STP Nuclear Operating Company
South Texas Project Electric Generating Station P.O. Box 289 Wadsworth, Texas 77483

September 21, 2009
U7-C-STP-NRC-090146

U. S. Nuclear Regulatory Commission
Attention: Document Control Desk
One White Flint North
11555 Rockville Pike
Rockville, MD 20852-2738

South Texas Project
Units 3 and 4
Docket Nos. 52-012 and 52-013
Responses to Requests for Additional Information

Attached are responses to NRC staff questions in Request for Additional Information (RAI) letter number 202, related to COLA Part 2, Tier 2, Sections 2.4S.12, “Groundwater,” 2.5S.2, “Vibratory Ground Motion,” and 2.5S.4, “Stability of Subsurface Materials and Foundations.”

This letter includes the complete response to RAI letter number 202. Attachments 1 through 19 provide the responses to the following NRC staff questions:

02.04.12-27
02.04.12-28
02.04.12-29
02.04.12-30
02.04.12-31
02.04.12-32
02.04.12-33
02.04.12-34
02.04.12-35
02.04.12-36
02.05.02-21
02.05.02-22
02.05.02-23
02.05.02-24
02.05.02-25
02.05.02-26
02.05.02-27
02.05.04-29
02.05.04-30

When a change to the COLA is indicated, the change will be incorporated into the next routine revision of the COLA.

Enclosures 1 and 2 to this letter contain computer model input and output files as requested by the staff. Please note that the files on the enclosed DVDs are unable to comply with the requirements for electronic submission in NRC Guidance Document, "Guidance for Electronic Submissions to the NRC," dated November 20, 2007. The NRC Staff requested that the files be submitted in the native formats required by the software utilized to support development of the STP 3 & 4 COLA. These files contain input/output codes for various models and calculation packages that support the responses to RAI 02.04.12-32 and RAI 02.05.02-23.

There are no commitments in this letter.

If you have any questions regarding these responses, please contact me at (361) 972-7136, or Bill Mookhoek at (361) 972-7274.

STI 32535229

D091
NRO

I declare under penalty of perjury that the foregoing is true and correct.

Executed on 9/21/09

Scott Head
Manager, Regulatory Affairs
South Texas Project Units 3 & 4

rhb

Attachments:

1. RAI 02.04.12-27
2. RAI 02.04.12-28
3. RAI 02.04.12-29
4. RAI 02.04.12-30
5. RAI 02.04.12-31
6. RAI 02.04.12-32
7. RAI 02.04.12-33
8. RAI 02.04.12-34
9. RAI 02.04.12-35
10. RAI 02.04.12-36
11. RAI 02.05.02-21
12. RAI 02.05.02-22
13. RAI 02.05.02-23
14. RAI 02.05.02-24
15. RAI 02.05.02-25
16. RAI 02.05.02-26
17. RAI 02.05.02-27
18. RAI 02.05.04-29
19. RAI 02.05.04-30

Enclosures:

1. DVD: STPNOC Letter U7-C-STP-NRC-090146
   Visual MODFLOW - Input-Output Files (RAI 02.04.12-32)
2. DVD: STPNOC Letter U7-C-STP-NRC-090146
   Site-Specific Soil Property Data (RAI 02.05.02-23)

cc: w/o attachments and enclosure except*
(paper copy)

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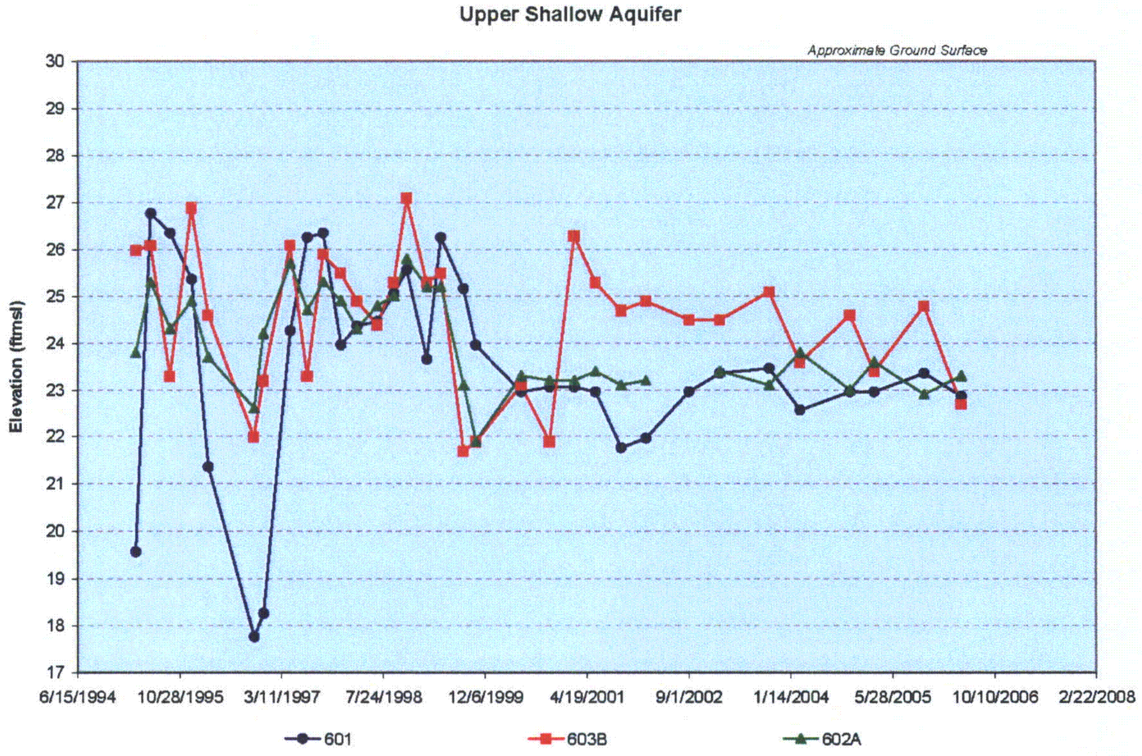
RAI 02.04.12-27

Question:

In its review of the applicant's responses to RAIs 02.04.12-08 and 02.04.12-26, and FSAR Rev 2 Section 2.4S.12.2.3, "Temporal Groundwater Trends", the staff noted that the applicant, STP, described Well 602A data as though it is presented in FSAR Rev 2 Figure 2.4S.12-23; however, the data is not presented in the figure. Revise FSAR Rev 2 Figure 2.4S.12-23 to include the Well 602A data.

Response:

FSAR Figure 2.4S.12-23 will be revised to include the hydrograph from Well 602A, which is shown below. This revised Upper Shallow Aquifer hydrograph will replace the existing top-left hydrograph in FSAR Revision 3, Figure 2.4S.12-23, and ER Revision 3, Figure 2.3.1-28, in a future COLA Revision.



RAI 02.04.12-28

Question:

In the review of (1) the FSAR Rev 2 Sections 2.4S.12.1.4, "Site-Specific Hydrogeology" and 2.4S.12.2.2. "Groundwater Flow Directions", (2) the applicant's response to RAI 02.04.12-09, (3) amendments to FSAR Section 2.4S.12.2.2 noted in the applicant's responses to RAI 02.04.13-4 and 02.04.12-6, (4) revised responses to ER RAIs 02.03-07 and 02.03-08, and (5) remarks contained in the groundwater model development and analysis report (see Section 2.4 on site groundwater levels), the staff note that the reviewed sections, (i.e., FSAR 2.4S.12.1.4 and 2.4S.12.2.2), require update to include current site characterization information and conclusions with regard to plausible pathways, mounding, gradients (including those to southwest), and maps showing the full seasonal variation of groundwater levels through 2008. Note especially conclusions in response to ER RAI 02.03-07 (see "third step" on pages 4 and 5 of 6 where applicant acknowledges flow to southwest, mounding in both Upper and Lower Shallow aquifers, and communication with Kelly Lake to the southeast.) Note also that the labeling of FSAR Figure 2.4S.12-17 is either incomplete or illegible (labeling of aquifers and dates).

Response:

A full year of monthly groundwater level measurements was collected from the Shallow aquifer 300 and 400 series observation wells, and the OW-910 and OW-928 through OW-934 observation wells from December 2006 through December 2007. The groundwater measurement data and corresponding analyses, which include tables and representative maps, have been incorporated into STP COLA Revision 3.

The addition of a groundwater pathway and a new point of exposure on the property line at a hypothetical domestic well (Pathway No. 1) and an analysis of mounding in the Shallow aquifer from the operation of the MCR using the 2006 and 2007 data also has been incorporated into STP COLA Revision 3. Additional discussions of updates to plausible pathways and communication with Kelly Lake based on 2008 hydrogeologic data are addressed in the responses to RAI 02.04.12-31 and RAI 02.04.12-33, respectively.

Quarterly groundwater monitoring was performed on March 28, 2008, June 29, 2008, September 22, 2008, and December 15, 2008 to provide insight to seasonal groundwater fluctuations in the Upper Shallow Aquifer and the Lower Shallow Aquifer for 2008. The third and fourth quarters of 2008 include data collected from 26 additional 900 series observation wells (OW-950 U/L through OW-962 U/L) installed in July and August 2008. The data collected from each of these quarterly monitoring events were used to prepare more comprehensive potentiometric surface contour maps, groundwater flow direction and hydraulic gradient evaluations, and average linear velocity and travel time analyses from STP Unit 3&4 to the site boundaries.

The results of the 2008 evaluation have been integrated with the 2007 data to provide an updated site-specific hydrogeologic characterization, including updated tables, hydrographs, and maps.

In addition, specific changes to certain subsections of FSAR Section 2.4S.12 and ER Section 2.3.1 have been identified to incorporate the hydrogeologic data collected in 2008. The proposed COLA text changes are to include:

- FSAR Section 2.4S.12.1.4, "Site Specific Hydrogeology," will be updated to reflect the inclusion of 26 additional observation wells.
- FSAR Section 2.4S.12.2.2, "Groundwater Flow Directions," and FSAR Section 2.4S.12.2.3, "Temporal Groundwater Trends," will be revised to incorporate the 2008 quarterly water level data.
- FSAR Section 2.4S.12.2.4.1, "Hydrogeological Parameters," will be updated to incorporate the 2008 slug test data.
- FSAR Section 2.4S.12.3.1, "Exposure Point and Pathway Evaluation," will be revised to provide a discussion of Kelly Lake in the pathway analysis.
- FSAR Section 2.4S.12.3.1, "Exposure Point and Pathway Evaluation," will be revised to provide discussion of a flowpath to the west from Unit 4 into the current pathway analysis.
- ER Section 2.3.1.2.3.2, "Site Specific Hydrogeologic Conditions" will be updated to reflect the inclusion of 26 additional observation wells.
- ER Section 2.3.1.2.3.4, "Groundwater Flow Directions and Subsurface Pathways," and ER Section 2.3.1.2.3.5, "Temporal Groundwater Trends and Variations, will be updated to incorporate 2008 quarterly water level data.
- ER Section 2.3.1.2.3.6, "Hydrogeologic Properties," will be revised to incorporate the 2008 slug test data.
- ER Section 2.3.1.2.5.1, "Groundwater Pathway," will be updated to provide a discussion of Kelly Lake and a west flowpath.

Complete COLA text changes to FSAR Sections 2.4S.12 and ER Section 2.3.1 are underway and will be provided separately in a supplement to this RAI in November 2009. These COLA text changes will be incorporated into a future revision of the COLA.

In regards to "acknowledged" mounding in the Lower Shallow aquifer during the "third step" on page 5 of the response to ER RAI 02.03-07, the response acknowledged that impacts from the MCR upon the Lower Shallow Aquifer were undetermined but plausible at that time. Since that time, 26 additional wells have been installed to collect groundwater levels around the MCR in the Lower Shallow Aquifer. In contrast to the Upper Shallow Aquifer, groundwater elevation data collected from the Lower Shallow Aquifer from these wells and the existing 28 observation wells since December 2006 show no obvious mounding impacts to the Lower Shallow Aquifer from the MCR. In addition, a groundwater model (Reference 1) has been completed since submittal of the response to ER RAI 02.03-07. Results of the groundwater model indicate no notable impact from the MCR to the Lower Shallow Aquifer.

With regard to the labeling of FSAR Figure 2.4S.12-17, the subtitles for FSAR Figures 2.4S.12-17, and also 2.4S.12-18, were inadvertently removed between STP COLA Revisions 1 and 2. The figures with the corrected subtitles are provided below and will be included in a subsequent COLA revision.

References:

1. "Groundwater Model Development and Analysis for STP Units 3&4", South Texas Project Letter No. U7-C-STP-NRC-080070, Attachment 2, dated December 15, 2008.

November 1, 2005 Upper Shallow Aquifer

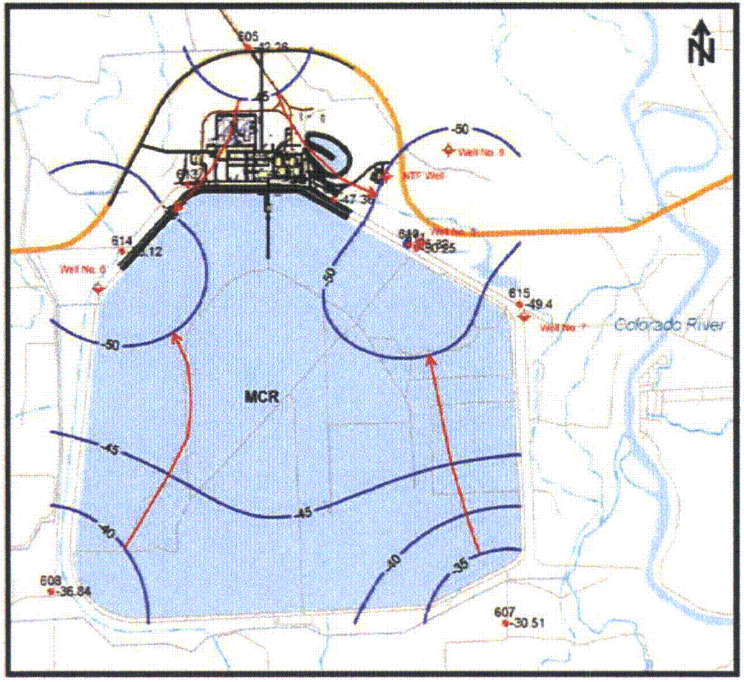
May 1, 2006 Upper Shallow Aquifer

November 1, 2005 Lower Shallow Aquifer

May 1, 2006 Lower Shallow Aquifer

Figure 2.4S.12-17 Shallow Aquifer Potentiometric Surface Maps

November 1, 2005 Deep Aquifer



May 1, 2005 Deep Aquifer

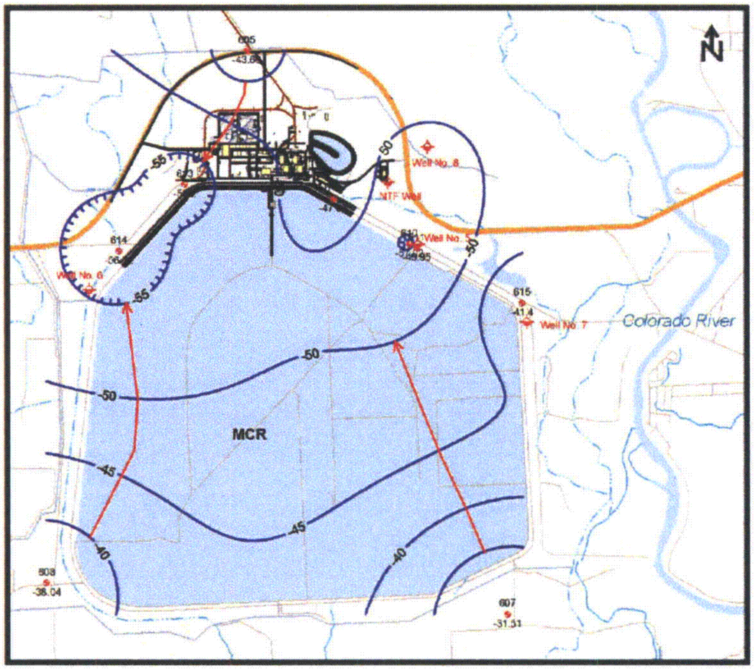


Figure 2.45.12-18 Deep Aquifer Potentiometric Surface Maps

RAI 02.04.12-29

Question:

In the review of the applicant's response to RAI 02.04.12-17, the staff noted that the applicant, STP, has assumed dilution of the tank volume in a substantial fraction of the building volume prior to its release. Staff does not view the dilution volume used as necessarily conservative and request the applicant provide a stronger rationale for adoption of the fraction of building volume applied. Since the normal groundwater level is above the level of the fractured tank, staff requests the applicant comment on the justification for using a fraction of building volume instead of the room that contains the tanks for dilution for conservatism.

In addition to the proposed text changes to Section 2.4S.13.1.2, some update to Section 2.4S.12.3.1, "Exposure Point and Pathway Evaluation", is necessary to reflect the logical inclusion or elimination of pathways. These revisions should also treat the pathways identified as plausible in Section 2.4S.12.2.2, "Groundwater Flow Directions", and Section 2.4S.12.2.3, "Temporal Groundwater Trends".

Please amend the response on chelating agents to include the citation for "Reference 2" (cited on page 3 of 7 of the response to RAI 02.04.12-17 but not listed in references).

Response:

Each of the liquid waste tanks within the Radwaste Building is located within an individual cubicle that is lined with stainless steel to a level high enough to provide secondary containment for the total volume of the tank. However, the entrances to the cubicles (which are above the level of the secondary containment) are not designed to be water-tight and the entrance to each cubicle is at an elevation about 10 ft below the groundwater level in the adjacent aquifer. Therefore, in the unlikely event that the floor or walls of the Radwaste Building were breached below the water level, groundwater would fill the building interior, including each of the tank cubicles, until the potentiometric level inside and outside the building was equal. Consequently, liquid waste simultaneously released from a breached radwaste tank would mix with groundwater filling the flooded building.

Engineering judgment was used to estimate the volume of the radwaste building interior that would be occupied by groundwater entering the building during the postulated release of liquid radioactive waste. Detailed design of the systems and components inside the building is not available, but it is unlikely that these systems and components would occupy a combined volume greater than 50% of the total building volume below the groundwater level. Nevertheless, a dilution volume of 25% of the building volume below the groundwater level is evaluated below to provide a sensitivity analysis.

As described in response to RAI 02.04.12-17, the estimated total volume of the Radwaste Building below the groundwater level is about 6,950,000 gallons. If 25% of this volume is void space, mixing of the heat in the radwaste and groundwater would occur within a volume of approximately 1,737,500 gallons ($\text{Volume}_{\text{mix}}$). Although only one tank ruptures in the postulated accident and it is unlikely that all four Low Conductivity Radioactive Waste Tanks would be full simultaneously, the four tanks are assumed to be filled with radwaste at their design temperature of 80° C (Temp_{rw}). Each tank has a volume of about 37,500 gallons. Therefore, the heat in about 150,000 gallons of liquid radwaste ($\text{Volume}_{\text{rw}}$) would mix with the heat in the groundwater that floods the building. The temperature of the ambient groundwater (Temp_{gw}) averages about 23.2° C.

