Addendum No. 1 to Geotechnical Report
For
Star Bend Setback Levee
Levee District No. 1
Sutter County, California

Prepared by:

BLACKBURN CONSULTING

November 20, 2007

For:

Wood Rodgers, Inc.
&
Levee District No.1
Sutter County

West Sacramento Office:
2437 Front Street • Sacramento, CA 95691
(916) 375-8706 • Fax (916) 375-8709

blackburn consulting

Main Office: (530) 887-1494
11521 Blocker Drive, Suite 110 • Auburn, CA 95603
Modesto Office: (209) 522-6273

Geotechnical • Construction Services • Forensics

File No. 788.3 and 788.4
November 20, 2007

Mr. Jeff Twitchell
Wood Rodgers, Inc.
3301 C Street, Building 100-B
Sacramento, California 95816
Ph. (916) 341-7760
Fax (916) 341-7767

Subject: **Addendum No. 1 to Geotechnical Report**
Star Bend Setback Levee
Levee District No. 1
Sutter County, California

Dear Mr. Twitchell,

Blackburn Consulting (BCI) is pleased to submit this Addendum No. 1 to our October 20, 2006 Geotechnical Report for the Star Bend Setback Levee. This addendum contains the following:

- Findings from BCI's additional subsurface explorations along the setback levee alignment and O'Conner Lakes borrow areas.
- Confirmation of geotechnical suitability of the proposed setback levee alignment.
- Confirmation of slurry wall depth.
- End-around seepage analysis at tie-in points.
- Updated findings and conclusions for O'Connor Lakes borrow sites.
- Response to USACE May 29, 2007 comments to the October 20, 2006 Geotechnical Report.

Please call if you have questions or require additional information. Thank you.

Sincerely;

BLACKBURN CONSULTING

Reviewed by:

Robert B. Lokteff, P.E., G.E.
Principal Geotechnical Engineer

W. Eric Nichols, C.E.G.
Senior Project Manager

Copies: 15 Addressee

Addendum No. 1 to Geotechnical Report
Star Bend Setback Levee
Levee District No. 1
Sutter County, California
BCI Project No. 788.3, and 788.4 November 20, 2007

TABLE OF CONTENTS

Addendum No. 1 to Geotechnical Report
Star Bend Setback Levee
Levee District No. 1
Sutter County, California
BCI Project No. 788.3 and 788.4 November 20, 2007

1 Introduction

1.1 Purpose

This Addendum No. 1 to our October 20, 2006 Geotechnical Report for the Star Bend Setback Levee contains:

- Findings from BCI's additional subsurface explorations along the setback levee alignment and O'Connor Lakes borrow areas.
- Confirmation of geotechnical suitability of the proposed setback levee alignment.
- Confirmation of slurry wall depth.
- End-around seepage analysis at tie-in points.
- Updated findings and conclusions for O'Connor Lakes borrow sites.
- Response to USACE's comments to the October 20, 2006 Geotechnical Report.

This addendum supplements our October 20, 2006 Geotechnical Report, and is for Wood Rodgers, Inc. (WRI), Levee District No. 1 (LD1) of Sutter County, the State Reclamation Board, California Department of Water Resources (DWR), and the U.S. Army Corps of Engineering (USACE) to use for 60% design. BCI is currently performing laboratory tests and additional analysis for final design. This addendum shall not be used or relied upon by others, or for different locations or improvements without the written consent of BCI.

1.2 Scope of Services

To prepare this addendum, BCI:

- Completed an additional seven mud rotary borings, eight Cone Penetrometer Test (CPT) probes and nine test pits at the Star Bend site in September and October 2007 to help assess/confirm the geotechnical suitability of the setback levee alignment and the slurry wall depths, and obtain information for end-around seepage analysis. Locations of the additional borings, CPTs and test pits are shown on Figure A-1 in appendix A. BCI's 2006 exploration locations are also shown on Figure A-1. Figure A-1 updates and replaces Figure 4 in the 2006 Geotechnical Report

- Reviewed CPT logs, sonic boring logs and mud rotary boring logs performed by others in the Star Bend area for the DWR to supplement our subsurface exploration data. Locations of the explorations are shown on Figure A-1.

- Excavated 15 additional test pits at the O'Connor Lakes borrow sites to help assess the presence/extent of useable borrow material. Locations of the additional test pits are shown on Figure B-1 in Appendix B. BCI's 2006 test pit locations are also shown on Figure B-1

- Performed preliminary end-around seepage analysis using SEEP 3D software.

- Consulted with WRI to help develop: 1) end-treatment alternatives at the setback levee tie-in points and 2) borrow area boundaries.

- Met with WRI, DWR and USACE representatives to review our findings and obtain design and analysis input.

2 Confirmation of Geotechnical Suitability of Proposed Setback Levee Alignment

Cross-section A-A' (see Figure A-2 in Appendix A) shows the subsurface conditions along the proposed setback levee alignment. The cross-section includes subsurface information from our original 2006 investigation and additional investigation in 2007. Additional cross-sections (B-B' through F-F') through the alignment are shown on Figures A-3 and A-4. Logs of our 2007 explorations are included in Appendix A.

BCI's subsurface exploration indicates that:

- At about 1 to 3 feet below the ground surface, the setback levee alignment is predominantly underlain by a 5-foot to 20-foot-thick layer of very stiff to hard clay/silt, which is capable of supporting the proposed levee without detrimental settlement. We interpret this layer as most likely the top portion of the Modesto Formation.

- At about 20 to 50 feet below the ground surface, the setback levee alignment is underlain by a relatively impermeable, 10-foot to 45-foot-thick layer of clay/silt, which is adequate for termination of a slurry cut-off wall.

- Subsurface soil conditions north, south and west of the setback levee alignment are similar to those underlying the proposed alignment. Therefore, no benefit (decreased settlement or slurry wall depth) would be achieved by shifting the setback levee to the west, or tying the setback levee into the existing levee farther to the north or south.

3 Confirmation of Slurry Wall Depth

Our additional subsurface investigation confirms that, beginning at depths of about 20 to 50 feet below the surface, the setback levee alignment is underlain by a relatively impermeable, 10-foot to 45-foot-thick layer of clay/silt, which is adequate for termination of a slurry cut-off wall. Therefore, the 40-foot and 62-foot depths recommend in our October 20, 2006 Geotechnical Report are confirmed. The recommended bottom-of-slurry wall depth is shown on Figure A-1 in Appendix A.

4 End-Around Seepage Analysis

Purpose of Seepage Analysis

BCI performed end-around seepage analysis to help determine:

- The minimum lateral extent of the cutoff wall into the existing levee at the north and south tie-in points needed to mitigate detrimental seepage along the setback alignment.
- The effects of end-around seepage at the ends of the cutoff wall.

This addendum contains our results based on preliminary modeling to satisfy 60% design requirements. BCI is currently refining the model based on laboratory permeability test results, and performing two-dimensional analysis to confirm the three-dimensional results. We will provide final results, conclusions and recommendations for final design.

Seepage Analysis Method

BCI performed end-around seepage analysis using Seep3D (v1.17), a three-dimensional finite element seepage analysis program developed by GEO-SLOPE International. While the benefits of the three-dimensional analysis are significant because they allow for the unique condition of seepage flow around the edge of the cutoff wall, there are also limitations to the modeling complexity available with the program. Therefore, BCI will perform two-dimensional analyses to verify the three-dimensional results utilizing SEEP/W (v.4.23), a two-dimensional seepage analysis program also developed by GEO-SLOPE International. Both the two- and three-dimensional analyses will also be compared to past performance at the site to verify the results.

Seepage Model Configuration and Assumptions

The length of the modeled section both parallel and perpendicular to the levee cross-section were limited due to three-dimensional modeling limitations. The results reported in this addendum are based on a 400-foot-long levee section; half with a cutoff wall, and half without a cutoff wall. The models extend 200 feet landward and riverward from the levee crown, and vertically to the design depth of the cutoff wall.

We modeled the cutoff wall as a void in the levee and foundation section because we can assume negligible flow through the cutoff wall.

North Tie-In Point

Based on our subsurface exploration, we used the subsurface profile shown on Figure C-1 in Appendix C for analysis at the north tie-in point. Subsurface soil layers consist of:
- An 8-foot-thick blanket layer at the ground surface, which consists of silts and clays;
- A 2-foot-thick sandy layer below the blanket;
- A 9-foot thick clay and silt layer beneath this sandy lens; and,
- A 5-foot-thick sandy layer, which extends from the waterside of the cross-section to about 50 feet beyond the landside toe.

The model for the north end extends vertically to an elevation of 2 feet above Mean Sea Level (MSL), which is the depth of the cutoff wall in this region. We evaluated one model with a deeper foundation section to confirm that this simplification did not substantially affect results.

The north-end model was evaluated with a river stage elevation of 64 feet MSL (1929 NGVD), and a ground water elevation on the landside vertical face equal to 36 feet MSL (1929 NGVD), which is the elevation of the top of the upper-most sandy layer. The landside slope of the levee and the ground surface beyond the levee toe were both treated as potential seepage surfaces.

