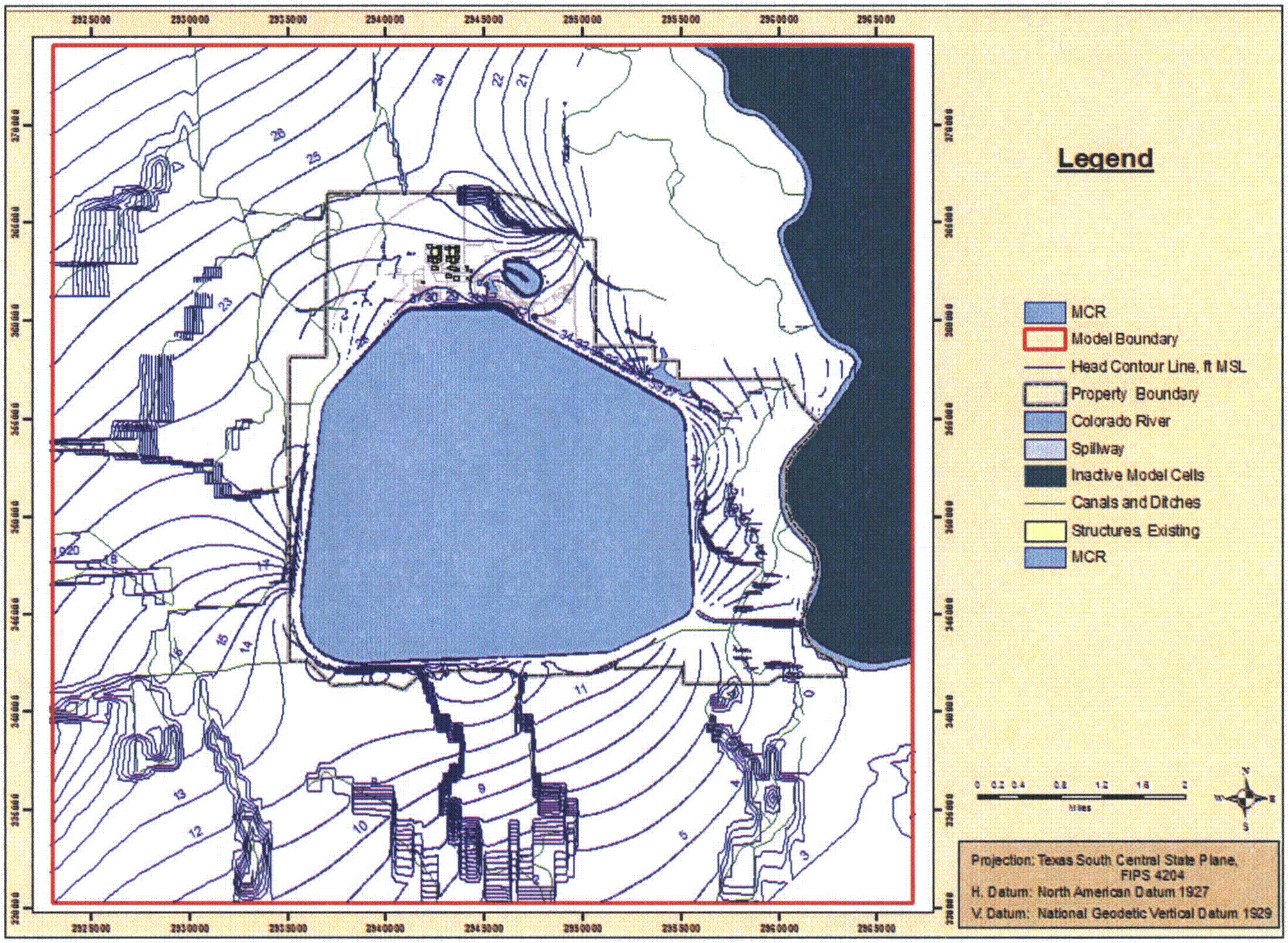


Figure 1. Location of flooded cells in Run 201.



Note: Areas where contour lines abruptly end denote dry cells.

Figure 2. Head contours in layer 1 (Stratum A/B) Run 201.