The volume of ambient groundwater ($\text{Volume}_{\text{gw}}$) that would be heated by the radwaste is simply the difference between $\text{Volume}_{\text{mix}}$ and $\text{Volume}_{\text{rw}}$, or 1,587,500 gal. The temperature of the mixing waters is calculated with a weighted average, based on the equation for heat transfer ($Q = mc\Delta T$) and the First Law of Thermodynamics. The temperature of water in the Radwaste Building after failure of the liquid waste tank and flooding of the building with groundwater (Temp_{mix}) would be:

$$\text{Temp}_{\text{mix}} = [(\text{Temp}_{\text{rw}})(\text{Volume}_{\text{rw}}) + (\text{Temp}_{\text{gw}})(\text{Volume}_{\text{gw}})] / \text{Volume}_{\text{mix}}$$

$$\text{Temp}_{\text{mix}} = [(80^\circ\text{ C})(150{,}000\text{ gal}) + (23.2^\circ\text{ C})(1{,}587{,}500\text{ gal})] / 1{,}737{,}500\text{ gal} = 28.1^\circ\text{ C}$$

The difference in temperature between the mixture of spilled radwaste and groundwater inside the building and ambient groundwater outside the building is estimated to be 28.1° C – 23.2° C, or 4.9° C. Based on this analysis, the heat within a postulated release of liquid radwaste does not appear to be great enough to cause thermal buoyancy of the waste.

Notwithstanding this conclusion, it should be noted that the discussion in FSAR Section 2.4S.12.3.1 presumes a release scenario in which liquid waste is released to both the Upper and Lower Shallow aquifers:

1. The waste tank that is postulated to fail is located in the basement of the Radwaste Building, which is within the Upper Shallow aquifer;
2. The excavation for construction of the deep foundations of the buildings in the Units 3 & 4 power block will penetrate the aquitard separating the Upper and Lower Shallow aquifers and terminate approximately 20 ft below the top of the Lower Shallow aquifer;
3. The excavation will be backfilled with relatively permeable engineered backfill; and,
4. Groundwater levels in observation well pairs throughout the site of Units 3 & 4 indicate a downward vertical flow gradient from the Upper to the Lower Shallow aquifer.

However, if it is assumed that thermal buoyancy would be a viable mechanism to raise liquid radwaste into the near-surface portion of the Upper Shallow aquifer during the postulated release, it would be contained within an isolated area by a low-permeability slurry wall that will be installed from land surface to the base of the Lower Shallow aquifer around the perimeter of the power block to allow construction dewatering. Within this contained area the buoyancy effect would dissipate within a short distance from the Radwaste Building because of mixing with and cooling by the ambient groundwater. The natural downward vertical hydraulic gradient would then transport the dilute radwaste downward into the Lower Shallow aquifer within the engineered backfill, which will have a hydraulic conductivity greater than that of the surrounding native soil.

This scenario has been evaluated using a three-dimensional numerical model of the groundwater system in the vicinity of STP 3 & 4. That model evaluates various groundwater pathways from the power block area, using a particle-tracking algorithm. Figure 94 from the report describing the model and its results (Reference 1) shows that a release within the Upper Shallow aquifer in the area of the STP 3 & 4 power block would be transported vertically downward into the Lower Shallow aquifer, and then laterally downgradient, completely within the Lower Shallow aquifer. The model includes post-construction simulations with and without a slurry wall to predict the effects of the slurry wall on the pathway analysis because a final decision on whether a slurry wall will remain after construction was unknown. Both post-construction simulations indicate that the postulated release would travel downward within the engineered backfill and flow to the southeast within the Lower Shallow aquifer, and that no significant effect to the pathway would be expected to occur whether or not a slurry wall is left intact following construction.

Updated contents for FSAR Section 2.4S.12.3.1, "Exposure Point and Pathway Evaluation", FSAR Section 2.4S.12.2.2, "Groundwater Flow Directions" and FSAR Section 2.4S.12.2.3, "Temporal Groundwater Trends", including supporting figures and tables, have been incorporated into STP COLA Revision 3.

Regarding the portion of the response to RAI 02.04.12-17 that discusses chelating agents, there is no Reference 2 for that response. Reference 1, which is provided in the response to RAI 02.04.12-17, was referred to in the response as Reference 2.

References:

1. "Groundwater Model Development and Analysis for STP Units 3&4", South Texas Project Letter No. U7-C-STP-NRC-080070, Attachment 2, dated December 15, 2008.

No further COLA revisions are required as a result of this RAI response.

RAI 02.04.12-30

Question:

In the review of the applicant's response to RAI 02.04.12-17, including review of FSAR Rev 2 Sections 2.4S.12.3.1, 2.4S.12.3.2, and 2.4.S.13.1.2, and the response to RAI 02.04.12-1, the staff noted the applicant has considered information in the Annual Environmental Operating Report (no specific report cited) to determine the site conceptual model. In staff's review of the applicant's Annual Environmental Operating Report for 2006 (issued April 2007), staff note that sixteen shallow aquifer wells were sampled for various radionuclide concentrations within the Protected Area. Since some values were detected above laboratory detection limits but were below the EPA drinking water standard, the following information is requested: Provide the well location and screen depth/interval of all wells that drew samples from the Upper Shallow Aquifer (or a relatively shallow depth near the facilities) and the location and screen depth/interval of wells that drew samples from the Lower Shallow Aquifer (or a relatively deep depth near the facilities). Comment on whether these data support or refute the assumption that releases will be forced downward into the Lower Shallow Aquifer by a downward hydraulic gradient. Revise the site conceptual model described in Section 2.4S.12.3.1, "Exposure Point and Pathway Evaluation", and Section 2.4S.13.1.2, "Conceptual Model" to reflect these observed contamination levels, their relative position, and whether they support or refute the existing conceptual model, (i.e., groundwater contamination moves from Upper to Lower Shallow Aquifer).

Response:

Table 1 provided below lists the screen-depth interval and tritium concentrations of 29 observation wells sampled quarterly in the STP 1 & 2 protected area over the past several years. Six shallow-deep well pairs (218 C&E; 220 C&E; 221 C&E; 223 C&E; 241 C&E and 245 C&E) and one shallow-deep well triplet (222 C, E&H) are listed in Table 1 and the locations of each of the listed wells are shown in Figure 1. In five of the six well clusters, measured tritium concentrations are greater in the deeper well. It can be noted that most of the protected area was excavated to a maximum depth of approximately 60 feet below grade to allow construction of deep foundations for various safety-related structures. Therefore, many of the observation wells within the protected area are completed within or adjacent to structural fill. The observed distribution of tritium concentrations is consistent with the site conceptual model that asserts: due to the pervasive downward vertical hydraulic gradient, releases to the Upper Shallow aquifer will flow downward to the Lower Shallow aquifer where the hydraulic conductivity of the material separating the aquifers is conducive to downward flow.

The sixth well pair (221 C&E) is located within 30 ft of an underground pipe that ruptured in 2003 and was the source of the tritium, as discussed in the STP Annual Environmental Operating Report of 2006. The tritium concentration is greater in the shallower well in this pair because it is located within the source area of the release, where residual tritium is likely adsorbed within the shallow unsaturated zone. The deeper well in the 221 C&E pair also contains a relatively high tritium level, indicating that tritium is being transported downward. This finding also supports the site conceptual model.

Results at the well triplet are indeterminate. The shallowest well (222 E) has a tritium concentration slightly above the minimum detectable concentration of 300 pCi/L, but no tritium was detected in the deepest well of the three (222 H). An unidentified anomaly in the local stragtigraphy or sampling error may have contributed to this result. In any event, any minor inconsistency in the tritium data at this location (which is very close to the lower limit of detection) is not sufficient to refute the site conceptual model that is consistent with a high proportion of the site data.

Updated contents for FSAR Section 2.4S.12.3.1, "Exposure Point and Pathway Evaluation" and FSAR Section 2.4S.13.1.2, "Conceptual Model", have been incorporated into STP COLA Revision 3.

No further COLA revisions are required as a result of this RAI response.

Table 1

Summary of Observation Wells Sampled in the Protected Area
STP Units 1 and 2

Well No.	Depth (ft)	Screen Interval (ft below grade)	Tritium Concentration (pCi/L)	Date Sampled
201E	83	78 - 83	<300	3rd Qtr 2008
203C	18	13 - 18	<300	4th Qtr 2005
218C	43	38 - 43	<300	4th Qtr 2005
218E	83	78 - 83	408	4th Qtr 2005
220C	21	16 - 21	<300	2nd Qtr 2009
220E	40	35 - 40	3,220	2nd Qtr 2009
221C	43	38 - 43	2600	2nd Qtr 2009
221E	82	77 - 82	2040	2nd Qtr 2009
222C	24	19 - 24	<300	4th Qtr 2008
222E	20	15 - 20	420	1st Qtr 2006
222H	50	45 - 50	<300	1st Qtr 2006
223C	43	38 - 43	274	4th Qtr 2005
223E	86	81 - 86	994	1st Qtr 2006
225C	28	23 - 28	<300	1st Qtr 2006
225E	43	38 - 43	<300	1st Qtr 2006
230C	44	39 - 44	971	1st Qtr 2006
238E	16	11 - 16	<300	4th Qtr 2005
241C	44	39 - 44	386	4th Qtr 2005
241E	85	80 - 85	442	1st Qtr 2006
243C	36	31 - 36	<300	1st Qtr 2006
243E	62	57 - 62	<300	4th Qtr 2005
244C	41	36 - 41	<300	4th Qtr 2005
244E	32	27 - 32	<300	1st Qtr 2006
245C	42	37 - 42	<300	4th Qtr 2005
245E	91	86 - 91	387	1st Qtr 2006
273K	>90	>90	<300	1st Qtr 2009
MW-801	31	20 - 30	<300	2nd Qtr 2009
MW-802	26	15 - 25	<300	2nd Qtr 2009
MW-803	29	23 - 28	<300	2nd Qtr 2009

Note: Colors denote well pairs.

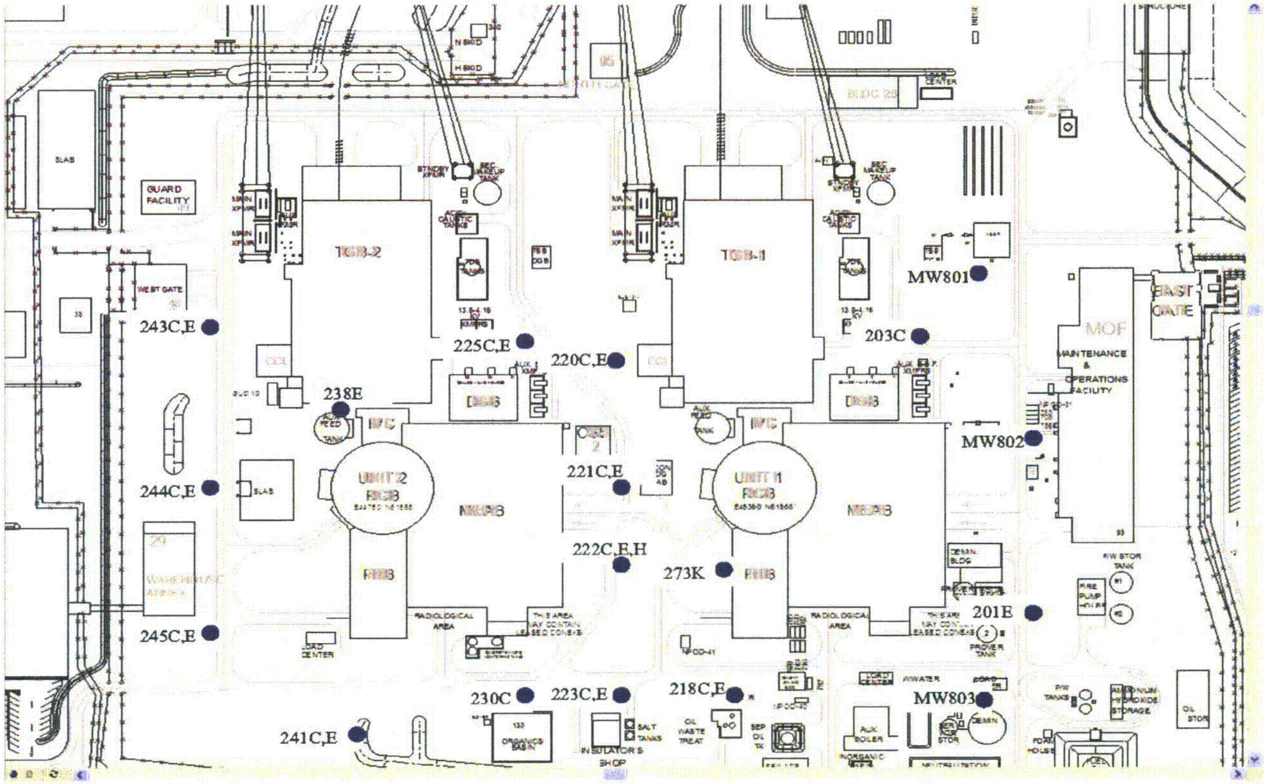


Figure 1 - Observation Wells Sampled in the STP 1 & 2 Protected Area

RAI 02.04.12-31

Question:

In the review of the applicant's response to RAI 02.04.12-18, the staff noted that the applicant, STP, refers to the future incorporation of changes to FSAR Sections 2.4.12 and 2.4.13 when "NRC commitment COM 2.4S-2" is complete. COM 2.4S-2 is in reference to changes to the application to reflect groundwater level measurements collected through 2008 and analyzed for one year of data from STP 3&4 observations wells. In the RAI response STP also committed to incorporating groundwater pathway changes including a point of exposure on the property line, (i.e., a groundwater well supplying domestic water). STP states that this will involve changes to Subsections 2.4S.12.3.1 and 2.4S.12.3.2, and Table 2.4S.12-17 as well as FSAR Section 2.4S.13. The staff request that the proposed changes to specific sections, tables, and figures be provided.

Any calculation packages associated with the new point of exposure be made available for staff review.

Regarding the commitment to incorporate changes in groundwater pathways, in the review of the applicant's revised response to ER RAI 02.03-07 and Safety RAI 02.4S.12-20, the staff noted that communication between Kelly Lake and the Upper Shallow Aquifer, and the upward gradient between the Lower and Upper Shallow Aquifers imply that Kelly Lake is a plausible exposure pathway for both the Upper and Lower Shallow Aquifers requiring evaluation in Section 2.4S.12.3.1. Staff request that the FSAR be revised to include this pathway.

Response:

The COLA revisions regarding the addition of a groundwater pathway and a new point of exposure on the property line at a hypothetical domestic well (Pathway No. 1) have been incorporated into STP COLA Revision 3. The specific sections of COLA Revision 3 that reflect these changes include: 1) FSAR Subsections 2.4S.12.3.1, 2.4S.12.3.2 and Table 2.4S.12-17; and 2) FSAR Subsections 2.4S.13.1.2, 2.4S.13.1.3, 2.4S.13.1.4, Table 2.4S.13-4 and Figure 2.4S.13-2. The COLA revisions that reflect the 2008 groundwater level measurements and analysis are provided in the response to RAI 02.04.12-28 and will be included in a future COLA revision.

The calculation package that includes Pathway No. 1 (i.e., the new point of exposure at the hypothetical domestic well located at the eastern site boundary 7,300 feet from the Unit 3 radwaste building) will be made available to NRC staff for review.

While the September 2008 water level data cited in the responses to ER RAI 2.3-7 and Safety RAI 02.04.12-20 (i.e., two well pairs OW-959U/L and OW-961U/L installed in the Shallow Aquifer near Kelly Lake) indicate a slightly upward vertical gradient, the December 2008 data from these same well pairs exhibited a slightly downward vertical gradient. A third well pair (OW-960U/L) immediately west of the lake exhibited no upward gradient during either the September 2008 or the December 2008 well measurements. The December 2008 data and analysis are presented in the response to RAI 02.04.12-28.

Although an exposure pathway within the Shallow Aquifer from Unit 3 to Kelly Lake may be plausible, the point of exposure within Pathway No. 1 is much closer than and in the same direction as Kelly Lake. Consequently, it is believed that the Pathway No. 1 point of exposure provides a more prudent analysis location than Kelly Lake considering that the lake is over 3,500 feet further to the southeast. The additional 3,500 feet of groundwater flow path for a postulated release of liquid effluent provides additional distance over which adsorption and mechanical dispersion can occur and additional travel time during which radioactive decay can occur. As stated above, the analysis for the Pathway No. 1 point of exposure has been incorporated into STP COLA Revision 3.

No further COLA revisions are required as a result of this RAI response.

RAI 02.04.12-32

Question:

In the review of the applicant's response to RAI 02.04.12-20, the staff noted the applicant, STP, (1) did not provide a copy of Figure 2.4S.12-XB, (2) noted the application of Visual MODFLOW to create and apply a site-specific groundwater model, and (3) commitment to future FSAR revisions that were not provided. The staff request (1) a copy of Figure 2.4S.12-XB, (2) copies of input and output representative of the Visual MODFLOW simulations completed and significant to conceptualizing the site and simulating plausible alternative transport pathways applied in FSAR Section 2.4.13, and (3) copies of proposed revisions to FSAR Sections 2.4.12 and Section 2.4.13 text, tables, and figures in response to RAI 02.04.12-20 and the completed groundwater model simulations.

Response:

(1) A copy of Figure 2.4S.12-XB is included with this response.