South Tie-In Point

We used the subsurface profile shown on Figure C-2 for our analysis of the south tie-in point. The subsurface soil layers include:
- A 4.5-foot-thick silt and clay blanket layer at the ground surface,
- A 4-foot-thick sandy layer below the upper blanket layer,
- Another clay and silt layer 5-feet-thick below the sand layer,
- And then a 39-foot-thick sand layer.
- Below the sand layer is a clay and silt layer, into which the cutoff wall will be tied.

As with the model at the north end, the model at the south end only extends to the depth of the cutoff wall, which in this case is an elevation of -20 feet MSL (1929 NGVD).

River stage was modeled at elevation 64 feet above MSL (1929 NGVD), and the landside vertical face was modeled with a head elevation equal to the ground surface elevation, 42.5 MSL (1929 NGVD).

In this region of the project levee, the river channel is over 1,000 feet away from the levee. However, with the limitations of the three-dimensional analysis program, the channel could not be modeled that far away from the levee. To assure reasonably conservative results, the river was modeled at a distance of 150 feet from the levee.

Seepage Analysis Findings and Results

Below, we summarize our seepage analysis findings and results to date from our three-dimensional evaluation. Figures C-3 through C-9 show results from the two (north-end and south-end) models.

Figures C-3 and C-4 show contours of total head for the north-end and south-end transitions, respectively. Figures C-5 and C-6 show contours of the xyz-gradient and xyz-velocity for the two models. These contours are calculated by averaging values at nearby nodes, and therefore offer a means of relative evaluation, although the actual numerical results at a given point may differ from the node value at that location on the contour plot.

Figure C-7 shows plots of the calculated blanket gradient at the two (north-end and south-end) tie-in locations. Blanket gradient is the difference in total head at the base of the blanket and the ground surface (the top of the blanket) divided by the depth of the blanket section, and can be used to calculate the factor of safety against piping and internal erosion. In this case, the saturated unit weight of the blanket material is about 125 pcf, which means that a blanket gradient of 0.6 would correlate with a factor of safety of about 1.7. Both plots show a "without-project" condition, for which the model was run with no cutoff wall in place. In both cases, the "without-project" blanket gradient is 0.61. As the "with-project" gradient approaches the far end of the model, it asymptotically approaches this value. On the lower plot, two sets of gradient data are provided. The darker lines show gradient through the upper blanket, and the lighter lines show gradient through the 13.5 feet of material above the thick sand layer.

If the "benefit" of the cutoff wall is defined as a resulting blanket gradient that is less than 0.5 (a factor of safety greater than 2.0), this benefit extends about 25 feet north of the cutoff wall for the north-end model, and about 6 feet south of the cutoff wall for the south-end model.

If "limited performance" of the cutoff wall is defined as a resulting blanket gradient that is greater than 0.3 (a factor of safety less than 3.3), limited performance of the wall extends about 30 feet south of the cutoff wall for the north-end model, and about 115 feet north of the cutoff wall for the south-end model.

As shown on the two plots in Figure C-7, the resulting blanket gradient reaches a point where further distance from the wall does not substantially affect the resulting blanket gradient. This distance for the north-end model is about 125 feet north of the wall, and for the south-end model it is about 150 feet south of the wall.

Plots of the vertical gradient at the landside toe, along the ground surface, are shown on Figure C-8 for the two models. Similar plots of the vertical velocity, in feet per hour, are shown on Figure C-9.

Seepage Analysis Conclusions/Recommendations

Based on the above:

- No excessive gradients or velocities develop in the transition zone at either the north or south ends of the wall. Therefore, we do not expect adverse seepage effects at the ends of the cutoff wall.
- The cutoff wall should extend at least 125 feet laterally into the existing levee at the north tie-in point and 150 feet at the south tie-in to mitigate detrimental seepage within the setback zone.

5 Updated Findings and Conclusions for O'Connor Lakes Borrow Sites

A Preliminary Site Plan of the O'Connor Lakes Borrow Sites prepared by WRI is shown on Figure B-1 in Appendix B. Cross-sections we developed from our original and additional test pits in the O'Connor Lake borrow areas are shown on Figures B-2 through B-6. Logs of the 2007 test pits are included in Appendix B.

Based on our additional test pits and previous analysis:

- At about 2 to 8 feet below the ground surface, 5-foot to 10-foot-thick, discountinuous layers of silt/clay are present that will meet the plasticity index and fines fraction requirements for levee fill. BCI is currently performing additional laboratory tests to confirm the liquid limit and fines content.

- The liquid limit of some of the clay/silt deposits exceeds the requirements for levee fill and will require mixing with less plastic soil from the borrow area or material obtained from the existing levee de-grade. BCI is currently performing laboratory tests to help determine the anticipated acceptable percentages for mixing.

- At about 8 to 12 feet below the ground surface, the soil moisture content is significantly higher than the anticipated optimum moisture content required for levee fill compaction. Therefore air-drying or mixing with drier material will be necessary to achieve adequate fill compaction.

In conclusion, soil is present in the O'Connor Lakes borrow areas that will meet the requirements for levee fill with some selective grading, mixing and drying. For 60% planning purposes, use a 7-foot-thick layer under 50% of the borrow area and a cut-to-fill volume decrease of 20% to estimate the amount of useable soil within the borrow area. Additional test pits are planned to help better determine the location and amount of useable soil.

6 Response to USACE Comments to the October 20, 2006 Geotechnical Report

Following, are BCI's responses to USACE's May 29, 2006 comments 1 through 20 on the October 20, 2006 Geotechnical Report and 30% design-level Plans and Specifications. USACE's comments are included in Appendix E. Comments 21 through 37 are generally related to design and plan details, and are addressed on the 60% Plans and Specification prepared by Wood Rodgers, Inc.

Comment No. and Response

1) BCI used SOP EDG-03 and EM 1110-2-1913 to develop the recommendations in the October 20, 2006 Geotechnical Report for the project. We will notify the COE of any conflicts we encounter in the different criteria that could impact our geotechnical design recommendations.

2) We will notify the COE of any geotechnical-related conflicts between the COE review comments and Sate of California Reclamation Board comments.

3) Wood Rodgers, Inc. (WRI) informed us that the minimum maintenance easements will be provided in the design.

4) WRI informed BCI that the USACE 1957 design water level is higher than the 200-year water surface, and that all irrigation and pump discharge pipelines will cross the levee above the USACE 1957 design water level.

5) The near-surface blanket material (silt/clay) contains relatively thin, discontinuous layers of relatively permeable sandy silt/silty sand, disturbance from farming and small root holes that are significant in seepage analysis. We modeled the effect of these features by using a relatively high hydraulic conductivity for this layer. We are currently performing laboratory tests to confirm the hydraulic conductivity and sensitivity analysis to determine the effect of a lower hydraulic conductivity in this layer.

6) BCI has performed preliminary end-around seepage analysis to determine the north and south extent of the slurry wall. Our findings are presented in Section 4 of this addendum.

7) The design team is currently developing the preferred borrow locations within the O'Connor Lake borrow area. We anticipate that the majority of borrow will be obtained from excavations located greater than 1,000 feet from the existing levee and that these excavations will have no significant adverse impact on seepage. BCI is currently performing seepage analysis to confirm our assumptions. Borrow pits located within 1,000 feet of the new or existing levee will be backfilled with compacted fill generated from the borrow area and/or from de-grading of the existing levee.

8) We have documented historical seepage and related mitigation in the Star Bend area and show the locations on Figure D-1 in Appendix D.

9) Pressure relief wells and seepage berms are not currently being considered for this project.

10) BCI obtained samples of borrow material from the O'Connor Lakes borrow area and may obtain additional samples during subsequent subsurface investigation. BCI is currently in the process of performing laboratory tests on remolded specimens to obtain the unconsolidated, undrained strength parameters of levee fill to update our end-of-construction stability analysis. We used consolidated, undrained total strength parameters in our previous analysis, from specimens conservatively remolded to 90% of ASTM D698. Therefore, we anticipate that our previous analysis is conservative, and our subsequent analysis will also indicate adequate stability.

11) Based on our additional subsurface investigation (borings, CPTs and test pits), the upper layers of clay and silt are predominantly stiff to very hard and lightly to strongly cemented with pocket penetrometer values ranging from about 3.0 to over 4.5 tsf. Based on this information, the description in our original October 20, 2006 Geotechnical Report is conservative regarding soft clay deposits and there are only isolated, thin layers of soft clay/silt.

    Correlations to the CPT tip resistance along the setback levee alignment indicate undrained shear strengths ranging from 1,000 psf to over 27,000 psf for the near surface clay/silt. We used $s_u = (q_c - p_0)/N_k$, where s_u = the undrained shear strength, q_c = the CPT point resistance, p_0 = the effective vertical stress and N_k = the cone factor. We assumed a soil unit weight of 115 pcf and cone factor of 18 to develop the correlations.

    Based on triaxial tests on samples obtained form the upper 5 to 6 feet, we conservatively used an unconsolidated, undrained shear strength of 600 psf in our original slope stability analysis, which yielded satisfactory factors of safety. Therefore, based on the above, our original slope stability analysis is conservative and additional testing of the native soil is not necessary.