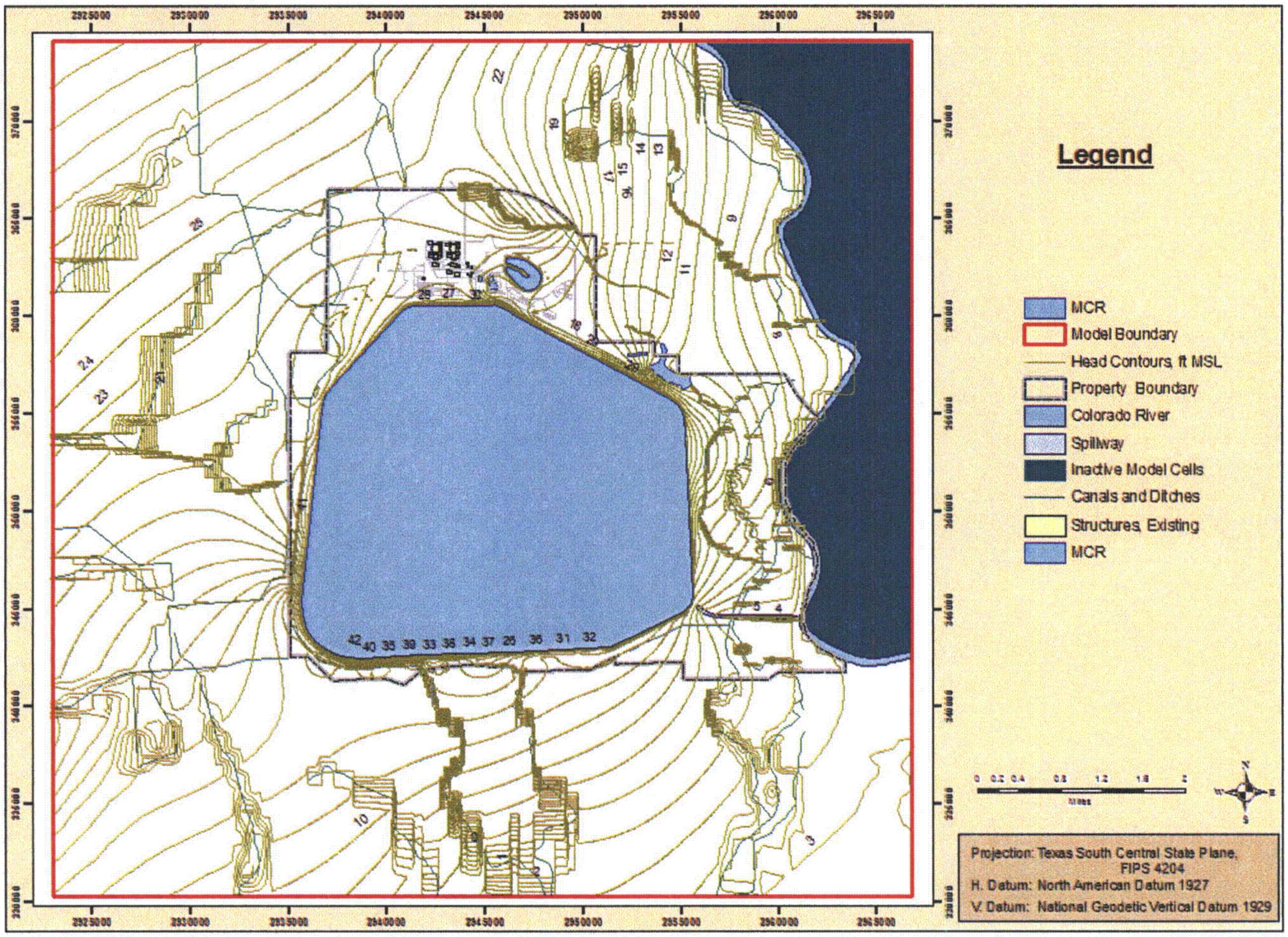
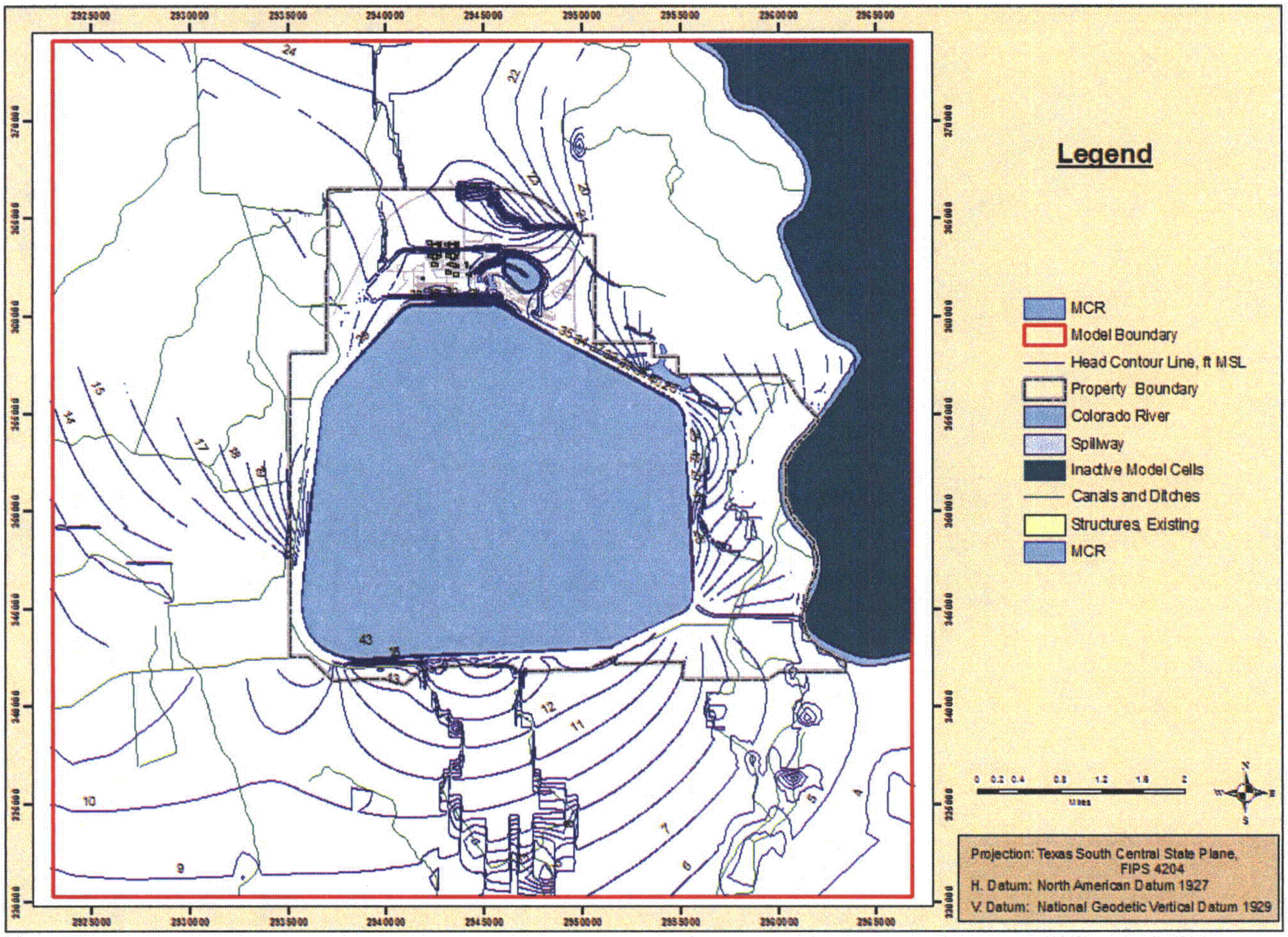


Figure 3. Head contours in layer 2 (Stratum A/B) Run 201.