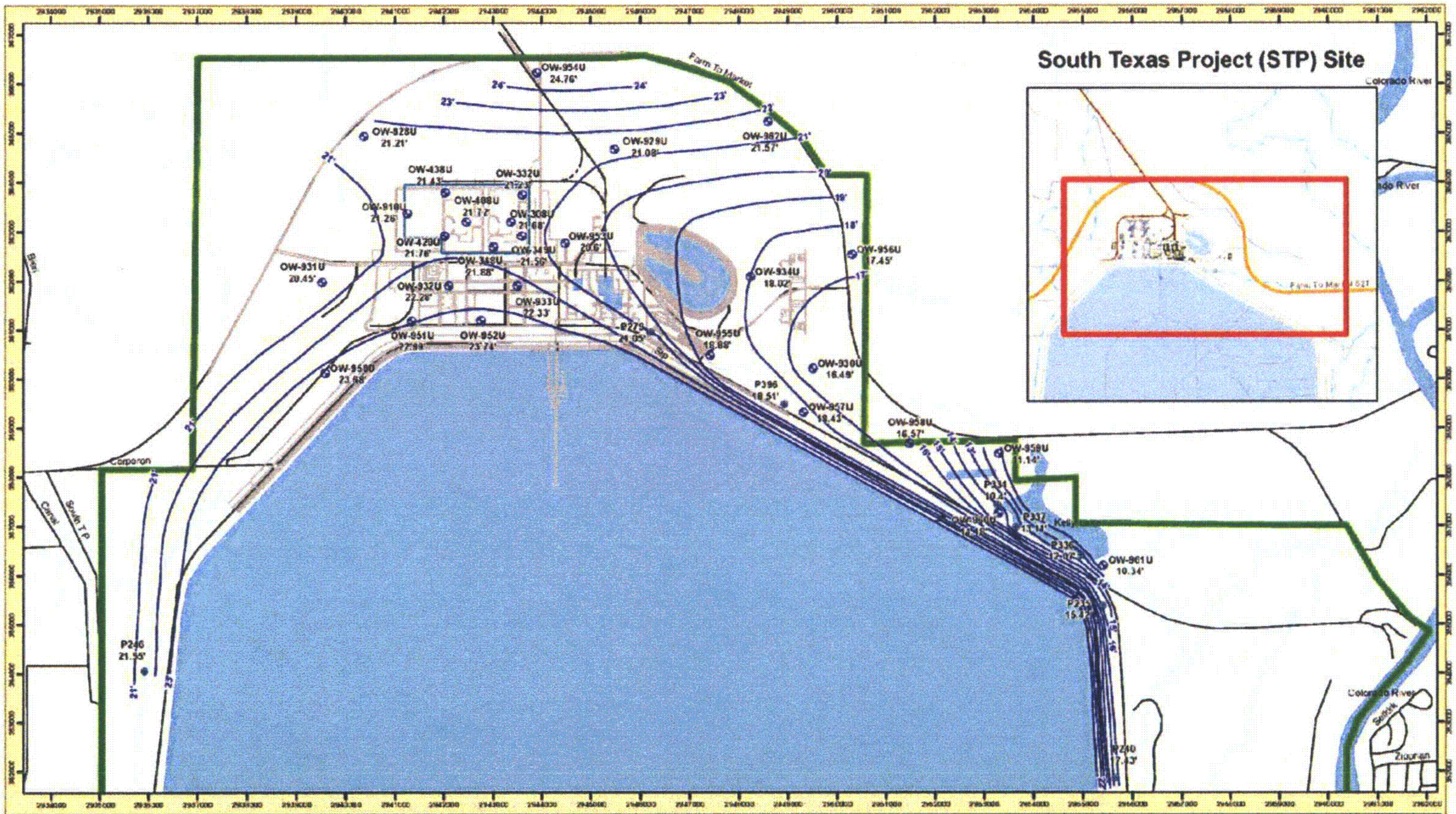
(2) Input and output files representative of the Visual MODFLOW simulations are provided on the enclosed DVDs.

(3) The COLA revisions in response to RAI 02.04.12-20 have been incorporated into STP COLA Revision 3. The completed groundwater model simulations are included in Reference 1.

No further COLA revisions are required as a result of this RAI response.

Reference

1: "Groundwater Model Development and Analysis for STP Units 3&4", South Texas Project Letter No. U7-C-STP-NRC-080070, Attachment 2, dated December 15, 2008.



Potentiometric Surface Map of the Upper Shallow Aquifer - September 22, 2008

Figure 2.4S.12-XB

Projection: Texas South Central State Plane, FIPS 4204
H. Datum: North American Datum 1927
V. Datum: National Geodetic Vertical Datum 1929
Display: Texas South Central State Plane
GIS Map Code: US STPR 000087 R000A

RAI 02.04.12-33

Question:

In the review of the document "Groundwater Model Development and Analysis for STP Units 3&4" provided as part of applicant's response to RAI 02.04.12.20, the staff noted that while the purpose of a groundwater flow model for a site goes beyond just calibration, one of the primary bases for determining a model's reliability to predict post-construction conditions is documenting its ability to reproduce existing field observation. The staff conclude from the review (of the FSAR Rev 2 Sections 2.4S.12 and 2.4S.13, and RAI responses including 2008 data and interpretations) that among the critical observed field conditions not reproduced by the existing model one must include (1) a groundwater divide in the Upper Shallow Aquifer in the immediate vicinity of the proposed location for STP Units 3&4, (2) a groundwater divide (that can not be excluded) in the Lower Shallow Aquifer in the immediate vicinity of the proposed location for STP Units 3&4, and (3) an exposure pathway in the vicinity of Kelly Lake where there is an upward gradient from the Lower to the Upper Shallow Aquifer and the Upper Shallow Aquifer is hydraulically connected to Kelly Lake. Provide either 1) a revised conceptual model to better represent the current observed field conditions, a revised numerical model, its revised results and conclusions, and proposed changes to the FSAR Sections 2.4.12 and 2.4.13, or 2) a justification of why these inconsistencies between observations and model predictions do not make the model unreliable for these assessments.

Reference: "Groundwater Model Development and Analysis for STP Units 3&4", South Texas Project, U7-C-STP-NRC-080070, Attachment 2, by Bechtel Power, December 2008.

Response:

1) Figure 60 of Reference 1 shows groundwater contours for the Upper Shallow Aquifer before construction of STP 3&4, simulated by the numerical model calibrated to the September 22, 2008 groundwater data. Figure 60, which uses a five-foot contour interval, shows a reasonably well calibrated model on a gross, model-wide scale when compared to the September 22, 2008 groundwater elevations immediately to the west (upgradient) and to the east (downgradient) of STP Units 3&4. However, the groundwater flow divide in the immediate vicinity of the proposed location of STP Units 3&4 is not apparent in Figure 60, or by contouring the results presented in Figure 60 with a one-foot contour interval. Consequently, revision to the conceptual model upon which the numerical model is based is warranted.

   Preliminary runs of the current numerical model were executed to evaluate the effectiveness of the following proposed modifications to the conceptual model.

   The groundwater divide in the Upper Shallow Aquifer appears as an area where groundwater inflow converges from the north and, to a lesser degree, from the south (sources), and where groundwater outflow is toward the east and, to a lesser degree, toward the west (sinks). Field data indicate potential influence from the unnamed surface drainage features shown in Figure 44 of Reference 1 on the potentiometric surface of the Upper Shallow Aquifer, and that seasonal changes affect the appearance and formation of the divide (see June 29, 2008 map provided with response to RAI 02.04.12-28). Conceptually, the source from the north may include the flooded marshes, ponds, and the levee-bound irrigation channels located along and beyond the north site boundary, as depicted on the 1995 Blessing SE, TX USGS 7½-minute topographic map provided as Figure 1 below.

The highlighted features of this map show levee-bound agricultural irrigation channels along the north and west site boundaries that provide water to local agricultural field-irrigation siphons by routing the water through the channels at elevated heads with respect to the land surface. Unlike the flooded marshes and ponds, these irrigation channels can be assumed to penetrate to the Upper Shallow Aquifer (layer 2 of the numerical model) considering construction of the levees likely required the layer 1 clay to be removed from the excavated channel to a depth where communication with the Upper Shallow Aquifer would occur. The irrigation channels are simulated in the current numerical model (Reference 1) as drain cells in layer 1 with a low conductance that greatly restricts communication with layer 2. However, conceptually it is plausible that these features actually function as a source and would be best represented in the numerical model by specified head cells with the head specified above land surface. This concept was tested by executing subsequent preliminary runs of the current numerical model. Results indicate that specified heads in layer 1 alone did not satisfactorily create the north source. However, when the specified head cells were extended to layer 2 to simulate an unlined irrigation channel in direct communication with layer 2, significant flow from the north occurred in the Upper Shallow Aquifer.

The general head boundaries (GHB) along the northern perimeter of the model represent conceptual lateral inflow within the Shallow aquifer system from aquifer recharge in the outcrop area beyond the model domain. Adjustments to these GHB can provide a more southerly, instead of southeasterly, flow direction to simulate the observed field conditions at STP Units 3&4.

The source from the south is likely caused by seepage from the MCR or the channel along the north perimeter of the MCR. The south source tends to be less pronounced based on FSAR Figure 2.4S.12-19b (June 2007 and September 2007) and the contour map of the March 2008 data provided with the response to RAI 02.04.12-28. Conceptually, these opposing sources from the north and south would create the convergence of groundwater flow best documented at STP Units 3&4 by the September and December 2008 data (provided with the response to RAI 02.04.12-28).

The existing groundwater sinks to the east that cause the prevalent east-southeast flow from STP Units 3&4 include the structural backfill at STP Units 1&2, the unnamed stream that discharges to Kelly Lake, Kelly Lake, and ultimately, the Colorado River. The current numerical model simulates a depression in the water table of the Upper Shallow Aquifer at Units 1&2. The footprints of various building foundations in the power block area are not considered in the current model. To better represent the observed potentiometric surface, the effect caused by the building foundations can be simulated by deactivating the cells that correspond to the building footprints, and by adjusting the hydraulic conductivity of the cells that represent the structural backfill at Units 1&2.

Sinks that can contribute to the formation of the minor component of outflow from STP Units 3&4 to the west may be the western Little Robbins Slough, the relief wells along the northwest and west perimeter of the MCR, and drainage ditches located about one mile to the west and southwest. Along with the described changes to the Unit 1&2 power block, the drain cells representing the MCR relief wells were altered in the preliminary revised numerical model by adjusting the activation heads along a linear array of cells rather than at discrete drain cells. These changes alone produced the minor west to southwest flow component indicated by the field data and reduced the depression in the water table at Units 1&2. However, the other drain cells have no apparent effect on formation of the groundwater divide in the current simulation of model layer 2 (Figure 60 of Reference 1). To further refine the numerical model, either the conductance of those drain cells can be increased, or the drain cells can be extended into model layer 2.

The numerical model simulates each aquifer as homogeneous and isotropic. However, the results of slug tests conducted at each of the 54 observation wells demonstrate that the aquifer hydraulic conductivity is not homogeneous and isotropic. Modeling the distribution of aquifer hydraulic conductivity as inhomogeneous and anisotropic may improve the simulation of observed heads. Maps illustrating the potential anisotropic condition within the Upper Shallow Aquifer and the Lower Shallow Aquifer will be presented in the response to RAI 02.04.12-28.

To achieve the desired results, the following were shown to be effective during preliminary subsequent runs of the current numerical model:

- Adjust the general head boundaries along the north perimeter of the model to achieve the more southerly flow pattern observed in the Upper Shallow Aquifer. In the preliminary run, effective results were achieved when these boundaries were increased to an elevation of 50 feet, and the conductance was adjusted by increasing the distance by 500 feet.
- Represent the relief wells located along the perimeter of the MCR with a linear array of drain cells instead of discrete drain cells. Adjust the drain cell activation heads in model layer 2 based on the water table and land surface elevations.
- Model STP Units 1&2 building foundations by inactivating cells that currently represent structural backfill.
- Adjust the hydraulic conductivity of cells representing structural fill at STP Units 1&2 one order-of-magnitude lower.
- Model groundwater sources to the Upper Shallow Aquifer using specified head boundaries that represent the presumably unlined, levee-bound irrigation channels located along and beyond the north and west site boundary. This change is most effective when the specified head boundaries are placed within layer 2 with a low conductance.

- Model Little Robbins Slough and drainage ditches located about one mile to the west and southwest of the proposed Unit 3&4 power block as sinks to the Upper Shallow Aquifer, using drain cell boundaries.
- Contour the hydraulic heads simulated by the revised model with a one-foot contour interval.
- Use the results of slug tests conducted at each of the 54 observation wells to justify anisotropic conditions in the numerical model, which may assist in better simulation of observed heads. Maps illustrating the potential anisotropic condition within the Upper Shallow Aquifer and the Lower Shallow Aquifer will be presented in the response to RAI 02.04.12-28.

Results of the preliminary run for the Upper Shallow Aquifer are not provided because they were not conducted with a final, calibrated model with a verified mass balance or a verification run. Verification of the validity of assumptions presented in the revised conceptual model, model recalibration and verification will be conducted during Revision 2 of the numerical model. Model results will be provided separately in follow-up response to this RAI in November 2009.

2) Based on groundwater levels measured at the site since December 2006, the prevalent flow direction in the Lower Shallow Aquifer has been consistently toward the southeast with a mean gradient of 0.0004. In the Lower Shallow Aquifer, the potentiometric surface has been relatively flat at STP 3&4 compared with the remainder of the site, which has resulted in variability in apparent flow direction. For example, the September 26, 2007 and March 28, 2008 data show no graphically discernable divide at STP 3&4; the December 17, 2007 data show a minor flow component converging at STP 3&4 from the west (OW-910L) and the southeast (OW-933L) toward OW-932L; the June 29, 2008 data show a minor flow component to the northwest from OW-910L to OW-928L; September 22, 2008 data show a minor southwest flow component from OW-951L to OW-950L; and December 15, 2008 data show a minor northeast flow component from OW-950L to OW-951L.

Compared to the prevalent southeast flow direction, the differences in hydraulic head between these wells are typically on the order of hundredths of feet across distances of hundreds to thousands of feet. Consequently, several factors can contribute to the apparent variability in flow direction, including:

- Changes in barometric pressure or tides during a water-level measurement event,
- Seasonal fluctuation in water levels, and
- Climatic trends.

The reasons for the flat potentiometric surface at STP Units 3&4 are not known. However, a sustained drought since April 2008 may have exacerbated the formation and effects of the flat potentiometric surface area, considering the lowered head would decrease the hydraulic gradient. This would accentuate the effects on the data by the possible causes outlined above. Considering these factors and the variability in groundwater levels west of STP Units 3&4, a consistent groundwater flow divide at Units 3&4 has not been documented by field data collected from the Lower Shallow Aquifer. The data collected to date demonstrate a consistent and prevalent southeast direction of groundwater flow in the Lower Shallow Aquifer from STP Units 3&4 and do not support the existence of a significant alternate pathway or gradient to the west of STP Units 3&4.

3) While the September 2008 water level data cited in the responses to ER RAI 2.3-7 and FSAR RAI 02.04.12-20 (i.e., two well pairs OW-959U/L and OW-961U/L installed in the Shallow Aquifer near Kelly Lake) indicate a slightly upward vertical gradient, the December 2008 data from these same well pairs exhibited a downward vertical gradient. A third well pair (OW-960U/L) immediately west of the lake exhibited no upward gradient from either the September 2008 or the December 2008 well measurements. The December 2008 data and analysis are presented in the response to RAI 02.04.12-28.

   Although Kelly Lake may be a plausible point of exposure for a release to the Shallow Aquifer system from Unit 3, the Pathway No. 1 point of exposure is much closer than, and in the same direction as, Kelly Lake. Consequently, it is believed that the Pathway No. 1 point of exposure provides a more conservative analysis location than Kelly Lake, considering that the lake is over 3,500 feet further to the southeast. The additional 3,500 feet of groundwater flow path for a postulated release of liquid effluent provides additional distance over which adsorption and mechanical dispersion can occur and additional travel time during which radioactive decay can occur. Further details regarding the analysis for the Pathway No. 1 point of exposure have been incorporated into STP COLA Revision 3.

No further COLA revisions are required as a result of this RAI response.

References:

1. "Groundwater Model Development and Analysis for STP Units 3&4", South Texas Project Letter No. U7-C-STP-NRC-080070, Attachment 2, dated December 15, 2008.

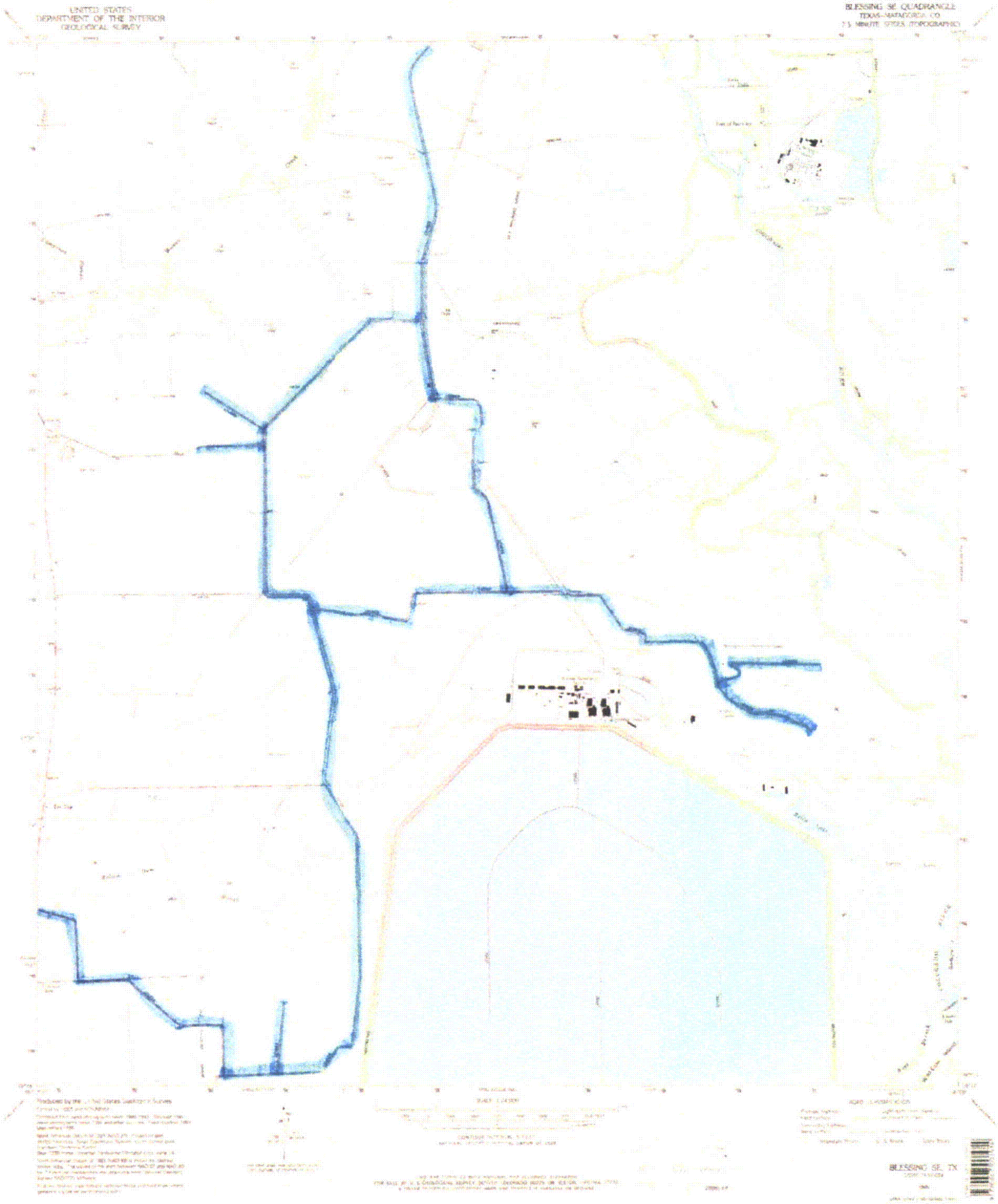


Figure 1: 1995 Blessing SE, TX USGS 7½-minute topographic map.

