TVA – Kingston Fossil Plant

<u>Presentation to Plant Manager - Kingston Fossil Plant</u>

Summary of Actions Taken

To Address Seepage through

Dredge Cell Dike And Recommended Path Forward

27 March 2007

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Agenda

- Kingston
  - Situation Analysis (November 2006)
  - Investigation
  - Findings and Conclusions
  - Seepage Model
  - Dredge Cell Restoration
  - Monitoring and Maintenance
  - Alternatives Analysis
    - KT-type analyses of alternatives
  - Go-forward Recommendation

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Aerial View of the Site
Seepage Area
Cell II
Existing Dredge Cells
Cell III
Cell I

Situation Analysis

- Excessive seepage and piping observed near toe of dike on November 1, 2006 (two locations, similar location to 2005)
- Decision made to lower water levels in Ash Pond, conduct dye test, install "temporary patch"
- The patch coupled with weather improvements minimized the immediate threat
- Suspended Dredging Operations
- Lowered Water Table

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Situation Analysis (cont.)

- GeoSyntec performed an inspection on November 2 and concurred with the actions taken by TVA
- TVA initiated inspections every 2-hours to monitor the situation
- GeoSyntec commenced planning for additional investigations and short-term repairs
- In the seep areas, water was observed to be flowing below the geonet drainage layer; water was also observed to be flowing through the geonet
- Surface water was observed on benches
- Underdrains currently discharge to benches

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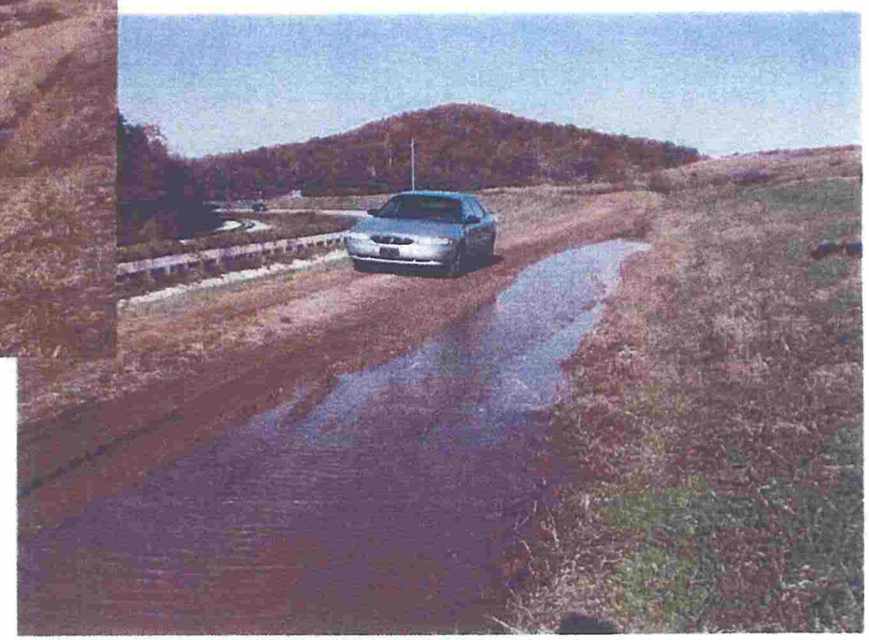
Situation Analysis (cont.)



Photos taken November 2, 2006
(dry weather conditions)
Note water on benches in
general vicinity of seeps

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Investigation Results

- Installed 33 drive-point piezometers along the toe of the slope
- Measured water levels and developed a water level profile
- Identified the area of concern based on the water levels that are within a foot or less of the ground surface
- In some instances water levels in piezometers were above the ground surface

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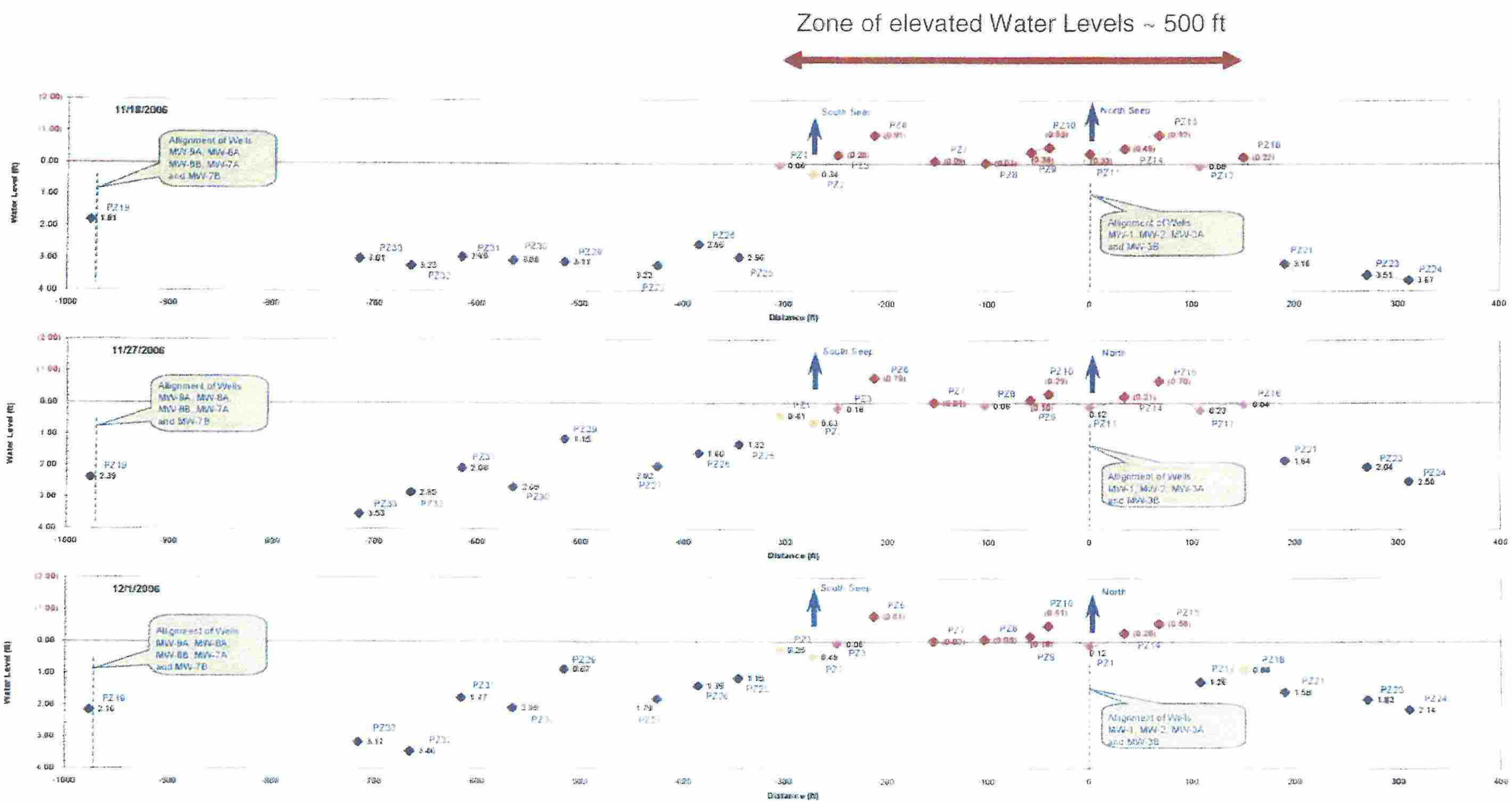
Investigation Results (cont.)



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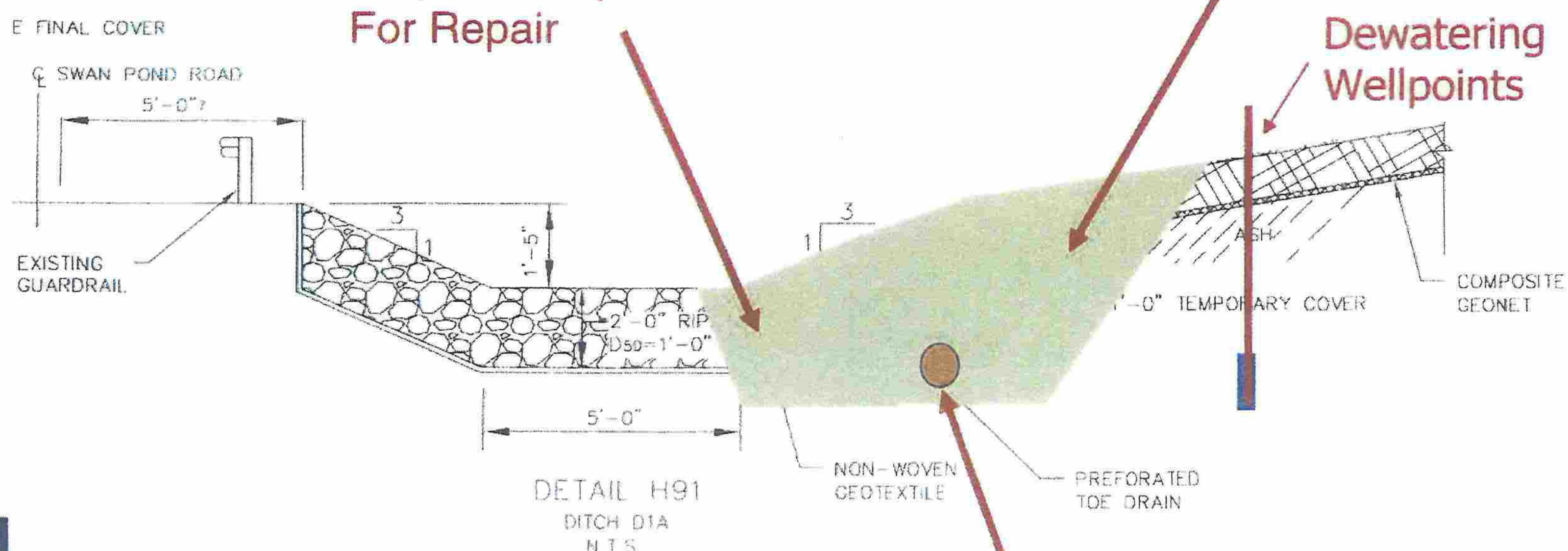
Investigation Results (cont.)

- Developed an intrusive investigation plan that could be coupled with temporary or permanent repair activities
- Identified southern seep area as the preferred location for the intrusive investigation due to continued observation of seepage, ash piping and high water levels



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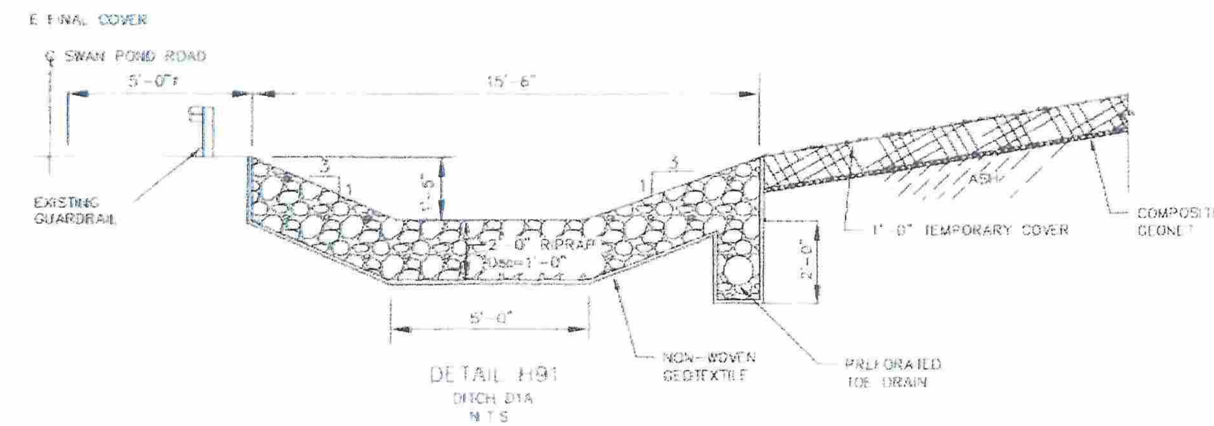
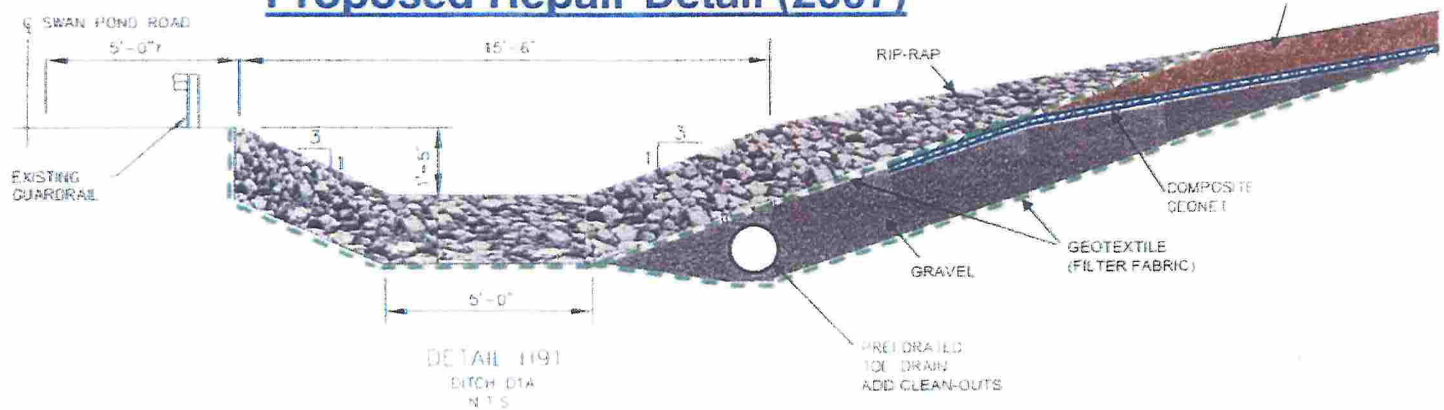
Investigation Results (cont.)

