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March 28, 2011
U7-C-NINA-NRC-110046

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

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

Reference: Letter, Scott Head to Document Control Desk, "Response to Request for Additional Information," dated November 22, 2010, U7-C-STP-NRC-100241 (ML103330369)

Attached is the Nuclear Innovation North America LLC (NINA) revised response to Request for Additional Information (RAI) question 02.04.04-15, related to Combined License Application (COLA) Part 2, Tier 2, Section 2.4.4, "Potential Dam Failures." This revised response replaces the original response submitted with the referenced letter.

When a change to the COLA is required, it will be incorporated into the next routine revision of the COLA following NRC acceptance of the RAI response.

There are no commitments in this letter.

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

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

Executed on 3/28/11

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

rhb

Attachment: RAI 02.04.04-15, Revision 1

D091
NRO

STI 32844141

cc: w/o attachment except*
(paper copy)

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RAI 02.04.04-15, Revision 1

QUESTION:

Provide FSAR updates that address the issues raised above: (1) justification for reliability and accuracy of RMA2 predictions at the STP site, (2) selection and justification of a reasonable value for the DEPLIMIT parameter, (3) a description of results of the SED2D simulation(s) that use the selected value of the DEPLIMIT parameter, (4) a qualitative and quantitative description of sediment deposition and scouring in the powerblock area, (5) a description of the physical and hydraulic integrity of the powerblock surface following the flood event, (6) a description of sediment mass balance for the SED2D simulations, (7) sediment deposition height and scouring depth maps within the powerblock area, (8) citations for precedents for the use of artificial sumps in applications of RMA2/SED2D.

Characteristics of the design-basis flood (e.g., flow velocities, scour, deposition) and post-construction cover (e.g., surface material map, associated properties) are to be consistent in RAIs 5101 and 5105. If the design-basis flood is revised, the revised characteristic shall be applied in FSAR Sections 2.4S.12 and 2.4S.13.

REVISED RESPONSE:

The original response to this RAI was submitted with STPNOC letter U7-C-STP-NRC-100241, dated November 22, 2010. The revisions (additions and deletions) to the original RAI response are indicated by revision bars in the right-hand margin.

This revised response is provided to include a bounding analysis for sediment accumulation in the powerblock area as a result of discussions with the NRC. This analysis replaces the SED2D sediment deposition analysis. A conservative sediment accumulation depth within the Units 3 and 4 powerblock area is estimated by assuming that twice the calculated total volume of sediment due to the MCR embankment breach is deposited fully and uniformly on a fan area extending from the breach to the peripheral road. The discussion and results of the SED2D analysis will be removed from the COLA. All proposed revisions to the FSAR to remove discussion of SED2D and incorporate the results of the bounding analysis are included in this revised response.

Previous RAI responses that discuss SED2D (RAI 02.04.04-7, RAI 02.04.04-10 and Supplement 1 to RAI 02.04.04-9) will not be revised as a result of this response.

The eight parts of this RAI are addressed below. The responses to parts (2), (3), (4), (6), (7) and (8) are revised.

(1) A discussion of the reliability and accuracy of the RMA2 model is added to Subsection 2.4S.4.2.2.3. Refer to FSAR markup.

(2) The bounding analysis for sediment accumulation replaces the SED2D sediment deposition analysis, and therefore no discussion is provided for the selection and justification of the value for the DEPLIMIT parameter used in the SED2D analysis.

(3) The bounding analysis for sediment accumulation replaces the SED2D sediment deposition analysis, and therefore no discussion is provided for how the DEPLIMIT parameter affects the SED2D results.

(4) Subsection 2.4S.4.2.2.4.2 is updated to include a qualitative and quantitative description of sediment deposition and scouring in the powerblock area. Refer to FSAR markup.

(5) A description of the integrity of the powerblock surface following the flood event is included in Subsection 2.4S.4.2.2.4.2. Refer to FSAR markup.

(6) The bounding analysis for sediment accumulation replaces the SED2D sediment deposition analysis, and therefore no discussion is provided for sediment mass balance for the SED2D simulations. The bounding analysis for sediment accumulation is based on the principle of mass balance. Refer to FSAR markup.