RAI 02.04.12-34

Question:

In the review of the applicant's response to RAI 02.04.12-26 (as well as responses to RAIs 2.4.12-09, 2.4.13-05, and 2.4.13-06), the staff noted there was no mention of the potential to apply the STP site groundwater model of the Upper and Lower Shallow aquifers to evaluate the post-construction setting and support the conclusion that a permanent dewatering system is not needed and that the DCD requirement of maximum allowable hydraulic head will not be exceeded. Provide a justification for not using the STP groundwater model, a revision of it, or a simpler model to incorporate the potential changes in hydrogeologic strata, hydraulic properties, and recharge rates in a post-construction setting, and to quantify the possible change in groundwater elevation in the vicinity of safety related structures for proposed Units 3&4.

Response:

The response to RAI 02.04.12-26, as well as responses to RAIs 2.4.12-09, 2.4.13-05, and 2.4.13-06, were submitted to the NRC in July 2008, prior to completion of the STP groundwater model. Consequently, model results were not available for inclusion in the aforementioned RAIs. An analysis of the modeled post-construction groundwater level, as it relates to the maximum allowable hydraulic head specified in the DCD, is provided in the following paragraphs.

The three-dimensional numerical model of the Shallow aquifer at the STP site was revised in December 2008 to incorporate data obtained from installation and monitoring of new observation wells and submitted to the NRC in Reference 1. The revised model incorporates the effects of the following factors to estimate post-construction groundwater levels:

- The placement of engineered fill, which has higher permeability relative to the native soil it replaces in the power block excavations at the sites of STP 1, 2, 3 and 4,
- Deep building foundations that divert groundwater flow at the sites of STP 1, 2, 3 and 4,
- Changes in groundwater recharge rates due to buildings, impermeable surfaces and stormwater drainage systems at the sites of STP 1, 2, 3 and 4,
- A low-permeability slurry wall around the perimeter of the STP 3 & 4 power block to allow dewatering of the construction excavation.

Figure 90 of the groundwater model development report (Reference 1) shows simulated post-construction groundwater contours in the Upper Shallow aquifer, including the area of the STP 3 & 4 power block. Figure 90 shows the simulated post-construction groundwater elevation contour at STP 3 & 4 to be about El 20 ft. The El 20 ft level is about 14 ft below the plant grade design elevation of 34 ft msl, and about 7 ft lower than the maximum observed groundwater level of El 26.8 ft at Piezometer 601 during the period from 1973 to 2007, as described in the response to RAI 02.04.12-26. Groundwater level measurements conducted from 2007 through 2008 during the STP 3 & 4 subsurface investigation indicate the maximum observed water level elevation to be El 27.59 ft at observation well OW-420U on August 30, 2007, which is about 8 ft higher than the simulated groundwater elevation from Reference 1 and about 1 ft higher than the previous recorded high of 26.8 ft. This reading, being suspiciously high based on the downward trend of adjacent wells over the same period, provides an estimate of about El 28 ft for a maximum measured groundwater level at STP Unit 3 & 4 based on recorded levels since 1973.

Comparison of Figure 90 with Figure 60 from Reference 1, which shows simulated pre-construction groundwater contours in the Upper Shallow aquifer, reveals that the post-construction water level in the vicinity of the STP 3 & 4 safety-related structures is estimated to decrease by about 2 ft. The post-construction groundwater level in the area of STP 3 & 4 is expected to decrease relative to pre-construction levels due to the following:

- Post-construction groundwater recharge to the area may decrease because the area will be largely covered by buildings and impermeable surfaces, and storm water will be diverted from the area in an engineered drainage system;
- The post-construction plant grade level (approximately 34 ft msl) will be no more than 4 ft higher than the pre-construction grade level and the horizontal hydraulic gradient in the area will not change significantly;
- The low-permeability slurry wall surrounding the power block area will reduce the rate of groundwater flow into the power block area;
- The pre-construction vertical hydraulic gradient in the STP 3 & 4 power block area ranges from about 6 to 8 ft downward from the Upper to the Lower Shallow aquifer. The power block excavation will extend to a depth approximately 90 ft below grade and will penetrate about 40 ft into the top of the Lower Shallow aquifer. This excavation will be backfilled with engineered fill that is more permeable, relative to the removed native soil. The engineered fill will provide enhanced hydraulic communication with the Lower Shallow aquifer, which will reduce the vertical hydraulic gradient and cause a lower groundwater level within the fill.

Based upon simulations of groundwater levels reported in Reference 1 and the 34-year record of observed water levels at the STP site, a permanent dewatering system will not be required to maintain groundwater levels at the STP 3 & 4 safety-related structures below the maximum allowable hydraulic head specified in the DCD.

References:

1. "Groundwater Model Development and Analysis for STP Units 3&4", South Texas Project Letter No. U7-C-STP-NRC-080070, Attachment 2, dated December 15, 2008.

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

RAI 02.04.12-35

Question:

Instead of echoing the plant parameter “61.0 cm (2 ft) below grade” by rephrasing it as a site characteristic “> 61.0 cm (2 ft) below grade”, NRC staff request a true site characteristic be assigned to the "maximum groundwater level" that provides some margin between site characteristic and the plant parameter. Also, with regard to the plant parameter for maximum groundwater level, clarify the "grade elevation" which is noted to be 35 ft MSL in Section 2.4S.12.5 and used to define the maximum groundwater level in the plant parameter, versus the “plant grade” which is defined to be 34 ft MSL in other subsections of Section 2.4S and elsewhere in the FSAR. Since the grade within the powerblock varies from 36.5 to 32 ft MSL and the selection of 35 ft MSL seems arbitrary, why isn't the more rigorously defined and repeatedly cited "plant grade" used to define the maximum groundwater level?

Response:

Based on measured groundwater levels in observation wells and modeled post-construction groundwater levels, the maximum post-construction groundwater elevation at the STP Units 3 and 4 site is estimated to be 28 ft above mean sea level (MSL). Relative to the nominal post-construction plant grade elevation in the power block area of 34 ft MSL, this site characteristic for maximum groundwater level would be equivalent to a level of 6 ft below grade. As currently stated in Section 2.4S.12.5 of the STP Units 3 and 4 FSAR (Tier 2), the finished (i.e., post-construction) plant grade in the power block area is anticipated to be between approximately 32 ft MSL and 36.5 ft MSL. This would result in the maximum groundwater level in the power block area being no higher than approximately 4 ft below finished grade (32 ft MSL minus 28 ft MSL). Therefore, the STP Units 3 and 4 site characteristic of 28 ft MSL for maximum groundwater level is well bounded by the plant parameter “61.0 cm [2 ft] below grade” that is specified for the standard plant site in ABWR DCD (Tier 1) Table 5.0 and ABWR DCD (Tier 2) Table 2.0-1. FSAR (Tier 2) Table 2.0-2 will be revised to reflect the STP Units 3 and 4 site characteristic of 28 ft MSL for maximum groundwater level.

As stated in FSAR (Tier 2) Section 2.4S.12.5, subsurface hydrostatic loading estimates for structures at STP Units 3 and 4 were evaluated using two approaches. For the first approach, the evaluation was performed by conservatively assuming that groundwater level is at the site parameter maximum groundwater level of 61 cm (2 ft) below grade as specified in ABWR DCD (Tier 1) Table 5.0 and ABWR DCD (Tier 2) Table 2.0-1. In this evaluation, the plant ground floor elevation of power block structures – 35 ft MSL – was inadvertently used as “grade” elevation. As noted in the NRC RAI question above, the appropriate “grade” elevation to use in establishing maximum groundwater level for this first approach would be nominal finished plant grade elevation, or 34 ft MSL. As indicated in the markups below, FSAR (Tier 2) Section 2.4S.12.5 and Figure 2.4S.12-32 will be revised to use the 34 ft MSL nominal finished plant grade elevation to define the maximum groundwater level for the hydrostatic loading evaluation using the first (conservative) approach.

FSAR (Tier 2) Section 2.4S.12.5 and Figure 2.4S.12-32 also will be revised to reflect the STP Units 3 and 4 site characteristic of 28 ft MSL for maximum groundwater level as discussed above. Specifically, the second of the two approaches used in FSAR (Tier 2) Section 2.4S.12.5 to evaluate subsurface hydrostatic loading estimates involved the use of the maximum groundwater level elevation – 25.85 ft MSL – observed during the period from December 2006 through June 2007. The second approach reflected in both FSAR (Tier 2) Section 2.4S.12.5 and Figure 2.4S.12-32 will be revised to use the site characteristic maximum groundwater level of 28 ft MSL instead of 25.85 ft MSL. With this change, the FSAR description of the two approaches will reflect the "margin" between the conservative evaluation of hydrostatic loading estimates using the ABWR DCD plant parameter (first approach) and the evaluation using the STP Units 3 and 4 site characteristic (second approach).

The FSAR changes described above are shown in the following markups:

The entry for "Maximum Ground Water Level" in supplemental Table 2.0-2 will be revised as follows:

Table 2.0-2 Comparison of ABWR Standard Plant Site Design Parameters and STP 3 & 4 Site Characteristics

Subject	ABWR Standard Plant Site Design Parameters	STP 3 & 4 Site Characteristics	Bounded (Yes/No)	Discussion
Maximum Ground Water Level	61.0 cm (2 ft) below grade	~~> 61.0 cm (2 ft) below grade.~~ 28 ft MSL	Yes	Maximum groundwater level site characteristic is 6 ft below nominal finished plant grade. Further information on maximum groundwater level is provided in Subsection 2.4S.12.

The first, second, and last paragraphs of FSAR Section 2.4S.12.5 will be revised as follows:

> Subsurface hydrostatic loading estimates for structures at STP 3 & 4 were evaluated using two approaches. First, the evaluation was performed by conservatively assuming that groundwater level is at the maximum groundwater level of 61 cm (2 ft) below ground surface as specified in ABWR DCD (Tier 1) Table 5.0 and ABWR DCD (Tier 2) Table 2.0-1~~ for the ABWR~~. ~~The existing plant grade at the site is approximately 30 ft MSL and the finished plant grade in the Power Block area is anticipated to be between approximately 32 and 36.5 ft MSL,~~The nominal post-construction plant grade elevation in the power block area will be approximately 34 ft MSL. T~~t~~hus, ~~a grade elevation of 35 ft MSL would result in a maximum~~the assumed groundwater elevation for the evaluation using the first approach would be~~of~~ ~~33~~32 ft MSL. For ~~T~~the evaluation using the second approach, it was assumed that groundwater level in the power block area is at the "site characteristic" maximum groundwater level of 28 ft MSL as specified in Table 2.0-2 ~~uses the maximum observed groundwater level elevation (December 2006 – June 2007), within the STP 3 & 4 power block area, elevation 25.85 ft MSL from observation well~~

~~OW-332U on April 27, 2007~~. The maximum hydrostatic loading is estimated using the following formula:

$$\rho_w = z_w \times \gamma_w$$

where:

ρ_w = hydrostatic pressure (psf)

z_w = depth below groundwater level (ft)

γ_w = unit weight of water (62.4 pcf)

Figure 2.4S.12-32 presents a graph of building elevation versus hydrostatic pressure. Two lines are provided on the graph, one representing the upper bound condition using the DCD maximum groundwater level and the second using the ~~maximum observed groundwater level~~site characteristic maximum groundwater level of 28 ft MSL in the power block area.

…

In summary, based on measured groundwater levels in observation wells and modeled post-construction groundwater levels, the maximum post-construction groundwater elevation at the STP Units 3 and 4 site is estimated to be 28 ft MSL, as reflected in Table 2.0-2. The nominal finished plant grade in the power block area is approximately 34 ft MSL, six feet higher than the site characteristic maximum groundwater level. Therefore, the STP Units 3 and 4 site characteristic of 28 ft MSL for maximum groundwater level is well bounded by the maximum groundwater level plant parameter "61.0 cm [2 ft] below grade" that is specified for the standard plant site in ABWR DCD (Tier 1) Table 5.0 and ABWR DCD (Tier 2) Table 2.0-1~~the water level elevations collected to date, the groundwater depth in both power block areas is below the maximum groundwater level of 61 cm (2 ft) below ground surface as specified in DCD Table 2.0-1 for the ABWR~~. Based on this observation, a permanent dewatering system is not anticipated to be a design feature for the STP 3 & 4 facility. Post-construction groundwater conditions are anticipated to have some localized changes resulting from excavation and backfilling, however, based on observations of STP 1 & 2 post-construction groundwater conditions, the effects would be minimal and may include localized communication between the Upper and Lower Shallow Aquifers and an increased cone of depression in the Deep Aquifer resulting from increased groundwater use for STP 3 & 4. The groundwater supply wells to be installed for STP 3 & 4 are not a safety-related source of water because the UHS has a 30-day supply of water, which is sufficient for plant shutdown without a supplementary water source.

FSAR (Tier 2) Figure 2.4S.12-32 will be revised as follows:

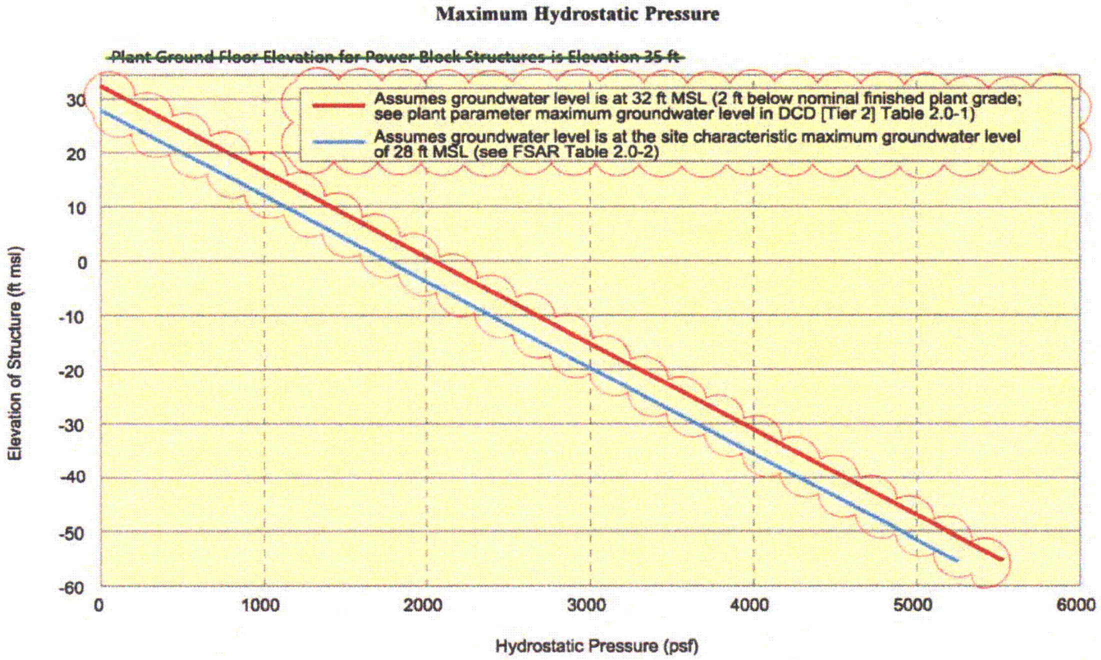


Figure 2.4S.12-32 Subsurface Hydrostatic Loading

RAI 02.04.12-36

Question:

This three-part RAI is a result of inconsistencies that have appeared between the Rev 2 versions of the ER and the FSAR with regard to groundwater usage.

(1) In the review of FSAR Rev 2 Sections 2.4S.12.1.6, "Plant Groundwater Use" and 2.4S.12.3.3, "Plant Groundwater Use and Effects", the staff noted that the normal and peak groundwater rates provided in the FSAR are not the same as those appearing in the ER Rev 2 Section 3.3, "Plant Water Use", and ER Rev 2 Table 3.3-1,"STP 3 & 4 Water Flow Table". This also calls into question the expected range shown in the FSAR section. If the FSAR Rev 2 Sections referenced above are correct, so state; if not, correct and identify the source of the new water flow rates.

(2) The ER Rev 2 states that any groundwater source requirement beyond the permitted rate of 1860 gpm (3000 ac-ft/yr) will be obtained from the MCR (see ER Rev 2 Section 5.2.2.2). If this is true, then for consistency with the ER and clarity with regard to groundwater use, the FSAR should note the intent to not exceed the permitted limit of groundwater withdrawal, i.e., 3000 ac-ft/yr in FSAR Sections 2.4S.12.1.6, "Plant Groundwater Use" and 2.4S.12.3.3, "Plant Groundwater Use and Effects".

(3) The last sentence in the third paragraph under Section 2.4S.12.3.3 beginning "Peak demand..." needs to be clarified. If only use MCR water will be used to supplement the groundwater supply whenever necessary, ad is indicated in ER Section 5.2.2.2, then so state. However, if the FSAR statement "by increasing the permitted groundwater allotment for short-term uses" is an intended path forward, then it requires an explanation of the process to be followed to obtain the increased allotment, and the increased permitted level being sought as well as its duration of use.

Response:

The requested information regarding STP Units 3 and 4 groundwater usage is provided below. This information is provided as numbered items that correspond with the three numbered items in the NRC RAI. It is noted that the information requested in this RAI question is substantively similar to that requested in NRC RAI No. 05.10-04 related to the STP Units 3 and 4 Environmental Report (ER). Therefore, additional details and markups of the ER to incorporate and/or conform to this response are provided in the STPNOC response to RAI No. 05.10-04.

(1) The water use data associated with operation of STP Units 3 and 4, including normal and peak groundwater flow rates, were changed and incorporated in ER Section 3.3 and Table 3.3-1 as part of COLA Revision 2. However, conforming changes to the water use values cited in FSAR Sections 2.4S.12.1.6 and 2.4S.12.3.3 inadvertently were not made in COLA Revision 2. This resulted in the inconsistencies noted in the NRC RAI question.

The source of the STP Units 3 and 4 operating water use data is Fluor Nuclear Power Calculation U7-SITE-G-CALC-DESN-2001, "Plant Water Balance," which recently has been updated. This calculation update results in further changes to a number of the water use values presented in the ER and FSAR, including normal and peak groundwater flow rates. Markups of the affected FSAR sections (including Sections 2.4S.12.1.6 and 2.4S.12.3.3) to reflect the updated operating plant water balance calculation are provided at the end of this response. Markups of the ER (including Section 3.3 and Table 3.3-1) that similarly reflect the updated operating plant water balance calculation results are provided in the response to NRC RAI No. 05.10-04.

(2) As detailed further in the STPNOC response to RAI No. 05.10-4, STPNOC has determined that the existing groundwater permit limit provides adequate water supply for the operation of STP Units 1 and 2 and the construction, initial testing, and operation of STP Units 3 and 4. Therefore, STPNOC does not intend to pursue an increase in the STP site groundwater operating permit limit. The MCR and Colorado River remain as alternative sources in the unlikely event that unanticipated peak site water demands would require additional water sources. STPNOC's intent to not exceed the permitted limit of groundwater withdrawal is reflected in the FSAR (including Sections 2.4S.12.1.6 and 2.4S.12.3.3) markups at the end of this response, and in the ER markups provided in the STPNOC response to NRC RAI No. 05.10-04.