Original Detail (2005)



Proposed Repair Detail (2007)



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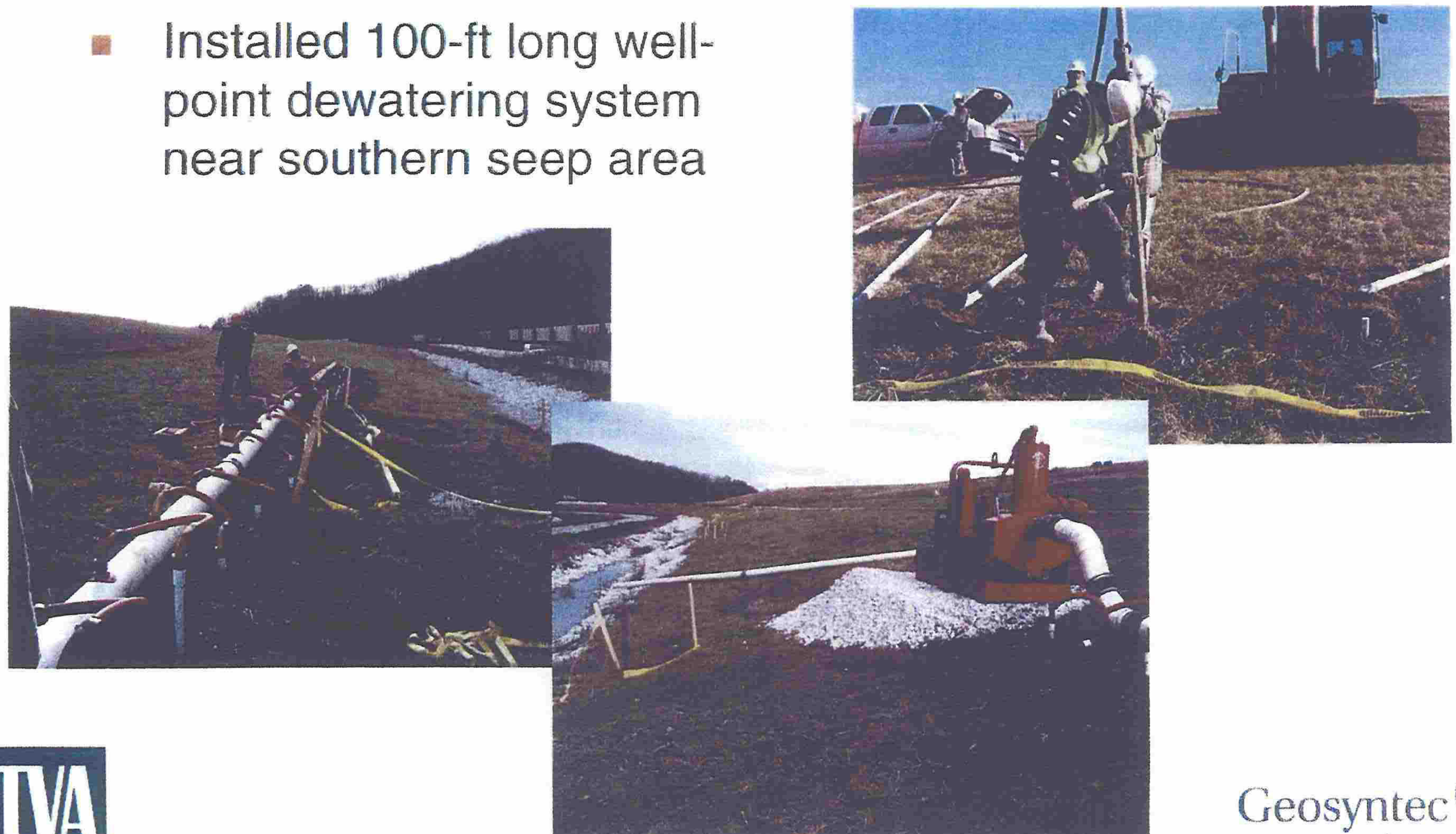
Investigation Results (cont.)

- Installed 100-ft long well-point dewatering system near southern seep area



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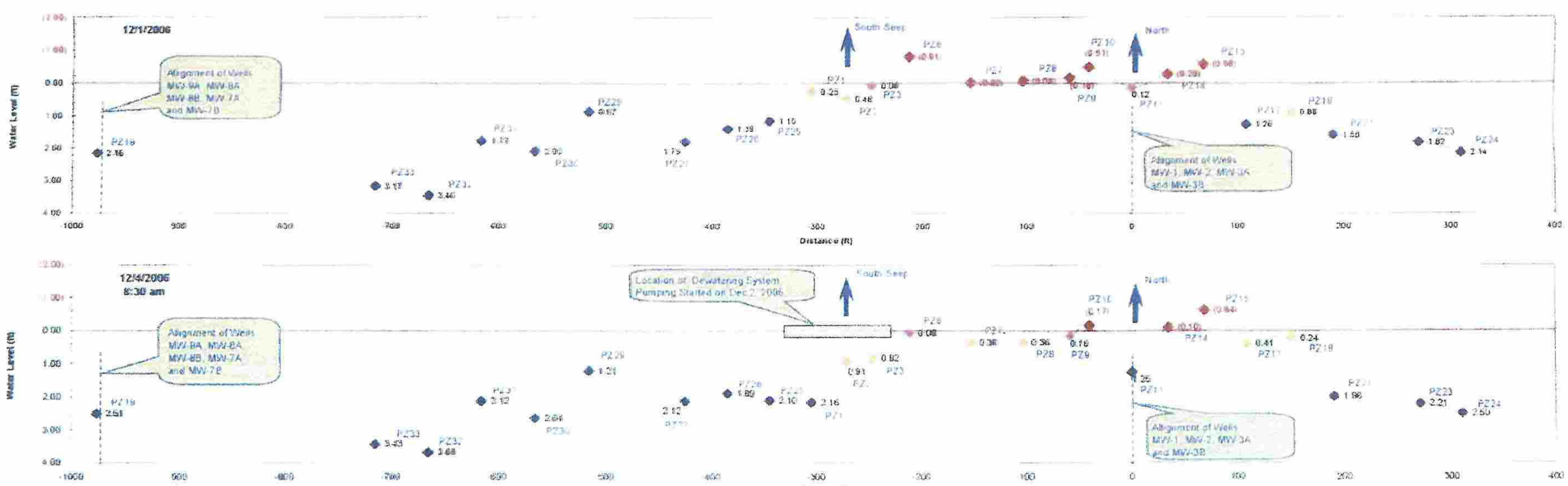
Investigation Results (cont.)

- Monitored water level response to dewatering
- Initiated intrusive investigation once water levels were below ground surface



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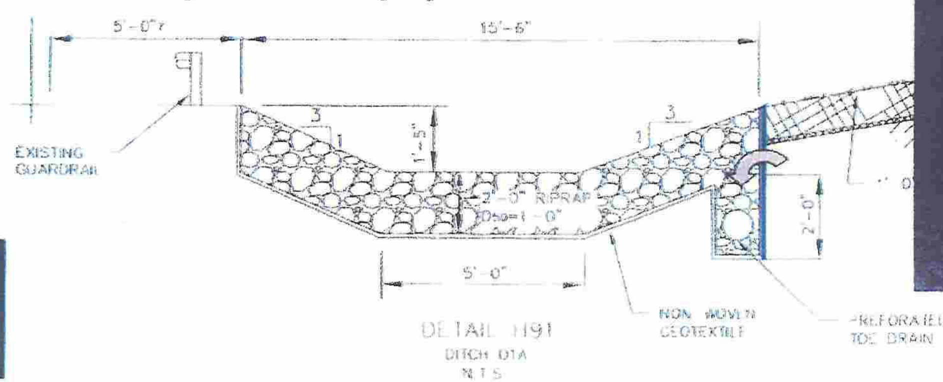
Investigation Results (cont.)

- Excavation at toe, note:
  - water level is below ditch invert, drainage pipe is below water and not draining freely
  - observed non-woven geotextile beneath rip-rap per design
  - woven geotextile at drain/ash interface appears shorter than as designed, and ash may be in pipe trench



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Investigation Results (cont.)

- Removed top soil over the geonet drainage layer
  - no water evident in geonet
  - some clay in contact with ash; no geotextile separator (woven geotextile in trench does not provide separation between soil and ash)
- Geonet was cut into panels and peeled back

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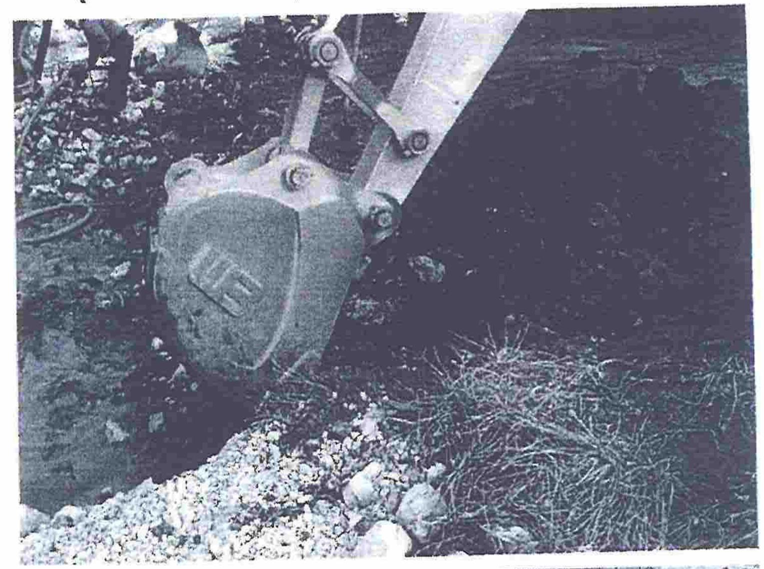
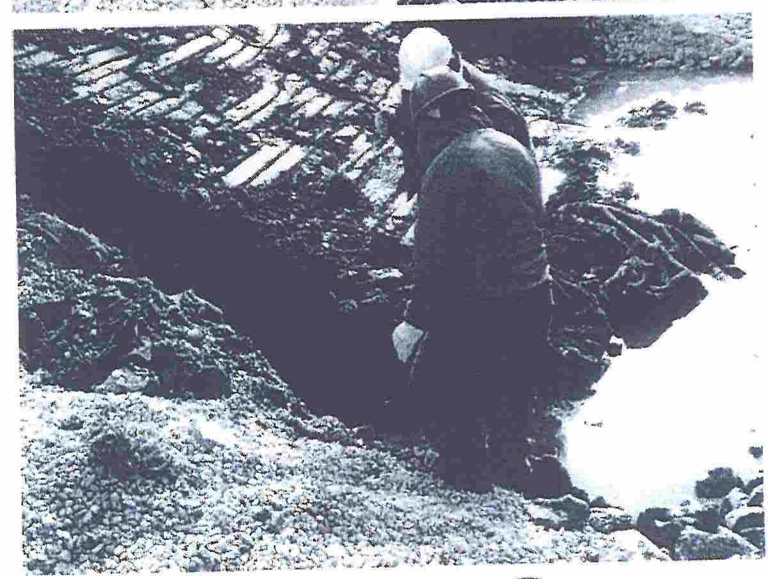
Investigation Results (cont.)

- Fly ash excavation
  - relatively dry
  - very stable (dewatering system functioning)
  - groundwater level was at about 1 ft below ditch invert





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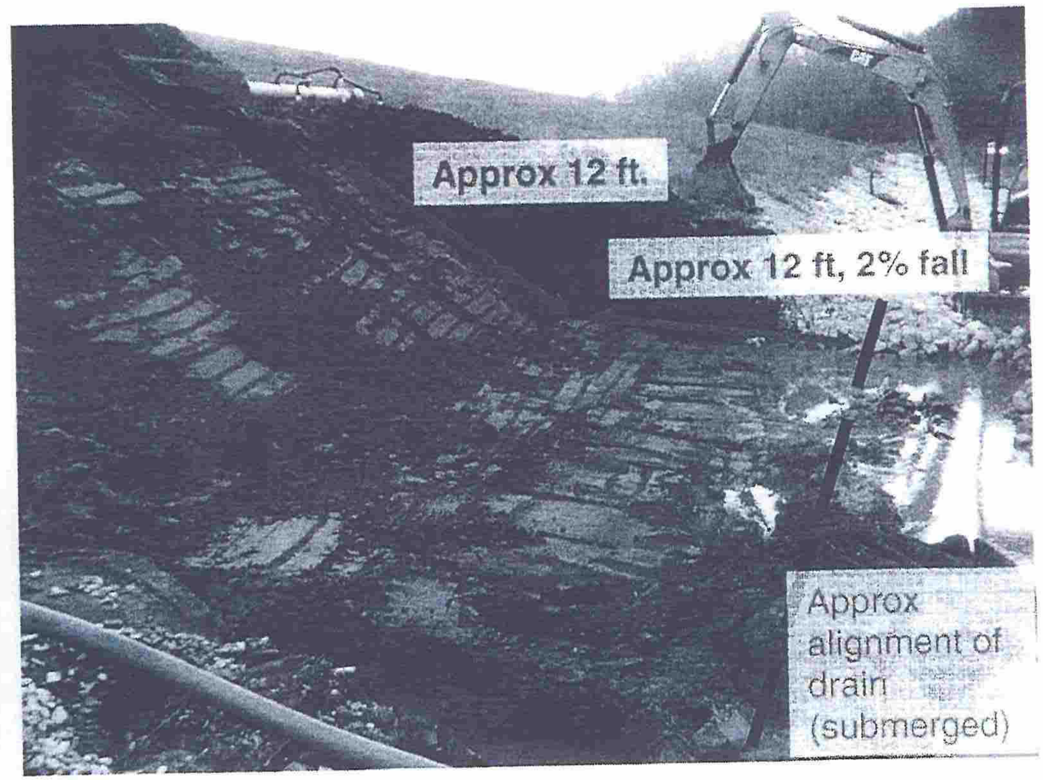
Investigation Results (cont.)

- Conditions immediately prior to repair/placement of new buttress drain



- Overall goal:
  - Improve toe drain
  - Contain ash to prevent piping

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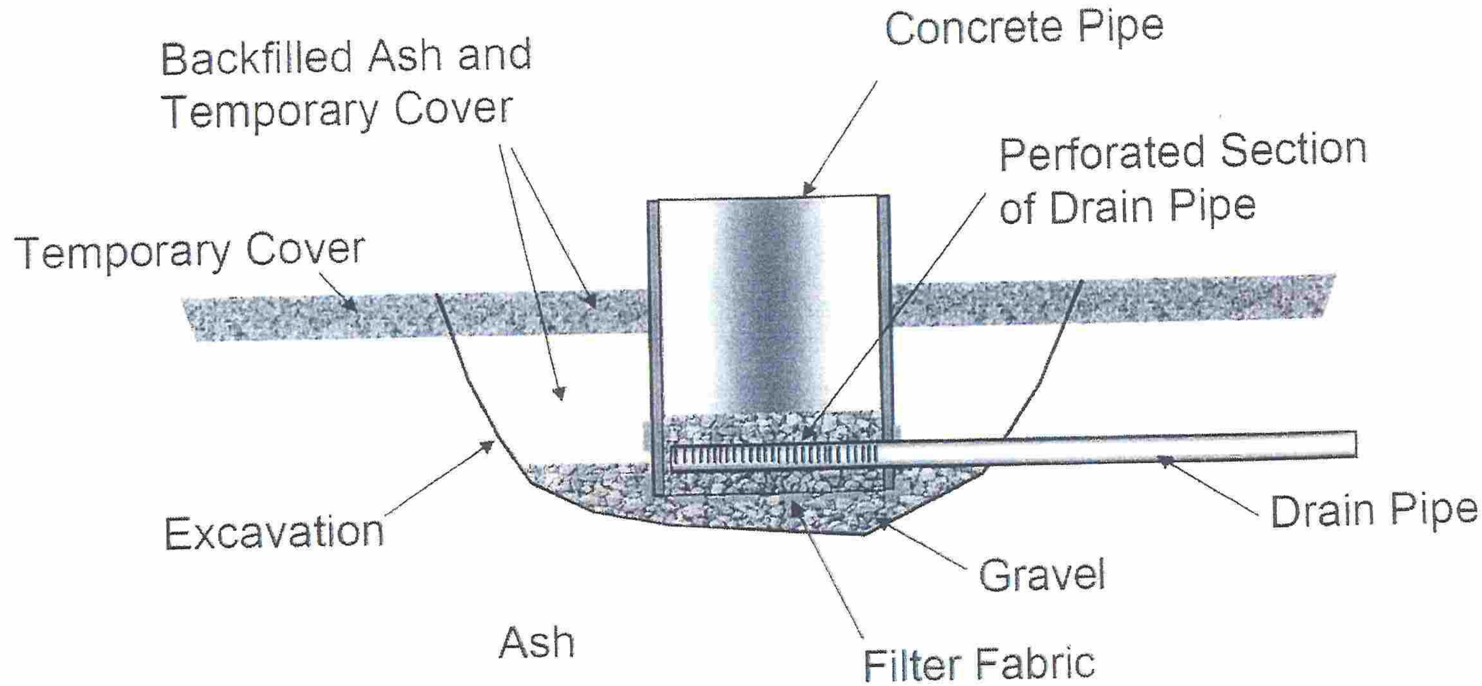
Investigation Results (cont.)