(7) As discussed in Subsection 2.4S.4.2.2.4.2, the anticipated erosion/scouring within the powerblock area is not significant. The sediment deposition zone considered for the bounding analysis for sediment accumulation is shown in Figure 2.4S.4-21(f1). Refer to FSAR markup.

(8) Citations for precedents for the use of artificial sumps in applications of RMA2 have been added to Subsection 2.4S.4.2.2.3.1. Refer to FSAR markup.

The FSAR will be revised as follows as a result of this response:

Subsection 2.4S.4.2.2 will be updated as follows:

2.4S.4.2.2 MCR Embankment Breach Analysis

FLDWAV, a computer program developed by the National Weather Service (Reference 2.4S.4-12), was used to generate the outflow flood hydrograph from the MCR embankment breach, based on breach parameters discussed in Subsection 2.4S.4.2.2.2.2. This flood hydrograph was used as input to the two-dimensional flow model downstream of the breach.

RMA2 is a two-dimensional (2-D), depth-averaged finite-element hydrodynamic numerical model developed by the United States Army Corps of Engineers (USACE) (Reference 2.4S.4-12a). RMA2 was used to determine the flood elevations and velocities at the safety-related facilities of STP Units 3 and 4. The computer program can simulate dynamic water surface elevations and horizontal velocity components for subcritical, free-surface flow in a 2-dimensional flow field. The governing equations of RMA2 are the depth-integrated equations of fluid mass and momentum conservation in two horizontal directions. The

governing equations are solved by finite-element method using the Galerkin Method of weighted residuals, and the integration in space is performed by Gaussian integration. Derivatives in time are replaced by a nonlinear finite difference approximation. The solution is fully implicit and the set of simultaneous equations is solved by the Newton-Raphson nonlinear iteration scheme. The computer code executes the solution by means of a front-type solver, which assembles a portion of the matrix and solves it before assembling the next portion of the matrix. The Surface Water Modeling System (SMS) (Reference 2.4S.4-12c) was used as the pre- and post-processor for the RMA2 model.

A 2-D model grid was developed based on topographic information and assigned parameters, such as Manning's roughness coefficient. Breach characteristics and a breach outflow hydrograph were incorporated into the 2-D grid, based on the breach analysis and FLDWAV results. A sensitivity analysis was conducted to evaluate the RMA2 results.

~~RMA2 does not have sediment transport modeling capability, and therefore, SED2D computer model (Reference 2.4S.4-12b) was used to conduct sediment transport simulation using RMA2 results as the driving hydrodynamics. The SED2D model, developed by the USACE, included a dynamic inflow load of sediments that was developed based on the breach erosion and sediment load analysis. The SED2D results were then evaluated for sediment concentrations and deposition depths at any given location. The Surface Water Modeling System (SMS) (Reference 2.4S.4-12c) was used as the pre- and post-processor for RMA2 and SED2D models.~~

Subsection 2.4S.4.2.2.3 will be updated as follows:

2.4S.4.2.2.3 RMA2 Two-Dimensional Model Simulation

After developing the maximum credible breach scenario, resulting hydrograph and resulting embankment erosion rates, the next step is to route the breach hydrograph to the safety-related facilities. Because of the complex topography of the site, a 2-dimensional (2D) simulation was considered appropriate. RMA2 has been used widely to conduct dynamic simulations of water level and velocity distribution in rivers, reservoirs, and estuaries, and is considered an acceptable tool to model the flood flow from the MCR embankment breach.

2.4S.4.2.2.3.1 Bathymetry Elevations and Two-Dimensional Grid Development

The topography of the STP site was used to determine model bathymetry for routing the flood flow resulting from the MCR embankment breach. The 2-D grid was developed using: (1) STP Site Topography; (2) STP Units 3 and 4 Site Grading Plan; and (3) STP Units 3 and 4 Plot Plan. The grading plan around Units 3 and 4 power block site is shown in Figure 2.4S.4-14. The grade elevation at the center of the power block is EL. 36.6 ft and slopes to El. 32 ft at the four corners. Facilities included in the model grid are the Reactor, Turbine, Control, Radwaste, Service and Hot Machine Shop buildings for Units 1 through 4. The Ultimate Heat Sinks for Units 3 and 4 and Essential Cooling Pond (ECP) for Units 1 and 2 were also included in the model grid.

