Petty, Harold L.

From: Smith, Daniel R (Chattanooga) [Daniel.R.Smith@worleyparsons.com]
Sent: Wednesday, October 26, 2005 7:19 AM
To: Purkey, Ronald E.
Cc: Petty, Harold L.; Bowers, Larry C
Subject: Requirements for underdrain in coal combustion by-product waste disposal

In reply to your request, here are technical and regulatory points to address underdrains for CCB waste disposal. This email is not intended to address all aspects of this issue (that would be beyond an email), but to briefly address the topic. I copied Larry Bowers for his thoughts, if any.

TDEC Solid Waste Regulations (Chapter 1200-1-7) have been promulgated to comply with EPA's RCRA Subtitle D regulations (40CFR258). TVA is allowed specific waivers from these requirements by TDEC due to the nature of waste disposal.

Subtitle D requires a 2-ft compacted clay liner (or equivalent) (see 1200-1-7-.04 (4) (a)) to a hydraulic conductivity of 1 E-7 cm/s, with a geomembrane installed immediately on top as a minimum. TVA has been granted a waiver from this, with a requirement of meeting a 1 E-6 cm/s, 3 ft thick buffer, without a geomembrane.

Facilities built to comply with TDEC 1200-1-7 are also required to have a drainage layer immediately above the liner. The reason for this is that a properly designed drainage layer will minimize the hydrostatic head on a liner, thus minimizing leakage through the liner. Leachate must be collected and treated prior to discharge.

TVA has recently (late '80's, early '90's) started permitting "closure" of existing wet ash ponds or ponds that were converted from wet disposal to dry disposal (JOF, JSF to name a couple), in response to TDEC requirements. Recently, TVA has permitted new "Greenfield" locations. The requirements for those successfully permitted have had to meet the requlations for landfills in general, with the exceptions and waivers granted TVA by TDEC. One might ask the question as to why drainage layers are needed for ponded waste (impoundments). Although the facilities that undergo wet disposal will essentially function as ponds during their active life, once closed, it is advantageous to have a functioning drainage layer to minimize the head on the liner (this lessens the migration of leachate to groundwater) – can be thought of as "buying insurance". Waste disposal facilities are subject to the Groundwater Protection/Monitoring Standards contained in 1200-1-7-.04 (7), and must implement corrective measures if groundwater contamination occurs. Remediating groundwater contamination can get quite expensive.

Another reason for a drainage layer is that it will allow leachate to drain from the stack, and when coupled with construction of a good final cover, infiltration into the disposal facility is minimized. This lowers the internal water table and improves overall stack stability. Virtually the entire state of Tennessee (and much of KY) is within a seismic impact zone as defined by EPA, and the long-term stability is increased when a drainage layer is constructed.

TVA has obtained waivers from having to collect and treat leachate, by routing leachate to wet ponds, and discharged through NPDES monitored discharges. Treating leachate prior to discharge would incur much more $$. Other states may require leachate treatment prior to discharge for similar facilities.

Let me know if this answers your question.

Daniel R. (Dan) Smith, PE
Supervising Civil Engineer
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Chattanooga, TN 37450 Fax (423)266-0922
Email: daniel.r.smith@worleyparsons.com

Petty, Harold L.

From: Petty, Harold L.
Sent: Thursday, November 03, 2005 1:42 PM
To: Smith, Daniel R.; Lowery, Kenny R.; Toney, Calvin L.; Bowers, Larry C; Workman, Brad
Cc: Purkey, Ronald E.; Radford, Larry D.; Latsch, Mitchell D.
Subject: KIF - Gypsum Peninsula - coordination highlights

Here's a bullet list of what we talked about in today's meeting.

Dan Smith is to resend the drawings (as a .pdf file) and the quantities to Brad Workman & Kenny Lowery.

Kenny Lowery and Brad Workman (HED) are estimating the gypsum storage area heavy earthwork (civil) construction per the quantities that Dan is providing. Two estimates are expected. **Stage 1** - (expected construction) building the partial pond on the side closest to the plant and dewatering area. The **Stage 2** estimate is really a total build out of the entire footprint. HED's input to Calvin is due to him Nov. 10th (but can be read as in his hands the morning of Nov 14th.)

Dan (WorleyParsons) is finishing up the other input (electrical, mechanical, some civil) that includes the pumps, xformers, pump platforms, discharge line pipe, etc. That is due to Calvin on the same timeframe - Nov. 10th (but can be read as in his hands the morning of Nov 14th.).