Note: Areas where contour lines abruptly end denote dry cells.

Figure 4. Head contours in layer 1 (Stratum A/B) Run 301.

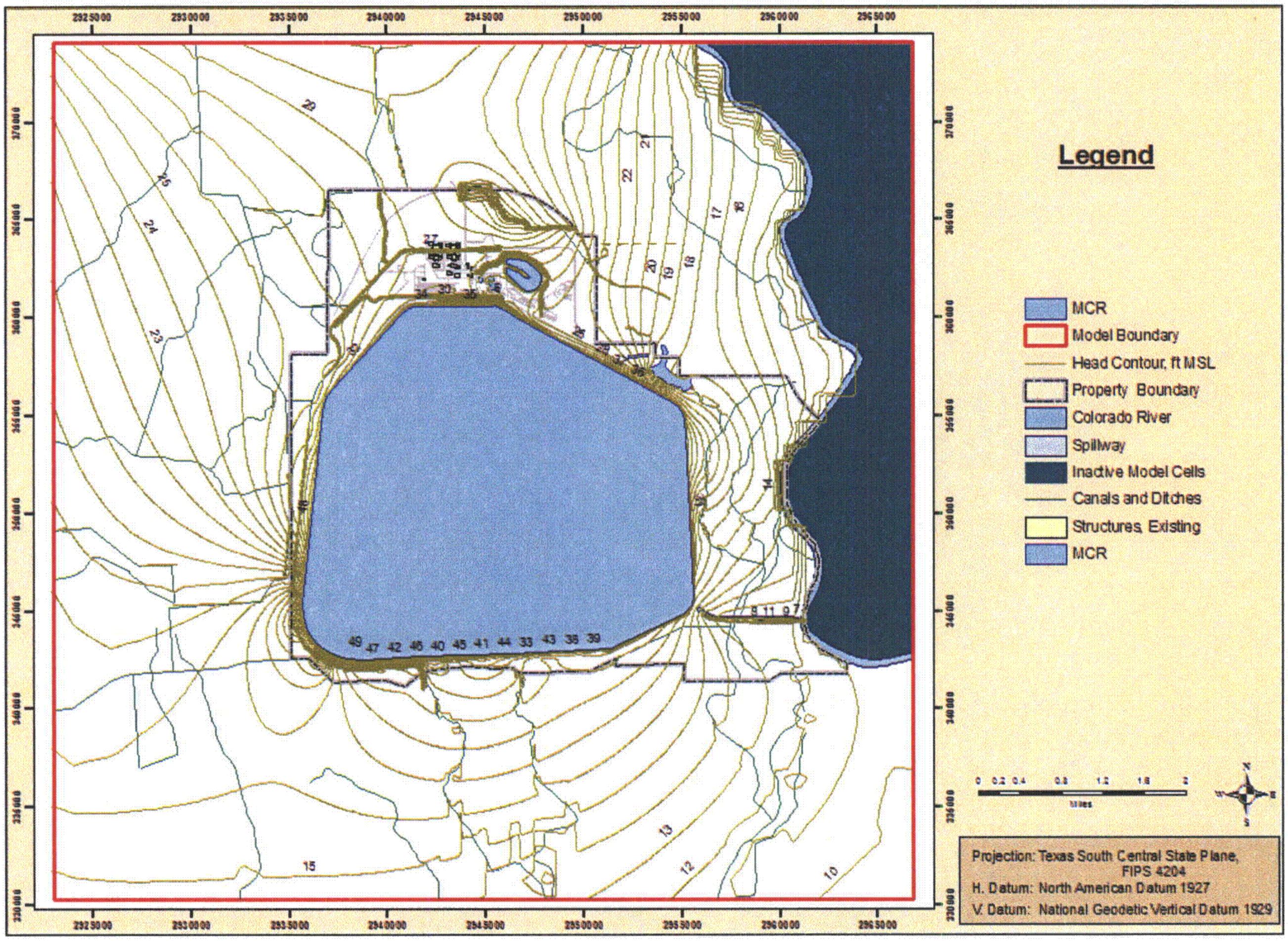


Figure 5. Head contours in layer 2 (Stratum A/B) Run 301.

RAI 02.04.12-46

QUESTION:

To meet the requirements of 52.79(a) and assist staff in its analysis, additional information concerning the groundwater modeling and the influence of the model bias is required. While the calibration gives reasonable metrics like RMSE, the distribution of the positive and negative residuals shows spatial correlation in each of the strata. In Layer 3, (i.e., Stratum C), points along the north/northeast side of the MCR (where facilities are located) have a higher calculated head than observed head, while around the MCR, the calculated heads are lower than observed. In Layers 5 and 7, (i.e., strata E and H), calculated heads west and northwest of the facilities are higher than observed while calculated heads at locations to the east and southeast are lower than observed. Provide a discussion of whether the spatially biased residuals seen in the calibration could act to remove a plausible southwest directed pathway from the analysis in the Upper and Lower Shallow Aquifer. The ER and FSAR note that the hydraulic gradient observed to the southwest is quite low and nearly flat. Accordingly, higher predictions of piezometric elevation to the northwest of proposed Unit 4 in the model would seem to diminish the possibility of a predicted southwest pathway in either the Upper or Lower Shallow Aquifer. In this discussion, include consideration of the predicted and/or observed groundwater piezometric depression and mound in the Upper and Lower Shallow Aquifer, respectively, in the vicinity of proposed STP Units 3&4.