The datums of the 2-D grid are in NAD 27 State Plane Texas South Central for the horizontal datum and NGVD 29 for the vertical datum. The northern embankment of the MCR was selected as the southern boundary of the 2-D grid, and road FM 521 was chosen

as the northern boundary of the grid. The western and eastern boundaries of the grid were selected to be sufficiently far from Units 3 and 4 so the target area is not impacted by the model boundaries (Figure 2.4S.4-15).

To assist the 2-D model stability associated with the wetting and drying of model elements and to further ensure that the target area is not impacted by model boundaries, a hypothetical sump was modeled along the east, north, and west boundaries of the developed 2-D grid outside of FM-521. The use of the sump to help with model stability is a common practice in the 2-D modeling field. Reference 2.4S.4-12e3 and Reference 2.4S.4-12e4 describe the use of sumps in physical models to control (and vary) the boundary conditions for calibration and the concept of "hybrid modeling" where results from a physical model of a complex region are used as input or boundary conditions for a comprehensive numerical model. References 2.4S.4-12e5 through 2.4S.4-12e8 show precedents for the use of artificial sumps in RMA2 applications. ~~and t~~ The sensitivity analysis described below indicates that the hypothetical sump has no impact on model results in and around Units 3 and 4. As a result, the developed 2-D grid (excluding the artificial sump area) covers an area of 1,477 acres: 5,873 ft in the north-south direction, and 12,455 ft in the east-west direction. Figures 2.4S.4-16 and 2.4S.4-17 show the 2-D grid with elevations for the east breach and west breach, respectively. The sump is the deeper area on the outside of the model grid. The 2-D grid includes 2,348 nodes and 1,088 elements. The size and location of these elements were selected to best represent physical features, particularly around Units 3 and 4. The areas of the 2-D elements range from about 2,500 square feet near the reactor buildings to about 144,000 square feet away from the units.

Subsection 2.4S.4.2.2.4.1 will be updated as follows:

2.4S.4.2.2.4.1 Water Levels and Velocities

Critical STP 3 and 4 site locations for RMA2 model results are shown on Figure 2.4S.4-19. To determine the maximum effect on each of the Units 3 and 4, separate east and west breach locations were simulated. The variation in water surface elevation at these locations from 1.2 hours to 2.5 hours of the model simulation are presented in Figures 2.4S.4-20 and 2.4S.4-21 for the east breach and west breach, respectively. This selected period includes the peak water level and peak velocity near the plant buildings. The peak water level of 38.8 feet occurred at the Unit 4 Ultimate Heat Sink structure for the west breach scenario. Peak water surface elevations for the east breach and west breach are shown on the plan grid in Figures 2.4S.4-21(a) and 2.4S.4-21(b), respectively. Peak velocities associated with the east breach and west breach are shown in Figures 2.4S.4-21(c) and 2.4S.4-21(d), respectively. The maximum velocity of the flood flow was found to be 4.72 feet per second and occurred between Units 3 and 4 (point 8 on Figure 2.4S.4-19). The variation in velocity at locations 1 through 8 for the period containing peak velocities for the east and west breach scenarios is shown in Figures 2.4S.4-21(e) and 2.4S.4-21(f), respectively.