Further to that end we identified a point (coordinates later) of where the power will be supplied to by Advatech. That serves as an interface point location to identify scope of who does what and where.........

Calvin will roll up the estimate the week of Nov 14th (he is out of the office Nov. 18th) giving him time to ask questions for clarification, etc. His roll up will be complete Nov 21st.

We also discussed the blanket underdrain and need for speedy resolution.

Our next coordination meeting will be Wednesday 11/9/05 at 10 am. I'll send out a meeting notice. Anyone who cannot attend can call in via phone.

Thanks,
Lynn

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Thanks,
Lynn

APPENDIX
DRAINAGE LAYER STUDY (Rev B – 110805)

General

This appendix discussed technical and regulatory aspects of a drainage layer to be installed above the clay liner to be constructed for the proposed gypsum disposal facility. Currently two scenarios are envisioned for development of this facility: 1) Phase 1– Construction of a limited footprint (approximately 37 ac) for disposal of dewatering plant effluent and periodic blowdown bypass when the dewatering facility is non-operational; and 2) Full Build Out– Construction of the full footprint for the facility (approximately 80 ac). The permit application will address both scenarios, and will also include a provision to expand the Phase 1 area to the full footprint as for the full build out scenario.

This appendix addresses: 1) regulatory aspects of drainage layers, 2) technical aspects of drainage layers, and 3) four specific options for construction of drainage layers. A fifth option examines ramifications of waste disposal without a drainage layer.

Regulatory Aspects of Drainage Layers

TDEC Solid Waste Regulations (Chapter 1200-1-7) have been promulgated to comply with EPA's RCRA Subtitle D regulations (40CFR258). TVA is allowed specific waivers from these requirements by TDEC due to the nature of waste disposal.

Subtitle D requires a 2-ft compacted clay liner (or equivalent) (see 1200-1-7-.04 (4) (a)) to a hydraulic conductivity of 1 E-7 cm/s, with a geomembrane installed immediately on top as a minimum. TVA has been granted a waiver from this, with a requirement of meeting a 1 E-6 cm/s, 3 ft thick buffer, without a geomembrane.

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Technical Aspects of Drainage Layers

Drainage Issues

Reasons why drainage layers are needed for ponded waste (impoundments) are discussed herein. Facilities that undergo wet disposal will essentially function as ponds during their active life. A drainage layer that can remain unsaturated (i.e., has a greater capacity to discharge leachate than the waste) can minimize the head on the liner during its active life. In the case of KIF gypsum disposal facility at the peninsula site, this could be 30 years or more, depending primarily on waste disposal rates. This in turn lessens the hydraulic head on the liner, and migration of leachate through the liner is much less when compared to the case when the liner does not have a leachate collection layer. This can be thought of as "buying insurance". Waste disposal facilities are subject to the Groundwater Protection/Monitoring Standards contained in 1200-1-7-.04 (7), and must implement corrective measures if groundwater contamination occurs. Groundwater remediation can become quite complicated and expensive depending on the underlying geology.

Stability Issues

Another reason for a drainage layer is that it will allow leachate to drain from the stack, and when coupled with construction of a good final cover, infiltration into the disposal facility is minimized. This lowers the internal water table and improves overall stack stability. Virtually the entire state of Tennessee (and much of KY) is within a seismic impact zone as defined by EPA, and the long-term stability is increased when a drainage layer is constructed. Once closed, the stack will drain much more rapidly with a drainage layer, than without one.

Presence of the mixed fly ash-bottom ash drainage layer (or alternate drainage layer such as crushed stone) will accelerate consolidation of the gypsum above it and, consequently, the shear strength of the sluiced interior gypsum which has a much lower shear strength. The bottom drainage layer is provided to facilitate drainage into the lateral drain pipes, but more importantly to minimize seepage of sluiced water onto the groundwater table below by intercepting and draining it into the stilling basin.

The need for this drainage system is explained through the computer-model results presented in <u>Attachment 1</u> to this appendix. This analysis was performed for the ash pond drainage layer, and assumed mixed ash and gypsum and under isotropic conditions. The plots with the titles labeled "Lat 2-3U No Bot" indicated the runs for the no drainage layer case. By contrast, the plots with the titles labeled "Lat 2-3V Yes Bot" are the output for the drainage layer case. Specifically, without the drainage layer, once the stack was completed it took over 50 years for the water table to drop two thirds of the way down the height of the stack. By contrast, with the drainage blanket, the water table dropped to just 1/6th the height of the stack above the drainage blanket in 5 to 10 years. Consequently, those results suggested that the blanket drains would accelerate consolidation of the stack, achieve air space/stack volume gain, reduce the liquefaction potential, and allow faster stack-strength gain. Similar results would occur for the peninsula site.