Spring Box Detail (used for localized pressure relief)



Purpose:
- Provides controlled relief of excess water pressure
- Allows release of water from localized anomalies while containing fines (ash)

Investigation Results (cont.)

- Placed the spring box (36-in concrete pipe) over the geotextile (see next slide).
- Backfilled the area surrounding the concrete pipe with gravel.
- Placed gravel inside the concrete pipe (~1 to 2 ft)
- Completed the placement of gravel blanket layer.

- Attempts to dewater and expose the toe drain pipe were not successful due to pump capacity and excess water.
- Placed gravel over the pipe and a layer of geotextile over gravel.
- Groundwater level was at about 1 ft below ditch invert.

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Investigation Results (cont.)

- Geonet that was peeled back during the removal of top soil was put back over the gravel blanket layer.
- Geotextile was rolled back over the gravel blanket layer.

- Rip-rap at the toe was placed back to re-form the ditch.
- Top soil was placed over the geotextile and lightly tamped with backhoe bucket.
- The first segment of the repair area was completed on the morning of December 9.

Due to the success of the fist area, a decision was made to continue and address the 500 ft. length of dike

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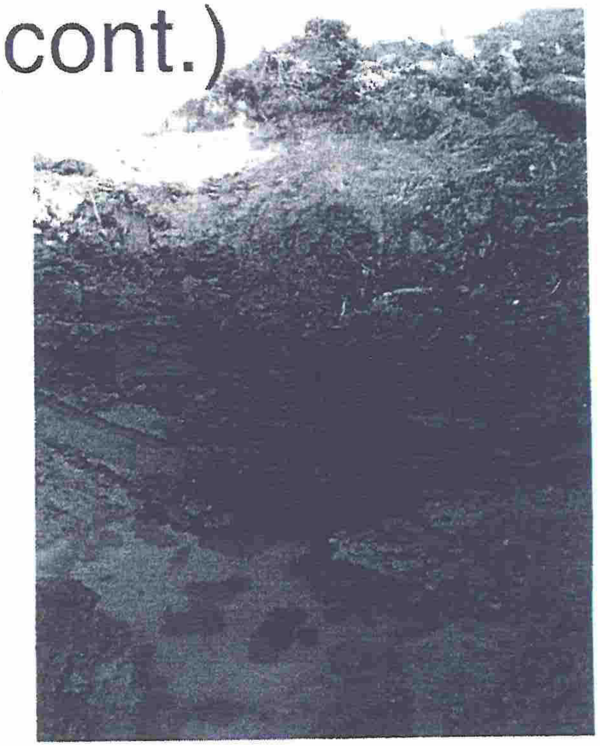
Investigation Results (cont.)

- The topsoil was removed from the next 25-ft segment of the repair area.
- High water table was observed a few feet from the wellpoints.
- Confirmed that wellpoints were operational.
- This segment corresponds to the area where significant surface depressions were observed due to seepage and ash piping.



- Geonet was found deeper and strained due to depressions.
- Seepage from the adjacent untouched segment was observed at the sidewall of the excavation.
- Geonet could not be salvaged and removed with topsoil.

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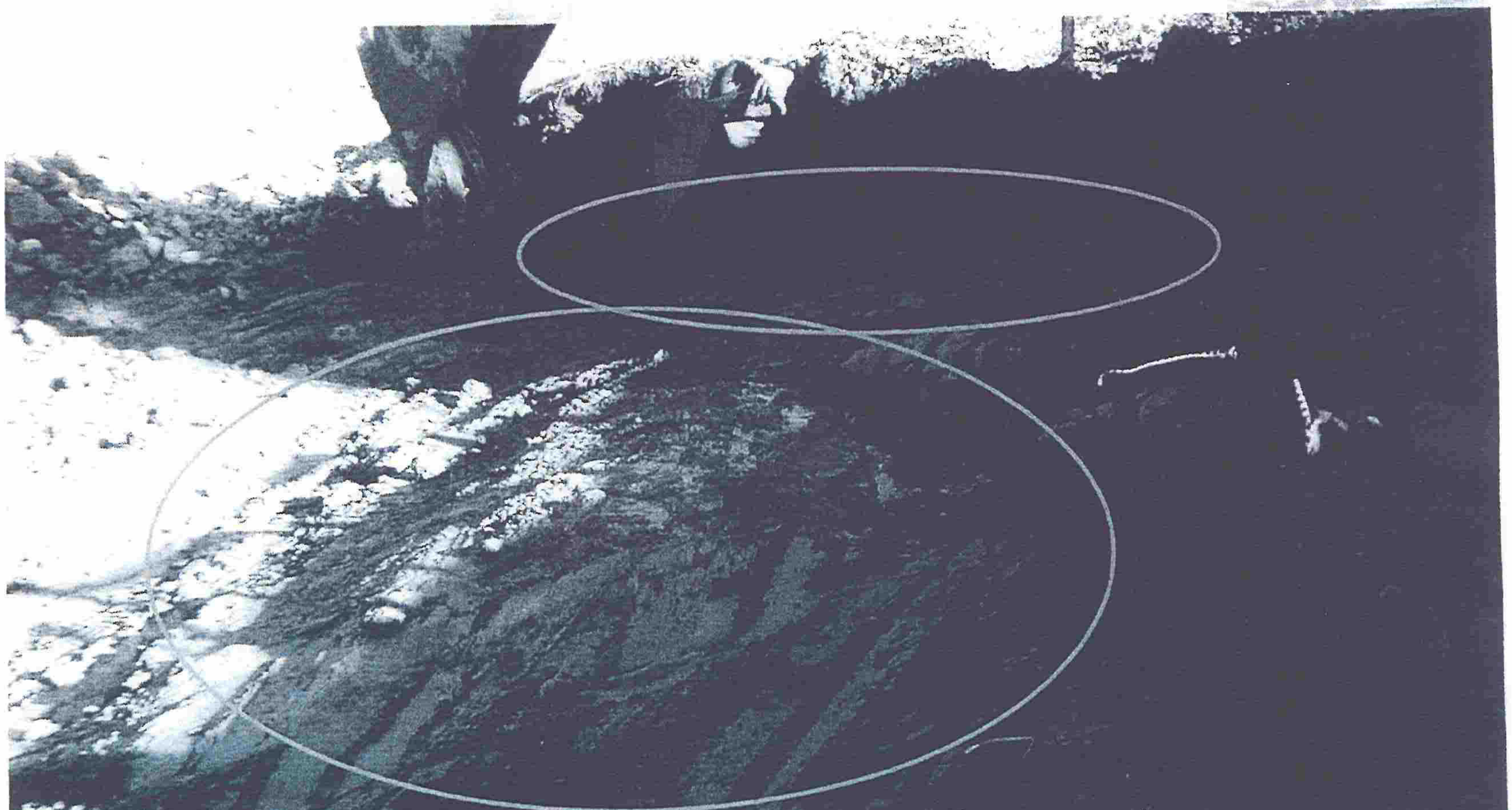
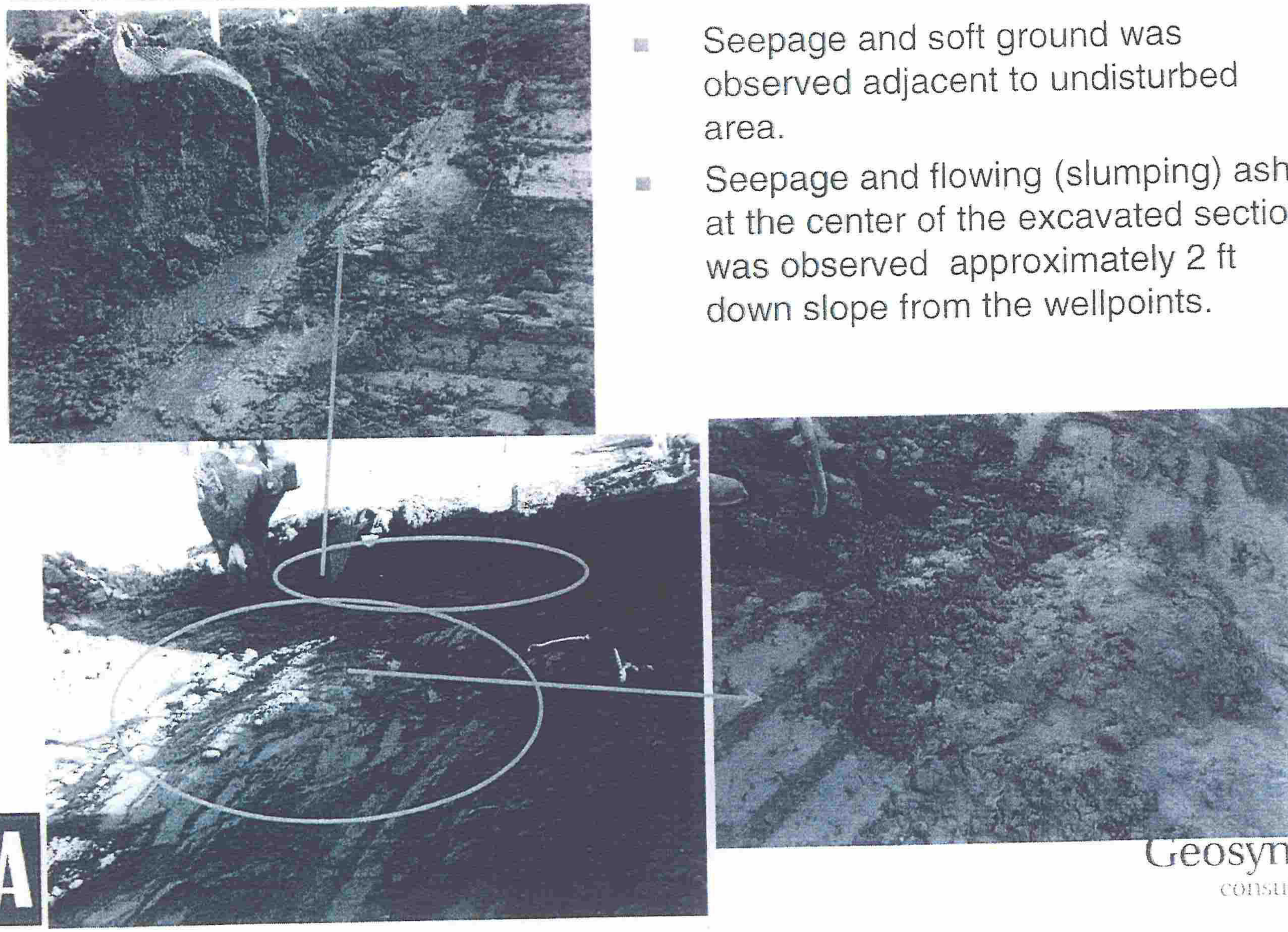
Investigation Results (cont.)



- Flyash was cut back similar to the earlier repair segment.
- Unlike the earlier repair segment, relatively moist and less stable (localized anomaly)
- Visible water seepage and movement (slumping) of ash was observed.

Investigation Results (cont.)



- Seepage and soft ground was observed adjacent to undisturbed area.
- Seepage and flowing (slumping) ash at the center of the excavated section was observed approximately 2 ft down slope from the wellpoints.

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Dredge Cell Restoration
(summary of short-term actions completed)

- Based on the success of the 50 ft long pilot area, a decision was made to continue implementation of toe drain improvements along the problem area
  - Wellpoint dewatering system extended towards north for the entire length of the area of concern (~ 500 ft)
  - Repairs implemented along the entire problem area in a similar manner.

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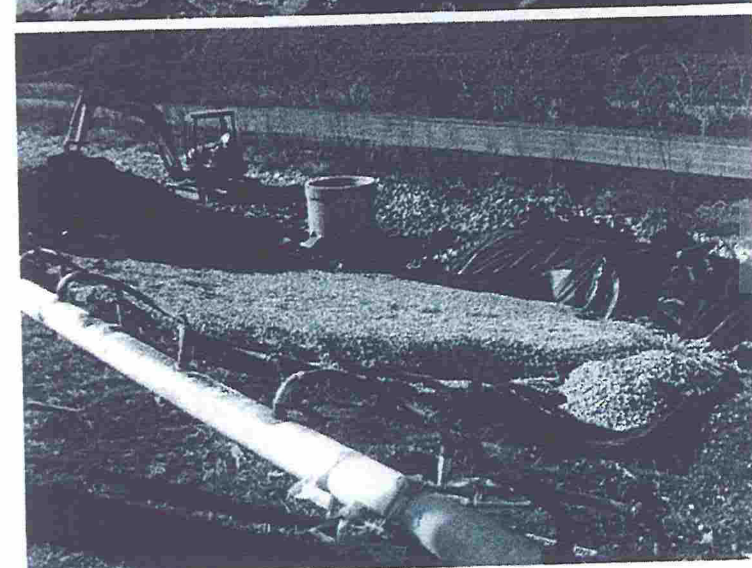
Investigation Results (cont.)