Subsection 2.4S.4.2.2.4.2 will be updated as follows:

2.4S.4.2.2.4.2 Effects of Sedimentation and Erosion

The MCR embankment breach analysis also considered the material eroded during the breach. The embankment material eroded is comprised mostly of clay, with a small percentage of sand from the internal drainage system and soil cement from the interior embankment slope lining. The erosion process will also produce a scour hole downstream of the breach that extends below the breach bottom elevation. The dimensions of this scour hole, based on lab results from Reference 2.4S.4-12i, are estimated to be 20 feet deep, 203 feet long and 380 feet wide. The scour hole contributes 1,543,000 cubic feet of clay to the flood flow. The material eroded from the MCR embankment contributes an additional 1,697,314 cubic feet of clay; 75,644 cubic feet of sand; and 117,562 cubic feet of soil cement. The total volume of sediment eroded under the breach scenario is 3,433,517 cubic feet. The flood flow from the MCR embankment breach would not cause erosion ~~aterode~~ the STP 3 and 4 plant site area because surfacing in this area is mostly concrete or asphalt pavement or compacted stone surfacing~~gravel and grass~~. The maximum velocity of 4.72 ft/s would not cause severe erosion of these surfaces, and any minor erosion around corners of the buildings would not impact the safety-related facilities of Units 3 and 4. Therefore, the power block surfacing would remain intact following the MCR embankment breach flood.

~~SED2D sediment modeling indicated some deposition on the outer edge of the model domain and relatively little deposition within the STP site. These results are consistent with the sediment concentration results in that~~It is anticipated that sedimentation will not have a significant effect on the site and the maximum water level resulting from the MCR breach flood. ŧThe majority of the clay and sand loads would be suspended in the flood flow and washed downstream, north of FM 521 and beyond the STP site. The soil cement lining on the interior wall of the embankment ~~was not simulated. This material~~ would likely enter the water as chunks or blocks as the embankment collapses, and these large concrete blocks would be carried only a short distance from the breach before settling to the bottom. The sediment loading would cease when the breach opening expansion ends; however, low-sediment ~~free high~~ flows would continue for a number of hours~~long period~~ afterwards until the water in MCR is totally emptied. This continued~~high~~ flow period would prevent any remaining clay or sand particles from settling and would wash away any small depositions in the study area.

RMA2 does not have sediment transport modeling capabilities, thus a bounding analysis was performed to determine a conservative sediment accumulation depth within the Units 3 and 4 power block area. This analysis is based on conservatively assuming twice the calculated total sediment volume from the MCR breach and scour hole and applying it on a fan area (potential sediment deposition area) extending from the breach to the peripheral road to estimate the maximum sediment depth near the plant area. Though the sediment material is primarily clay, most of which would remain in suspension, it is assumed for this bounding analysis that all the material settles uniformly within the fan area.

The analysis includes both the east and west breach scenarios. For each of the scenarios, a sediment fan area is considered that extends from the MCR breach to FM 521. The fan areas, shown in Figure 2.4S.4-21(f1), were selected by reviewing the RMA2 flow fields so

that the fan areas follow the main path of the simulated breach flows. The total area of selected 2-D elements within a fan area is reported automatically by SMS. The building areas are excluded from the area calculations. The total volume of sediment material considered for this analysis is 6,867,040 cubic feet. The areas of the fans for the east and west breach scenarios are 19,646,580 square feet and 17,948,623 square feet respectively. The estimated sediment depths within the fan areas are 0.35 feet and 0.38 feet for the east and west breach scenarios, respectively.

The bounding analysis shows that the sediment depths near the power block would be in the range of 0.35 to 0.40 feet. Even with the sediment depth of 0.4 feet, and further assuming that the flood water elevation were raised by the same amount, the maximum water level due to MCR breach flood would be 39.2 feet instead of 38.8 feet. The design basis flood level of 40 feet for the STP Units 3 and 4 will not be affected due to sedimentation.

Subsection 2.4S.4.2.2.4.3 will be updated as follows:

2.4S.4.2.2.4.3 Hydrodynamic Forces

The maximum water levels and velocities obtained near Units 3 and 4 were used to assess the hydrodynamic loadings on the plant buildings. Figures 2.4S.4-21(~~eg~~) and 2.4S.4-21(~~fh~~) show the time-dependent plots of the velocities ~~at this location~~ during the east and west breach scenarios, respectively. The peak velocities observed in between Units 3 and 4 were 4.72 and 4.68 feet per second for the east and west breach scenarios, respectively. ~~Figures 2.4S.4-21(g) and 2.4S.4-21(h) also show the sediment concentrations predicted by the SED2D model. The sediment-laden water density was used for hydrodynamic load calculations.~~ The sediment loads associated with the flow from the MCR embankment breach were developed to determine sediment concentrations and the sediment-laden water density. The time-dependent, well-mixed sediment concentrations were obtained assuming that no sediment gets transported outside of the study domain. The sediment concentration corresponding to the peak velocity occurring at T=1.7 hours was 22.33 kg/m^3. Therefore, a sediment concentration of 23 kg/m^3 was used to determine the sediment-laden water density. ~~The figures show that the sediment concentrations at the time and location of peak velocities would be 16.5 kg/m^3 and 15 kg/m^3 for the east and west breach scenarios, respectively. However, Figure 2.4S.4-21(g) shows a maximum concentration of 23 kg/m^3 occurring at approximately T = 1.3 hours. Conservatively, the maximum sediment concentration was used in conjunction with the maximum velocity to determine the hydrodynamic loads on the STP 3 and 4 plant facilities. Selecting a 23 kg/m^3~~ With a sediment concentration of 23 kg/m^3, a water density of 1023 kg/m^3 or 63.85 lb/ft^3 was used for load calculations. The maximum hydrostatic force on any plant building would be due to the depth of floodwater at the maximum water level. Hydrodynamic loads were calculated using the drag force formula with a drag coefficient conservatively set to 2.0, as presented below:

$$\text{Force (lb/ft}^2\text{)} = 2.0 \times \text{Density (lb/ft}^3\text{)} \times \text{Velocity}^2\ \text{(ft}^2\text{/sec}^2\text{)} / 2g$$

Subsection 2.4S.4.2.2.4.4 will be updated as follows:

2.4S.4.2.2.4.4 Spatial Extent of Flooding Due To MCR Embankment Breach

For both the east and west MCR embankment breach scenarios flood water from the breach opening will flow through the area encompassing Units 1 and 2 and Units 3 and 4, and will spread into the area bounded by FM 521. The model simulations end at the boundary cells immediately outside of FM 521. This road has a top of road elevation of approximately 28 feet to 30 feet, as seen from the USGS topographic map of the area (Figure 2.4S.4-21(i)). North of FM 521 and west of the west MCR embankment there are levees with approximate top elevations of 29 feet to 30 feet. South of the MCR along its south embankment is an east - west canal with levees on both sides. The area around the STP plant has an approximate grade elevation varying from 25 feet to 30 feet.

The area around the STP plant slopes east towards the Colorado River. Therefore, most of the flood water from the breach would flow to the Colorado River. A portion of the breach flow will also reach the Little Robins Slough to the west, which flows south along the west MCR embankment. From there, the water will either flow east to the Colorado River or will flow under the east-west canal through existing siphons and may flow through several swampy areas to the intracoastal waterway.

~~It is unlikely that the breach flood water will overflow over FM 521 and west levees. If this happens, a~~A small portion of the breach flood flow may reach the Tres Palacios River to the west of the STP site.

The references for Subsection 2.4S.4 will be revised as follows:

2.4S.4-12b ~~"User's Guide to SED2D WES", Version 4.5., Coastal and Hydraulics Laboratory, Waterways Experiment Station, Engineer Research and Development Center, U.S. Army Corps of Engineers, April 14, 2003.~~Not Used

2.4S.4-12e3 Ettema, R. Hydraulic modeling: concepts and practice. Environmental and Water Resources Institute (U.S.). ASCE Publications. 390 pages, 2000.

2.4S.4-12e4 Hughes, S.A. 1993. Physical Models and laboratory techniques in coastal engineering. USACE. ERDC.

2.4S.4-12e5 Su, Y.C., E. Lehotsky, and D. Fuller. 2009. "The Sabine Pass LNG Terminal, Challenges for a new LNG Terminal in Louisiana", Caring for the Coast: Texas Coastal Conference 2009, Galveston, Texas, June 4-5, 2009.

2.4S.4-12e6 Su, Y.C. and J. Mahmoud. 2007. Beneficial use of dredged materials at Louisiana shoreline near Sabine Pass. International Erosion Control Association Conference, Reno NV.