RESPONSE:

Run 201 of the groundwater model (Reference 1) will be further evaluated for spatial model bias. Additional analyses will be performed to evaluate whether there is an impact on the existing model calibration or particle pathlines. Sensitivity analyses will be performed to further remove or minimize the spatial bias and to further assess the potential for the development of a southwest pathway in the Upper and Lower Shallow Aquifers without the existing spatial bias. The additional sensitivity analyses will consider:

1) Altering boundary conditions, including altering the specified heads of general head boundaries, river boundaries and constant head boundaries;

2) Altering hydraulic conductivity zones, i.e., varying zones of hydraulic conductivity in areas of the model domain where the groundwater observation wells are located, and comparing simulated to observed heads;

3) Weighting groundwater elevation measurements (e.g., data sets, observation well networks); and

4) Evaluating the viability for a southwest pathway to develop in response to altering model inputs.

The spatial bias in the groundwater model (Run 201) is shown graphically in Figures 1 through 3. As discussed in response to RAI 02.04.12-40, there is likely to be a bias of negative residuals (i.e., calculated heads less than observed heads) amongst the level A and B piezometers in the MCR embankment due to the high hydraulic gradient and model grid size. Consequently, the negative bias observed in model layer 3 around the MCR is to be expected. Although these residuals have a minimal impact to the simulated groundwater flow pattern at the focus area of the model, the impact will be further evaluated in a supplement to this RAI response.

The STP Units 3 & 4 power block area is characterized by positive residuals in Run 201, model layer 3 (Figure 1). These residuals are small in magnitude as they range from approximately 0.26 ft at OW-933U to 1.74 ft at OW-928U with the majority of the residuals below one foot for the Upper Shallow Aquifer. Two small negative residuals also occur in this area in model layer 3. In model layers 5 and 7 (Lower Shallow Aquifer) these positive residuals range from approximately 0.06 ft at OW-933L (Figure 2) to 2.79 ft at OW-928L (Figure 3).

Considering that these residuals are generally positive (i.e., calculated heads exceed observed heads) for the areas in and north of the Units 3 & 4 power block, the simulated groundwater levels are, therefore, artificially high in each model layer. This could create a favorable condition (e.g., higher hydraulic gradient or mounding) for the development of a southwest pathway, specifically in model layer 3 (Upper Shallow Aquifer). The residuals in model layer 3 (Figure 1) are oriented in a manner that could artificially induce a southwest flowpath compared to the observed conditions. In this case, correction of such residuals would lessen the possibility for a southwest pathway to be simulated by the groundwater flow model. For the Lower Shallow Aquifer, the residuals bias in model layer 7 (Figure 3) is similar to the conditions described for the Upper Shallow Aquifer (model layer 3). For model layer 5 (Figure 2), the positive residual bias at OW-950L and 225C could restrict the development of both a southwest and a southeast pathway.

Run 301, developed during the sensitivity analysis discussed in the responses to RAIs 02.04.12-40 and RAI 02.04.12-45, Supplement 1, shows an improvement in the magnitudes of the residuals compared to Run 201. In Run 301, there is some improvement of the residuals in model layer 3 (Figure 4), north of the MCR as compared to Run 201 (Figure 1). The reduction in the positive residual at OW-928U from 1.74 ft to 0.67 ft reduces the spatial bias northwest of the STP Units 3 & 4 power block. The simulated groundwater flow for both runs remains similar; suggesting the spatial bias in the Upper Shallow Aquifer is not impeding the simulation of a southwest pathway from STP Units 3 & 4.

A more significant improvement between Run 201 and Run 301 is shown for model layer 5 by comparing Figure 2 (Run 201) to Figure 5 (Run 301). Figure 5 (Run 301) shows a reasonable balance between positive and negative residuals at the STP Units 3 & 4 power block area, which range from 0.79 ft at OW-910L to -0.76 ft at OW-953L. The magnitudes of most of the Run 301 residuals in the model domain have been reduced. An improvement in the magnitudes of the residuals in model layer 7 is also apparent within and around the Units 3 & 4 power block as shown by a comparison of Figure 3 with Figure 6. Even with the improvement in the spatial bias and the magnitude of the residuals in Run 301, groundwater in the Lower Shallow Aquifer is simulated to flow to the southeast.