- ***Rehabilitation procedure continued similar to other areas***
  - Geotextile was placed over the slope.
  - Gravel blanket layer was placed over geotextile starting from the toe and progressing up slope to buttress ash and minimize movement
- ***Approximately 500 linear feet of dike along Swan Pond Road was rehabilitated***



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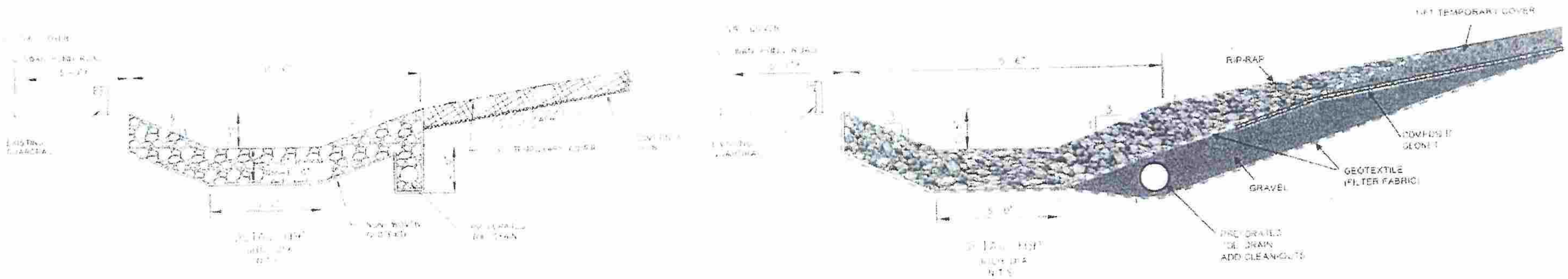
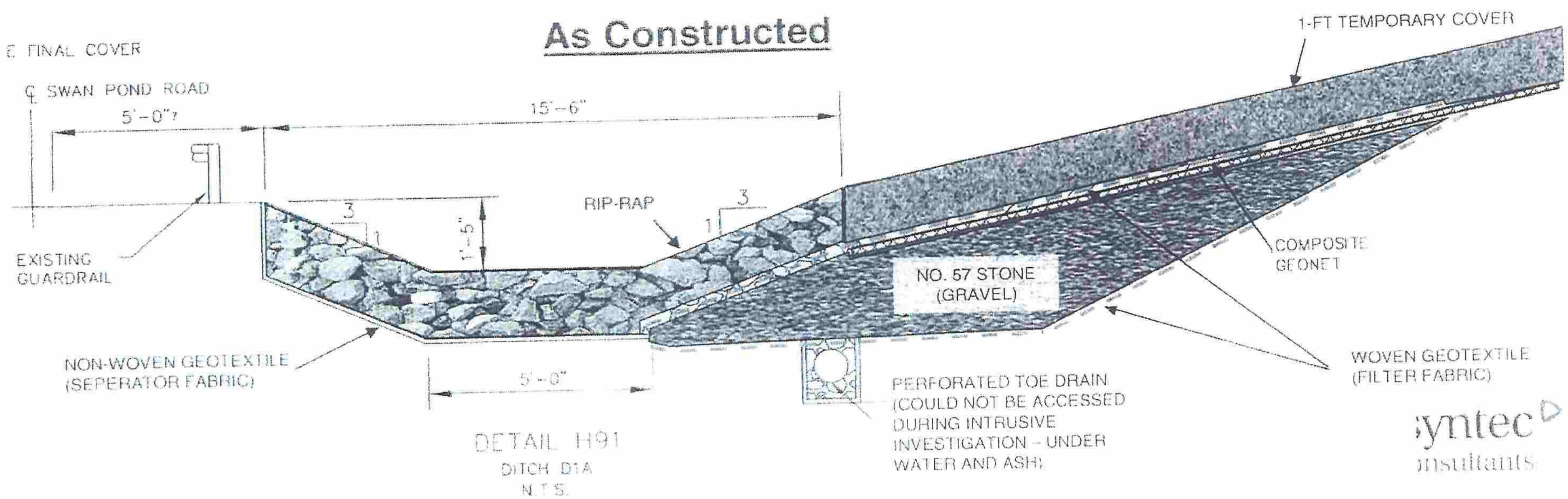
Investigation Results (cont.)

Proposed Repair Detail



As Constructed



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Findings and Conclusions

- Drainage pipe – ineffective
  - No free outlet
  - Almost flat gradient
  - Poor water conductivity between ash and drain/ditch
  - Ash possibly present in pipe trench
- Small surface area of the drain as designed was not adequate to capture flow from lenses and anomalies identified during the recent investigation
- Zones of variable material observed
  - Results in preferential flow paths and wet areas
  - Original fix (global) did not anticipate local anomalies
- Standing water observed on benches
  - Provides a constant source of water to infiltrate dike
  - Some underdrains discharge to benches

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Findings and Conclusions

- Working hypothesis
  - Localized preferential flow paths present in seepage area; these were not anticipated in original design
  - Water on benches provides an additional source of water during wet weather
  - Clay embankment and presence of a shale layer beneath Swan Pond Road has a dam effect
  - Toe drain not adequate to capture anomalies and does not adequately contain ash

Development of Seepage Model

A mathematical flow model was also used to assess the situation

- Model developed using SEEP/W (finite element seepage model)
- Model geometry and material properties developed from 2005 geotechnical investigation
- Purpose of model – simulate conditions before and after rehabilitation

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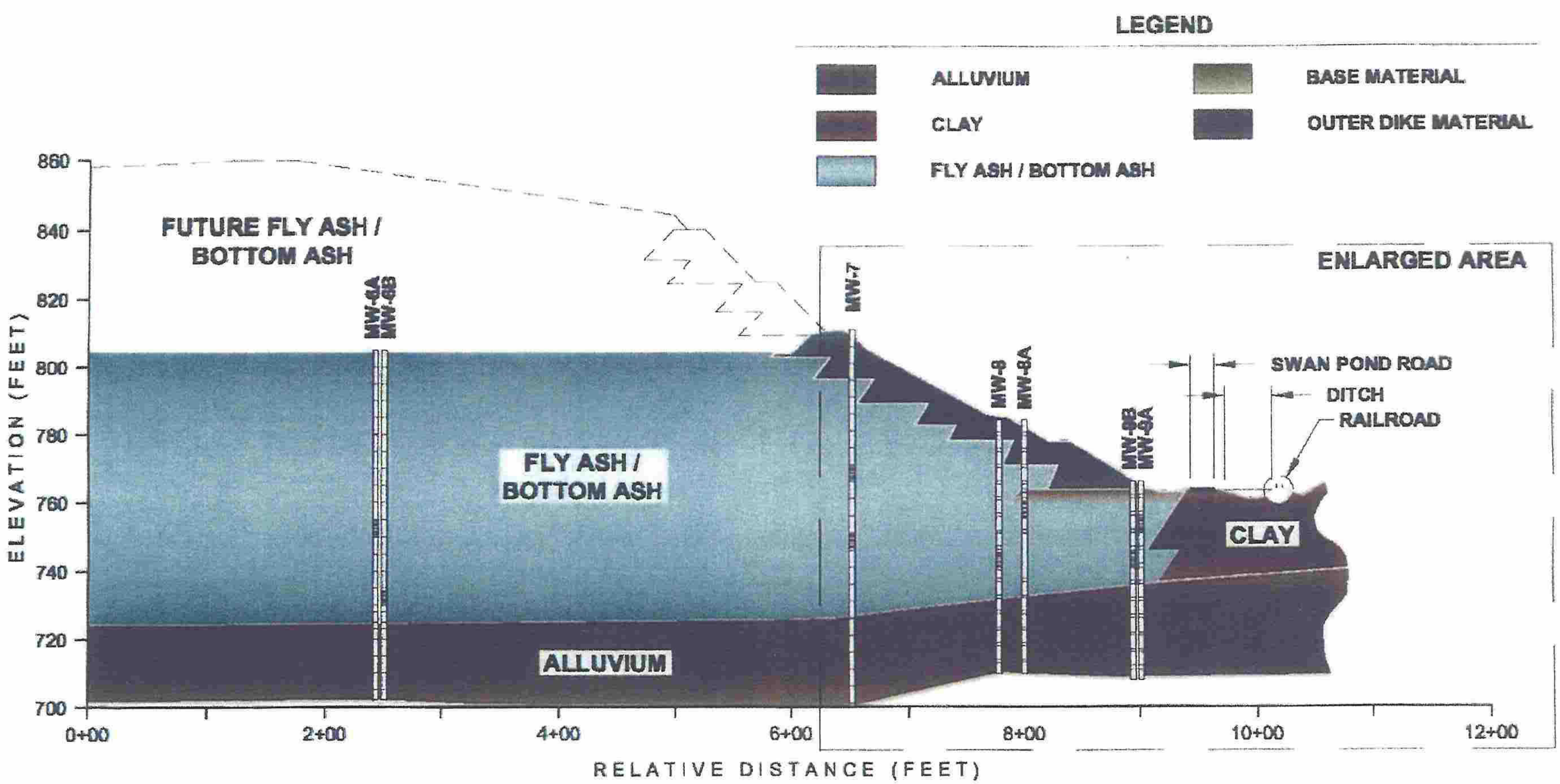

Cell 1 Cross Section (No Problem Area)

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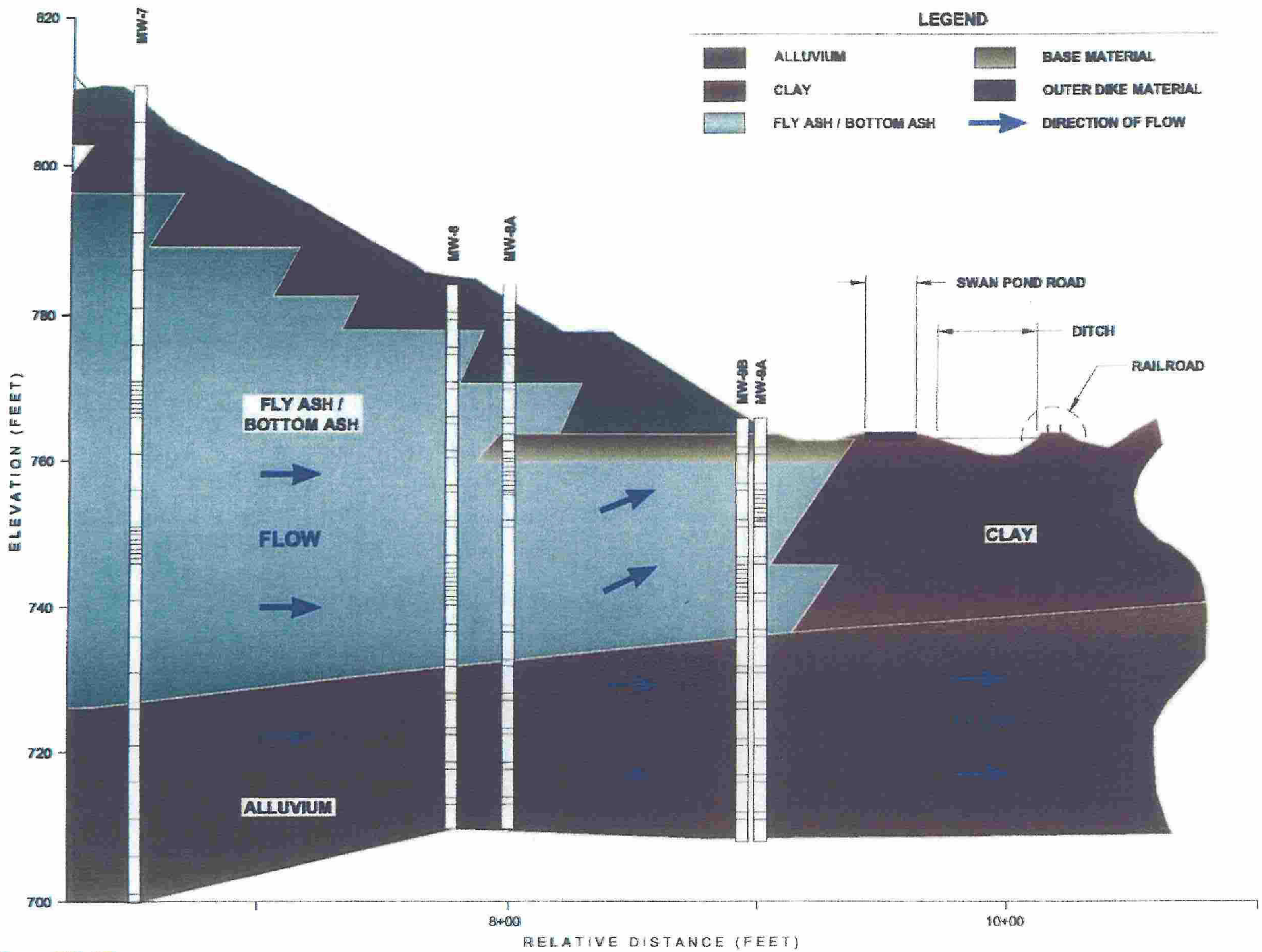

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Cell 1 Cross Section (No Problem Area)

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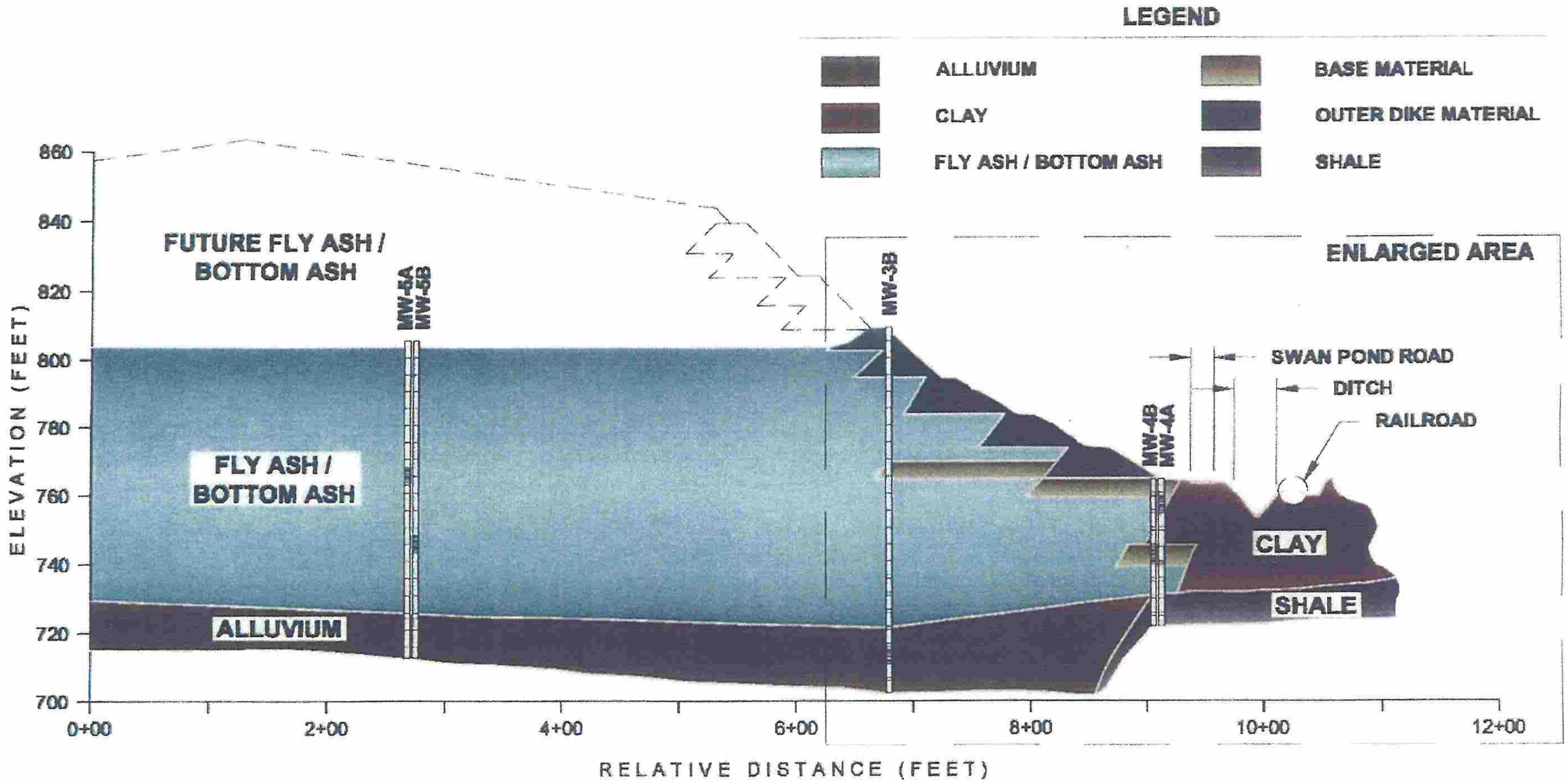