2.4S.4-12e7 Su, Y.C., J. Koutny, J. Benoliel, J. Mahmoud, M. Heaney, and D. Granger. 2005. "Sediment Transport Modeling of Dredged Disposal Materials Near Sabine Pass." Coastal Texas 2020 Technical Erosion Conference 2005, Houston, Texas, September 14-16, 2005.

2.4S.4-12e8 Su, Y.C., C. Woodward, J. Koutny, and J. Benoliel, and W. Crull. 2004. "Modeling of Flood Control Channels Using SMS/RMA2." TFMA 17th Annual Texas Flood Conference, Fort Worth, Texas, 2004.

(The proposed FSAR Table 2.4S.4-7b has been removed as a result of the response to Revision 1 of RAI 02.04.04-15)

(The proposed FSAR Figure 2.4S.4-21f1 has been removed as a result of the response to Revision 1 of RAI 02.04.04-15. A new FSAR Figure 2.4S.4-21f1 is provided on Page 16 of 18)

(The proposed FSAR Figure 2.4S.4-21f2 has been removed as a result of the response to Revision 1 of RAI 02.04.04-15)

(The proposed FSAR Figure 2.4S.4-21f3 has been removed as a result of the response to Revision 1 of RAI 02.04.04-15)

(The proposed FSAR Figure 2.4S.4-21f4 has been removed as a result of the response to Revision 1 of RAI 02.04.04-15)

(The proposed FSAR Figure 2.4S.4-21f5 has been removed as a result of the response to Revision 1 of RAI 02.04.04-15)

(The proposed FSAR Figure 2.4S.4-21f6 has been removed as a result of the response to Revision 1 of RAI 02.04.04-15)

The following figure will be added to the FSAR:

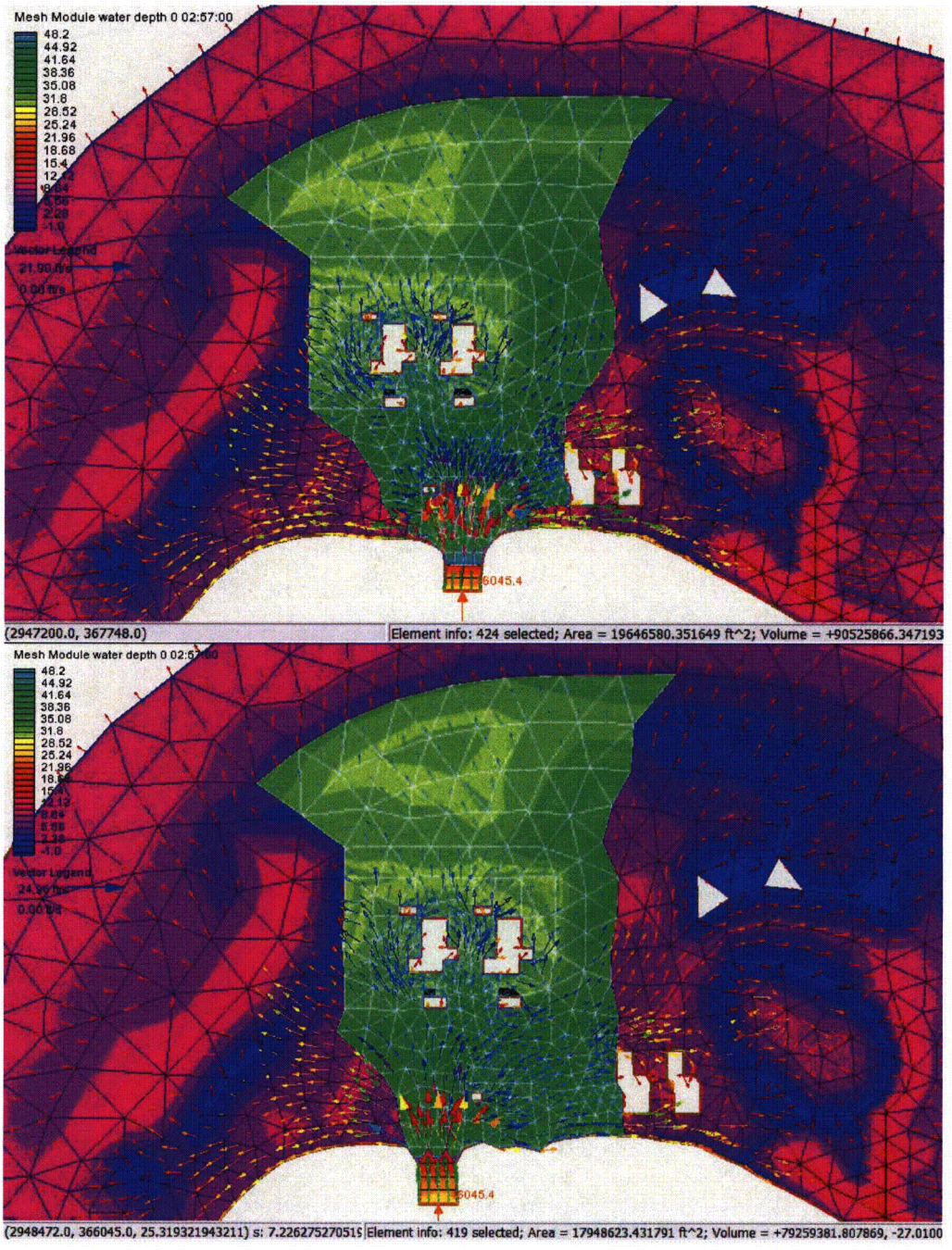

Figure 2.4S.4-21f1 Selected Fan Areas Associated with East Breach Scenario (top) and West Breach Scenario (bottom)

Figure 2.4S.4-21g will be deleted from the FSAR.