(3) As indicated in the response to Item (2) above, STPNOC does not intend to pursue an increase in the STP site groundwater operating permit limit. The MCR and Colorado River remain as alternative sources in the unlikely event that unanticipated peak site water demands would require additional water sources. Accordingly, FSAR Section 2.4S.12.3.3 will be revised to reflect this response. Conforming changes will be incorporated into the FSAR and ER as shown in the FSAR markups at the end of this response, and in the ER markups provided in the STPNOC response to NRC RAI No. 05.10-04.

Changes to FSAR sections and tables are below with changes indicated with gray shading. Related changes to affected ER sections and tables are provided in the response to NRC RAI No. 05.10-04.

The third and fourth paragraphs of FSAR Section 2.4S.12.1.6 will be revised as follows:

> Groundwater use from these wells includes a makeup water source for the Essential Cooling Pond (ECP), makeup of demineralized water, the potable and sanitary water system, and the plant fire protection system (Reference 2.4S.12-9). Table 2.4S.12-3 presents the combined monthly groundwater withdrawals from the five production wells between 1995 and 2006. ~~The table indicates that an annual groundwater usage of between 1200 and 1300 acre-ft is typical.~~ From the data in this table, the average annual groundwater use for operation of STP Units 1 and 2 from 2001 through 2006 was determined to be approximately 798 gpm (approximately 1288 acre-feet/year).

Groundwater is projected to be the main source of water for STP 3 & 4 plant operations. ~~Operation of STP 3 & 4 is predicted to require a typical groundwater consumption of 1077 gpm or 1738 acre-ft per year. The peak groundwater consumption (i.e., plant outage) for STP 3 & 4 is expected to be as great as 3935 gpm. The projected combined STP plant typical groundwater consumption for STP 1 & 2 and STP 3 & 4 is expected to be between 2938 acre-ft and 3038 acre-ft per year.~~ Based on the results of an operating plant (Units 3 and 4) water balance calculation (Reference 2.4S.12-xx) and a site groundwater use calculation (Reference 2.4S.12-xy), STPNOC has determined that the STP site groundwater operating permit limit provides adequate groundwater supply for water uses required for the operation of STP Units 1 and 2 and the construction, initial testing, and operation of STP Units 3 and 4. Water uses projected for the operation of STP Units 3 & 4 are derived from system design data as well as from operational water use data for specific systems for which such data is available (Reference 2.4S.12-xx). Conservative water use projections for simultaneous operation of both STP Units 3 and 4 include a total estimated normalized groundwater demand of approximately 975 gpm (approximately 1574 acre-feet/year), and approximately 3434 gpm for maximum short-term steady-state conditions. The impacts to the local groundwater aquifer system are discussed in Subsection 2.4S.12.3.3.

FSAR Section 2.4S.12.3.3, Revision 3, will be revised as shown below.

Groundwater is projected to be the main source of water for STP 3 & 4 plant construction and operation. During construction, groundwater use requirements will vary and will be used for the following activities: onsite personnel consumption and use; manufacturing of concrete, concrete curing, and clean-up; dust control; addition of moisture and placement of engineered backfill; and piping hydro tests and flushing. ~~Preliminary estimates indicate that up to 1200 gpm of groundwater will be required during construction.~~ Based on the results of an operating plant (Units 3 and 4) water balance calculation (Reference 2.4S.12-xx) and a site groundwater use calculation (Reference 2.4S.12-xy), STPNOC has determined that the STP site groundwater operating permit limit provides adequate groundwater supply for water uses required for the operation of STP Units 1 and 2 and the construction, initial testing, and operation of STP Units 3 and 4.

The permit allows groundwater withdrawals from the five site production wells up to a limit of 9000 acre-feet over the permit term of approximately 3 years. For discussion purposes, this permit limit may be described herein as "approximately 3000 acre-feet/year," recognizing that groundwater withdrawal in a single year may exceed 3000 acre-feet provided that total withdrawals over the permit term do not exceed 9000 acre-feet. As a point of reference, if the permit limit were exactly 3000 acre-feet/year (which is not necessarily the case due to slight variances in the permit term with each permit renewal), the equivalent "normalized" withdrawal rate assuming continuous pumping every minute of every day of each year would be approximately 1860 gpm.

Historical groundwater withdrawal rates associated with operation of Units 1 and 2 is provided in Table 2.4S.12-3. This data shows that from 2001 through 2006, annual groundwater use for operation of STP Units 1 and 2 averaged approximately 798 gpm (approximately 1288 acre-feet/year). A small but not insignificant portion of this amount has been diverted to the MCR as a result of manual operation of the groundwater well pump and header system. With the installation of appropriate automated groundwater well pump and header system controls, this diverted groundwater would be available for use by Units 3 and 4. However, as documented in the site groundwater use calculation (Reference 2.4S.12-xy), it has been determined that even if this water were not available to Units 3 and 4, the existing STP site groundwater operating permit limit provides adequate groundwater supply for water uses required for the operation of STP Units 1 and 2 and the construction, initial testing, and operation of STP Units 3 and 4.

Water uses projected for the operation of STP Units 3 and 4 are derived from system design data as well as from operational water use data for specific systems for which such data is available (Reference 2.4S.12-xx). Conservative water use projections for simultaneous operation of both STP Units 3 and 4 include a total estimated normalized groundwater demand of approximately 975 gpm (approximately 1574 acre-feet/year), and approximately 3434 gpm for maximum short-term steady-state conditions.

Water uses for the construction (including concrete production) and initial testing of STP Units 3 and 4 were estimated for each month during the construction period through the commencement of unit operation (Reference 2.4S.12-xy). As documented in the site groundwater use calculation (Reference 2.4S.12-xy), monthly construction water uses are projected to range from a normalized rate of approximately 10 gpm to approximately 228 gpm. Similarly, monthly water uses associated with initial testing of STP Units 3 and 4 are projected to range from a normalized rate of approximately 47 gpm to approximately 491 gpm.

When evaluating whether the total site groundwater demand can be satisfied by the available groundwater supply, the site groundwater use calculation (Reference 2.4S.12-xy) considers the schedule projected for each use, and evaluates the total site groundwater usage at each point in time from the commencement of STP Units 3 and 4 construction until both Units 3 and 4 are in operation (i.e., Units 1, 2, 3 and 4 are operating simultaneously). With consideration for the need to maintain water storage capacity to provide for peak site water demands, this evaluation confirms that total site groundwater demand remains below the existing site groundwater permit limit during construction, initial testing, and operation of STP Units 3 and 4. Notwithstanding, the MCR and Colorado River remain as alternative sources in the unlikely event that unanticipated peak site water demands would require additional water sources.

~~STP is currently permitted to use up to 3000 acre-ft per year of groundwater from their existing production wells. STP currently uses about 1300 acre-ft per year for plant operations. Therefore, approximately 1700 acre-ft per year (1050 gpm) of groundwater could be available for construction use. Water demand could be met by increasing the yield of the existing wells or by installing new wells with the objective that total STP use would not exceed the 3000 acre-ft per year permitted amount. A detailed evaluation of groundwater availability and estimates of aquifer drawdown, requirements for permitting of new wells and yields, water conservation measures, and the identification of alternative sources, if practicable, will be addressed as part of the detailed engineering for STP 3 & 4.~~

~~Operation of STP 3 & 4 is predicted to require a typical groundwater consumption of 1077 gpm or 1738 acre-ft per year, whereas the peak groundwater consumption for STP 3 & 4 is expected to be as great as 3935 gpm, when required (i.e., outages). The projected combined STP plant normal groundwater consumption for STP 1 & 2 and STP 3 & 4 is expected to be between 2938 and 3038 acre-ft per year, which is approximately equal to the current STP permitted use of 3000 acre-ft per year. Peak demand for outages could be met by increasing the permitted groundwater allotment for short-term uses or by obtaining water from other sources such as the MCR or the Colorado River.~~

~~Based on these estimates, additional groundwater wells will be required to satisfy site demands. Three of the existing site production wells yield 500 gpm each. The remaining two wells yield 200 and 250 gpm. Assuming a new well yields 500 gpm, two wells will be required in order to meet the anticipated peak plant demand while also insuring an adequate margin for well water system maintenance activities. Specific details will be established during the detailed engineering for STP Units 3 & 4. These wells would pump from the Deep Aquifer within the Beaumont Formation.~~ The design groundwater withdrawal capacity associated with the five site production wells covered by the existing site groundwater operational permit is approximately 1950 gpm. Of this design capacity, not more than approximately 1650 gpm is considered to be available based on operating experience and the fact that use of the NTF pump is limited to providing fire protection water for the NTF. Therefore, STPNOC intends to install at least one additional site groundwater well with a design capacity of 500 gpm. As with the existing five site production wells, any new well(s) would be installed to depths within the deep portion of the Chicot Aquifer. As documented in the site groundwater use calculation (Reference 2.4S.12-xy), this additional capacity will allow for sufficient groundwater withdrawal to meet water uses required for: (1) operation of STP Units 1 and 2 and the construction, initial testing, and operation of STP Units 3 and 4; and (2) potential temporary capacity reduction as a result of equipment failure/unavailability.

As with STP 1 & 2, it is expected that no sustained pumping will be permitted within 4000 ft of the plant safety-related facility areas in order to minimize the potential for regional subsidence resulting from lowering of the Deep Aquifer zone potentiometric head. Based on this requirement, the ~~location of the~~ additional groundwater well(s) ~~required for expanded plant operations~~ would most likely be located in the west, northwestern or northeastern sections of the STP site or alternately in the southeastern and southwestern site areas adjacent to the MCR.

As stated in Subsection 2.4S.12.2.2, comparison of a regional potentiometric surface map for the Deep Aquifer in Matagorda County in 1967 (Figure 2.4S.12-15) and that of a potentiometric surface map for the Gulf Coast Aquifer from data collected between 2001 and 2005 (Figure 2.4S.12-16) suggests that groundwater elevations have increased in some parts of Matagorda County. In 1967, groundwater elevations above mean sea level were primarily located in the northern portion of the county. In the 2001-2005 potentiometric surface map, groundwater elevations in the northern and central portions of the county were above mean sea level. Therefore, the regional impacts of groundwater production on the aquifer groundwater levels appear to be decreasing, thus minimizing impact to the regional aquifer as the result of STP plant expansion with the construction, initial testing, and operation of STP 3 & 4. Some additional aquifer drawdown would be expected near the STP site boundaries as the result of installing and operating any new groundwater well(s). Based on Figure 2.4S.12-18, it can be expected that the lowering of the potentiometric head in the Deep Aquifer at the existing STP production would expand over most of the northern portion of the site due to the installation of the new site production well(s). The decrease in head would be expected to extend beyond the site boundaries but the impact would be less than that beneath the site.

~~As part of the detailed engineering for the STP 3 & 4, the impact of the groundwater pumping in the Deep Aquifer will be evaluated to the current site conditions and that of nearby, offsite groundwater users (Figure 2.4S.12-13). Permitting of new wells and yields, plant water conservation methods, and the identification of alternative sources or recycling, if practicable, will be addressed as part of the detailed engineering for STP 3 & 4.~~

Two references will be added to FSAR Section 2.4S.12.6 as follows:

2.4S.12-xx "Plant Water Balance," Fluor Nuclear Power Calculation No. U7-SITE-G-CALC-DESN-2001.

2.4S.12-xy "Site Groundwater Use for Construction, Initial Testing, Startup, and Operations," Fluor Nuclear Power Calculation No. U7-SITE-G-CALC-DESN-2002.

The typographical error in the total gallons in Table 2.4S.12-3 be corrected as follows:

Month	...	2005 (gallons)	2006 (gallons)
⋮	⋮	⋮	⋮
Total (gallons)	...	**422,~~363~~333,662**	**423,935,565**
Total (acre-feet)	...	**1,296**	**1,301**

RAI 02.05.02-21

Question:

In responding to RAI 2.5.2-13, you indicated that a SSHAC level two study was conducted in characterizing the Gulf Costal seismic source. Please describe how the experts' opinions were integrated into the development of the final Gulf Costal source model, how any conflicting opinions between the experts were dealt with, and how the final source model represents the informed consensus of the community?

Response:

The updates to the maximum magnitude (Mmax) distributions for the Gulf Coastal Source Zones (GCSZs) of the EPRI-SOG earth science teams (ESTs) described in FSAR Subsection 2.5S.2.4.3 were developed following a Senior Seismic Hazard Analysis Committee (SSHAC) level 2 process (Bunditz et al., 1997). The various levels of SSHAC studies are described in detail in NUREG/CR-6372 (Bunditz et al., 1997). The essential components of a level 2 study with respect to the GCSZ update are:

- Technical integrators (TIs) responsible for developing the updated Mmax distributions through discussions with experts and reviewing of available information and data;
- Resource and proponent experts who provide expert insight and opinions that are considered in the development of the study results;
- A participatory peer review panel that provides unbiased feedback, critical review, and guidance throughout the development of study result.

The TIs for this study were Dr. Christopher Fuller and Dr. Jeff Unruh from William Lettis & Associates, Inc. The experts queried for this update included academics and commercial geoscientists with expertise in tectonics and seismicity within the Gulf of Mexico (e.g., Dr. James Dewey of the USGS; Dr. Frank Peel of BHP Billiton Petroleum; Dr. Meredith Nettles of Lamont-Doherty Earth Observatory; Dr. Joe Dellinger of BP; Dr. Goran Ekstrom of Lamont-Doherty Earth Observatory; Dr. Martin Chapman of Virginia Tech; Dr. James Pindell of Rice University) and members of the original EPRI-SOG ESTs (e.g., Dr. Joe Litehiser of the Bechtel team; Mr. George Klimkiewicz of the Weston team; and Mr. Jim McWhorter of the Dames & Moore team). The peer review panel consisted of the seismic Technical Advisory Group (TAG) members for the STP 3 & 4 project: Dr. Carl Stepp, independent Consultant; Dr. Robert Kennedy of RPK Consulting; Dr. Cliff Frohlich, University of Texas; Dr. Allin Cornell of Stanford University (deceased); and Mr. Donald Moore of Southern Company.

Background:

As discussed in FSAR Section 2.5S.2, development of the probabilistic seismic hazard analysis (PSHA) used in the STP COLA followed the guidelines of NRC Regulatory Guide (RG) 1.208 (NRC, 2007). The EPRI-SOG PSHA model (EPRI, 1986-1989), considered an acceptable base model per RG 1.208, was used as the starting base model. Following the guidance of RG 1.208, this base model was evaluated in light of new data developed since the EPRI-SOG study to determine whether modifications needed to be made to the model to ensure that it adequately represents the most recent information. The guidance from RG 1.208 describing this process includes the following language:

> "The results of these [site-specific] investigations will also be used to assess whether new data and their interpretation are consistent with the information used in recent probabilistic seismic hazard studies accepted by NRC staff" (RG 1.208, page C-1).
>
> ". . . determine whether there are any new data or interpretations that are not adequately incorporated into the existing PSHA databases" (RG 1.208, page 11).

The key criteria specified by RG 1.208 for evaluation of the EPRI-SOG model is whether the model "adequately" describes, or is "consistent" with, the new data.

The decision to modify the GCSZs of the EPRI-SOG model resulted from an extensive review by the TIs of information and data published since the EPRI-SOG study, as recommended in RG 1.208 (see FSAR Sections 2.5S.1 and 2.5S.2). The specific new data that triggered the update was the occurrence of the 10 February 2006 and 10 September 2006 earthquakes, hereafter referred to as the February and September 2006 earthquakes, which have magnitudes greater than the lower-bound maximum magnitude of some of the GCSZs containing the earthquakes. Earthquakes with magnitudes greater than their host source zone's maximum magnitude represent new data that require a revision to the EPRI-SOG model because the maximum magnitude for a source zone cannot be less than the largest observed historical earthquake within the zone.

SSHAC Process:

As described in NUREG/CR-6372, SSHAC guidelines can be applied to any aspect or issue of a PSHA. The issues explicitly addressed in this investigation were:

1. Does Gulf of Mexico seismicity, and in particular the February and September earthquakes, provide evidence that EPRI-SOG GCSZ characterizations need to be updated?
2. What components of the characterizations (e.g., geometry, recurrence, Mmax) need to be updated?
3. What methodology should be used to update those components?

The investigation followed a modified version of the steps recommend by NUREG/CR-6372 for the TI approach to a SSHAC process. The recommended steps include (pages 28-29 and 78-79 of NUREG/CR-6372):

1. Identify and select peer reviewers
2. Identify available information and design analyses and information retrieval methods
3. Perform analyses, accumulate information relevant to issue and develop representation of community distribution
4. Perform data diagnostics and respond to peer reviews
5. Document process and results

The following discussion describes the steps taken in the SSHAC level 2 study.

Step 1: Select Peer Reviewers:

The first step of the investigation was to form the peer review panel. The panel was comprised of members of the seismic TAG for the STP 3 & 4 COLA project. The members of the panel were: Dr. Carl Stepp, Dr. Robert Kennedy, Dr. Cliff Frohlich, Dr. Allin Cornell, and Mr. Donald Moore.

Step 2: Assemble Data and Information:

Extensive datasets were compiled and interviews with experts were conducted as part of the second step. The data compilation and analysis were conducted following the guidance of RG 1.208, as documented in FSAR Sections 2.5S.1 and 2.5S.2. For example, gravity and magnetic data are reviewed in Section 2.5S.1; publications on the tectonic setting of the Gulf of Mexico region are reviewed in Section 2.5S.1; and seismicity data are reviewed in Section 2.5S.2.

With respect to the key issue of whether the GCSZ characterizations needed to be revised, the compiled seismicity data validated the initial observation that at least some of the GCSZs required updating based on the occurrence of the two earthquakes with magnitudes greater than the lower-bound Mmax for the zones in which they occurred. Because this initial observation was the impetus for the study, the majority of the data compilation focused on resolving the other two issues: (1) what components of the GCSZs need to be updated; and (2) what methodology should be followed in performing the updates.

As part of the data collection numerous experts were interviewed to help define the "legitimate range of technically supportable interpretations among the entire informed technical community" (NUREG/CR-6372, page 6) with respect to the geologic and seismo-tectonic setting of the two earthquakes. Most of the interviews were initiated at this stage of the study, but some interviews were conducted before and after the study. Interviews also were initiated with additional experts as new information became available from those experts. The on-going interview process provided assurance that the most current and accurate information was used in the study.