12) We used CPT correlations to help confirm the conservative nature of soil strength parameters used in our original slope stability analysis (see response to Comment 11 for results).

13) We performed additional borings and test pits to help determine the presence of soft clay deposits (see response to Comment 11 for findings).

14) We will make the change to the maximum rock size and maximum limit to match the levee fill requirements in Sacramento District's SOP-EDG03.

15) Our test pits and discussions with property owners in the area indicate that the root system of the existing trees likely extend 2 to 3 feet below the surface. Therefore, a minimum 2-foot over-excavation will likely be necessary to adequately remove tree roots. Deeper over-excavation may be necessary where relatively large trees are located along the existing seepage ditch.

16) Our preliminary end-around seepage analysis indicates a minimum 125-foot to 150-foot lateral extension of the slurry wall into the existing levee to mitigate detrimental underseepage (see Section 4 of this addendum). The tie-in detail is shown on Wood Rodger's 60% Plans.

17) The amount of soft soil was conservatively represented in our previous report. We do not anticipate significant unstable soil conditions during grading provided construction begins in June or later. Soft unstable soil should be scarified and air-dried prior to compaction or removed and replaced with drier soil generated from the original ground preparation.

18) BCI is currently performing updated settlement analysis based on the findings of our additional subsurface exploration. Our original consolidation settlement estimate is conservatively based on the presence of relatively soft clay in the upper 7 feet of the soil profile. Therefore, we expect that additional analysis will result in less consolidation settlement (on the order of 2"). We will revise our compression index values to reflect the actual soil conditions (i.e., very stiff to hard silt/clay).

19) At this time, we are not sure if a spoil berm will be necessary. We will perform preliminary analysis including the influences of a spoil berm to determine the resulting settlement impacts.

20) Settlement monitoring plates will be installed and monitored as suggested.

21-37) Please refer to wood Rodgers' 60% Plans and Specifications for response to USACE May 29, 2007 comments 31 through 37.

7 Risk Management

Our experience and that of our profession clearly indicates that the risks of costly design, construction, and maintenance problems can be significantly lowered by retaining the geotechnical engineer of record to provide additional services during design and construction. For this project, BCI should be retained to:

- Review and provide comments on the civil plans and specifications prior to construction.
- Monitor construction to check and document our report assumptions. At a minimum, BCI should monitor grading and slurry wall construction, and review settlement monitoring data.
- Update this report if design changes occur, 2 years or more lapses between this report and construction, and/or site conditions have changed.

If we are not retained to perform the above applicable services, we are not responsible for any other party's interpretation of our report, and subsequent addendums, letters, and discussions.

8 Limitations

BCI performed services in accordance with generally accepted geotechnical engineering principles and practices currently used in this area. Where referenced, we used ASTM or Caltrans standards as a general (not strict) *guideline* only. We do not warranty our services.

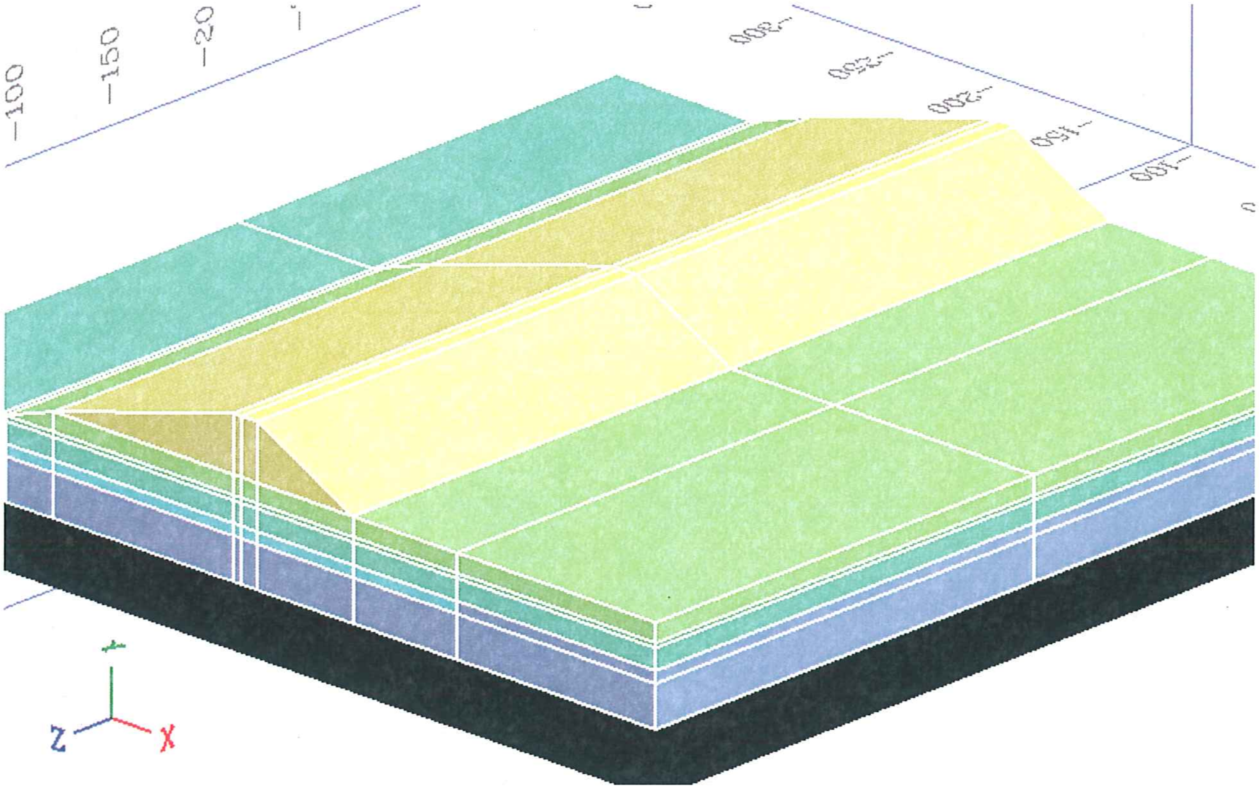
BCI based this report on the current site conditions. We assumed the soil and ground water conditions encountered in our borings, CPT probes and test pits are representative of the subsurface conditions across the site. Actual conditions between explorations could be different.

Our scope did not include evaluation of on-site hazardous material or biological pollutants. Please contact BCI if you would like an evaluation of one or more of these potentially damaging issues.

Logs of our exploratory borings and test pits are attached. The lines designating the interface between soil types are approximate. The transition between soil types may be abrupt or gradual. Our recommendations are based on the final logs, which represent our interpretation of the field logs and general knowledge of the site and geological conditions.

Modern design and construction are complex, with many regulatory sources/restrictions, involved parties, construction alternatives, etc. It is common to experience changes and delays. The owner should set aside a reasonable contingency fund based on complexities and cost estimates to cover changes and delays.

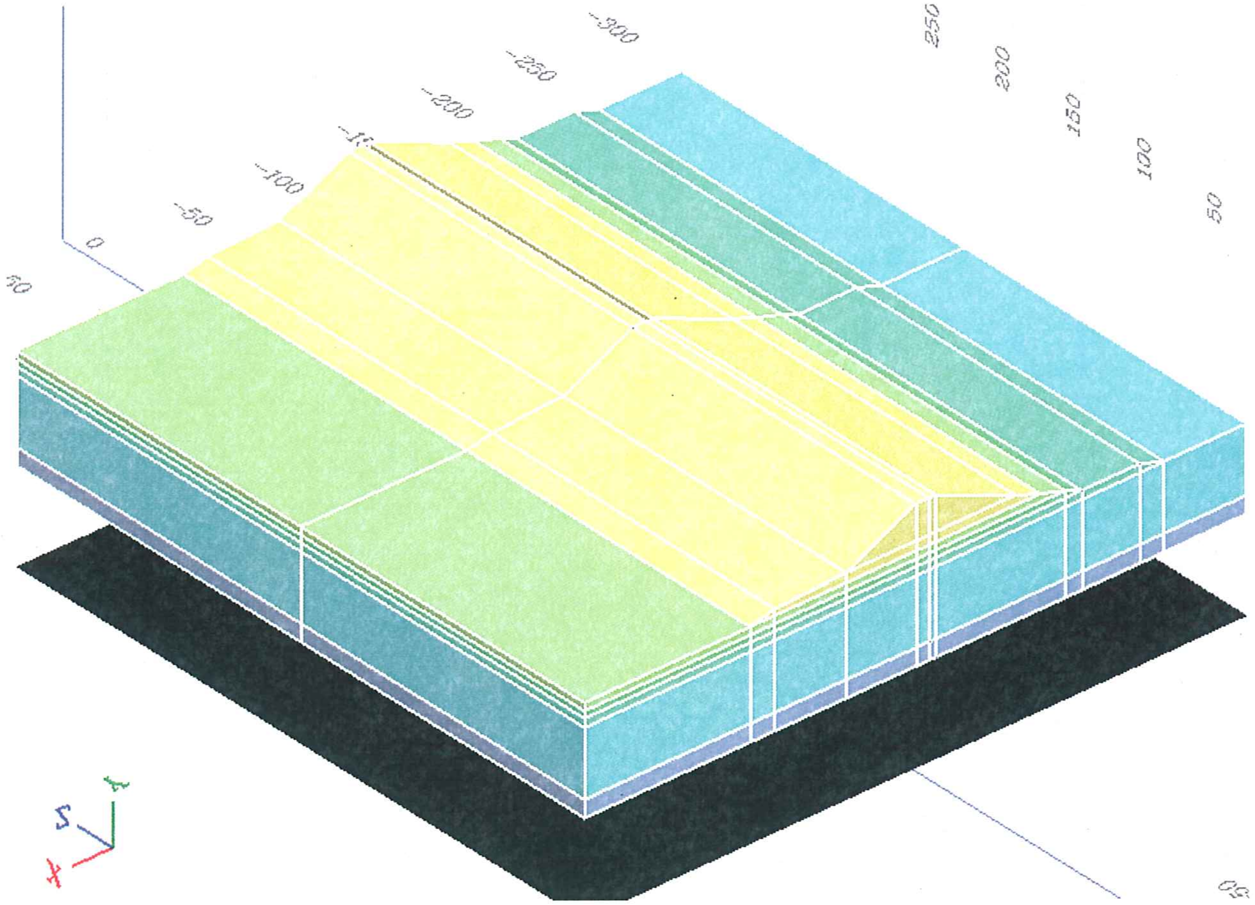
North End Transition – Cutoff wall shown as void on back right side of cross-section