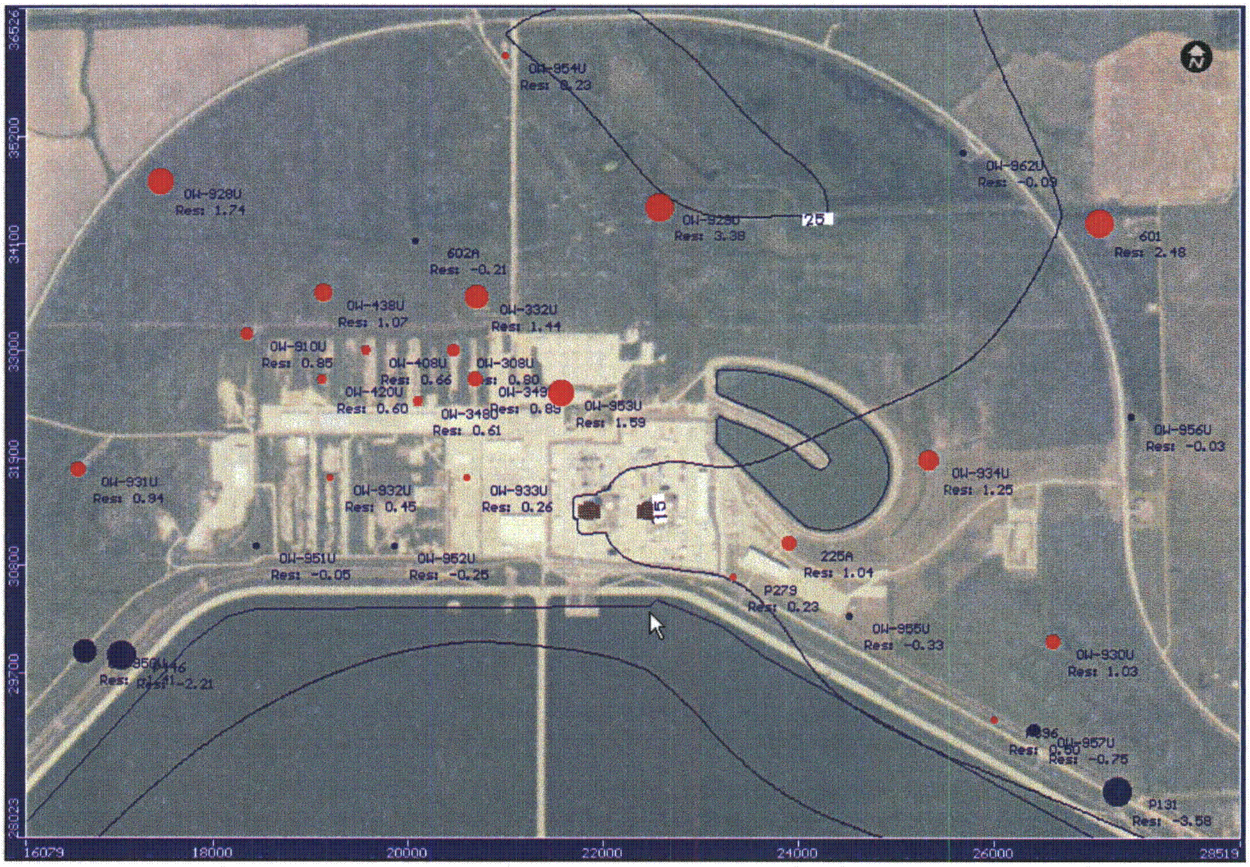
The improvement in the residuals in Run 301 does not result in a southwest pathway from STP Units 3 & 4 as indicated by the release of particle pathways from Units 3 & 4 as discussed in the response to RAI 02.04.12-48. Based on the results of this initial sensitivity analysis and the subsurface hydrogeologic conditions southwest of STP Units 3 & 4 (see response to RAI 02.04.12-50), a southwest pathway within the Lower Shallow Aquifer is not apparent.

Additional sensitivity analyses will be performed to further reduce and evaluate the Run 201 residuals, including the positive residual at OW-950L (southwest of STP Units 3 & 4), and the negative residuals to the east and southeast of STP Units 3 & 4. The results of the complete sensitivity analysis for spatial bias in the groundwater model and the final evaluation concerning the influence of spatial bias on a potential southwest pathway will be provided in a supplement to this RAI response which is scheduled to be submitted by December 15, 2010.

No COLA revision is required as a result of this RAI response.

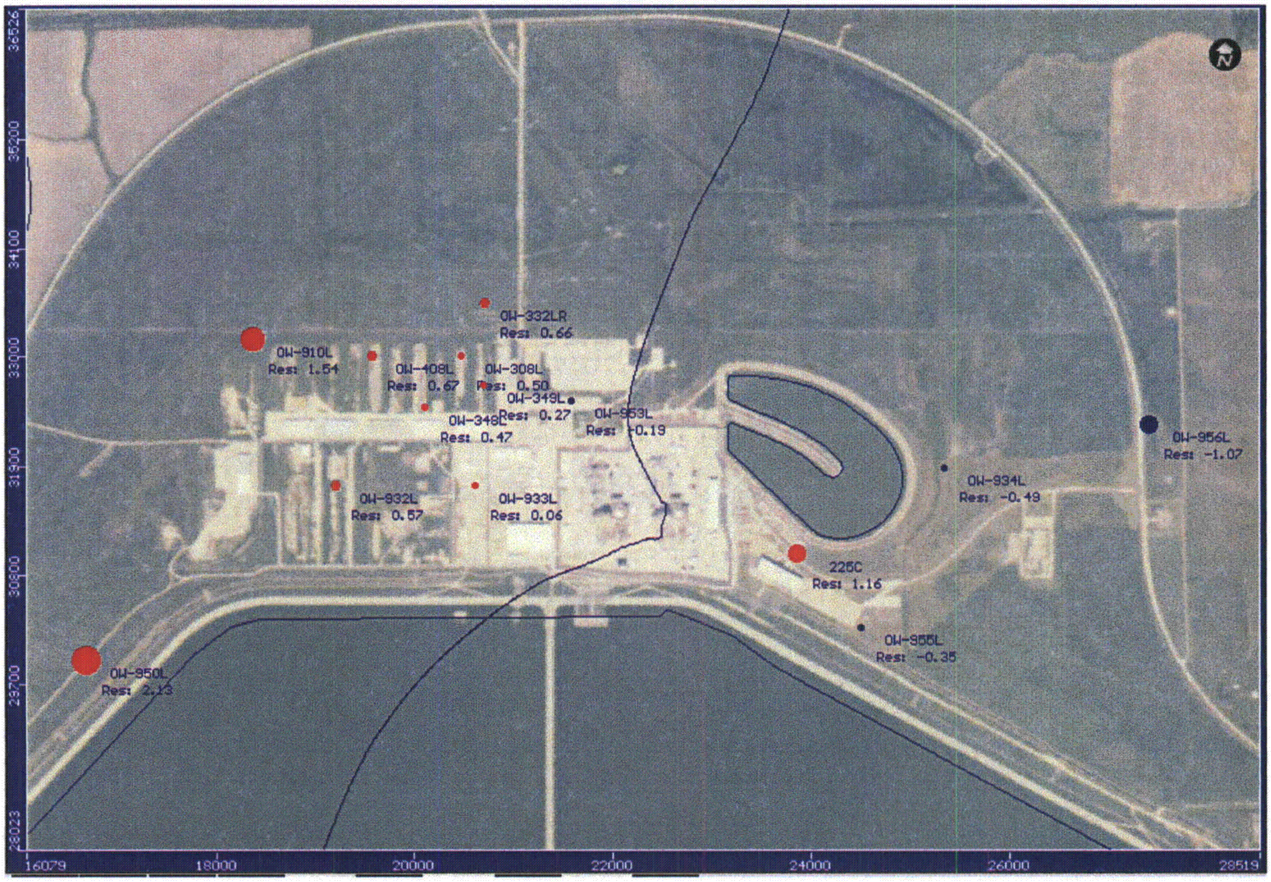
<u>Reference</u>:

1) STPNOC Letter No. U7-C-STP-NRC-090206, "Supplemental Response to Requests for Additional Information," dated November 30, 2009, Attachment 2, "Groundwater Model Development and Analysis for STP Units 3 & 4".