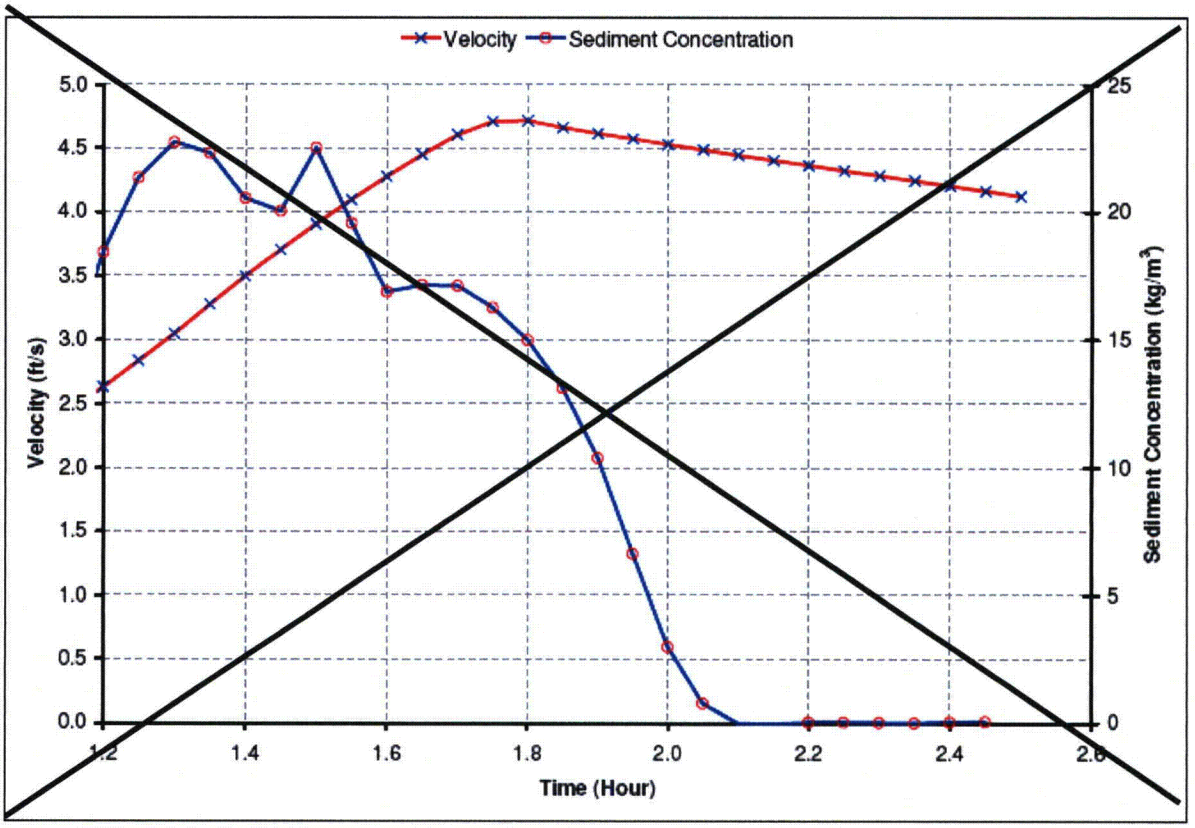

Figure 2.4S.4-21g ~~Velocities and Sediment Concentrations In Between Units 3 and 4 with East Breach Scenario~~ Not Used

Figure 2.4S.4-21h will be deleted from the FSAR.

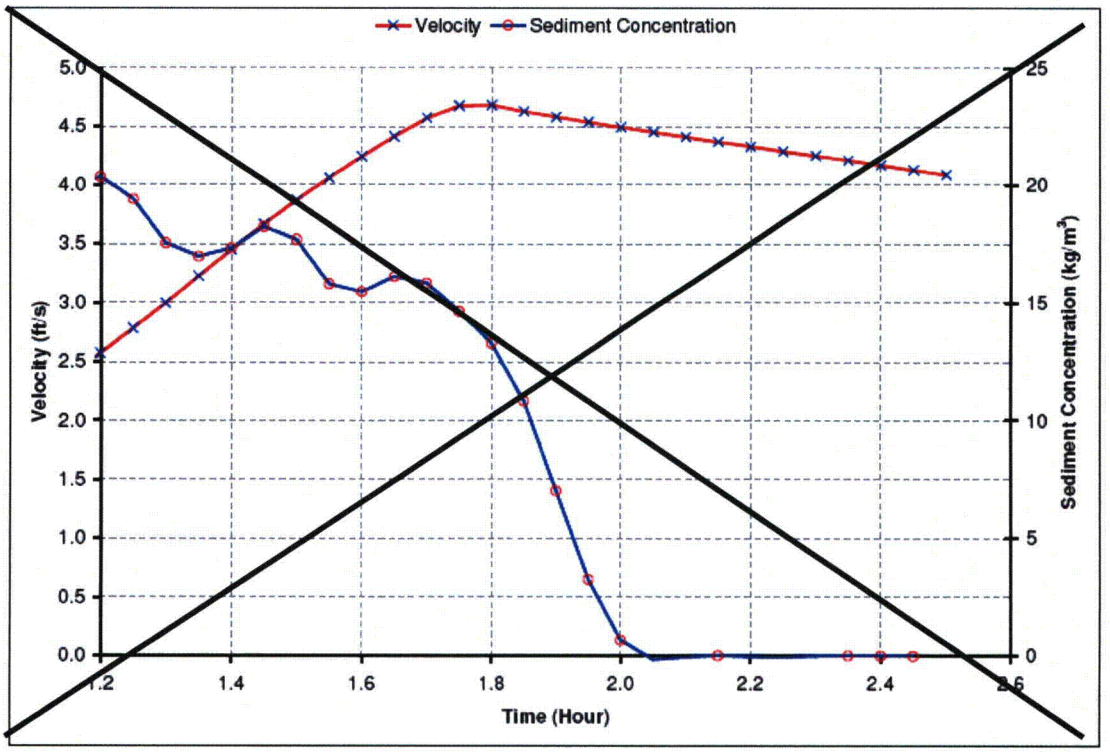

Figure 2.4S.4-21h ~~Velocities and Sediment Concentrations In Between Units 3 and 4 with West Breach Scenario~~ Not Used