Material color	Material	Hydraulic Conductivity	
		k_h (ft/hr)	k_h/k_v
Yellow	Existing Levee	0.12	4
Light Green	Silt/ Clayey Silt / Sandy Silt	0.047	4
Green	Sand/ Silty Sand/ Sandy Silt	0.47	9
Aqua	Lean Clay / Silt	0.023	4
Aqua Blue	Sand / Silty Sand	0.47	9
Blue	Clay /Silt	0.00047	4

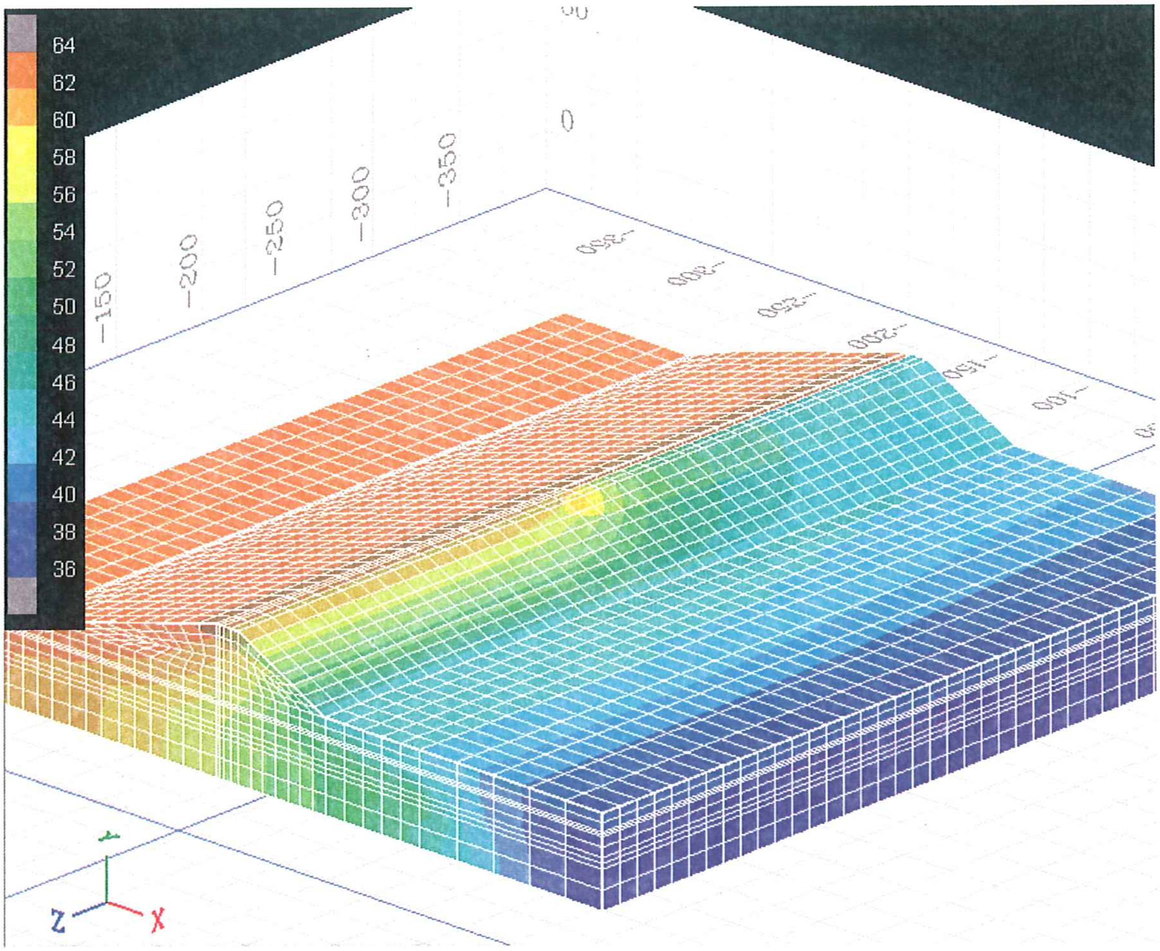
Figure C-1

South End Transition – Cutoff wall shown as void on back left side of cross-section

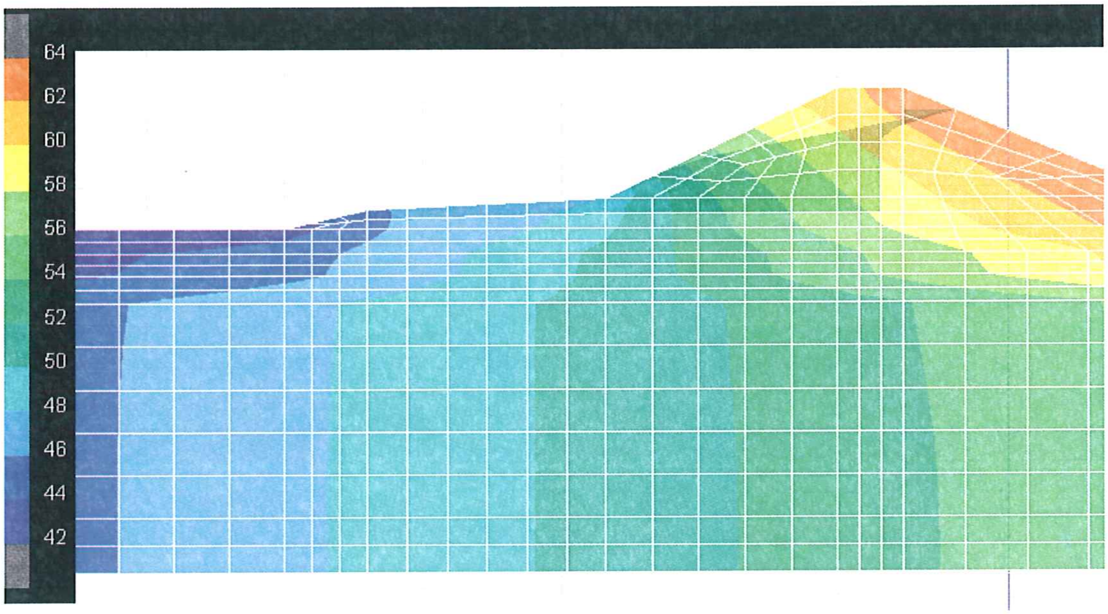


Material color	Material	Hydraulic Conductivity	
		k_h (ft/hr)	k_h/k_v
Yellow	Existing Levee	0.12	4
Light Green	Silt/ Clayey Silt / Sandy Silt	0.047	4
Green	Sand/ Silty Sand/ Sandy Silt	0.47	9
Aqua	Lean Clay / Silt	0.023	4
Aqua Blue	Sand / Silty Sand	2.4	9
Blue	Sand/ Gravelly Sand/ Sandy Gravel	0.00047	4