The interviews focused on determining: (1) whether the experts were familiar with the two earthquakes, and (2) if the experts knew of any distinguishable geologic features or structures that may have been sources for the earthquakes. Summaries of these interviews are presented in Table 1 of this response. The interviews demonstrated that there is no consensus among the informed technical community as to whether a distinguishable geologic feature or structure is associated with either earthquake. For example, Dr. Peel hypothesized that the September 2006 event may be related to the oceanic-continental crust boundary. In contrast, Dr. Pindell did not know of any obvious structure, including any boundary faults that could potentially be related to the earthquake. Also, Dr. Nettles and Dr. Dellinger expressed the opinion that the February 2006 earthquake may have been caused by a large-scale landslide at the edge of the Sigsbee escarpment (i.e., continental shelf edge) (e.g., Nettles, 2007), but Dr. Dewey did not believe the earthquake could be constrained to the shallow depths where such a mechanism would be plausible.

Step 3: Develop Initial Characterization Based on the Community Distribution:

The TIs used the information and data gathered in the previous step to develop an initial characterization of the updated GCSZs. This characterization was developed to represent the TI's evaluation of the community distribution on what elements of the GCSZ characterizations needed updating. PSHA seismic source characterizations have three basic components: (1) the source geometry; (2) the earthquake recurrence model; and (3) the Mmax distribution. As previously discussed, the occurrence of the February and September 2006 earthquakes indicated that the Mmax distributions needed updating. The earthquake recurrence model (i.e., rates) was analyzed separately (see FSAR Section 2.5S.2), and it was determined that the recurrence model did not need to be updated.

The remaining issue was whether the data and information collected in Step 2 suggested the presence of a new seismic source or suggested that one of the GCSZs does not adequately characterize the earthquake source geometry in light of the updated seismicity. Evaluating this issue was one of the main focuses of the SSHAC investigation, and the evaluation was conducted separately for each earthquake.

For the September 2006 earthquake, the TIs concluded from the data collected in Step 2 that the existing GCSZ geometries adequately characterize the community distribution of potential seismic sources that may have caused the earthquake. The TIs adopted this position because the interviews demonstrated that uncertainty exists with respect to whether the earthquake is related to an identifiable feature (e.g., geologic structure). Some of the experts suggested that the earthquake may have occurred along structures associated with the oceanic-continental crust boundary off Florida near the location of the earthquake (e.g., Dr. Peel), but they could not identify any explicit structures. Other experts did not even think there were any known candidate structures in the region that were likely to have caused the earthquake (e.g., Dr. Pindell) (Table 1). The TIs concluded that if the earthquake could be related to a specific structure, then a source zone local to the earthquake encompassing that structure would be the best representation of the hazard presented by that structure. The TIs also believed that if the earthquake could not be related to a specific structure, the best representation of the potential hazard posed by the earthquake would be to allow a similar earthquake to occur anywhere within the Gulf of Mexico. Because of the uncertainty in whether the earthquake was related to a specific structure, the TIs determined that both options for the characterization of the September earthquake needed to be considered.

Through evaluating the available data and the existing GCSZ characterizations, the TIs determined that the existing EPRI-SOG GCSZ geometries adequately characterize both options and thus capture the "legitimate range of technically supportable interpretations among the entire informed technical community" (NUREG/CR-6372, page 6). This conclusion was based on the observation that: (1) three of the ESTs source zones included the earthquake epicenter, and thus these source zones represent the interpretation that an earthquake similar to the September event can occur anywhere within the Gulf of Mexico (Bechtel, Weston, Rondout); and (2) three of the ESTs source zones do not include the earthquake epicenter, and thus represent the interpretation that the earthquake is related to a source local to the epicenter and outside of the existing source zones.

For the February 2006 earthquake, the TIs also determined from the data collected in Step 2 that the existing GCSZ geometries adequately encompass the community distribution of potential geologic features or structures that may have caused the earthquake. All of the new data, information, and interviews indicated that there is considerable uncertainty with respect to what geologic feature or structure may have been responsible for the earthquake. For example, some of the experts interviewed suggested that a large-scale landslide on the Sigsbee escarpment may have caused the earthquake. This hypothesis implies that similar earthquakes may occur along other segments of the Sigsbee escarpment, thus suggesting the presence of a potential seismic source along the escarpment. The TIs evaluated these opinions and concluded that:

- The hypothesis that the February earthquake was caused by a large-scale landslide is not uniformly accepted within the technical community and represents only a single model of the possible cause of the earthquake.
- The existing EPRI-SOG GCSZ geometries capture this hypothesized source as well as other potential sources (e.g., the hypothesis that the earthquake occurred in the basement beneath the sedimentary section). For example, Dr. Dewey notes that within uncertainty the depth of the event could be between approximately 2 and 15 km.
- The existing EPRI-SOG GCSZs adequately characterize the "legitimate range of technically supportable interpretations among the entire informed technical community" (NUREG/CR-6372, page 6) with respect to the source of the February earthquake.

In summary, following a SSHAC level 2 process, the TIs concluded that the existing EPRI-SOG GCSZ characterizations are an adequate representation of the "legitimate range of technically supportable interpretations among the entire informed technical community" (NUREG/CR-6372, page 6) with respect to source geometry and recurrence rates. The TIs also determined that only the Mmax values for the GCSZs did not adequately describe, or were not consistent with, the new data (i.e., the two earthquakes), and thus only the Mmax component of the GCSZ characterizations needed to be updated.

Pursuant to these conclusions, the TIs developed an updated Mmax distribution to apply to all of the GCSZs with the following magnitudes and weights: mb 6.1 [0.1], 6.6 [0.4], 6.9 [0.4], 7.2 [0.1]. The lower bound of the distribution was set at mb 6.1, corresponding to the magnitude of the September earthquake, and the upper bound was set to mb 7.2, corresponding to the Mmax used in the 2002 USGS National Seismic Hazard Map for the extended margin (Frankel et al., 2002). The mb 6.1 magnitude of the February event was chosen by the TIs as the lower-bound Mmax for the source zones, even those that did not contain the event, as a conservative Mmax estimate. The USGS Mmax value was used as an upper bound because the USGS Mmax represents a consensus value reached by experts within the USGS with subsidiary input from some external experts.

Steps 4 and 5: Interaction with Peer Reviewers:

The analysis performed in Step 3 was presented to the peer review panel during a March 2007 seismic issues TAG meeting. The conclusions of the peer review panel were:

- They supported the conclusion that only the Mmax values needed to be updated; and
- They did not think it was appropriate to base the updated Mmax distribution for each EST on the USGS National Seismic Hazard Map source characterizations.

Significant discussion during the meeting between the TIs, project personnel and the peer review panel elucidated and clarified the panel's opinion that the USGS Mmax distribution was not developed through a formal SSHAC process, was not intended to capture the "legitimate range of technically supportable interpretations among the entire informed technical community" (NUREG/CR-6372, page 6), and was primarily developed to reflect hazard associated with the short return periods of building codes. The peer review panel also indicated that the uniform adoption of the USGS Mmax values for all six EPRI-SOG EST characterizations of the GCSZ erodes the high-level, SSHAC-like character of the EPRI-SOG study. The peer reviewers suggested that modifications to EPRI-SOG model should be kept minimal to honor the different interpretations and modeling approaches of the six EST's, and to retain the distribution of community opinion captured within the model.

Step 6: Response to Review Comments:

In response to the peer review comments, the TIs re-evaluated the updated Mmax distributions. The TIs determined that simply updating the Mmax values of the GCSZ distributions was a minor modification to the existing EPRI-SOG source characterizations. Based on comments from the peer reviewers, the TIs concluded that this minor update should be made in a way that preserves the integrity and continuity of the EPRI-SOG model because the EPRI-SOG model was developed using a methodology that is largely equivalent to a SSHAC level 4 process. Specifically, the EPRI-SOG source model was developed using an expert elicitation/interaction process that involved six independent ESTs comprising scientists recognized as experts in the fields of seismology, geology, and geophysics. A key goal of the study was to capture and represent the range of uncertainty in the informed technical community about the occurrence of future earthquakes and seismic sources within the central and eastern US (CEUS). The resulting seismic source model for the CEUS was viewed as representing the state of knowledge of the informed expert community at the time of the study with respect to the seismogenic potential of the CEUS crust.

Because of the similarity of the EPRI-SOG study to a high-level SSHAC study, and because only the Mmax values of the GCSZs were determined to be inconsistent with modern data, the TIs decided that the revised updated Mmax values should be developed using the original EST methodology. The TIs believed that by following the original methodology described in the EPRI-SOG documentation, the high-level SSHAC heritage of the study would best be preserved, and the resulting updated source descriptions for each EST would be a reasonable representation of the "legitimate range of technically supportable interpretations among the entire informed technical community" (NUREG/CR-6372, page 6) with respect to GCSZ Mmax values. The updates for the GCSZs are described in detail in FSAR Subsection 2.5S.2.4.3.

The revised updates to the GCSZs presented in FSAR Section 2.5S.2.4.3 were presented to the peer review panel at a second TAG meeting in June 2007. At this meeting the panel indicated that the revised Mmax values addressed their earlier concerns. Specifically, the panel endorsed the TIs' proposed approach of applying the methodologies of the ESTs to revise the Mmax distributions in light of the February and September 2006 earthquakes.

Table 1: Experts Interviewed for Gulf Coastal Source Zones (GCSZ) Updates

Expert	Date	Interviewer	Qualifications	Comments
Dr. James Dewey *USGS Golden*	May to July 2007	C. Fuller	USGS seismologist who used proprietary industry seismic data from ocean bottom seismometers to develop a revised hypocentral location of the February event.	Dewey was communicated with through several phone conversations and emails. Dewey initially indicated he was working on relocating the event using proprietary data provided by Dellinger, so he could only provide vague information prior to providing a report to Dellinger. On July 3, 2007, Dewey provided a draft report on the event that gave an updated hypocentral location, a discussion of the data used, and a brief discussion of the uncertainty associated with the location. In the report Dewey noted that the 5-km focal depth was largely arbitrary and that waveform data from the ocean bottom seismometer array suggests that the event occurred within the upper crust (2-15 km depth). [Note: Dewey's effort resulted in a revised event location that was released as a NEIC Monthly Earthquake Data Report].
Dr. Frank Peel *BHP Billiton Petroleum*	May 2007	M. Angell	Petroleum industry geologist with extensive knowledge of geologic structures within the Gulf of Mexico.	Peel was interviewed at the 2007 Offshore Technology Conference in Houston. Conversation focused on the February and September events and whether or not he knew of any potential structures that the events could be linked to. Peel suggested that these events may have occurred along the boundary between the oceanic and continental crust west of Florida. Based on mapping he had done elsewhere, he thought it was possible the boundary was near the earthquake epicenter.

Dr. Meredith Nettles *LDEO*	May 2006 to May 2007	M. Angell & C. Fuller	Seismologist with extensive experience developing earthquake hypocentral locations. Nettles was given access to seismic data from industry ocean-bottom seismometers to analyze the February earthquake. Nettles and Ekstrom developed the Harvard Moment Tensor solution for the September earthquake.	Nettles was interviewed several times to discuss both events. Initial interviews were conducted prior to the September event. To summarize her interviews, Nettles had no specific comment on the September event other than that it appeared to be a tectonic event. She has completed a detailed analysis and relocation of the February event that is documented in her paper for the 2007 Offshore Technology Conference. In the paper she hypothesizes that the event is a large-scale, gravity driven earthquake.
Dr. Joe Dellinger *BP*	May 2006 to December 2007	M. Angell and C. Fuller	Petroleum industry seismologist with extensive knowledge of Gulf of Mexico structure and seismicity. Ocean bottom seismometers operated by BP were used by Dewey, Nettles and Dellinger to analyze the February event.	Dellinger was originally interviewed by M. Angell, and Dellinger expressed his opinion that the earthquake was an anomalous shallow event and that he supported Nettles theory that the event was a gravity driven earthquake. C. Fuller attended a talk on the event by Dellinger at a December 2007 American Geophysical Union meeting. The conclusion presented by Dellinger was similar to that presented by Nettles, that the event was likely a relatively shallow, gravity driven landslide. Dellinger did not present any conclusive data to support this conclusion.
Dr. Goran Ekstrom *LDEO*	May 2006	M. Angell	Seismologist with extensive experience in developing earthquake hypocentral locations. Nettles and Ekstrom developed the Harvard Moment Tensor solution for the September earthquake.	Ekstrom was contacted about the February event. He had no specific comments about the event and directed questions to Nettles.

Dr. Martin Chapman *Virginia Tech*	February 2007	C. Fuller	Seismologist with extensive experience in analyzing seismicity within the central and eastern US.	Chapman was contacted regarding the two earthquakes. He was familiar with the occurrence of the events, but he didn't have any insight into any potential structures on which they may have occurred.
Dr. James Pindell *Rice University*	September 2007	C. Fuller	Geologist with extensive knowledge of Gulf of Mexico geologic setting and structure.	Pindell was interviewed at a conference. Conversation focused on the February and September events and whether or not he knew of any potential structures that the events could be linked to. He did not know of any structures that the events would be related to and mentioned that he did not think structures related to the Florida escarpment were likely sources.
Dr. Cliff Frohlich *Univ. Texas Austin*	March to June 2007	C. Fuller & J. Unruh	Seismologist and expert on earthquakes in and around Texas.	Frohlich was one of the reviewers of the source model updates and was part of conversations regarding the updates several times. He was very familiar with the occurrence of the earthquakes. He was aware of research being done by others on the events (e.g., Nettles), but he himself did not have any theories as to what caused the events or what geologic structures on which the events may have occurred.

Dr. Joe Litehiser *Bechtel (Bechtel EST)*	January to July 2007	C. Fuller & J. Unruh	Seismologist with extensive experience in analyzing earthquakes with respect to critical facilities. Project manager of original Bechtel Earth Science Team (EST)	Litehiser was part of the team working on the STP 3 & 4 COLA and was involved in discussions of the source model update throughout the entire process. In particular he was queried regarding his opinion and knowledge of the earthquakes and of the methodology used to develop the updated source characterization. With respect to the earthquakes, Litehiser knew of the events but did not have an opinion of their cause or related geologic structures. With respect to the methodology, Litehiser agreed that only the Mmax values needed updating and that following the original ERPI-SOG methodology to determine those values was a good approach.
George Klimkiewicz *Weston Geophysical Engineers (Weston EST)*	March 2007	C. Fuller	Project manager of original Weston EST.	Klimkiewicz was interviewed over the phone on the topic of the two earthquakes and the methodology to update the source model. He was aware of the occurrence of the events, and he supported the methodological approach of only updating the Mmax values of the Weston EST source model using the original approach of the Weston EST.
James McWhorter *Geoscience Services (Dames & Moore EST)*	March 2007	C. Fuller	Project manager of original Dames & Moore EST.	McWhorter was interviewed over the phone on the topic of the two earthquakes and the methodology to update the source model. He was not aware of the occurrence of the events, but he supported the methodological approach of only updating the Mmax values of the Weston EST source model using the original approach of the Dames & Moore EST.

No COLA Revision is required as a result of this RAI Response.

References:

- EPRI, 1986-1989, Seismic hazard Methodology for the Central and Eastern United States (NP-4726), Vol. 1-3 & 5-10, Electric Power Research Institute (EPRI).
- Frankel, A.D., Petersen, M.D., Muller, C.S., Haller, K.M., Wheeler, R.L., Leyendecker, E.V., Wesson, R.L., Harmsen, S.C., Cramer, C.H., Perkins, D.M., and Rukstales, K.S., 2002, Documentation for the 2002 Update of the National Seismic Hazard Maps, U.S. Geological Survey, Open-file Report 02-420, 33 p.
- Nettles, M., 2007, Analysis of the 10 February 2006: Gulf of Mexico Earthquake from Global and Regional Seismic Data, 2007 Offshore Technology Conference: Houston, TX, p. OTC 19099.
- NRC, 2007, Reg. Guide 1.208: A Performance-Based Approach to Define the Site-Specific Earthquake Ground Motion, US NRC, p. 53.

RAI 02.05.02-22

Question:

In responding RAI 2.5.2-15, you indicated that the magnitude for the hypothesized seismic sources associated with the liquefaction features found in the Arkansas and northeastern Louisiana are too small (approximately M6) and the distances too far from STP Units 3 and 4 (over 600 km) to have a significant impact to the site seismic hazard. Studies of these features have indicated the potential for earthquakes larger than magnitude 6. Please clarify the basis for your conclusion that the earthquakes are approximately 6.

Response:

As detailed in the response to RAI 02.05.02-15 submitted to the NRC on September 4, 2008 (STP Letter ABR-AE-08000070), the papers of Cox et al. (2004), Al-Shukri et al. (2005), and Tuttle et al. (2006) present essentially two hypotheses for the cause of liquefaction features that they describe:

(1) moderate magnitude earthquakes with epicenters proximal or close to the liquefaction, and
(2) large earthquakes related to the New Madrid seismic zone or other structures within the Reelfoot rift.

The statement in the first paragraph of the response to RAI 02.05.02-15 that is the subject of this RAI question is a simplifying summary statement regarding only the moderate magnitude, local earthquake model for the liquefaction. The sentence containing the statement reads, "Regarding the hypothesized sources proximal to the liquefaction features, the magnitudes are too small (approximately **M** 6) and the distances are too far from STP 3 & 4 (over 600 km) to have a significant impact on the site hazard." In the following paragraphs of the RAI response additional and more detailed information was provided with respect to the specific magnitude range that is hypothesized for the earthquakes that may have caused the liquefaction. This information is expanded below.

Cox et al. (2004) is the only study that explicitly discusses the potential earthquake magnitudes for a local source proximal to the liquefaction features. Cox et al. (2004) states, as discussed in the response to RAI 02.05.02-15, that the earthquake magnitudes were likely between **M** 5.5 and 6.5. This magnitude range is based on a simple analysis of the maximum extent of liquefaction features for two liquefaction fields (see page 1140 of Cox et al., 2004). Treating the two fields as having been caused by different earthquakes, Cox et al. (2004) estimated potential magnitudes for the causative events as **M** 5.7 and **M** 6.0. If the fields are treated as one continuous field caused by a single earthquake, Cox et al. (2004) estimated the magnitude as **M** 6.5. Cox et al. (2004) also states that it is most likely that the two fields were caused by separate earthquakes, thus implying that the **M** 6.5 earthquake is less likely than the **M** 6.0 or lower earthquake. Therefore, in the summary statement the magnitude was described as "approximately **M** 6.0" because: (1) 6.0 is intermediate to 5.5 and 6.5, and (2) Cox et al. (2004) expressed the opinion that the **M** 6.0 and **M** 5.7 magnitude earthquake scenario was more likely than the **M** 6.5 earthquake scenario.

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

References:

- Al-Shukri, H., Lemmer, R.E., Mahdi, H., and Connelly, J.B., 2005, Spatial and Temporal Characteristics of Paleoseismic Features in the Southern Terminus of the New Madrid Seismic Zone in Eastern Arkansas: Seismological Res. Lett., v. 76, p. 502-511.
- Cox, R.T., Larsen, D., Forman, S.L., Woods, J., Morat, J., and Galluzzi, J., 2004, Preliminary Assessment of Sand Blows in the Southern Mississippi Embayment: Bulletin of the Seismological Society of America, v. 94, p. 1125-1142.
- Tuttle, M.P., Al-Shukri, H., and Mahdi, H., 2006, Very Large Earthquakes Centered Southwest of the New Madrid Seismic Zone 5,000–7,000 Years Ago: Seismological Res. Lett., v. 77, p. 755-770.