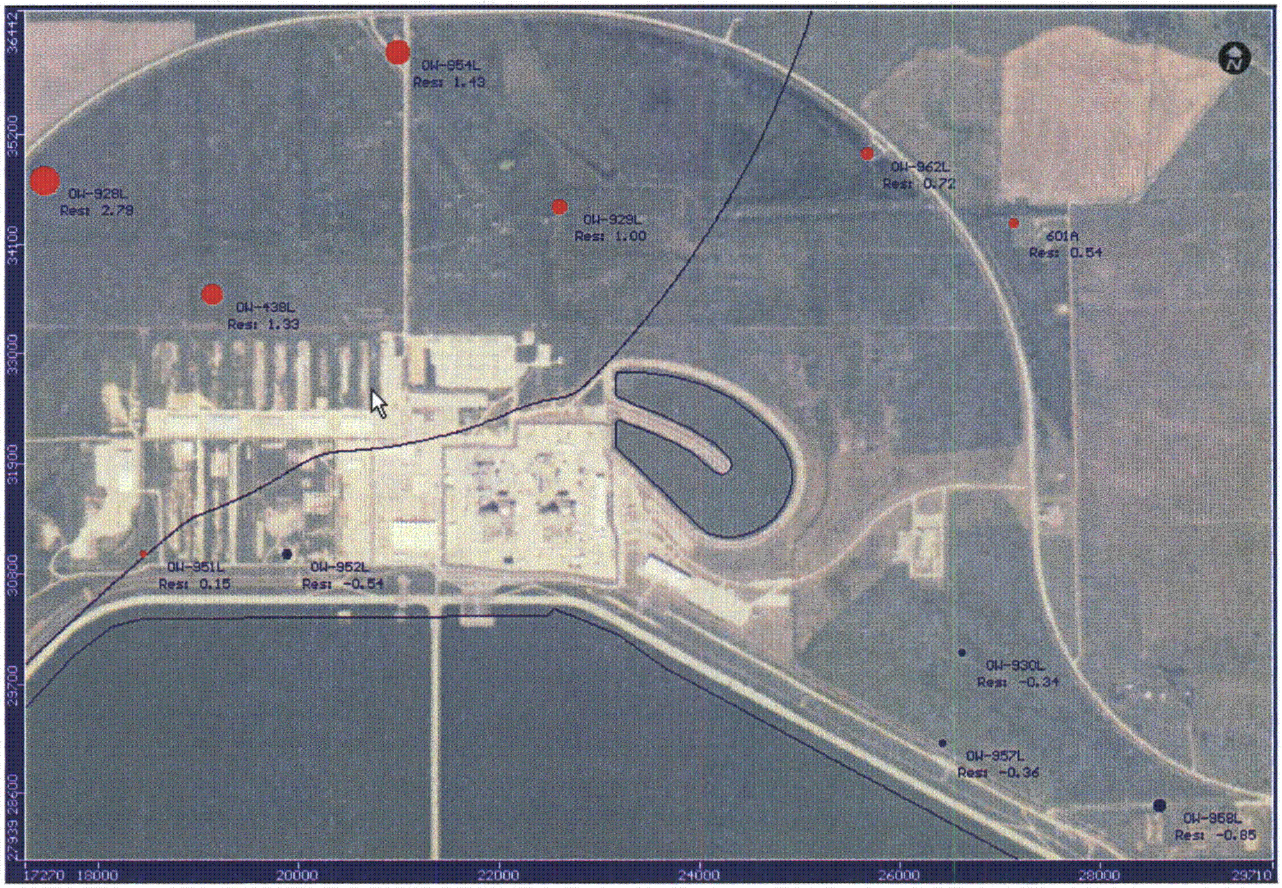
Legend: Red Circles = positive residuals; Blue Circles = negative residuals; Dark Blue Lines = potentiometric surface contours; Light Blue Lines = ditches and other surface water bodies. Scale as noted by model coordinates (ft).

Figure 1. Layer 3 (Upper Shallow Aquifer) Residuals – Run 201.