The pseudo static analyses for the Peninsula will use the computer program UTEXAS3. UTEXAS3 uses the multistage analysis technique developed by Duncan and Wright (1990) and Shinoak Software (1991) for earthquakes and rapid drawdown procedures for the Army Corps of Engineers. At the Peninsula, as in most Gypsum Stacks, **the most critical surface will likely be a wedge failure where a slip surface develops along the top of the clay barrier layer** where a mass or a part of the slope (of varying size) is assumed to fail along polygon shaped surface (that is, a the sliding-block analysis, in contrast to a circular surface). **A sliding block failure surface means that the back edge of the failure surface will go through the center of the stack where the strength is likely to be the lowest and where the need for a drainage layer is most critical.** The resistance to sliding is provided by friction and adhesion along the surface of sliding.

For the seismic condition, a horizontal destabilizing force is added to the total sliding force, which is equal to the weight of the sliding mass times a seismic coefficient, k_s, which is generally a fraction of the peak ground acceleration during the postulated design seismic event.

Whether the gypsum stack drains rapidly during construction or not is critical to the stability of the gypsum stack during an earthquake event. The UTEXAS3 analyses demonstrate the importance of drainage early in the construction process through the use of the multistage envelopes given in Figure 1 below:

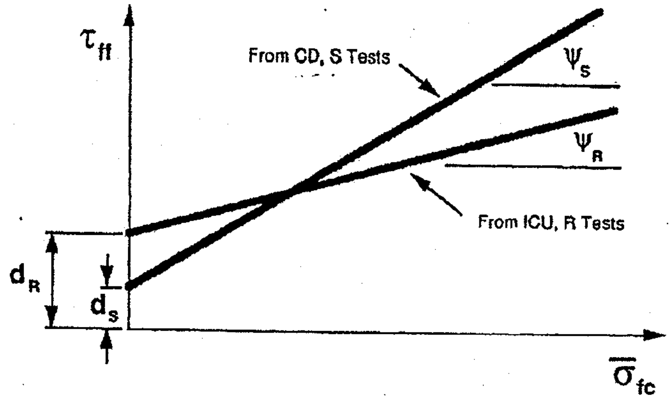


Figure 1. Shear Strength Envelopes Used to Compute Shear Strengths for Second Stage of Two-Stage Slope Stability Computations (After Wright, 1991).

Figure 1 shows two envelopes, the drained and the undrained strength envelopes for the second stage of the two-stage stability computation. **The sooner water consolidates out of the gypsum stack, the greater the strength gain on the first stage of the first envelope of the curve before proceeding to the undrained curve in the second stage. Note that the second stage undrained curve is used in the earthquake loading and** has a **much lower slope** and **less strength gain** with increasing consolidation stress. We want to increase the point on the first stage curve at which we start on the second stage curve to have as much shear strength as possible in the gypsum stack materials before an earthquake occurs. We want to get as high as possible on the first stage with consolidation and drainage because when the earthquake occurs **the second stage curve then must be used to calculate the shear strength. Consequently, the more consolidation and drainage that occurs before the earthquake occurs, the stronger the gypsum stack.**

RB

Options Studied for Drainage Layer

The following options were briefly reviewed in the context of adequacy as a drainage layer. Please refer to the sketches in <u>Attachment 2</u> to this appendix.

<u>Option 1</u>

Option 1 has individual drain pipes located so that the drainage is generally downslope. Perforated drain pipes are installed within a drainage blanket over the entire base footprint of the liner. A perimeter ditch is constructed along the southern boundary of the facility to intercept drainage from the individual drain pipes and convey leachate to a single stormwater pond located at the western end of the facility. This approach has the advantage of allowing the drain lines to drain to the ditch so that the lines remain submerged. This would minimize clogging of the lines due to crystallization of the gypsum if exposed to air. This arrangement is also conducive to installation of cleanouts, in the event drain lines require cleaning. As can be seen from the attached sketch, a drainage layer must extend over the entire footprint of the facility in order for it to properly function. This drainage layer could be constructed of bottom ash or a stone drainage layer. The bottom ash layer would be two feet thick, with a one-foot thick layer of bottom ash mixed with fly ash, for a total thickness of three feet. This type of drainage layer was tested in a column (JLT Laboratories, 2004). Because the bottom ash is placed directly on the clay surface, consideration may be given to installation of a geotextile to prevent infiltration of clay fines into the drainage layer. Another option would be to use a crushed stone layer with a geotextile overlain on top (probably top and bottom). The bottom geotextile would be required to keep fines from migrating into the layer from the bottom. Alternately, a graded filter could be constructed above the top geotextile to be an interface between the gypsum and stone/geotextile. Details would have to be developed during detailed (Phase 2) design.