RAI 02.05.02-23

Question:

In responding to RAI 2.5.2-18, you attached a paper, entitled "Random Vibration Theory Based Seismic Site Response Analysis." Presumably, the soil profile included in the paper is STP Units 3 and 4 site-specific soil profile. The profile has 15 layers characterized by different parameters. However, it does not match the detailed description of the soil layers underneath the site (from layer A to N) described in Section 2.5S.4. Please explain the discrepancy and provide site-specific soil property data to facilitate the staff's confirmative analysis. In addition, provide more details regarding the RVT methodology in FSAR.

Response:

The soil profile included in the paper entitled "Random Vibration Theory Based Seismic Site Response Analysis" is a generic profile used for comparison with the SHAKE results to demonstrate the adequacy of the new approach for site response analysis. The profile is documented in detail in Appendix B of the SHAKE91 User's Manual (Ref. 2.5S2-54), where the SHAKE input file of the example is printed in entirety. In all figures of the paper, the SHAKE results are directly adopted from the SHAKE91 User's Manual.

In response to the request for site-specific soil property data, site-specific randomized profiles are provided in a DVD enclosed with this RAI response. A total of 60 randomized profiles are used in the site response analysis, based on the RVT approach with acceleration response spectrum as input motion.

The description of the RVT approach in the STP COLA will be modified to include a more detailed discussion. The first and second paragraphs of FSAR Section 2.5S.2.5.4, COLA Revision 3 will be revised as follows:

> The site response analysis performed for the STP 3 & 4 site is conducted using the program P-SHAKE (refer to Appendix 3C), which uses a procedure based on Random Vibration Theory (RVT) (References 2.5S.2-52 and 2.5S.2-53) with the following assumptions:
>
> - Vertically-propagating shear waves are the dominant contributor to site response
> - An equivalent-linear formulation of soil nonlinearity is appropriate for the characterization of site response
>
> These are the same assumptions that are implemented in the SHAKE program (Reference 2.5S.2-54).~~ and that constitute standard practice for site-response calculations. In this respect, RVT and SHAKE solve the same problem, but RVT works with ground-motion power spectral densities or response spectra (and its relation to peak values), while SHAKE works with individual time histories and their Fourier spectra.~~ With respect to RVT implementation, the major steps used in P-SHAKE are as follows:

1. The input motion is provided in terms of acceleration response spectrum (ARS) and its associated spectral damping, instead of spectrum-compatible acceleration time histories. The input ARS is converted to acceleration power spectral density (PSD) using the RVT based procedure with the peak factor function.

2. From the frequency domain solution of the soil profile (following SHAKE approach), the transfer function for shear strain in each layer is obtained and convolved with the power spectral density (PSD) of input motion to get the PSD and the maximum strain in each layer. The effective strain is obtained from the maximum strain and is used to obtain the new soil properties (soil shear modulus and damping) for the next iteration.

3. The iterations are repeated until convergence is reached in all layers to the convergence limit set by the user.

4. Once the final frequency domain solution is obtained, the acceleration response spectrum at each layer interface can be computed from the solution using an inverse process of obtaining PSD from the acceleration response spectrum.

References:

2.5S.2-52 "Structural Response to Stationary Excitation," Journal of the Engineering Mechanics Division ASCE, v. 106, No. EM6, December, pp. 1195-1213, Der Kiureghian, A., 1980.

2.5S.2-53 "Site-Specific Validation of Random Vibration Theory-Based Seismic Site Response Analysis," Journal of Geotechnical and Geoenvironmental Engineering, Vo. 132, No. 7, July, pp. 911-922, Rathje, E. and Ozbey, C.M., 2006.

2.5S.2-54 "SHAKE91: A computer program for conducting equivalent linear seismic response analyses of horizontally layered soil deposits," Idriss, I. M., and Sun, J. I., Dept. of Civil and Environmental Engineering, Center for Geotechnical Modeling, Univ. of California, 1992.

RAI 02.05.02-24

Question:

Based on Section 2.5S.2, the EPRI SOG ESTs either assigned low maximum magnitudes and low probabilities of activities or provided no source coverage to the area located in the northwest corner of the site region (see FSAR Figure 2.5.2-8). With the result that the hazard contribution from this area is less than or equal to 1%. Please justify this lack of coverage and whether the EPRI SOG source models adequately characterize the hazard surrounding the site.

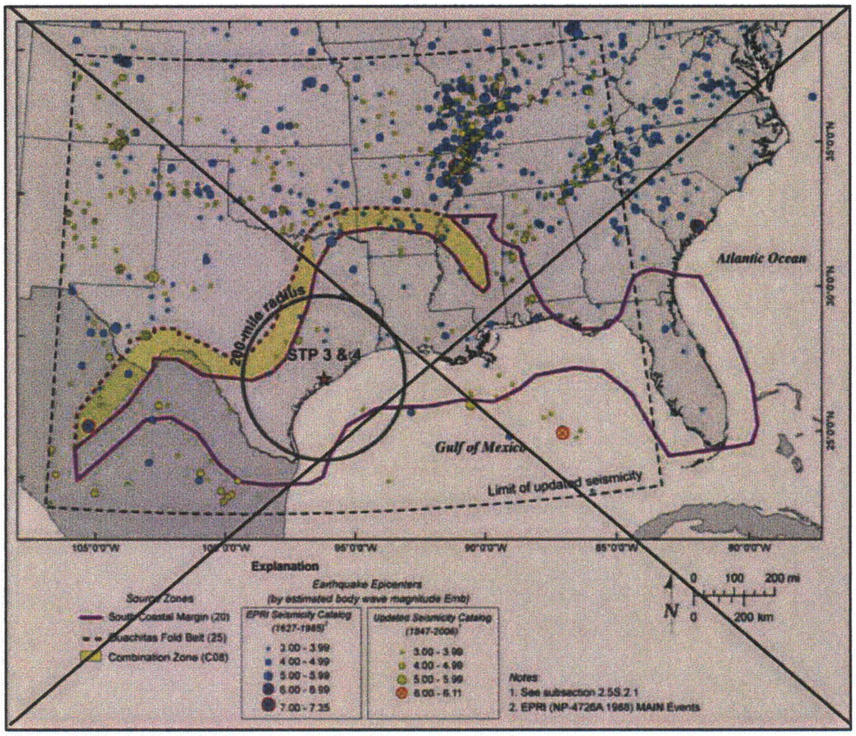
Response:

To address this RAI, revised COLA figures have been prepared mapping the additional EPRI SOG seismic sources that cover the northwest corner of the site region.

FSAR Figure 2.5S.2-8 is a composite map of all EPRI SOG seismic sources that specifically cover the Gulf of Mexico. FSAR Figures 2.5S.2-1 through 2.5S.2-6 are maps of the EPRI SOG seismic sources from each of the Earth Science Teams [EST] that contribute to 99% of the seismic hazard, including seismic sources that cover the northwest corner of the site region not shown in Figure 2.5S.2-8. Tables 2.5S.2-7 through 2.5S.2-12 list all EPRI SOG seismic sources from the ESTs that are located within 200 miles of the site region, including three sources not contributing to 99% of the seismic hazard, and, therefore, not mapped in the FSAR figures of EST seismic sources.

In response to this RAI, the three non-contributing seismic sources listed in Tables 2.5S.2-7 through 2.5S.2-12 that are not already plotted in Figures 2.5S.2-1 through 2.5S.2-6 -- Dames and Moore seismic source 67, Rondout seismic source C02, and Weston Geophysical Corporation seismic source C31 – are now plotted in their respective FSAR Figures 2.5S.2-2, 2.5S.2-4, and 2.5S.2-5. The revised COLA figures are included with this RAI response.

The composite EST seismic sources, which do cover the northwest portion of the site region, do adequately characterize the low contribution to seismic hazard from this area.



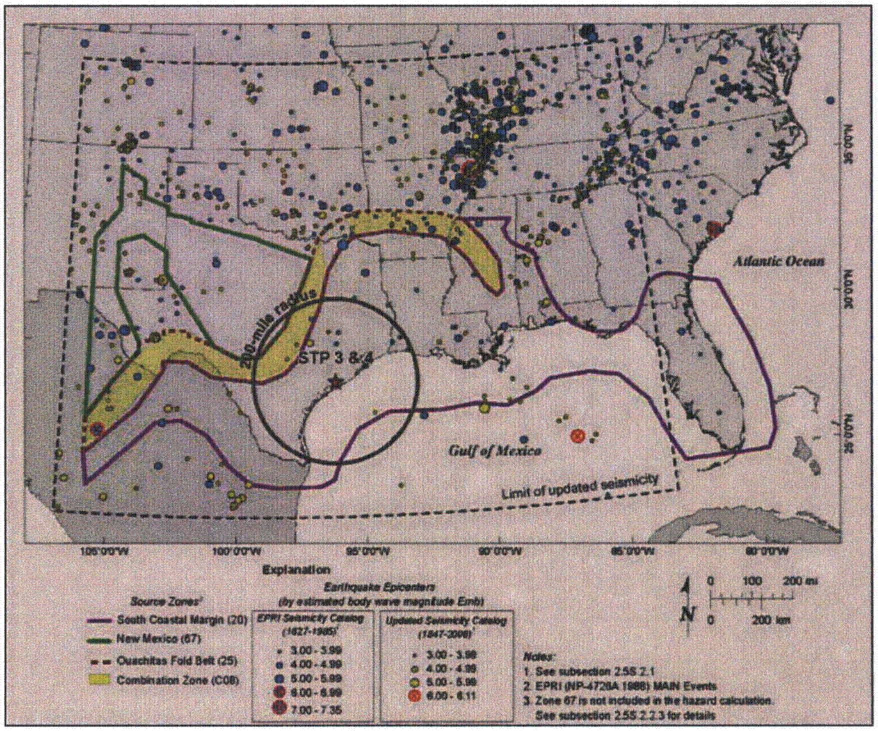
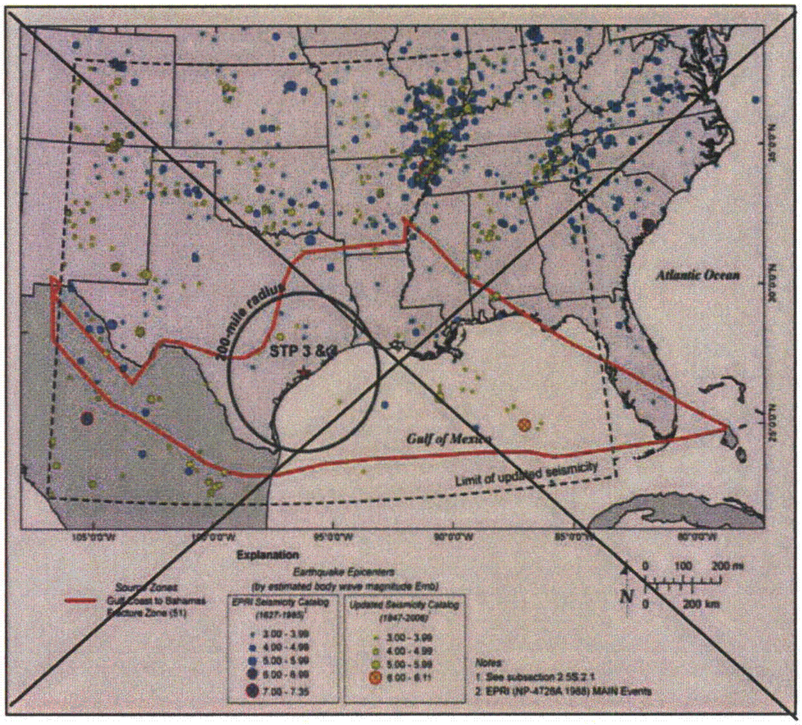


Figure 2.5S.2-2 Dames and Moore EPRI Source Zones



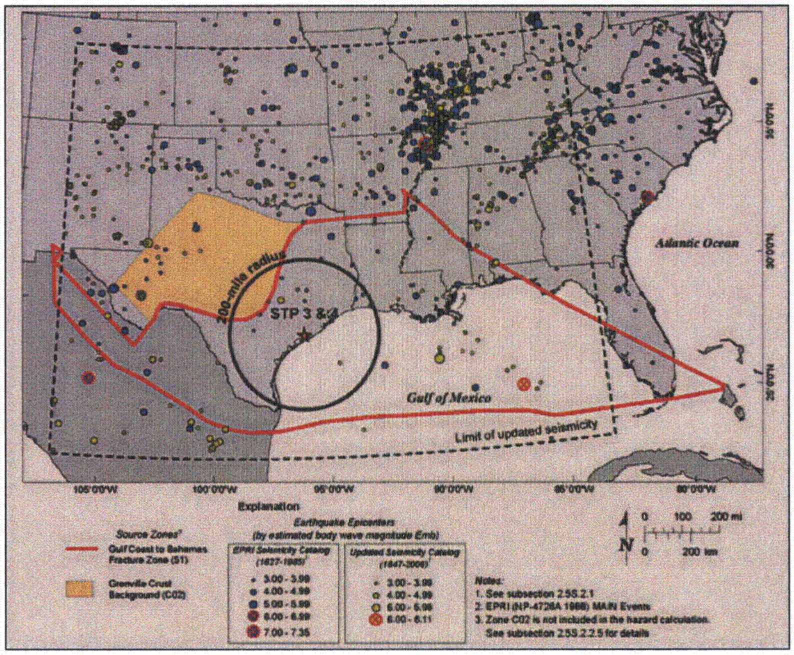


Figure 2.5S.2-4 Rondout Associates EPRI Source Zones

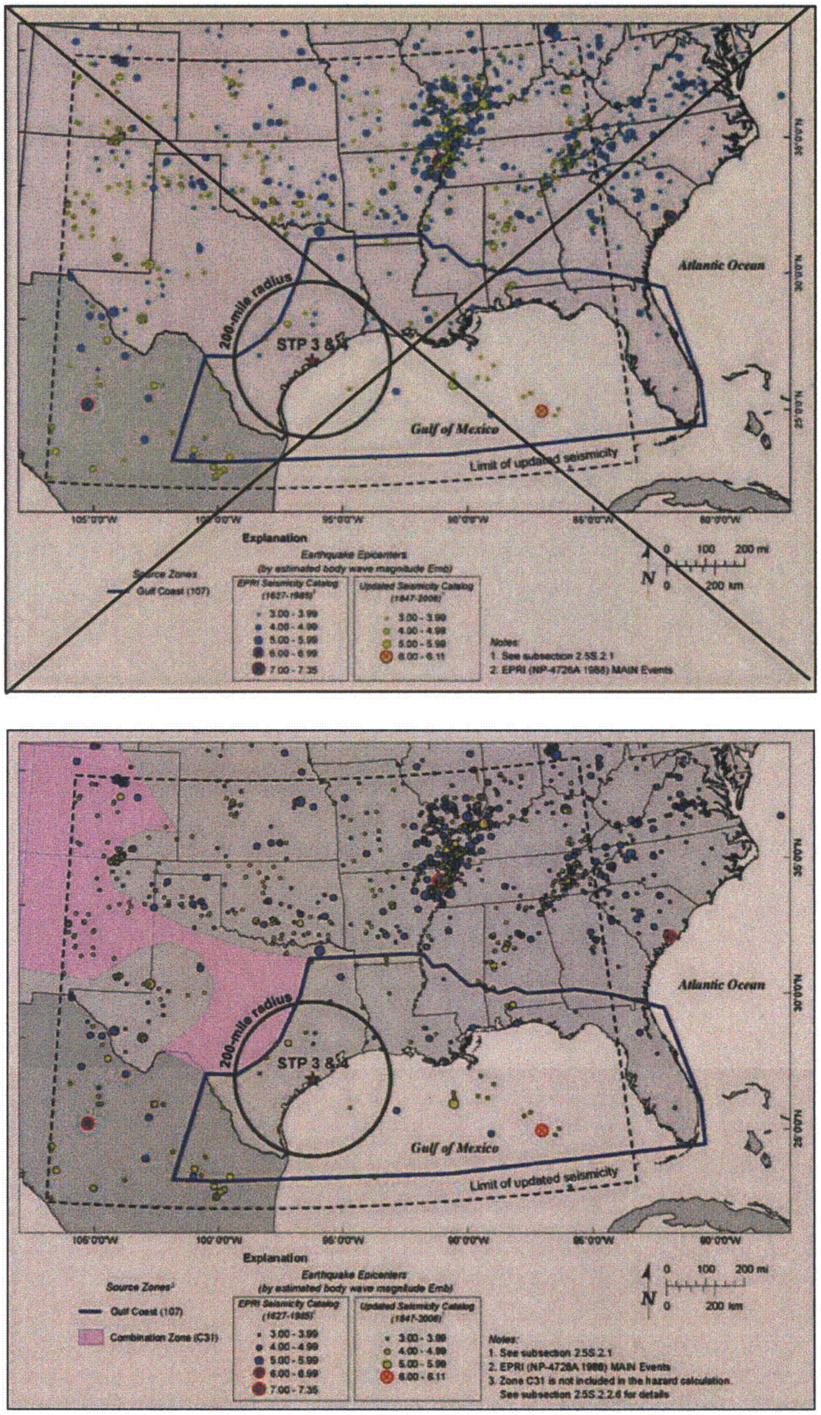


Figure 2.5S.2-5 Weston Geophysical Corporation EPRI (1989) Source Zones

RAI 02.05.02-25

Question:

In Section 2.5S.2.5, you mentioned that Vs =9200 fps "is located at more than 30,000 ft (9144 m) below the ground surface." However, Figure 2.5.4-57 in Section 2.5S.4 indicates that below 2500 ft, the Vs is about 9200 ft/s, and in the FSAR Com 2.5 S-1, you also indicated that "below 2500 ft depth, a hard rock shear wave velocity of 9285 ft/s was assumed." Please clarify this discrepancy.