Cell 3 Cross Section (Seepage Area)

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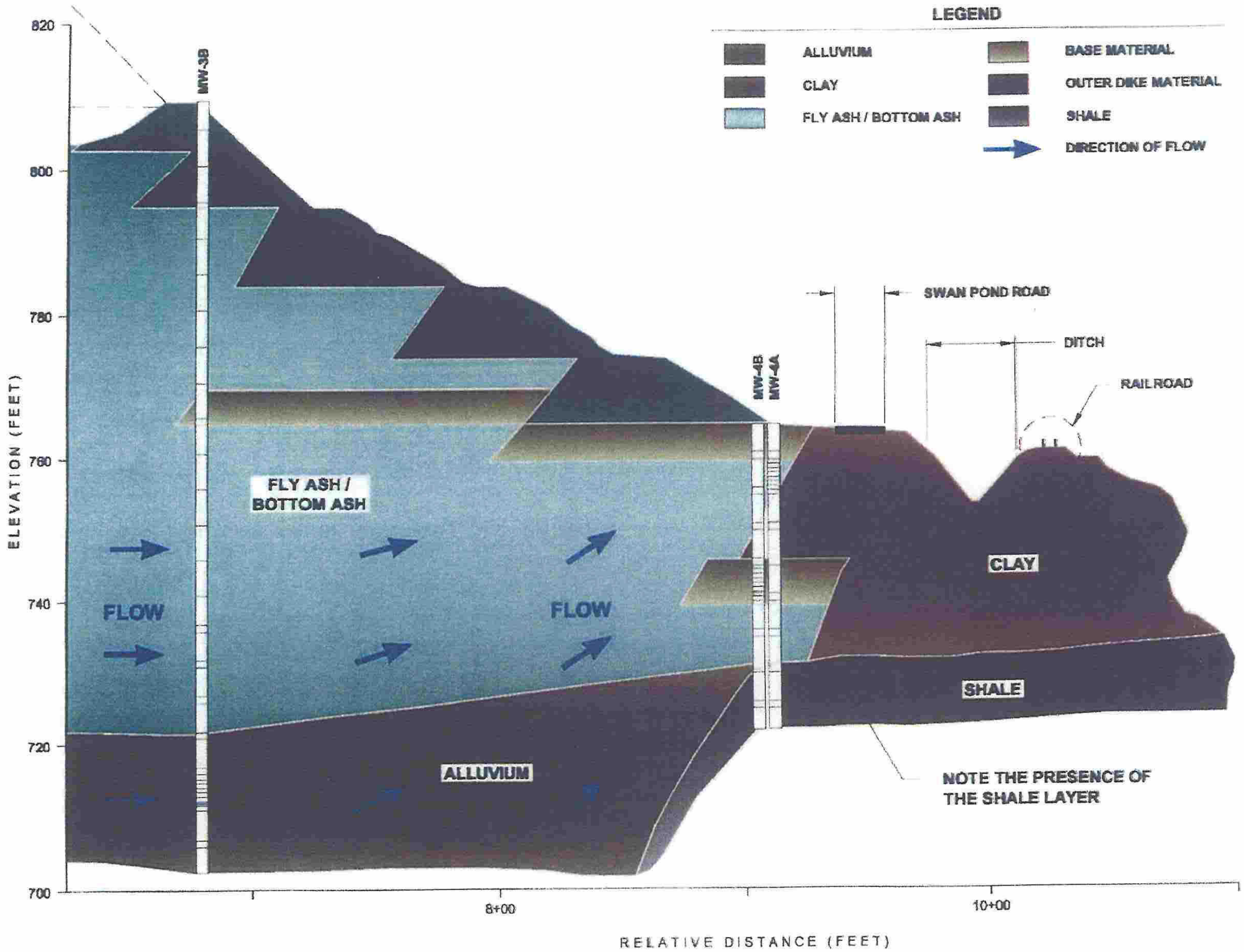

Cell 3 Cross Section (Seepage Area)

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Differences - Seepage Area

Key differences between the seepage area (former Cell 3) and the control area (former Cell 1):

- Localized anomalies found in seepage area during intrusive investigation
- Presence of shale layer identified at seepage area during 2005 geotechnical investigation
- Seepage model constructed using Cell 3 geometry and properties

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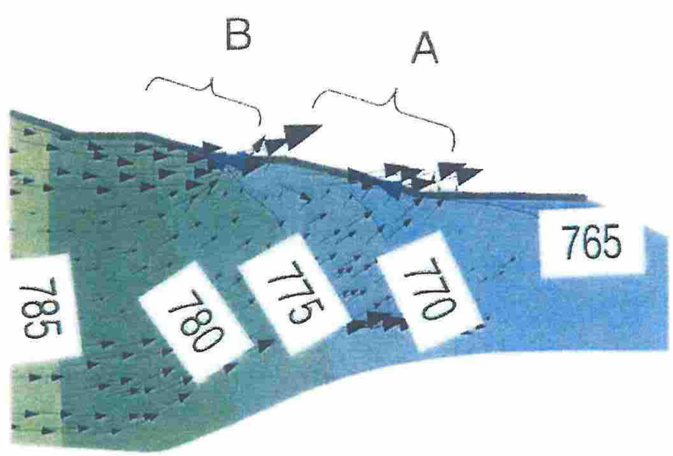
Model Predictions Prior to 2005 Improvements

Model-predicted Total Head Distribution (equipotential lines)



- Model clearly illustrates that without adequate drainage, seepage water will exit the lower portion of the slope
- The exact location is difficult to predict and is highly sensitive to localized zones of more permeable material (e.g., bottom ash which had been identified in borings)

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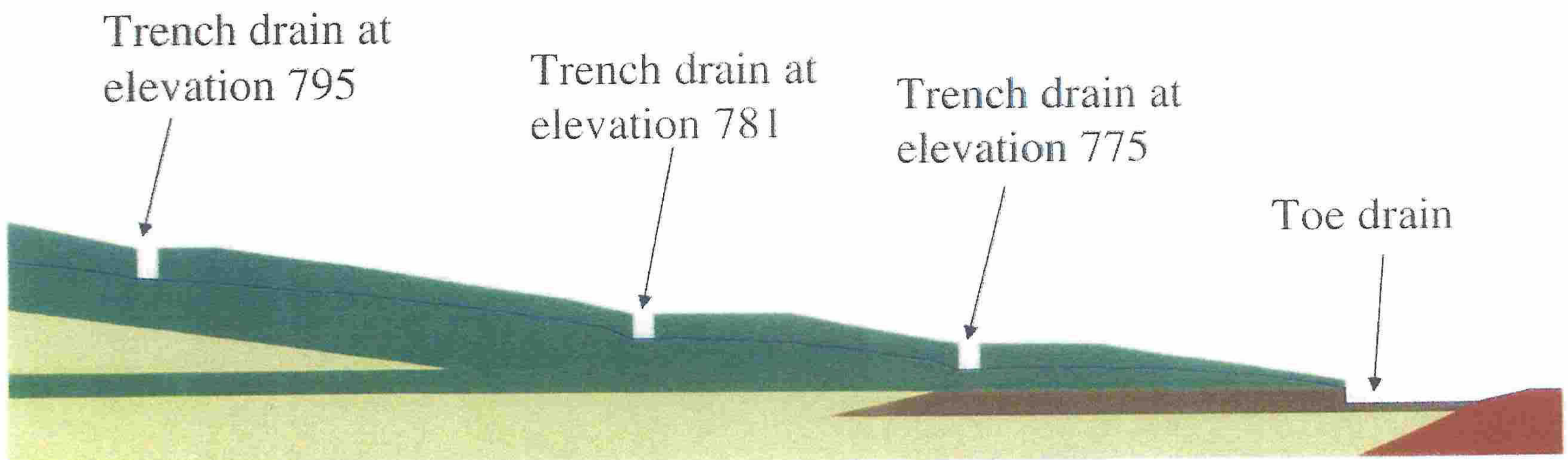
Summary of Improvements – 2005-2007

Proposed Improvements (2005)



A series of drainage improvements were developed, analyzed, and implemented (2005) with the goal of lowering the phreatic surface and controlling seepage at the toe

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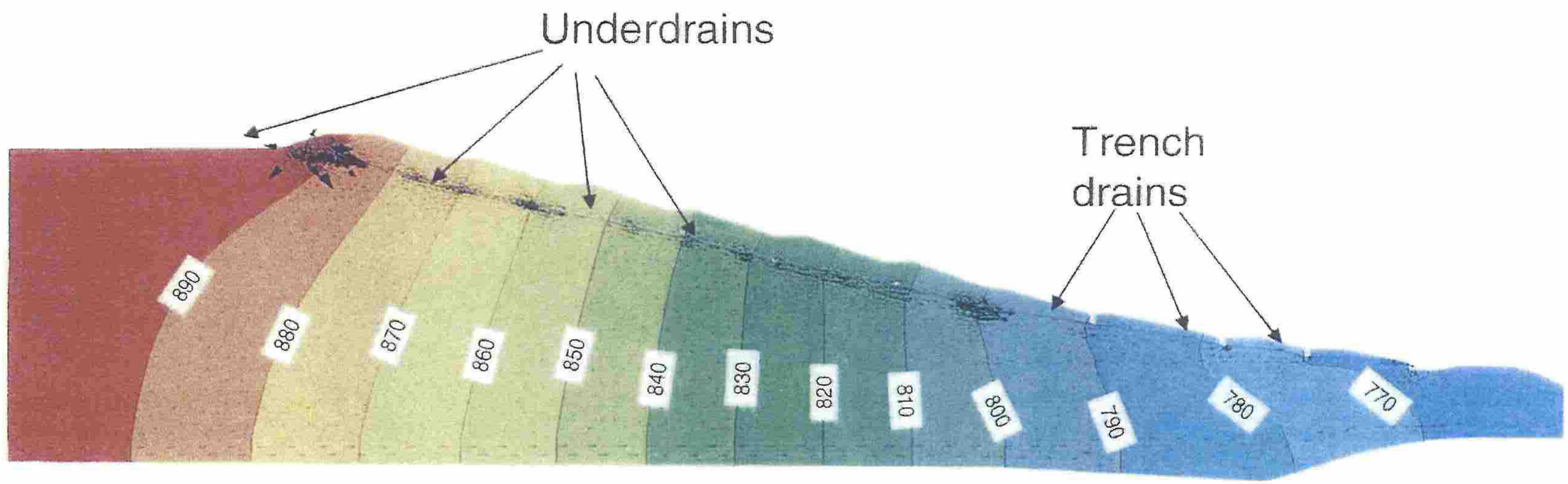
Model Predictions After 2005 & 2007 Improvements

Model-predicted Total Head Distribution (Future Conditions)



Model simulations indicated that the phreatic surface would be reduced and seepage will be controlled effectively

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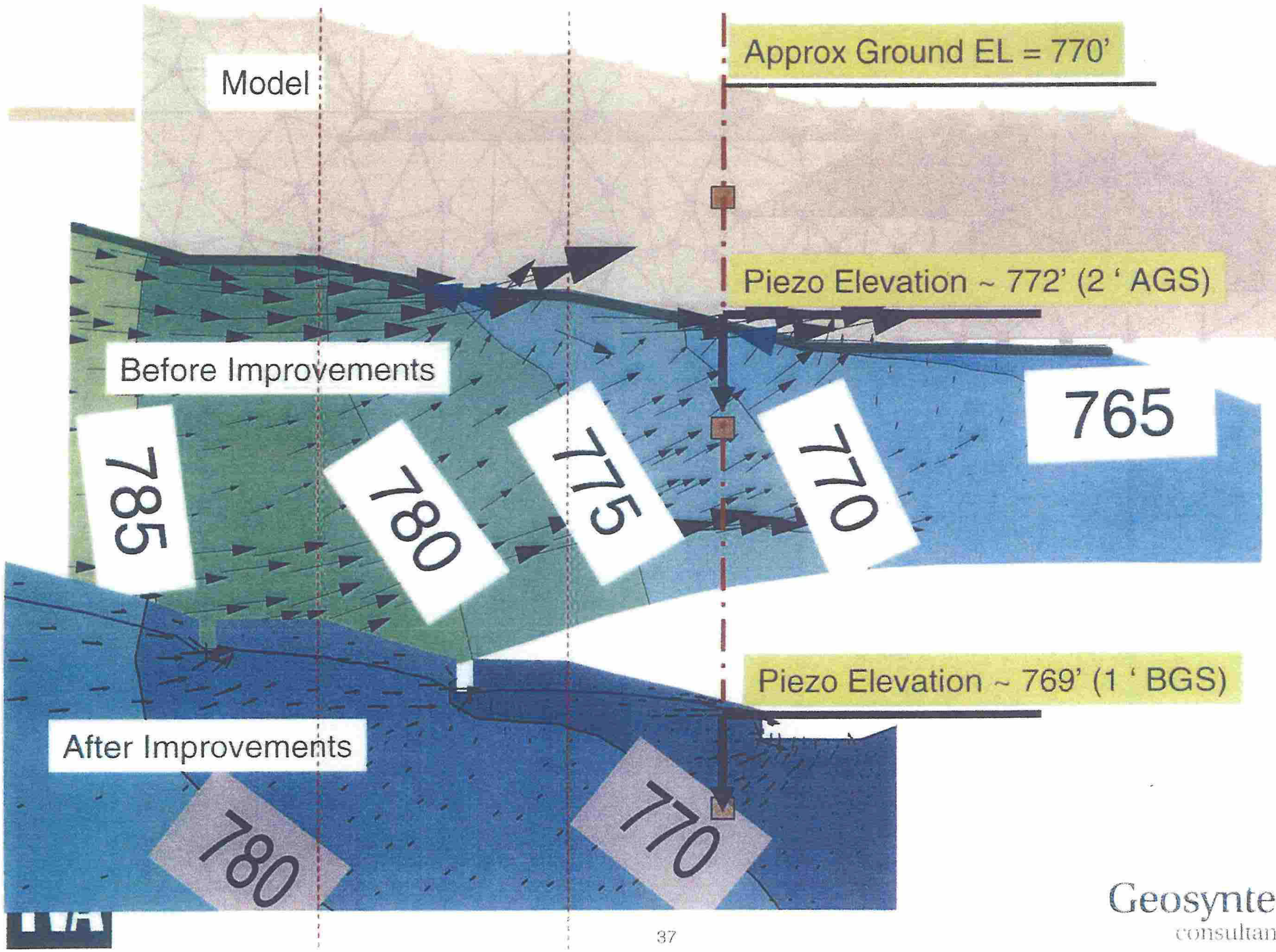

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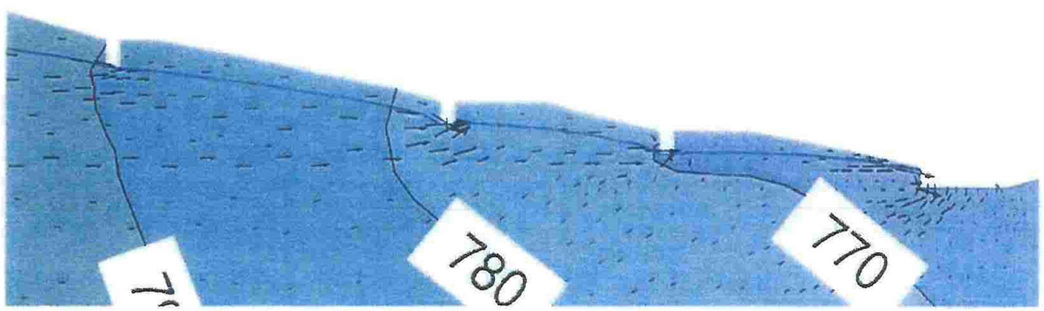
Model Predictions



Why did the 2005 recommended drainage improvements not solve the problem?