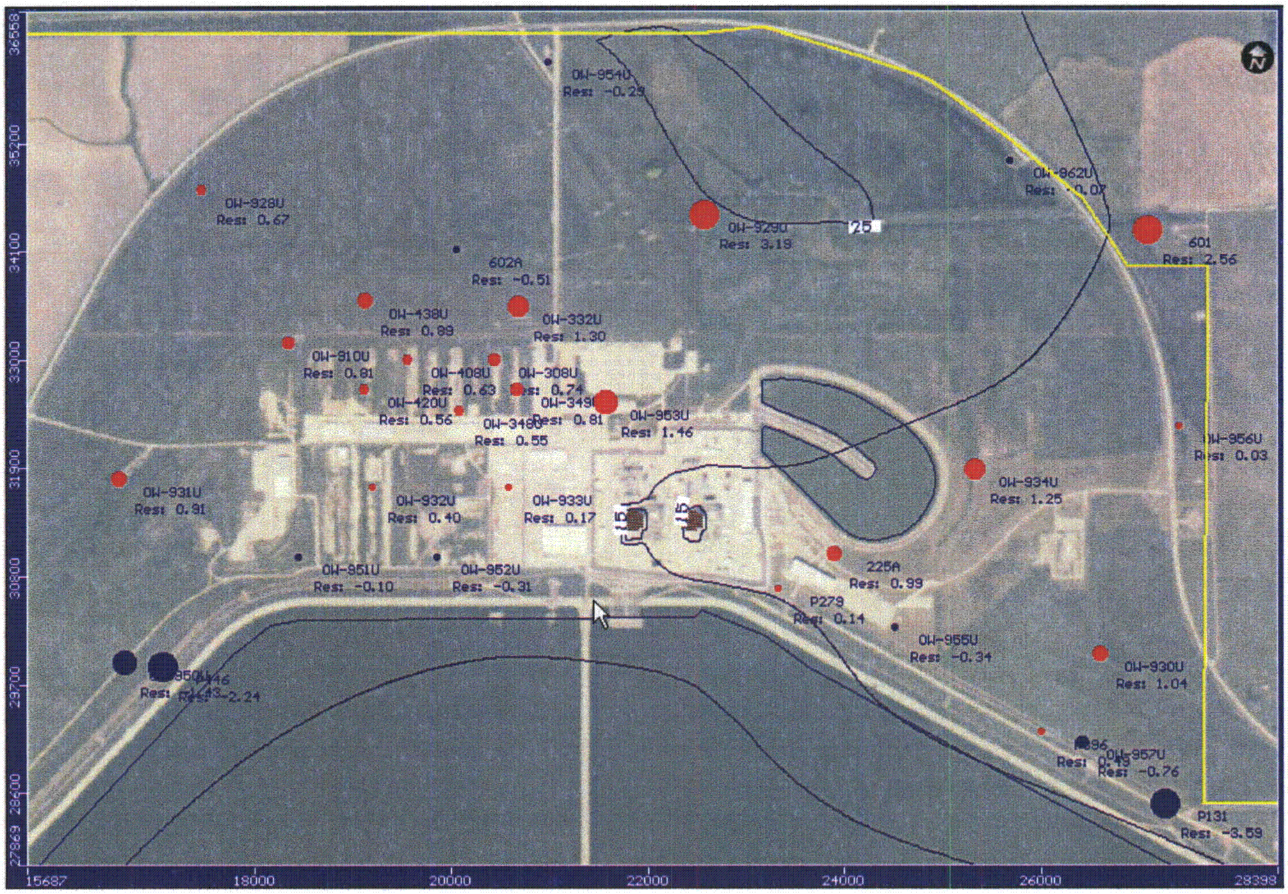
Legend: Red Circles = positive residuals; Blue Circles = negative residuals; Dark Blue Lines = potentiometric surface contours; Light Blue Lines = ditches and other surface water bodies. Scale as noted by model coordinates (ft).

Figure 2. Layer 5 (Lower Shallow Aquifer) Residuals – Run 201.



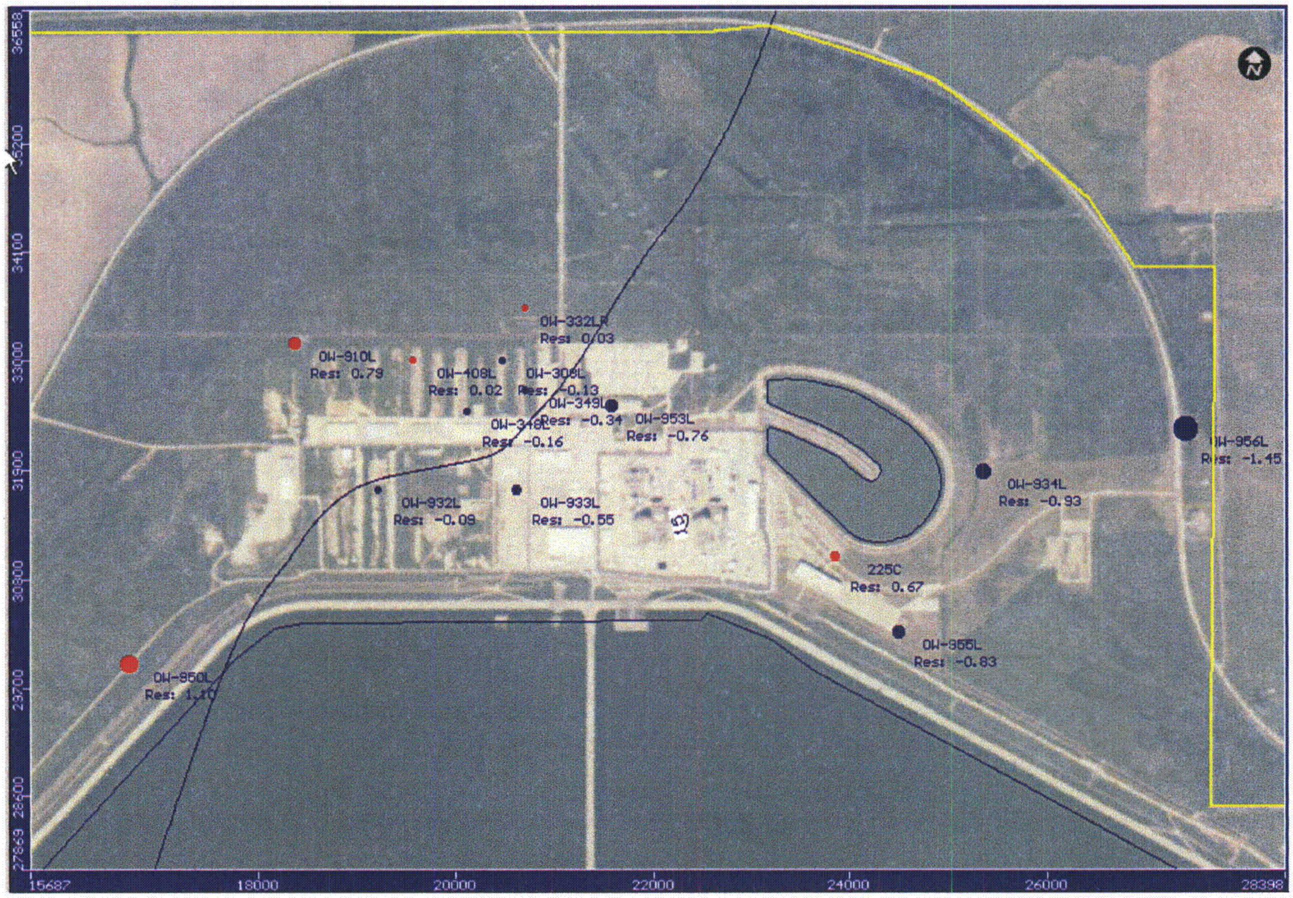
Legend: Red Circles = positive residuals; Blue Circles = negative residuals; Dark Blue Lines = potentiometric surface contours; Light Blue Lines = ditches and other surface water bodies. Scale as noted by model coordinates (ft).