Figure C-2

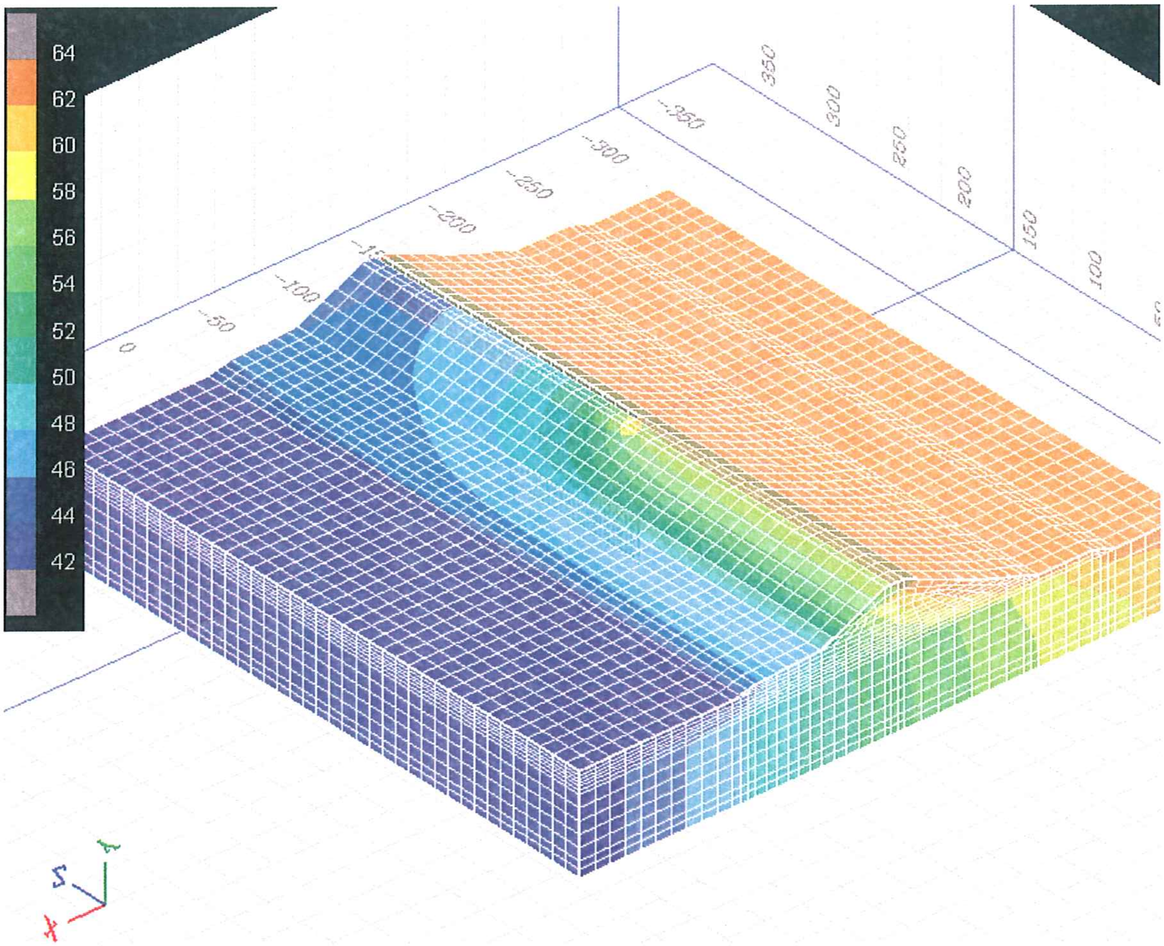


North End – Total Head Contours (shown as water surface elevation in feet).
Cutoff Wall is on back right side.

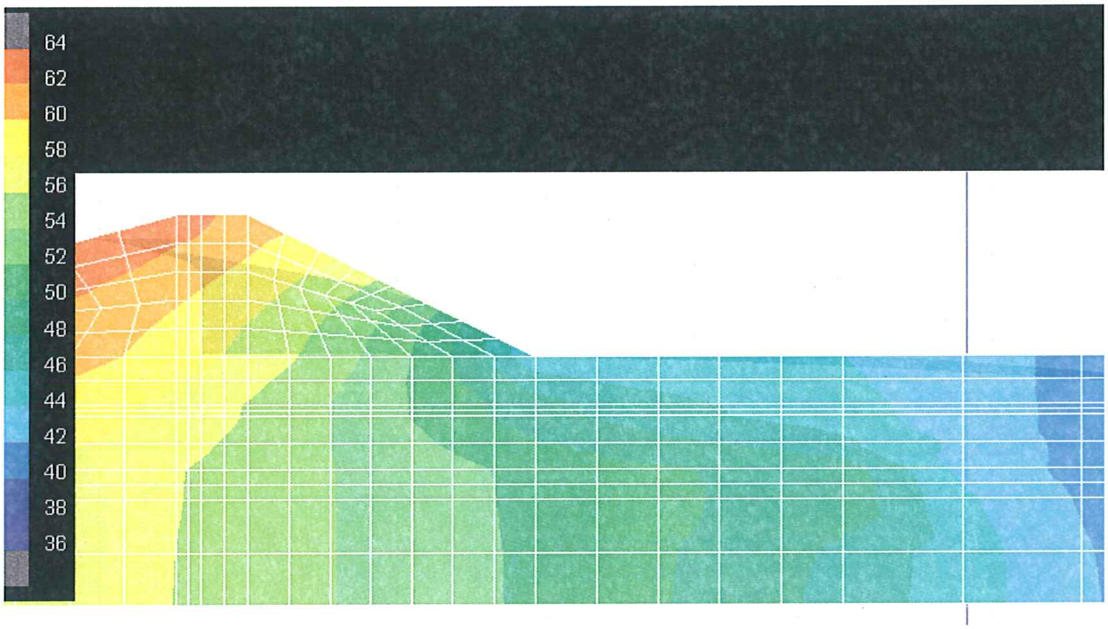


North End – View from North end of model (without cutoff wall)

Figure C-3

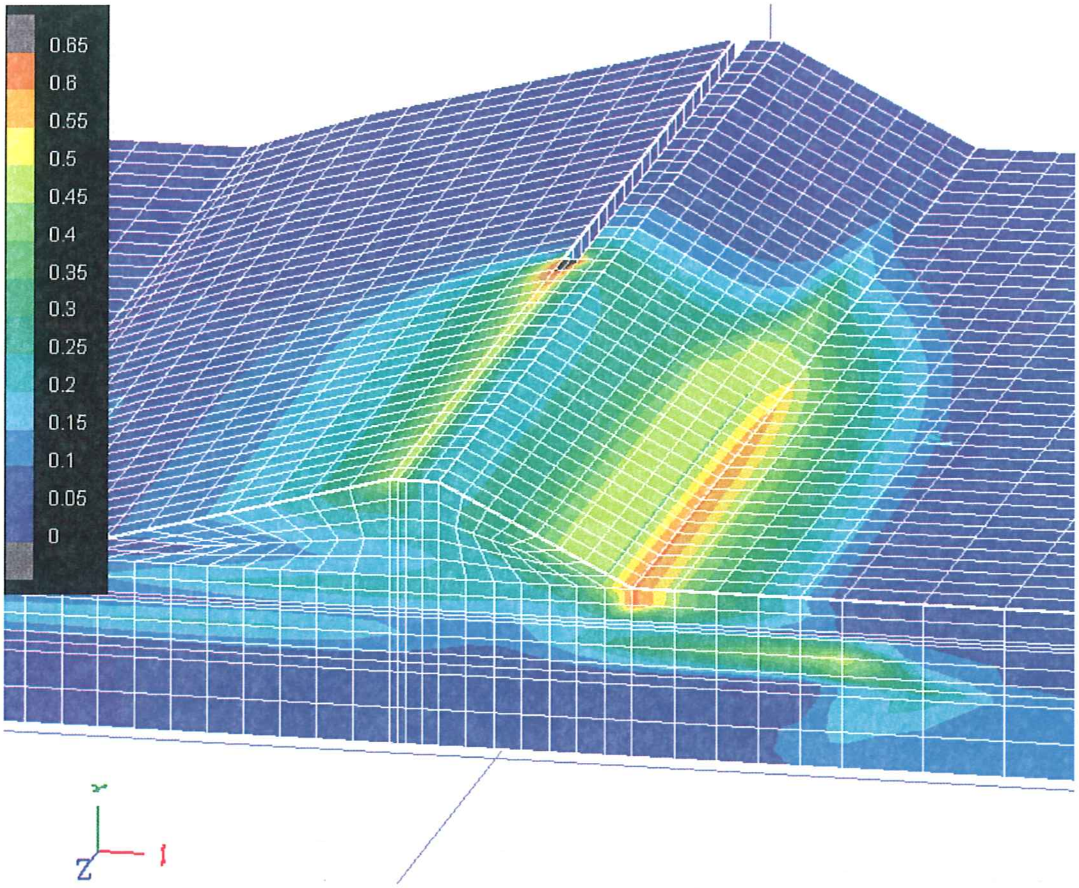


South End – Total Head Contours (shown as water surface elevation in feet).
Cutoff wall is on back left side.