- Model prediction indicates that seepage can be effectively controlled with a system of properly functioning trench drains and toe drain
- More monitoring points and periodic maintenance required to ensure proper function

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Model Predictions

- Two alternatives were developed in 2005:
  - (a) Rip-rap ditch improvements with integral toe drain
  - (b) Buttress drain set into lower slope
- TVA selected (a) based on the need to address general improvements to surface water conveyance
- While alternative (a) has worked well over the majority of the dike, it does not address seepage from localized lenses and anomalies that have since been identified during the intrusive investigation
- The improvements to the toe drain now address the problem area:
  - Greater surface area
  - Better connectivity to ash
  - Improved containment of ash

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Dredge Cell Restoration

- Short-term (Completed)
  - Improve toe drain to control seepage through lower slope, lower phreatic surface, and improve containment of ash
- Resume normal dredge cell operation, subject to implementation of more structured monitoring program
- Longer-term actions
  - Address surface water drainage on benches
  - Extend underdrain outlets to perimeter ditch
  - Develop and implement a more structured monitoring and maintenance program
  - ***Consider other long-term alternatives, if warranted***

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Dredge Cell Restoration

What are the consequences of a failure (blockage) in the drainage system? What is the effect of the shale layer?

- To answer these questions, we performed additional model simulations
  - Turned off trench drain
  - Changed permeability of shale
  - Effect of deepening trench drain

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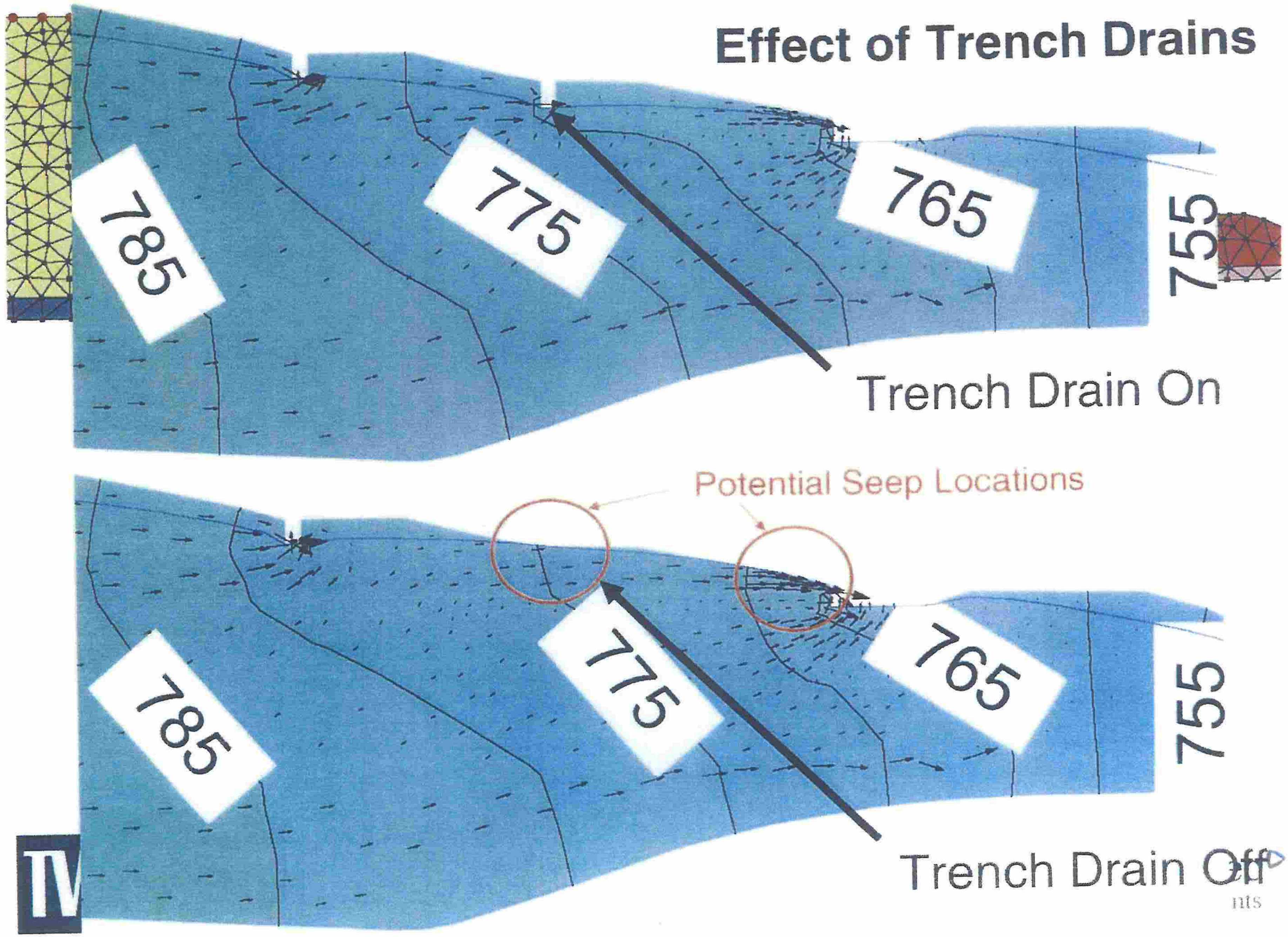
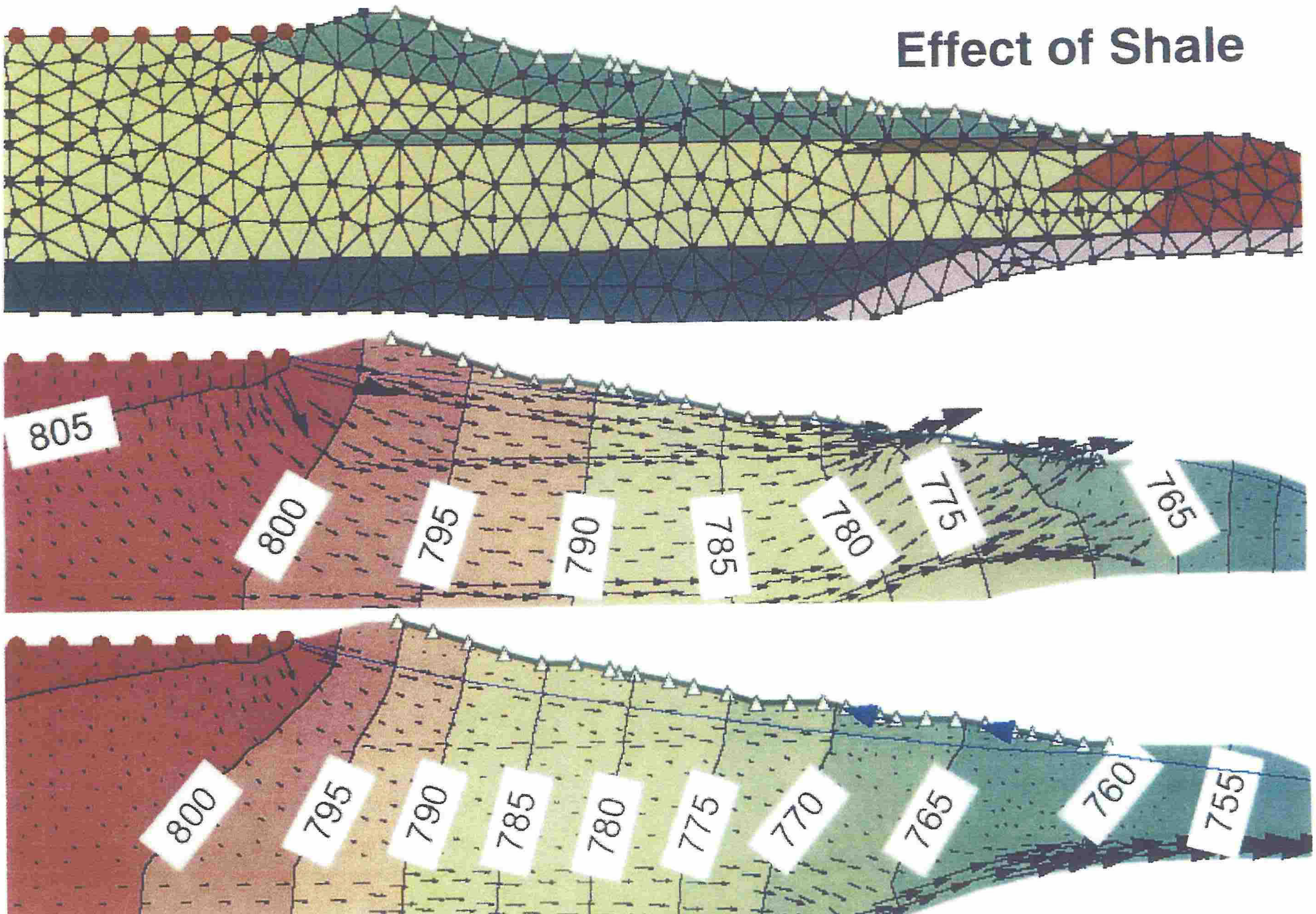
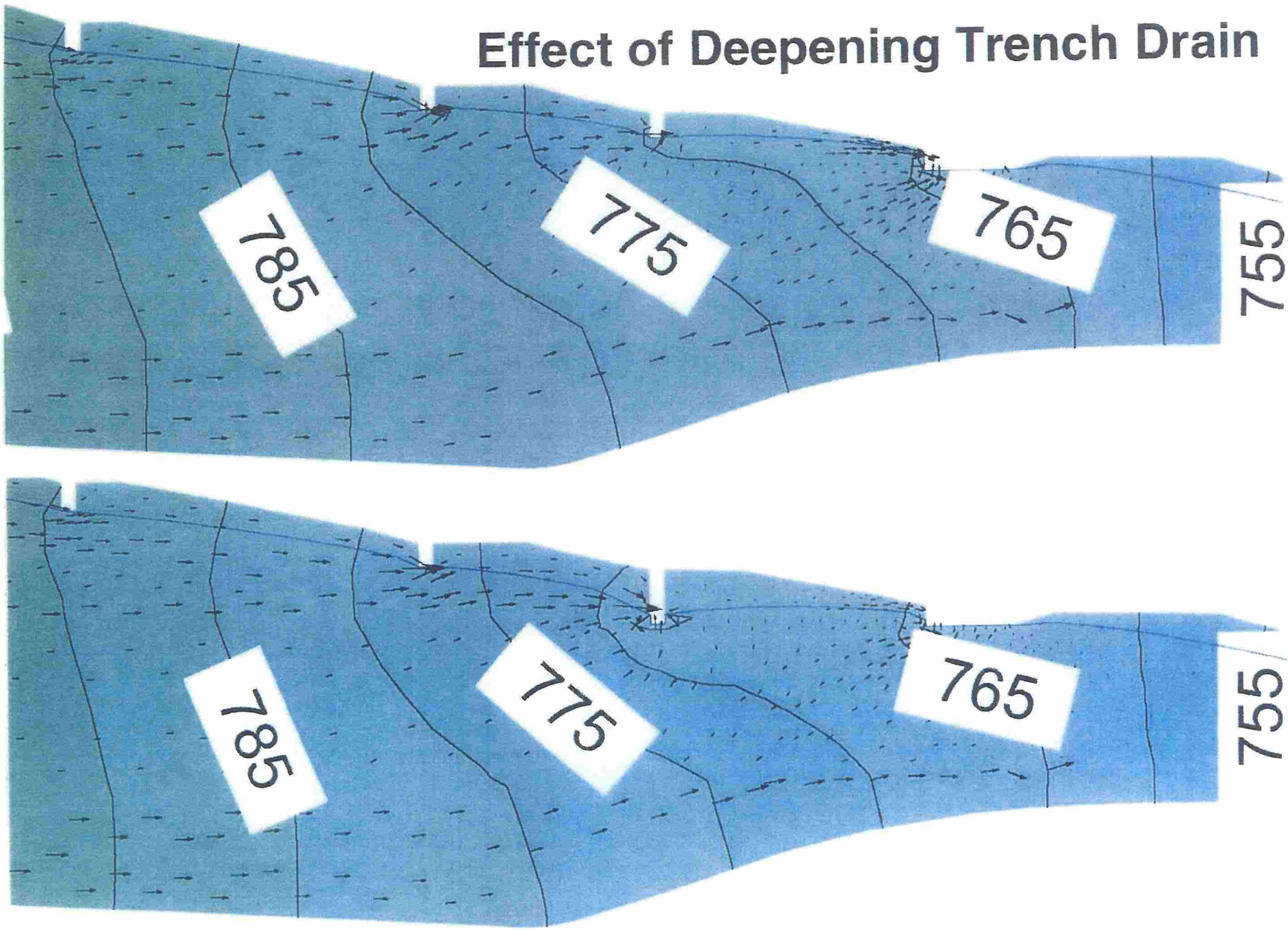
Effect of Trench Drains



Effect of Shale



Effect of Deepening Trench Drain



Dredge Cell Restoration

- Conclusion
  - All drainage components are required for safe operation of the Dredge Cell
  - Monitoring program needed to ensure drainage components are functioning
  - Surface water improvements are also needed

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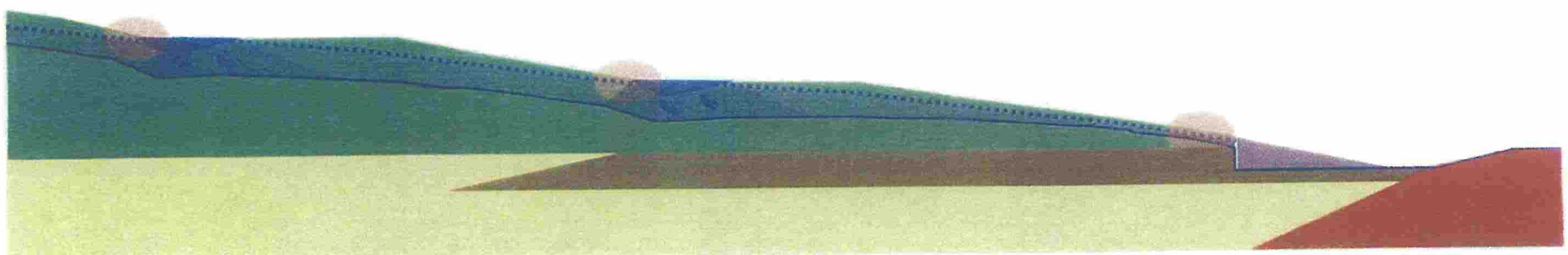
Longer-Term Considerations