Figure 3. Layer 7 (Lower Shallow Aquifer) Residuals – Run 201.



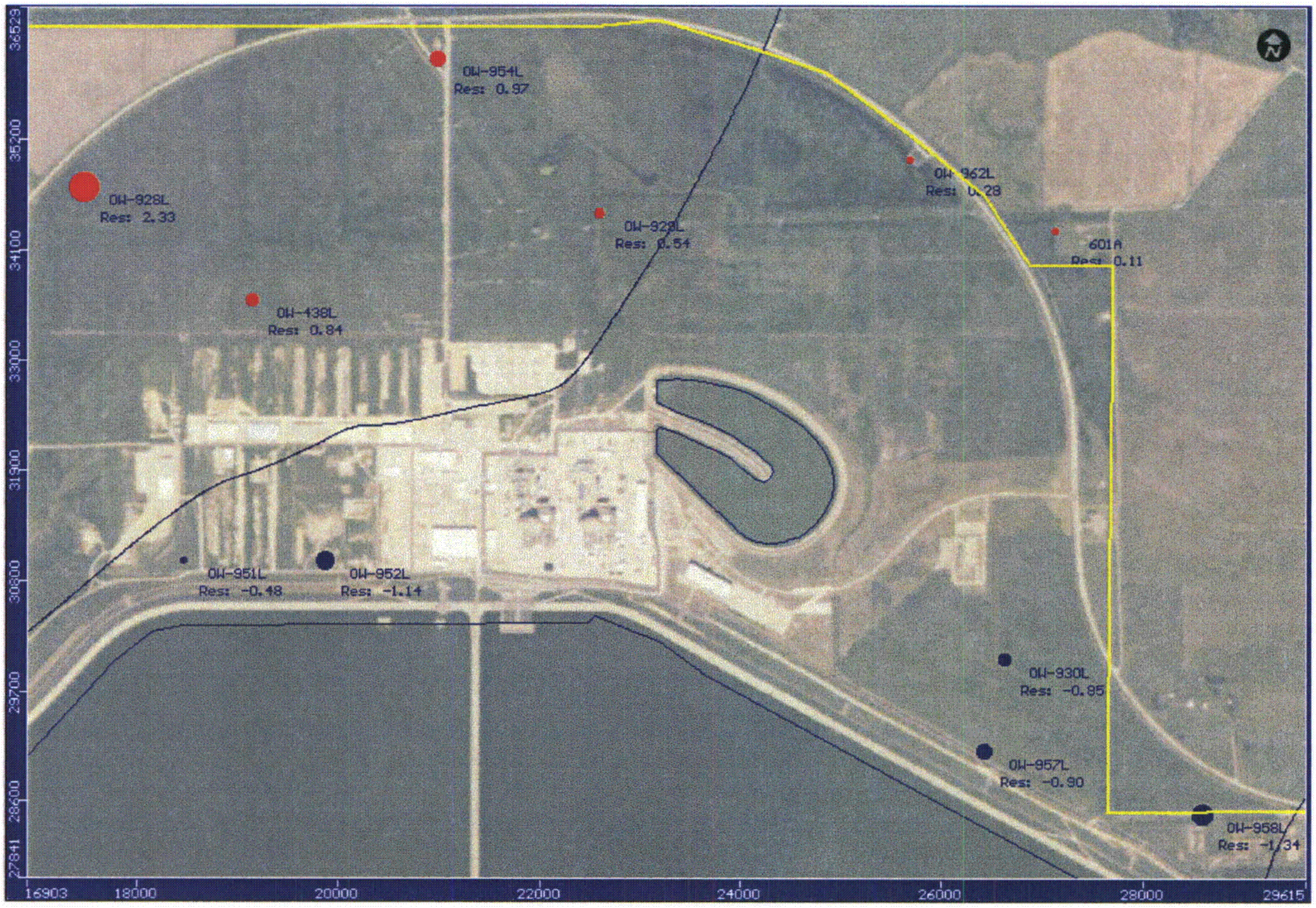
Legend: Red Circles = positive residuals; Blue Circles = negative residuals; Dark Blue Lines = potentiometric surface contours; Light Blue Lines = ditches and other surface water bodies. Scale as noted by model coordinates (ft).

Figure 4. Layer 3 (Upper Shallow Aquifer) Residuals – Run 301.



Legend: Red Circles = positive residuals; Blue Circles = negative residuals; Dark Blue Lines = potentiometric surface contours; Light Blue Lines = ditches and other surface water bodies. Scale as noted by model coordinates (ft).

Figure 5. Layer 5 (Upper Shallow Aquifer) Residuals – Run 301.



Legend: Red Circles = positive residuals; Blue Circles = negative residuals; Dark Blue Lines = potentiometric surface contours; Light Blue Lines = ditches and other surface water bodies. Scale as noted by model coordinates (ft).

Figure 6. Layer 7 (Upper Shallow Aquifer) Residuals – Run 301