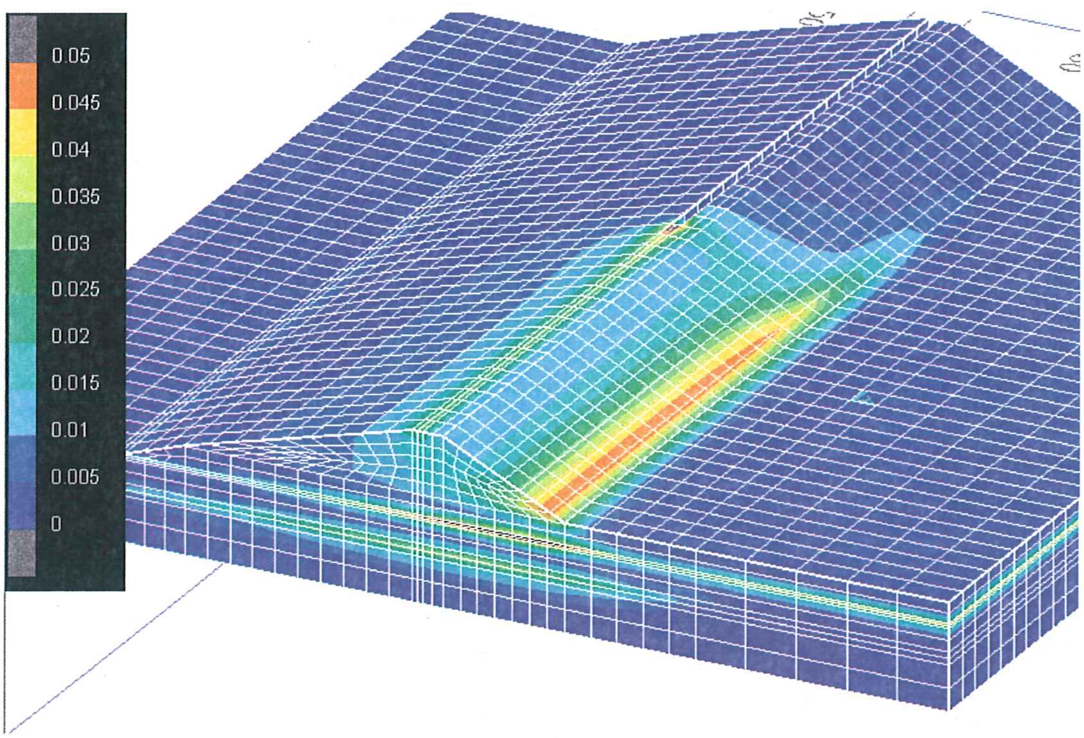


South End – View from South end of model (without cutoff wall)