- Implement bench drain improvements



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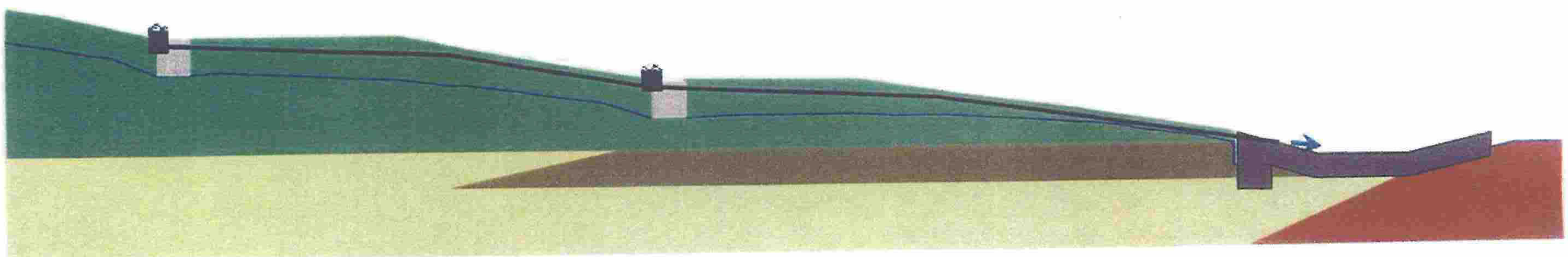
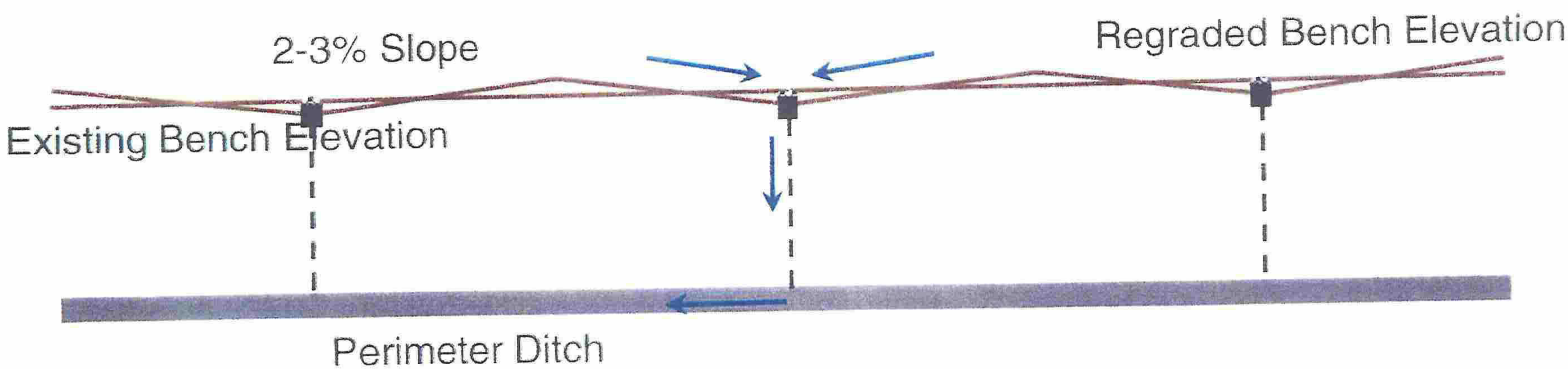
Longer-term Considerations

- Implement bench drain improvements





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Longer-Term Considerations

- Extend underdrain pipes to the perimeter ditch
- Leave selected wellpoints in place for near-term monitoring
- Develop a monitoring and maintenance plan

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Monitoring and Maintenance Plan

- Why is Monitoring Necessary?
  - Early warning system for drainage problems and other structural changes
  - If not addressed, drainage problems can quickly become stability problems
  - Credibility with regulators and the public; avoidance of "negligence" claims
- Ash ponds and gypsum stacks function in the same way as earth dams – all sizeable dams are regularly monitored to ensure drainage system is functioning

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Monitoring and Maintenance Plan

- Elements that are being considered:
  - Piezometers – expand the existing network of strategically located permanent piezometers for regular monitoring; consider automated data collection.
  - Other instrumentation – consider installing other instrumentation (e.g., inclinometers) in critical areas for early identification of possible issues
  - Contingency Planning – develop/document actions and repair procedures to address specific eventualities
  - Frequency of monitoring – establish seasonal baselines, operational changes, etc., include option to reduce frequency based on data/experience
  - Evaluate and modify (if appropriate) current groundwater quality monitoring program

Monitoring and Maintenance Plan

- Monitoring Plan
  - Two-tiered program
  - Establish baseline; then reduce frequency
  - Start with weekly monitoring of "Tier 1" wells and drainage features
  - Monthly for "Tier 2" (all wells and features)
  - After establishment of baseline, Tier 1 becomes monthly; Tier 2 becomes quarterly
  - Simplistic approach – most of the work can be done by technicians
  - Triggers to involve TVA Engineering and Corrective Actions
  - Annual review and reporting to ensure compliance

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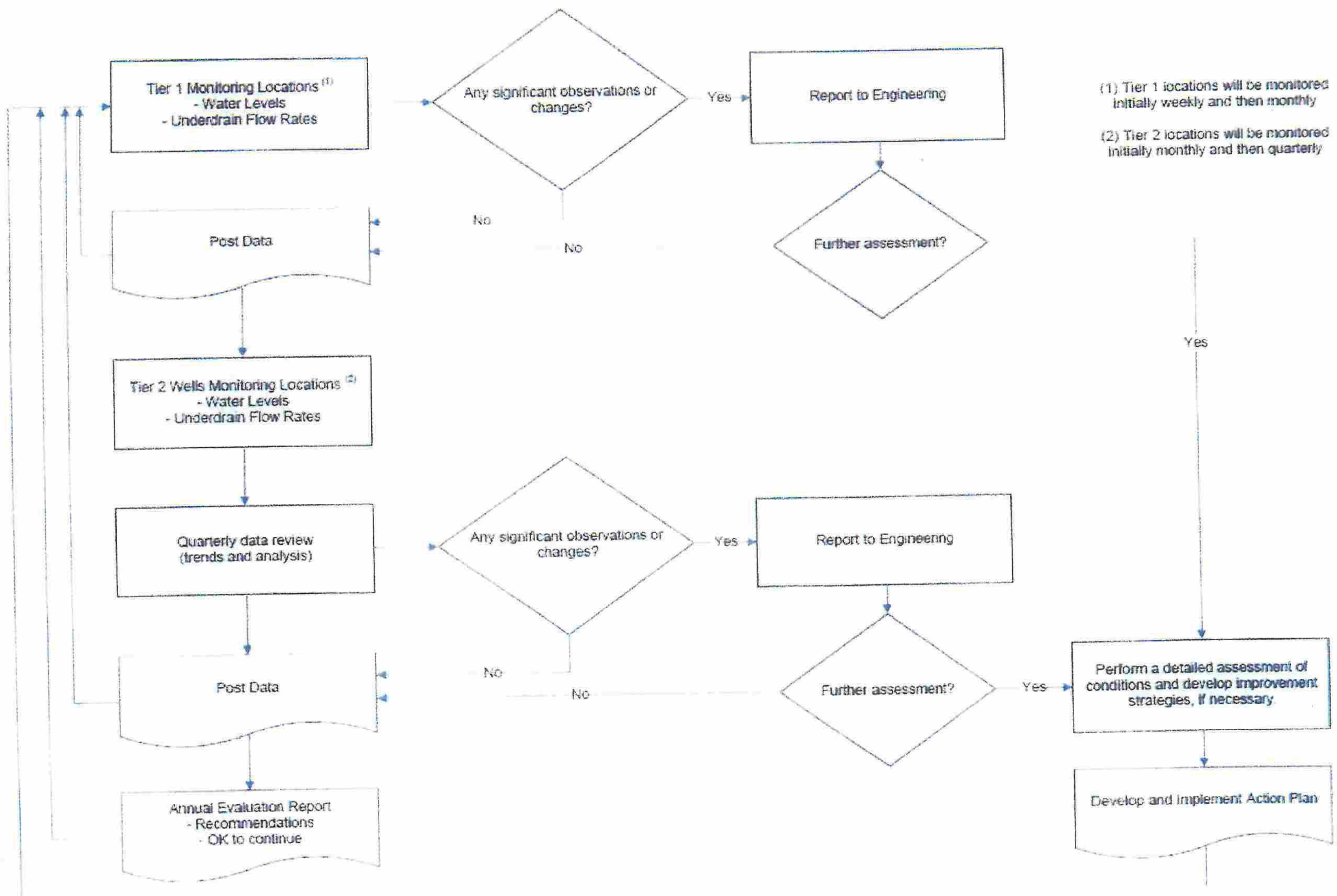
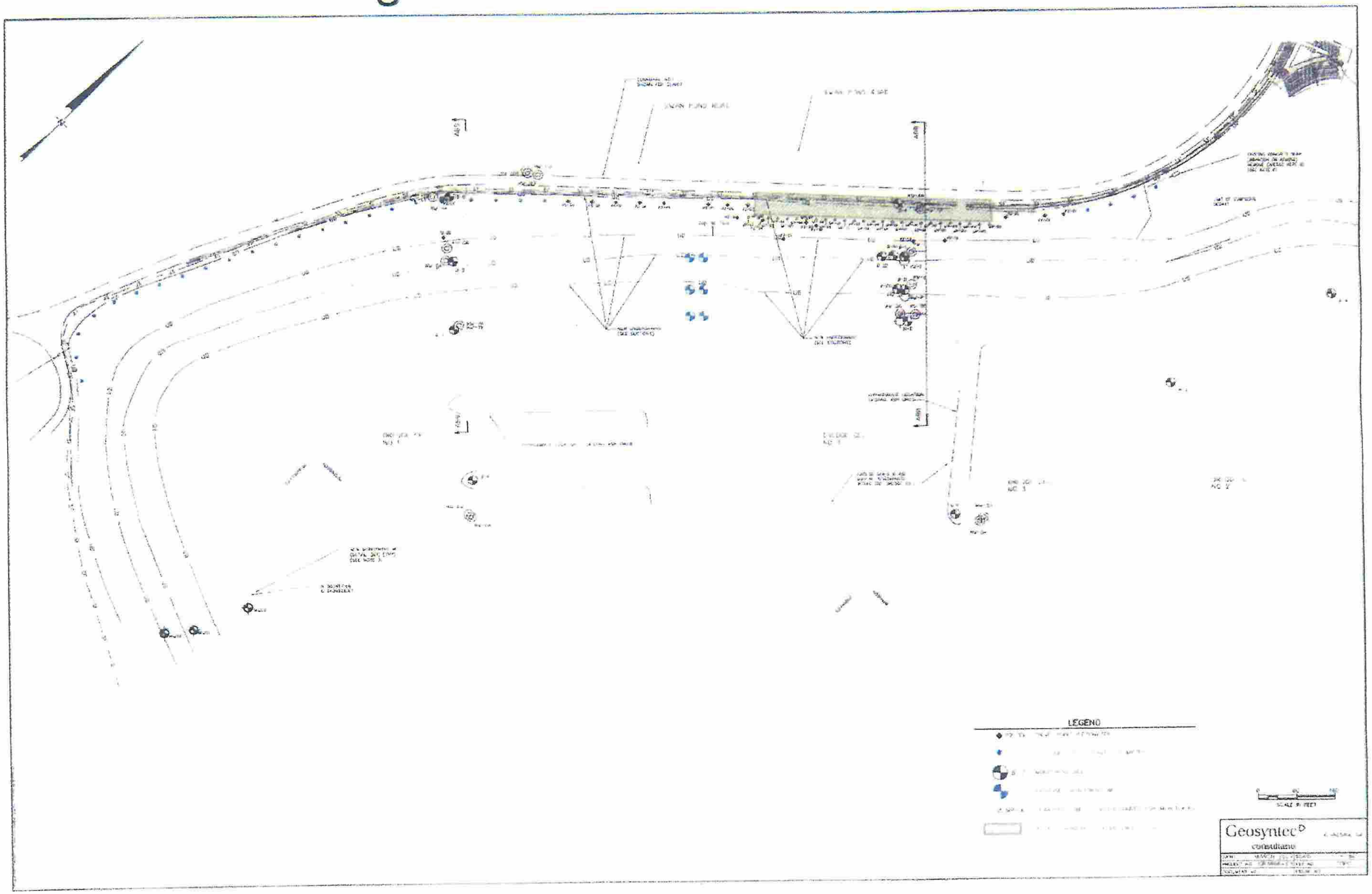
Monitoring Plan – Flow Chart



(1) Tier 1 locations will be monitored initially weekly and then monthly

(2) Tier 2 locations will be monitored initially monthly and then quarterly

Monitoring Plan – Water Level Locations



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Monitoring and Maintenance Plan

Monitoring Program

- Initial Cost (one-time)
  - Monitoring Plan
  - Install additional piezometers and wells
  - Training
  - Estimated cost ~ $70k to 85k
- Annual Cost (recurring)
  - Tier 1 monitoring
  - Tier 2 monitoring
  - Data review and posting
  - Annual report
  - Estimated cost ~ $45k to 60k

Typical Maintenance

- Periodic clean-out and minor repairs (Estimate $20k/yr)
- Replacement of internal drainage features (to be estimated on a case-by-case basis)

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Longer-Term Considerations

- Short-term (Completed)
  - Improve toe drain to control seepage through lower slope, lower phreatic surface, and improve containment of ash
- Resume normal dredge cell operation, subject to implementation of more structured monitoring program
- Longer-term actions
  - Address surface water drainage on benches
  - Extend underdrain outlets to perimeter ditch
  - Develop and implement a more structured monitoring and maintenance program
  - ***Consider other longer-term alternatives, if warranted?***