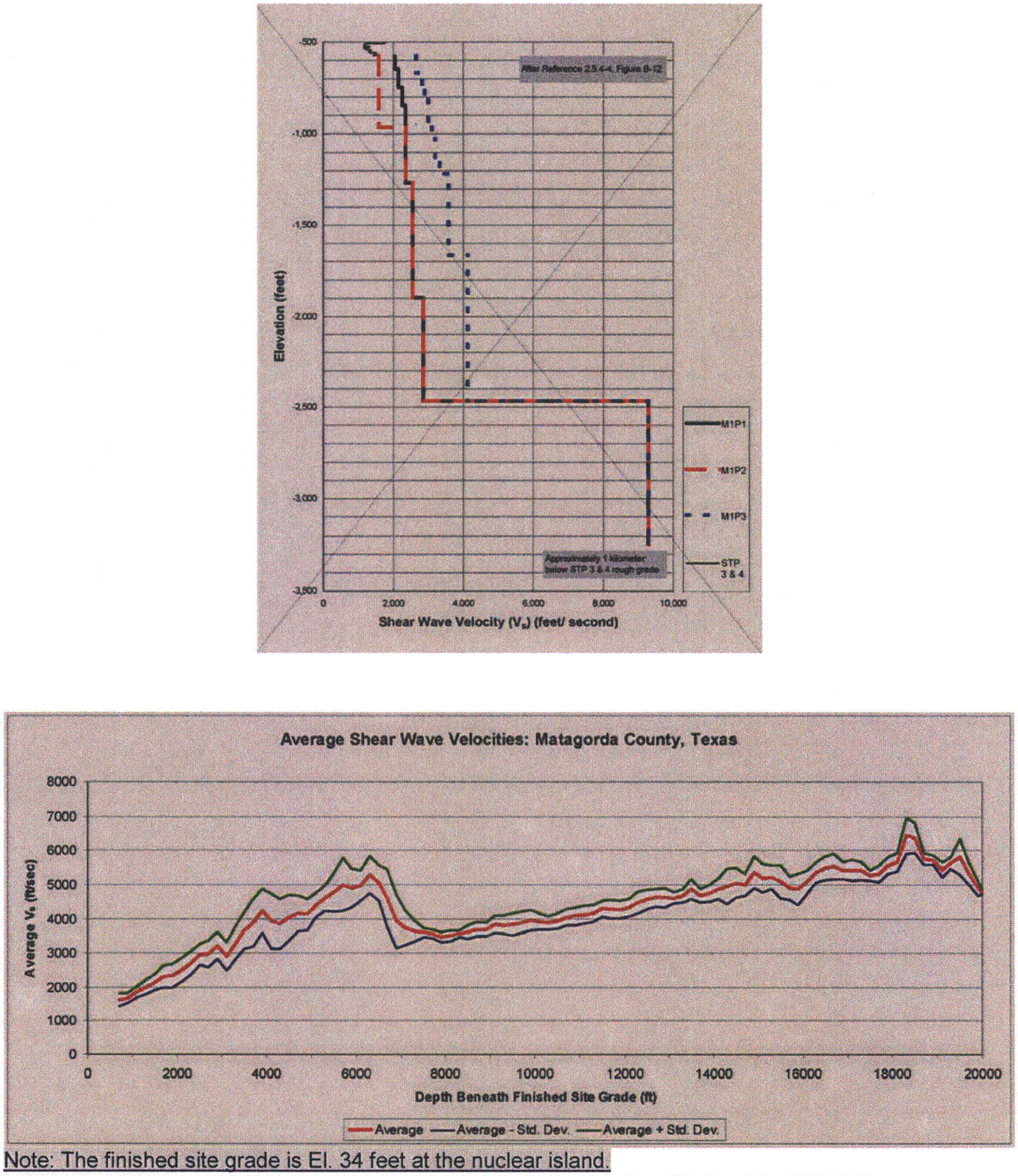
Response:

The statement in STP COLA Section 2.5S.2.5 describes the natural geologic condition. For the purpose of the STP site response analysis, the soil column profile is truncated at a depth of 8100 ft. The soil column truncation depth is selected to capture the seismic response for frequencies greater than or equal to 0.1 Hz. Below 8100 ft, bedrock is assumed with a shear wave velocity of 9200 ft/s and the UHS rock motion is applied at bedrock horizon. Further discussion of the selection of the soil profile for the STP site response analysis is presented in Section 2.5S.2.5 of STP COLA Rev. 3, which is planned to be submitted to the NRC in September 2009. To reflect the shear wave velocity derived from the deep sonic log data, Figure 2.5S.4-57 will be replaced in a future COLA revision, as shown below.

The following statement is included in the response to FSAR Com 2.5S-1 (Reference 1), "Previously, shear wave velocities below 600 feet depth were based on the more generic "Mississippi embayment lowlands profile" down to 2,500 feet depth. Below 2,500 feet depth, a hard rock shear wave velocity of 9,285 feet/second was assumed." However, as discussed in Reference 1, the above approach has been modified and an updated soil profile has been used in the analysis, as described in Section 2.5S.2.5 and shown in Figure 2.5S.2-35a in STP COLA Rev. 3. A copy of Figure 2.5S.2-35a from STP COLA Rev. 3 is included in this RAI response.

Reference:

1: "STP COLA FSAR Commitment (COM 2.5S-1)", South Texas Project Letter No. U7-C-STP-NRC-080070, Attachment 1, dated December 15, 2008.



Note: The finished site grade is El. 34 feet at the nuclear island.

Figure 2.5S.4-57 Deep Shear Wave Velocity Profile for the STP Site

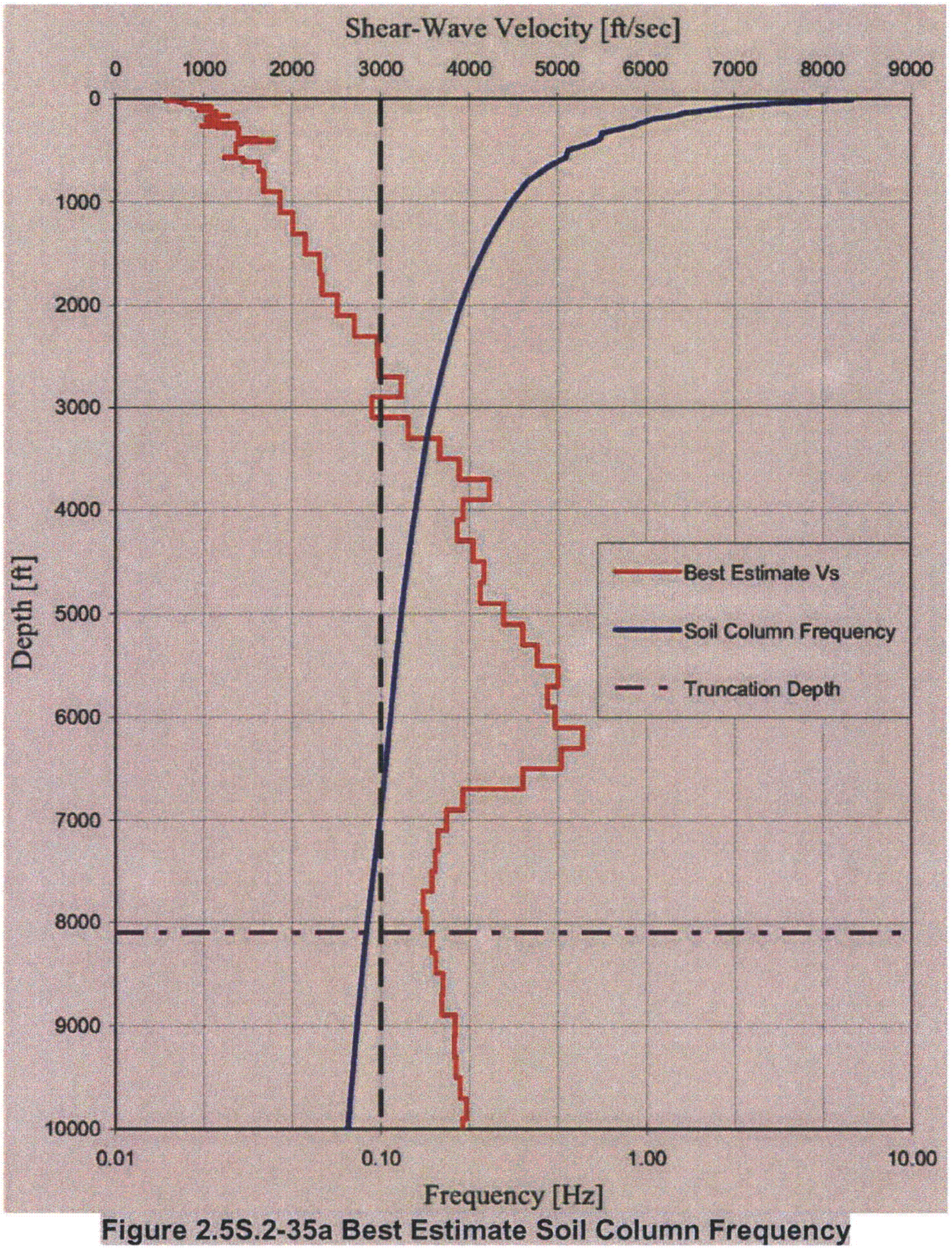


Figure 2.5S.2-35a Best Estimate Soil Column Frequency

RAI 02.05.02-26

Question:

FSAR Com 2.5 S-1 states that you replaced site-specific soil profile below the depth of 600 ft with a new profile converted from P wave measurements from oil exploration data. Please describe the corresponding changes to the Kappa value because of this new soil profile.

Response:

The best estimate total kappa value used for the entire soil profile excluding the crustal kappa is 0.04 sec. A logarithmic standard deviation (0.4) is used to include the variation of the kappa. Subtracting the kappa for the upper 600 ft (obtained from the soil nonlinear damping curves at low strain), the remaining kappa was used to develop the damping profile for the soil layers below 600 ft. As discussed in Section 2.5S.2.5 of STP COLA Rev.3, scheduled to be submitted to the NRC in September 2009, the new shear wave velocity profiles below the depth of 600 ft are used to obtain layer damping using the residual kappa for these layers. The damping ratio for the deep soil layers is computed to be 0.6%.

No further COLA revisions are required as a result of this RAI response.

RAI 02.05.02-27

Question:

Since Sections 2.5S.2.5, "Seismic wave transmission characteristic of the site" and 2.5.S.2.6, "Ground Motion Response Spectra" have been modified significantly, please provide complete updated FSAR contents for those sections, including all the supporting figures and tables, such as GMRS, 10^{-4} and 10^{-5} UHRS and other related tables.

Response:

Complete updated FSAR contents for FSAR Sections 2.5S.2.5, "Seismic Wave Transmission Characteristics of the Site," and 2.5S.2.6, "Ground Motion Response Spectra," including all the supporting figures and tables, such as GMRS, 10^{-4} and 10^{-5} UHRS, and other related tables, have been incorporated into STP COLA Revision 3.

No further COLA revisions are required as a result of this RAI response.

RAI 02.05.04-29

Question:

In response to RAI 2.5.4-15, you provide a brief description of the calculation procedure used to determine the dynamic bearing capacity, but you did not report the calculated factor of safety for the safety-related structures under SSE dynamic loading. Similarly, in the mark up of the FSAR submitted as response to question RAI 2.5.4-13, Supplement 1, FSAR subsection 2.5.4.10.3 does not indicate the factors of safety calculated for the safety-related structures. Additionally, reference was made to a criterion factor of safety of 1.5 when dynamic or transient loading conditions apply. The staff has two questions related to this RAI response.

1. What are the factors of safety for STP Units 3 and 4 safety-related structures under the dynamic SSE loading?

2. Given that reference 2.5S.4-69 is a 1980 era document, and higher factors of safety are being applied by other applicants, please justify the use of a factor of safety of 1.5 for STP Units 3 and 4.

Response:

1. The site-specific seismic analysis of Reactor and Control Buildings and UHS/RSW Pump House is currently being performed. Factors of safety (FOS) for these safety related structures for dynamic bearing capacity for the site-specific conditions will be provided by December 31, 2009.

2. The ABWR DCD does not contain any requirements on acceptable dynamic bearing capacity FOS. The NRC SRP 2.5.4 also does not provide any guidance on acceptable dynamic bearing capacity FOS. The use of a minimum FOS of 1.5 for bearing capacity under SSE loading for STP Units 3 and 4 is acceptable based on the following:
   a. Reference 2.5S.4-69 is an applicable reference for nuclear power plants. This manual was prepared by an ASCE editing board and task groups of the ASCE Committee on Nuclear Structures and Materials. We are not aware of new research findings or publications in professional journals that question the guidance provided in Reference 2.5S.4-69 on FOS for dynamic bearing pressure.
   b. Regulatory Guide 1.198 (Procedures and Criteria for Assessing Seismic Soil Liquefaction at Nuclear Power Plant Sites) indicates that the acceptable FOS for soil liquefaction evaluation is 1.4. Since, soil bearing and soil liquefaction are of similar importance as far as the foundation stability is concerned, use of 1.5 for bearing capacity for SSE loading is considered acceptable.
   c. The SSE is a very short duration load where the peak loading is a momentary load that decreases rapidly. The oscillatory nature of the seismic loading with only a few peak stress cycles would allow full mobilization of the bearing capacity only for a short period

of time (milliseconds) during which limited soil deformations could occur even if the factor of safety was approaching 1.0 or even lower.

d. The peak dynamic bearing pressure for the SSE loading is at a corner under the foundation with the dynamic bearing pressure decreasing rapidly away from the foundation corner. A foundation bearing capacity failure under the highly localized and transient loading is not postulated. For bearing capacity failure of structures with mat foundation, a significant area under the mat foundation has to be loaded beyond the bearing capacity of the founding strata. For SSE loading, this average loading is significantly smaller than the peak corner loading. An FOS of 1.5 under such conditions is thus considered acceptable.

e. Industry codes and standards for structural design (i.e. ACI 349 and ANSI/AISC N690-1994) specify FOS approaching 1.0 against failure for SSE loading by allowing higher allowable stresses or smaller load factors for SSE loading combinations.

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

RAI 02.05.04-30

Question:

The response to RAI 2.5.4-21 states that the following language will be added to the FSAR, " Construction sequencing will be necessary to address the time-rate of settlement for the Category 1 structures...." and "The acceptance criteria for settlement of Category 1 structures will be developed during design of these structures and will be consistent with the DCD." The staff finds this level of detail vague and requests that you provide more information.

1. Please elaborate on your means of using construction sequencing to evaluate time-rate of settlement.
2. Please provide your settlement criteria for fuel loading. How will you ensure that settlements after fuel loading will not be damaging settlements?

Response:

1. Due to the expanse of the area of construction, the deep depths of excavation and foundation bearing elevations, proximity between heavily loaded structures, and sensitivity to total settlement and tilt of some structures, the settlement with time will be calculated and monitored through the course of construction. Predicted settlement/tilt can then be evaluated and construction sequencing adjusted accordingly during the planning and design. This will set a baseline for comparison with actual settlements measured during construction so if there is a variation in actual settlement versus predicted, the variation can be evaluated and schedules for interconnection of services between buildings can be adjusted as necessary. Considerations used in the analysis consist of the following:

   a. Building Dimensions; width and length (mat and concrete fill), bottom elevations, coordinates of building corners.
   b. Structure Loads, including standard plant and nuclear safety related structures and other loaded structures/equipment present during construction (i.e. cranes).
   c. Load on mat as structure is being constructed including backfill placement.
   d. Crane Pad retaining walls; location and depth.
   e. Excavation schedule (Including time and top elevations).
   f. Backfill schedule (Including time and top elevations).
   g. Foundation and structure construction schedule.
   h. The dewatering and rewatering schedule in relation to backfill schedule.
   i. Piezometer levels.
   j. Date of fuel load.
   k. Range of soil properties.

   From the constructor's plans for construction sequencing and scheduling, the start and finish dates for the individual items that cause change in the soil stress beneath a location (structure) of interest will be assembled. The load variation with time from the individual items will be determined (or, if appropriate, assumed linearly varying from the start to the finish date). The soil stress changes over time from the various items will be input to a time rate of calculation tool, such as Plaxis 2D/3D (Reference 1 and 2). The time rate of settlement output will be checked using a simple calculation tool such as either a spreadsheet (Reference 3) or a computer program such as CONSOL (Reference 4).

A range of soil properties will be utilized to account for uncertainty. The settlements versus time for the various locations of interest will thus be determined and compared between locations of interest for differential settlement evaluation or tilt. If the predicted differential movements thus determined are considered to be of concern, alternatives for construction sequencing and scheduling will be considered. Monitoring of settlement associated with the construction loading will be performed and settlement calculations will be modified, as appropriate, to obtain agreement of computed and measured settlements with time.

The time-rate of settlement analyses will be updated periodically through construction using real-time structural, construction, and geotechnical field information. As described previously, this will allow evaluation of settlement issues and allow appropriate actions to mitigate their impact.

The settlement calculations described above will predict settlement and tilt during three phases:

- Rebound
- Construction Settlement
- Post-Construction Settlement

Rebound recovery and construction settlement will be monitored during construction. These measurements will be used for two purposes:

- Determine the construction settlement
- Provide actual data to compare with predicted results and modify the post-construction settlement calculations, if appropriate.

The analysis and design of SSCs will accommodate the predicted post-construction settlement and tilt, with appropriate margins in the values.

This is accomplished by using these values in analyses of piping, cable trays and conduit, HVAC ducts and other components that connect between adjacent structures. Similar analyses will be conducted for buried services connecting to buildings.

Final connections of services between buildings will occur after analysis of the actual versus predicted construction settlements has been made.

2. Determination of the differential settlement and tilt values to be used for analysis and design will be based upon the post construction settlement values determined by the analysis described above. The safety of safety-related structures, systems and components (SSC) from potentially damaging settlements occurring after the fuel load will be documented by the

preparation of an engineering study that will predict the magnitude of future settlements and show that the predicted settlements are within the values used for design.

References:

1. Plaxis 2D Finite Element Code for Soil and Rock Analysis, Plaxis BV, Version V9.0
2. Plaxis 3D Finite Element Code for Soil and Rock Analysis, Plaxis BV, Version V2.0
3. Excel, Microsoft, Versions 2003 and 2007
4. CONSOL, 1D Consolidation Analysis of Layered Soil, Virginia Polytechnic Institute and State University, Version 3.0

Information References:

1. Plaxis 2D Resource Information Page
2. Plaxis 3D Resource Information Page
3. CONSOL 1D Resource Information Page

COLA Part 9, Inspections, Tests, Analyses, Acceptance Criteria, will be revised to include the following ITAAC:

Table 3.0-13 Settlement

Design Commitment	Inspections, Tests, and Analyses	Acceptance Criteria
Settlement of structures predicted to occur after fuel load will be accounted for in the analysis and design of safety-related SSCs.	Field measurements of actual settlement of Seismic Category I structures and other structures, the integrity of which could potentially impact Seismic Category I structures, will be made at prescribed times throughout the construction process, including at the conclusion of construction, prior to the loading of fuel. These field measurements will be compared to the settlements predicted by the construction sequence-based time rate of settlement analyses. The results of these comparisons will be used to predict future settlement that might occur over the operating life of Units 3 and 4. These predicted settlements will be compared to the allowable settlements associated with the safe operation of safety-related SSCs.	An engineering report exists that concludes that future settlements of structures after the loading of fuel and throughout the operational life of Units 3 and 4 will be no greater than those used for the analysis and design of safety-related SSCs.

Information Reference 1:

PLAXIS

2D - Version 9.0

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CONSOL 3.0: A COMPUTER PROGRAM FOR 1-D CONSOLIDATION ANALYSIS OF LAYERED SOIL

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