Figure C-4

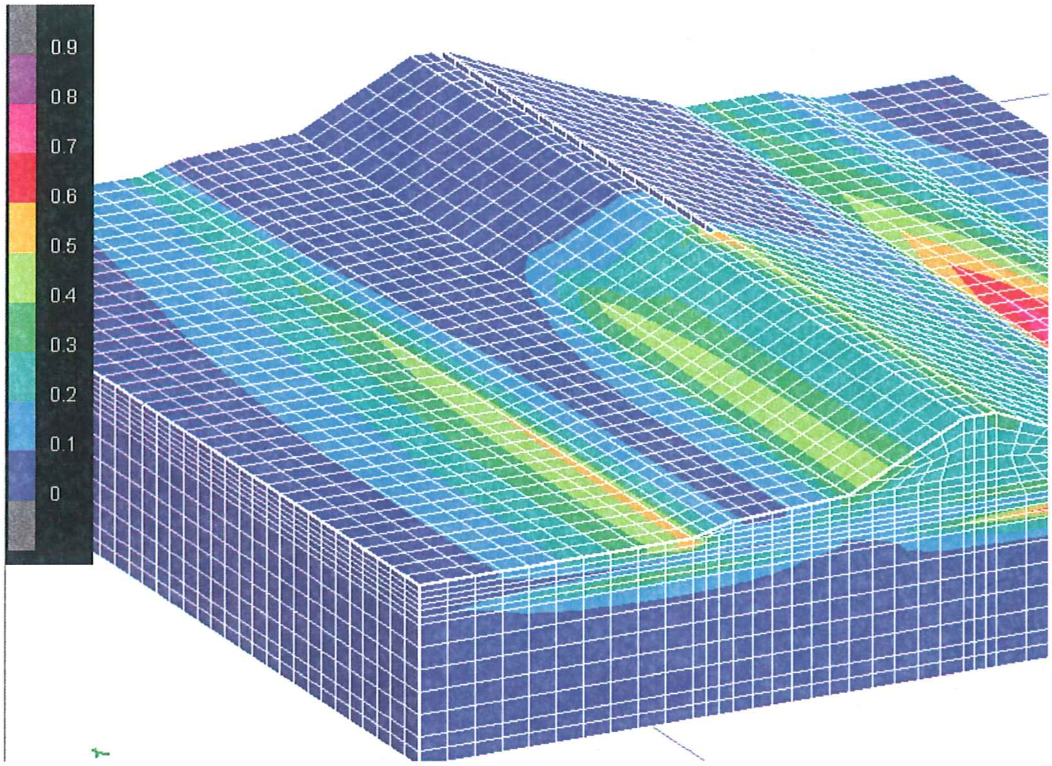


North End – XYZ-gradient contours

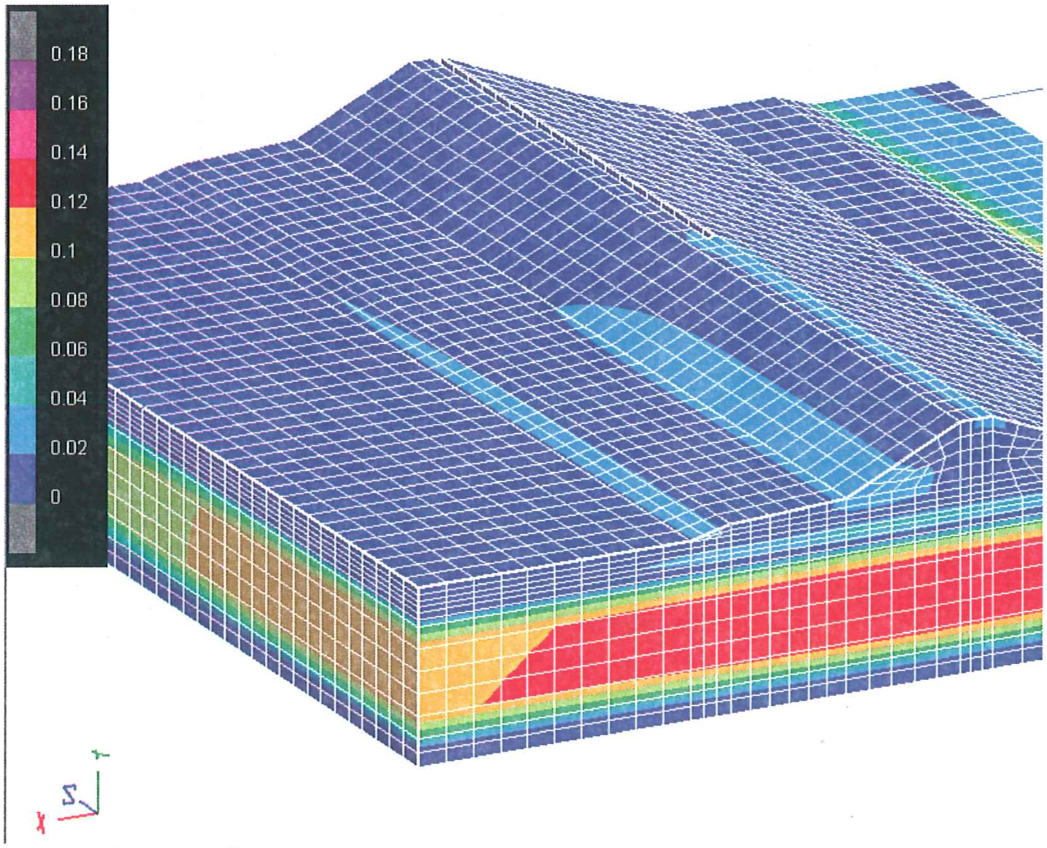


North End – XYZ-velocity contours

Figure C-5

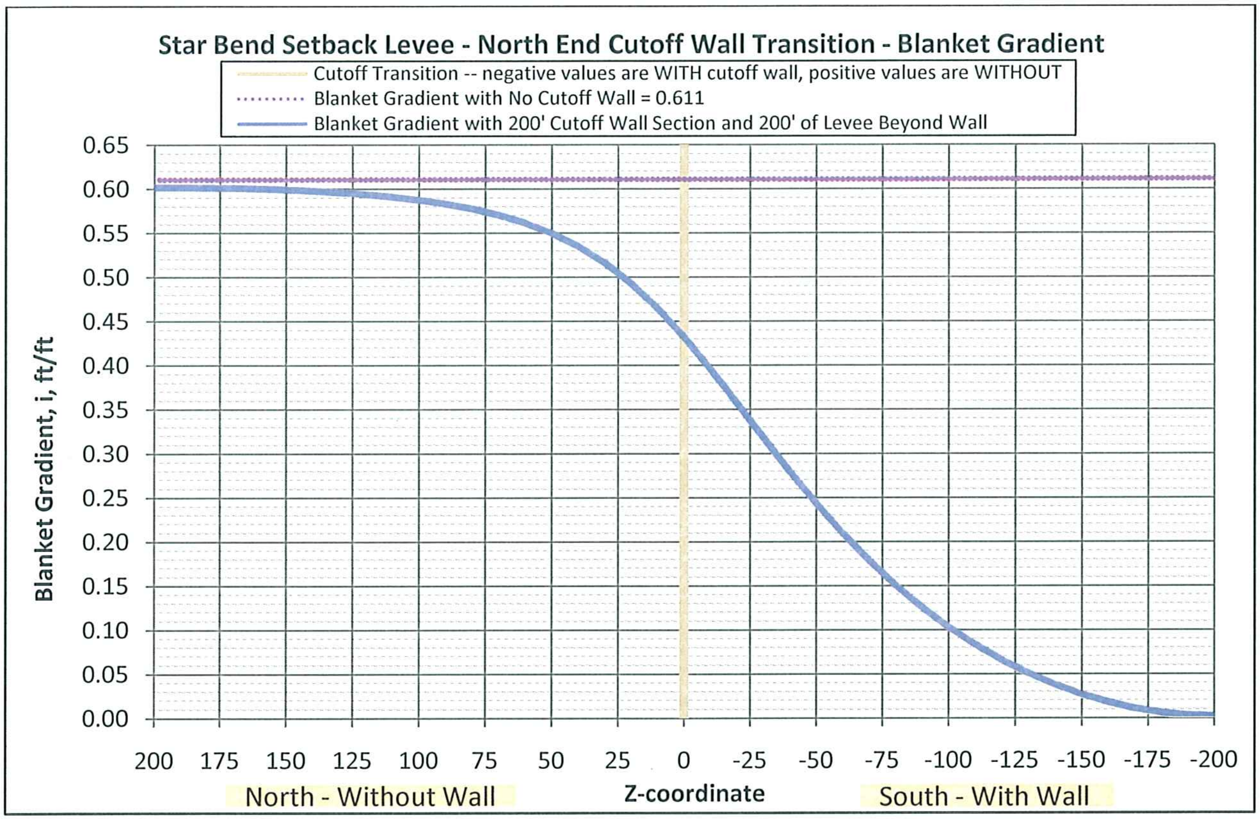


South End – XYZ-gradient contours



South End – XYZ-velocity contours

Figure C-6


Star Bend Setback Levee - North End Cutoff Wall Transition - Blanket Gradient
Cutoff Transition -- negative values are WITH cutoff wall, positive values are WITHOUT
Blanket Gradient with No Cutoff Wall = 0.611
Blanket Gradient with 200' Cutoff Wall Section and 200' of Levee Beyond Wall
Blanket Gradient, i, ft/ft
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
200
175
150
125
100
75
50
25
0
-25
-50
-75
-100
-125
-150
-175
-200
North - Without Wall
Z-coordinate
South - With Wall

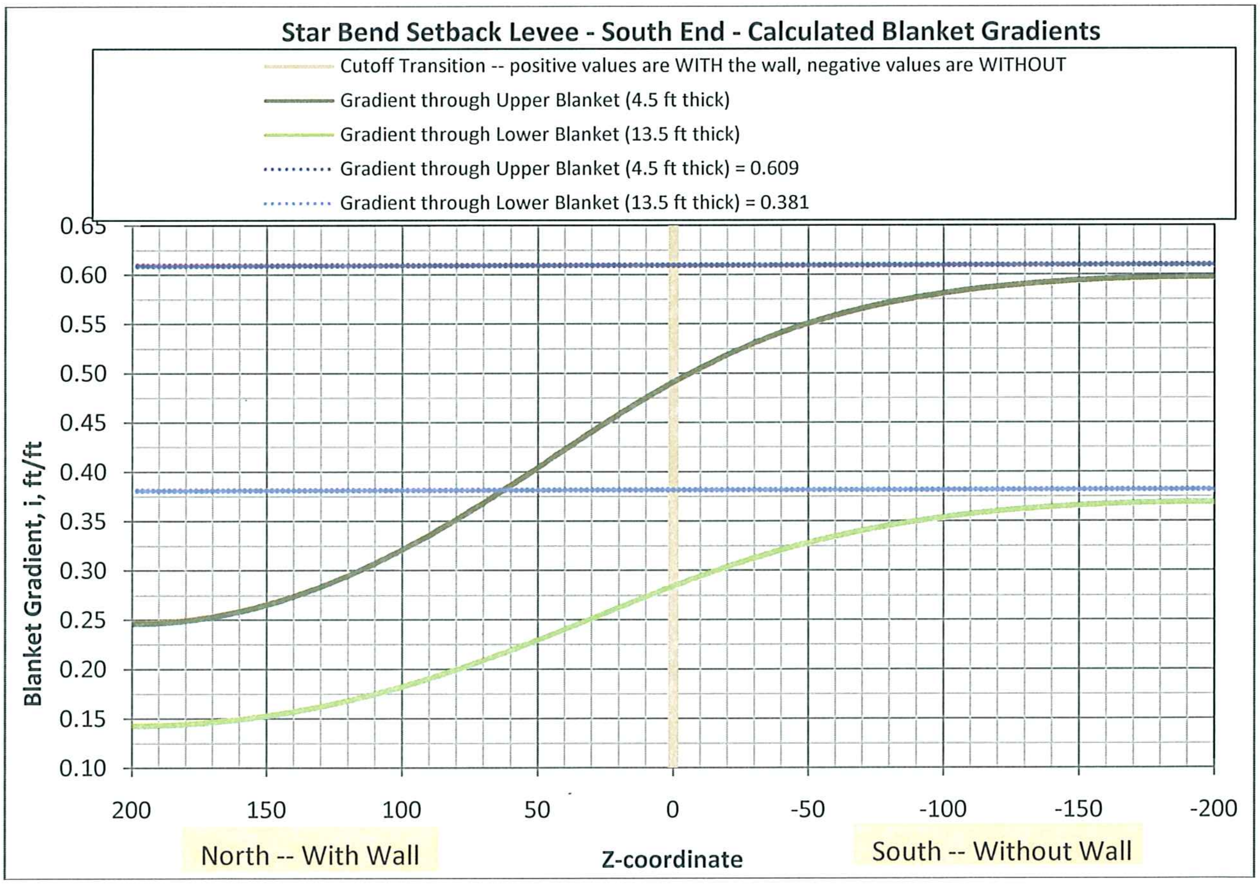
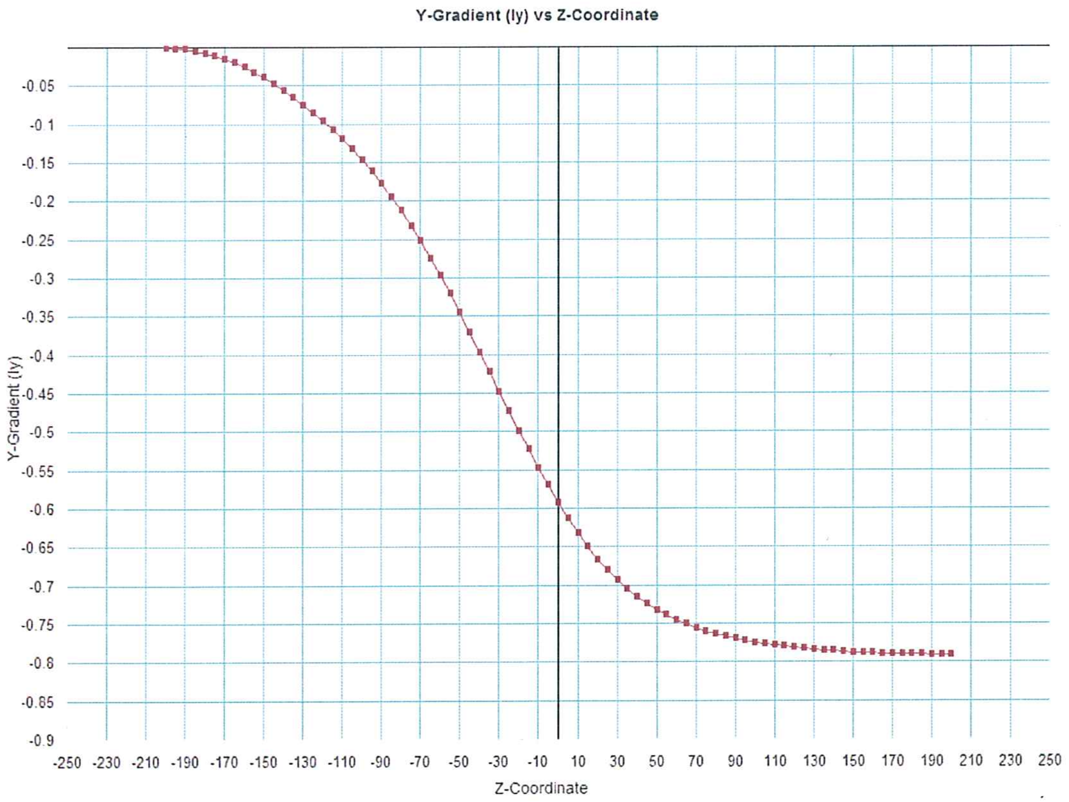
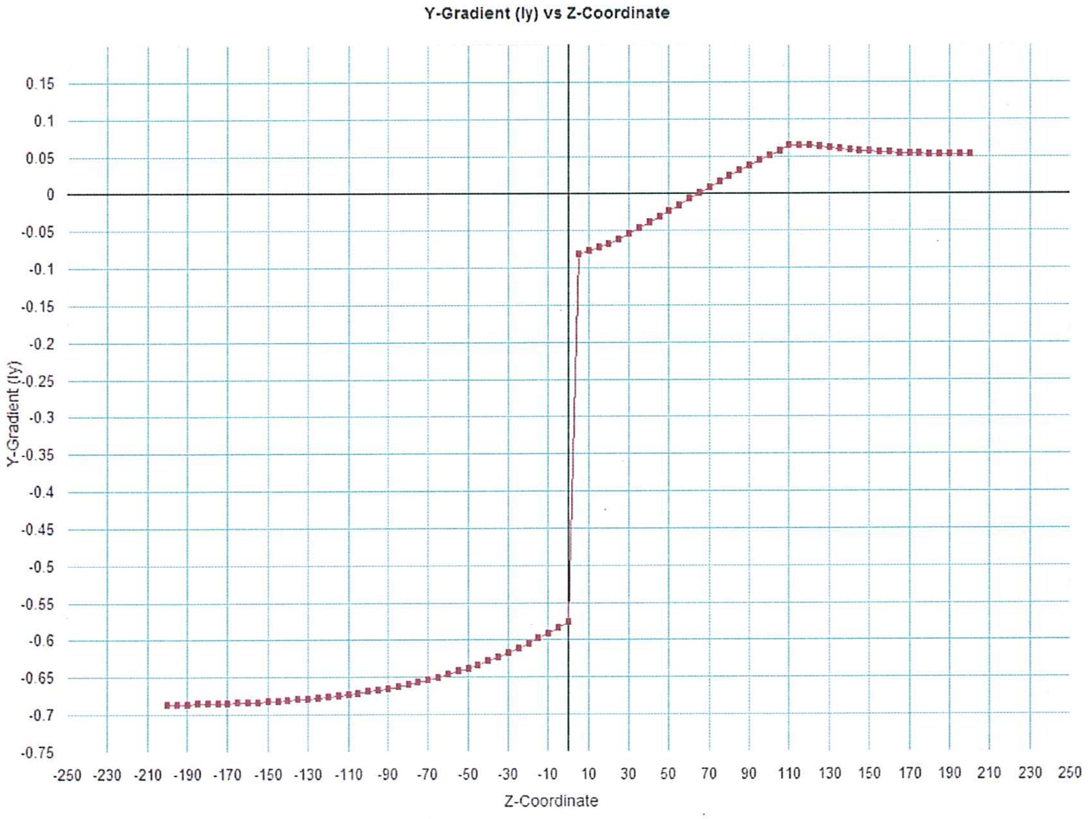