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Analysis of Alternatives

Kepner-Tregoe type Analysis of Alternatives

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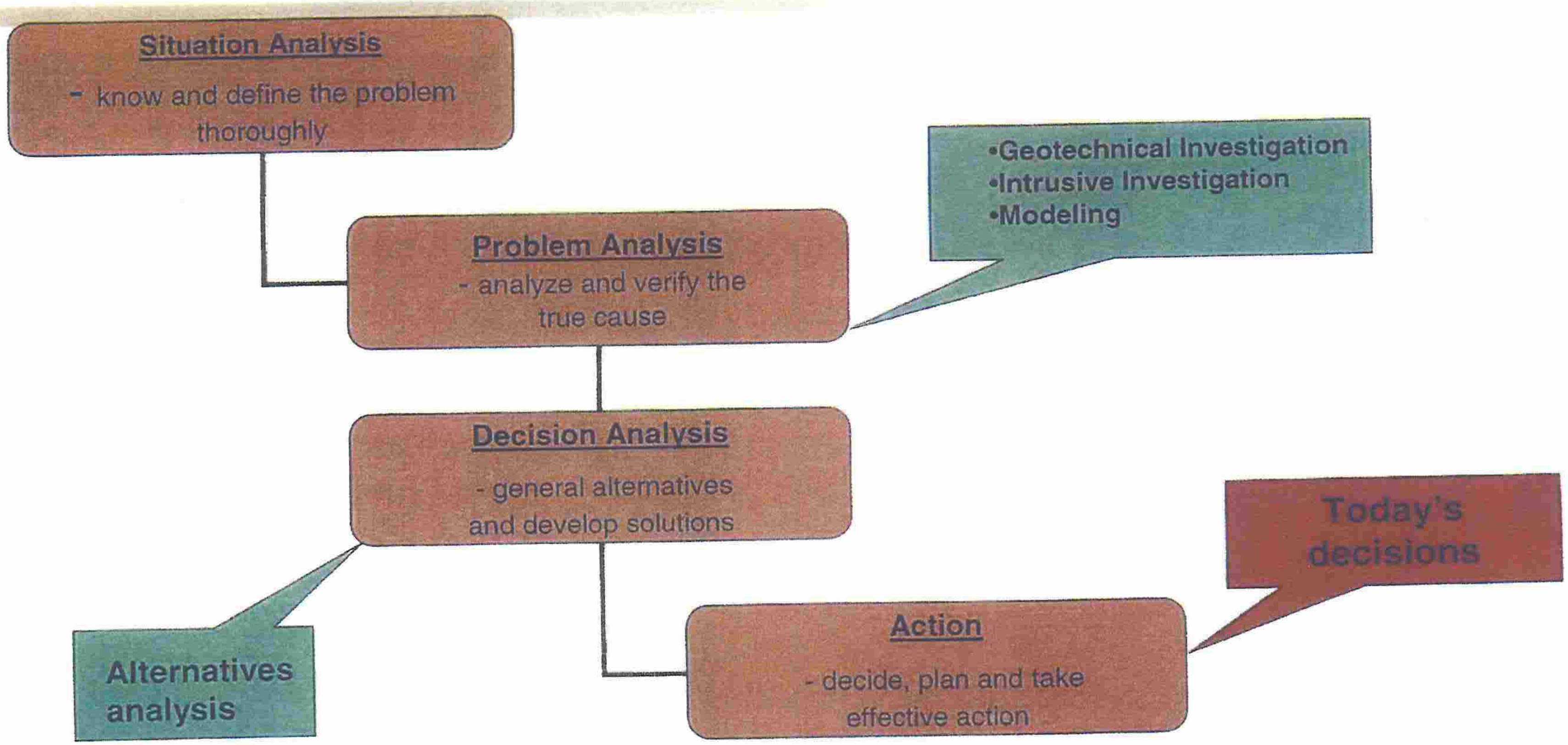
Kepner-Tregoe Type Analysis



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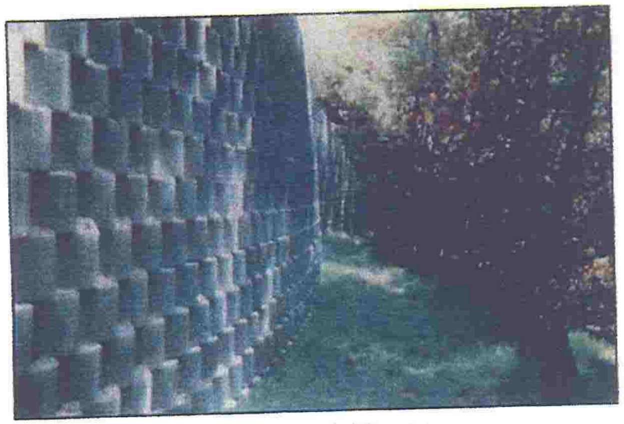
Alternatives Considered

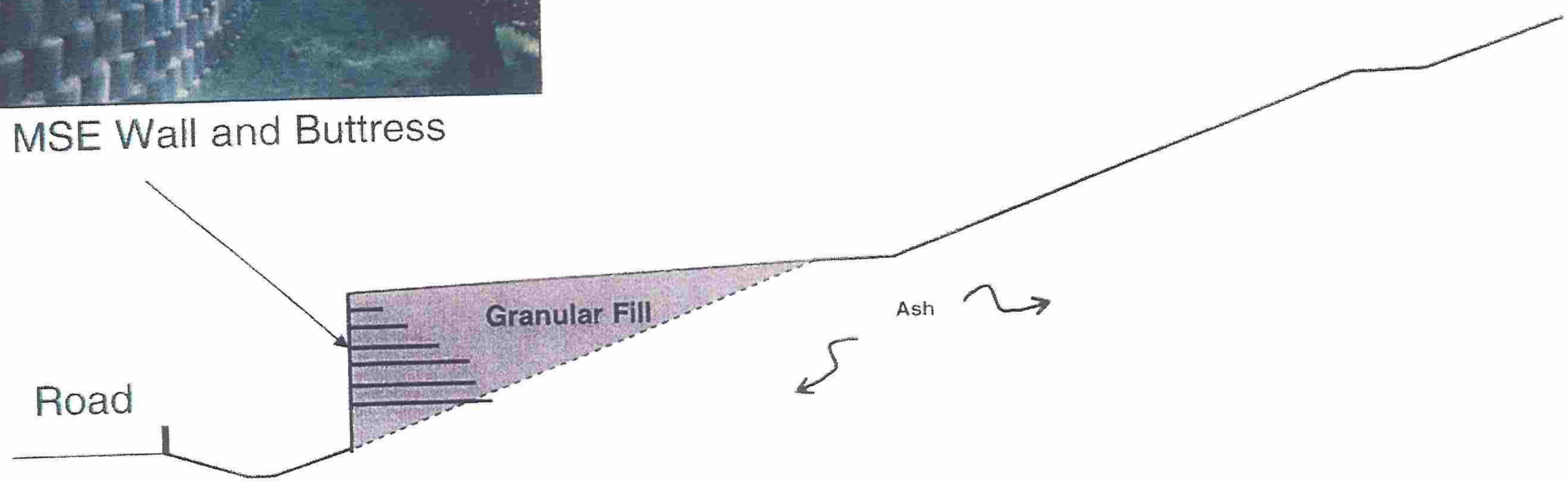
1. Improve toe drain along entire length of Swan Pond Road
2. Dense investigation to identify other problem areas and localized improvements
3. Deep trench drain along entire length of Swan Pond Road
4. Dense investigation to identify other problem areas and localized trench drain
5. MSE Buttress along entire length of Swan Pond Road
6. Dense investigation to identify other problem areas and MSE Buttress in localized areas
7. Dry ash disposal
8. Localized toe drain improvements (already implemented in seep area). Return to normal Dredge Cell operations with additional monitoring, maintenance, surface water improvements, and contingencies

Typical MSE Buttress – Alternative 5&6



MSE Wall and Buttress

Purpose:
- Captures all future seepage and contains ash
- Improves stability of slope
- Could provide additional airspace

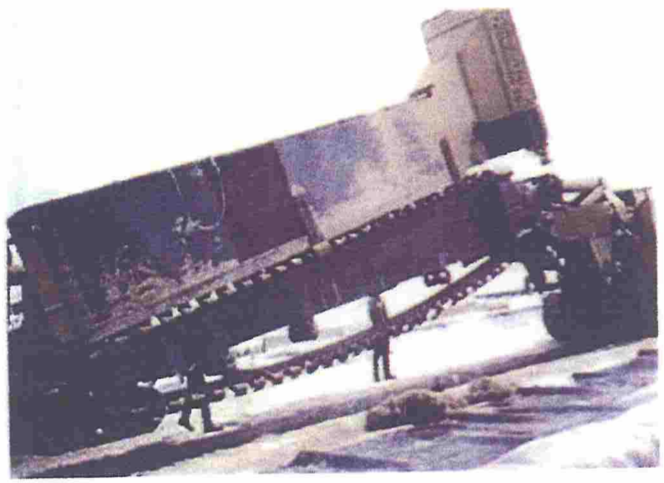


TVA

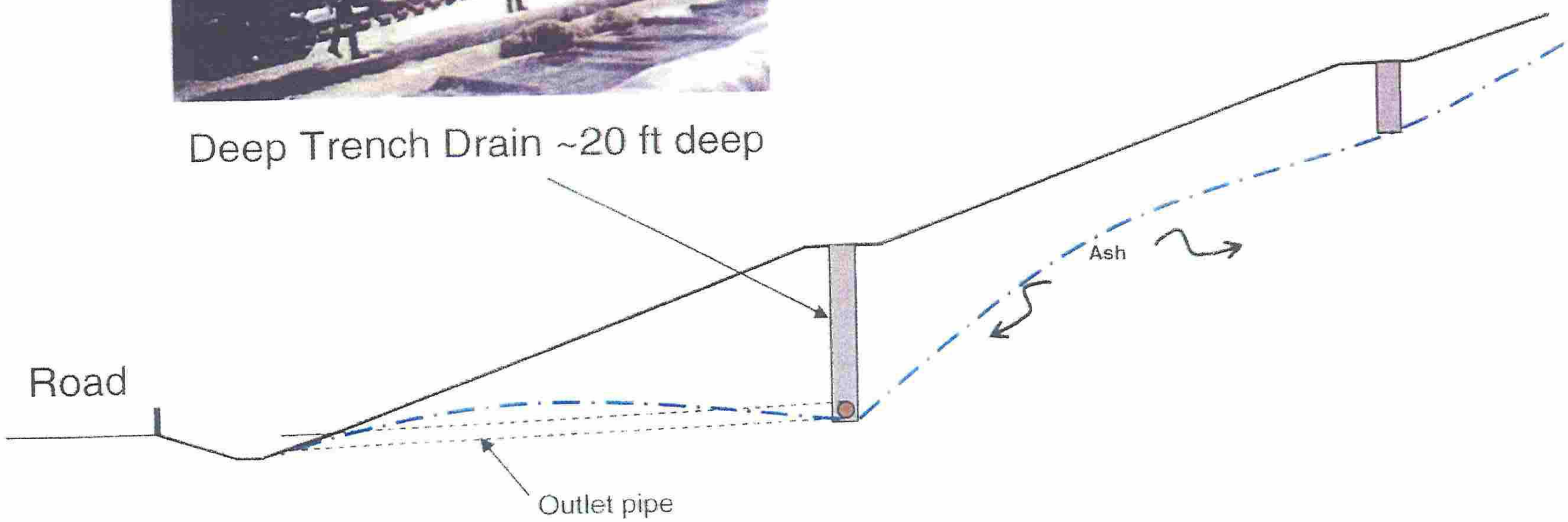
Geosyntec consultants

TVA-00029454

Typical Deep Trench Drain – Alternative 3&4



Deep Trench Drain ~20 ft deep



TVA

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consultants

Summary of Scoring (by TVA Team)

Alt.	Description	Total Score	Rank
1	Improve toe drain along entire length of Swan Pond Road	168	5
2	Dense investigation to identify other problem areas and localized improvements	170	4
3	Deep trench drain along entire length of Swan Pond Road	184	2
4	Dense investigation to identify other problem areas and localized trench drain	178	3
5	MSE Buttress along entire length of Swan Pond Road	166	6
6	Dense investigation to identify other problem areas and MSE Buttress in localized areas	164	7
7	Dry ash disposal	78	8
8	Localized toe drain improvements (already implemented in seep area) Return to normal Dredge Cell operations with additional monitoring, maintenance, surface water improvements, and contingencies	196	1

Ranking of 1 – Best Alternative Ranking of 8 – Least Favorable Alternative

TVA

Geosyntec consultants

Go-Forward Recommendations

- Select Alternative 8 – Localized toe drain improvements (already implemented in seep area).
- Recommend developing/implementing:
  - Structured monitoring/reporting program
  - Surface water drainage improvements along Swan Pond Road (common to all alternatives)
- Return to normal Dredge Cell Operations
- Monitor and maintain existing drainage systems.

Questions?

- Thank you

Campbell, Linda F

Subject:	FW: KINGSTON DREDGE CELL
Location:	PLANT MANAGER'S CONFERENCE ROOM
Start:	Tue 03/27/2007 12:30 PM
End:	Tue 03/27/2007 2:00 PM
Show Time As:	Tentative
Recurrence:	(none)
Meeting Status:	Not yet responded

This is the plant meeting to present findings and a recommendation for path forward

Agenda:

1. Introductions - Lynn Petty

2. Study Findings - PowerPoint Presentation - Neil Davies -GeoSyntec

   Situation Analysis (November 2006)
   Investigation
   Findings and Conclusions
   Seepage Model
   Dredge Cell Restoration
   Monitoring and Maintenance

3. Alternatives Analysis (KT matrix) - Lynn Petty

4. Path Forward

From: Jackson, Beth H
Sent: Tuesday, March 13, 2007 2:42 PM
To: Jackson, Beth H; Beckham, Michael T; Campbell, Linda F; Rushing, Finis D; Settles, James Thomas; Petty, Harold L; Poston, James M
Subject: KINGSTON DREDGE CELL
When: Tuesday, March 27, 2007 12:30 PM-2:00 PM (GMT-05:00) Eastern Time (US & Canada).
Where: PLANT MANAGER'S CONFERENCE ROOM

Alternatives Considered

Decision Factors		Alternative No. 1 Improve Toe Drain Along the Entire Length of Swan Pond Road		Alternative No. 2 Dense Investigation to Identify Other Problem Areas and Localized Improvements		Alternative No. 3 Deep Trench Drain Along the Entire Length of Swan Pond Road		Alternative No. 4 Dense Investigation to Identify Other Problem Areas and Localized Trench Drai		Alternative No. 5 MSE Buttress Along the Entire Length of Swan Pond Road		Alternative No. 6 Dense Investigation to Identify Other Problem Areas and MSE Buttress in Localized Areas		Alternative No. 7 Dry Ash Disposal		Alternative No 8 Localized Toe Drain Improvements (Already Implemented in Seep Area) - Return to Normal Dredge Cell Operations with Additional Monitoring, maintenance, surface water improvements, and contingencies	
Capital Cost (Internal Drainage)		$2.7M		$1.1M		$950K		$550K		$3.4M		$1.02M		$30M		No additional cost [1]	
Capital Cost - Surface Water Drainage Improvements		$320K		$320K		$320K		$320K		$320K		$320K		$320K		$320K	
Annual O&M Cost [2]		$75K		$75K		$125K		$125K		$75K		$75K		$3M		$50K	
Description	**Weight**	Rating	Score	Rating	Score	Rating	Score	Rating	Score	Rating	Score	Rating	Score	Rating	Score	Rating	Score
MUSTS: Return to Long Term Reliable Operations	10	Go		Go		Go		Go		Go		Go		Go		Go	
MUSTS: Meets Regulatory Requirements	10	Go		Go		Go		Go		Go		Go		Go		Go	
MUSTS: Eliminate Possibility of Catastrophic Failure	10	Go		Go		Go		Go		Go		Go		Go		Go	
Possibility of Major but non-catastrophic blow-out	5	8	40	7	35	8	40	7	35	10	50	7	35	9	45	6	30
Initial Capital Cost	8	6	48	8	64	8	64	9	72	5	40	8	64	2	16	10	80
Operational and Maintenance Cost	7	8	56	8	56	8	56	8	56	10	70	8	56	2	14	8	56
Time to Implement	3	8	24	5	15	8	24	5	15	2	6	3	9	1	3	10	30
OVERALL MUSTS DECISION / WANTS SCORE		Go	168	Go	170	Go	184	Go	178	Go	166	Go	164	Go	78	Go	196
OVERALL RANKING		5		4		2		3		6		7		8		1 (Preferred)	

Notes:
(1) Improvements already implemented. No additional cost other than addressing surface water drainage, monitoring etc.
(2) Additional O&M Cost represents cost over and above current O&M e.g., quarterly monitoring of wells and piezometers, inspections, data analysis and reporting