Star Bend Setback Levee - South End - Calculated Blanket Gradients
Cutoff Transition -- positive values are WITH the wall, negative values are WITHOUT
Gradient through Upper Blanket (4.5 ft thick)
Gradient through Lower Blanket (13.5 ft thick)
Gradient through Upper Blanket (4.5 ft thick) = 0.609
Gradient through Lower Blanket (13.5 ft thick) = 0.381
Blanket Gradient, i, ft/ft
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
200
150
100
50
0
-50
-100
-150
-200
North -- With Wall
Z-coordinate
South -- Without Wall

Figure C-7

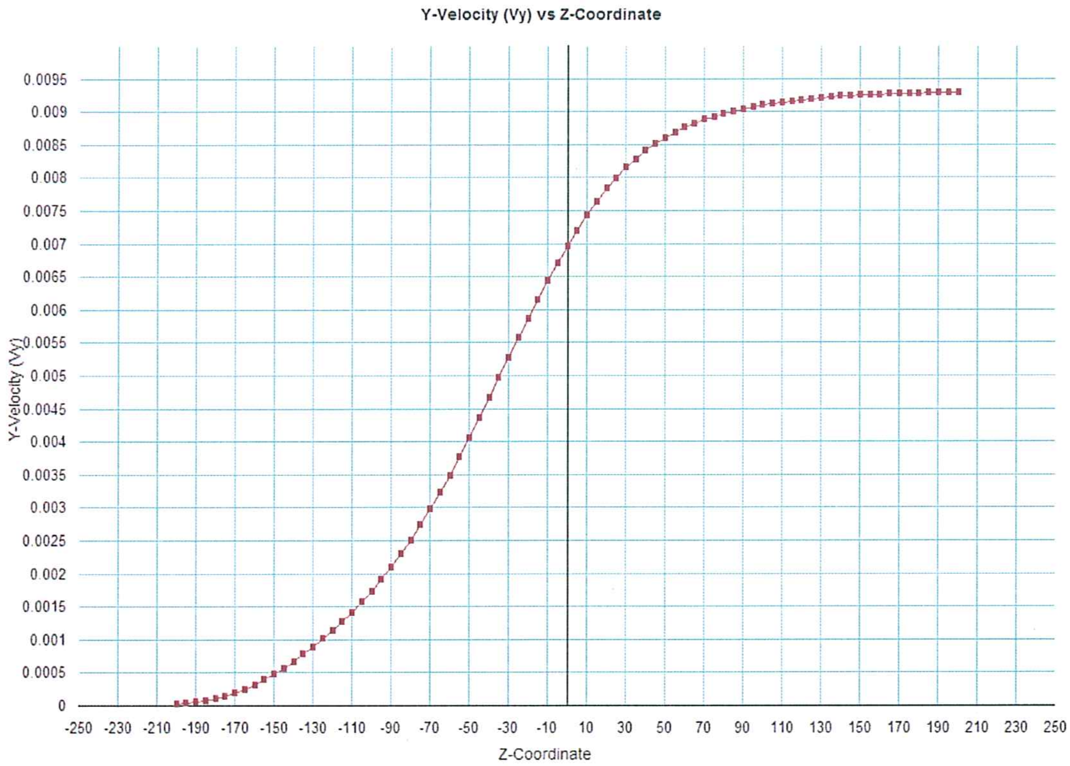


North End – Y-gradient along landside toe

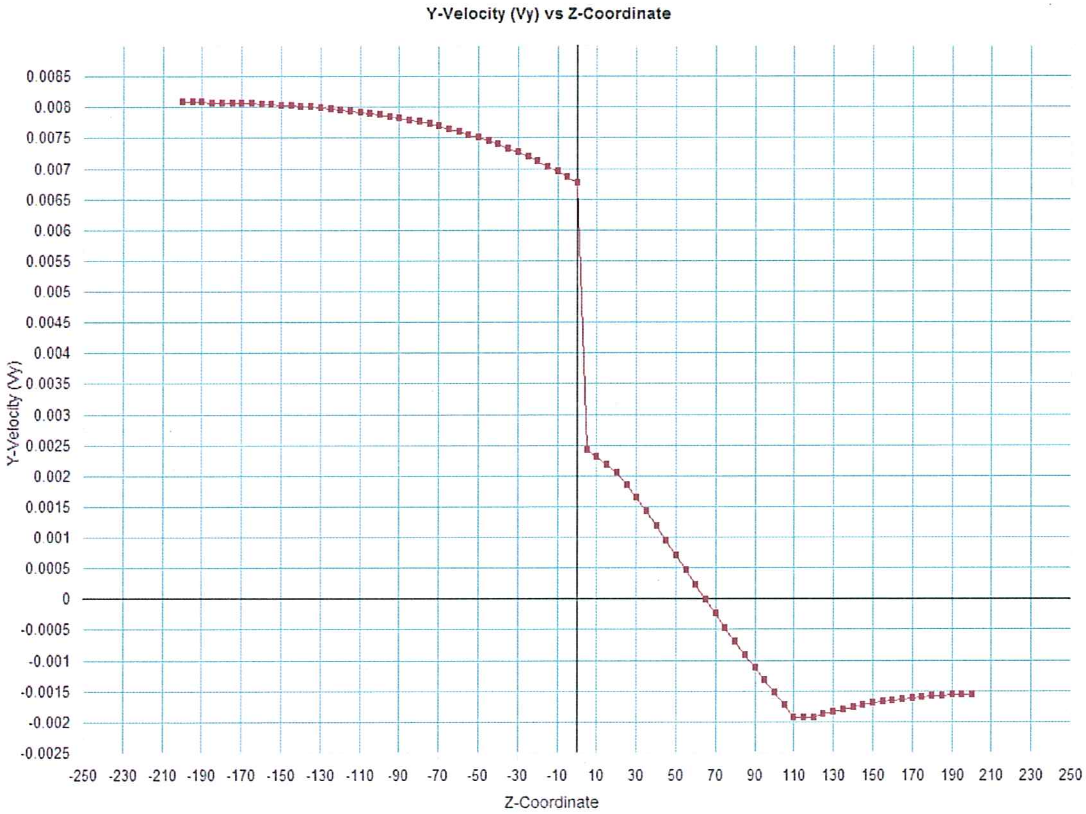


South End – Y-gradient along landside toe

Figure C-8



North End – Y-velocity (ft/hr) along landside toe



South End – Y-velocity (ft/hr) along landside toe

Figure C-9