Option 1 would be conducive to a phased construction approach. If Phase 1 were initially constructed, and later the disposal facility needed to be expanded, the drainage layer could simply be expanded, because the Phase 1 portion of the perimeter ditch is the lower end. Option 1 would only require a single pond, but may require more earthwork (see Appendix XX).

Option 2

Option 2 is essentially the same as Option 1, except that the drain pipes are oriented as shown on the attached sketch. This option would also require a drainage layer beneath the entire footprint. The main disadvantage with Option 2 is that a second pond is required to capture leachate. A pump and platform would be required to convey leachate back to the stormwater pond located at the western end of the facility. Option 2 may also require far less earthwork (TO BE CONFIRMED). Option 2 is also conducive to facility expansion, if Phase 1 is initially constructed. Cleanouts can be readily installed.

Option 3

Option 3 involves the use of a composite geonet to function as a drainage layer. The overall stack height proposed for wet disposal is 120 ft. At 84 pcf gypsum density, this is about 10,000 psf at the base. Should the stack be built to the maximum projected height (dry stacking), the height would approach 200 ft, and there would be about 20,000 psf at the base. The literature reviewed for TENAX geonet (Attachment 3) states that it was designed and tested for 45,000 psf loads. This landfill application, however, probably involved a composite liner (geomembrane placed on a compacted clay liner). As such, the composite geonet bears on the geomembrane, not directly on the clay. A concern would be that the high pressure exerted on the geonet by the waste, coupled with the grid pattern inherent in geonets, could "push" the geonet into the clay and reduce its thickness. This application may require laboratory testing under the pressures expected, in order to verify its effectiveness.

Option 3 is conducive to expansion, and would require two separate ponds, as is the case for Option 2.

Option 4

The sketch for Option 4 depicts a liner base that is graded the same as Option 2. In this case, a perforated perimeter drain is installed at the edge of the drainage layer for the Phase 1 portion and the expanded portion of the facility. For discussion purposes, it is assumed that the drainage blanket is extended 200 feet within the footprint of the base of the facility. The areal extent of the base that has a drainage layer is 77 percent and 73 percent of the total area respectively for Phase 1 and the expanded portion of the facility. This assumes that the portion of the footprint that has the steeper (existing) slope does not have the drainage blanket. If the steeper sloping portion of the facility requires a drainage blanket, those percentages would be lower. Therefore, this approach does not offer any real advantage because the savings is only 25 percent on the average. This approach is conducive to expansion, and cleanouts could be installed. It is likely that this option would be slower to drain, however.

Option 5

This option would be a facility constructed without any drainage layer. For the reasons discussed earlier, this is not a viable approach.

Discussion of Pipe and Drainage Media Placed in Trenches vs Blanket Drainage Layer

Another approach would be to install discrete trenches versus a blanket. For constructability, it would be likely that the trenches would have to be "cut into" the liner, because it would be difficult to install the pipes on top of the liner and then place stone (or bottom ash) around the pipe along with geotextile. This would in all likelihood require that a five-foot thick liner be constructed, so that the trenches can be excavated for the pipes and crushed stone, to allow a minimum of three feet of liner beneath the drainage pipes. The other option would be to grade the liner surface such that the grade varies sufficiently for installation of the pipe and drainage media. This approach in all likelihood would require substantially greater volume of drainage media. If this approach is to be considered, the constructor should be consulted on which approach is most cost effective. However, a thicker liner would add additional costs.

Volume of Bottom Ash Available

Phase 1 Construction

Attachment 4 details the available bottom ash over the next 10 years. In summary, approximately 300,000 tons will be required to construct the dredge cell dikes (50-50 mixture of bottom and flyash). This would be approximately 30,000 tpy needed to be reserved. The bottom ash generated at KIF is 88,000 tpy, or 880,000 tons over 10 years. If 30,000 tons are removed per year for dredge cell dike construction, then 58,000 tons remains for use in the Phase 1 construction. Approximately 200,000 tons would be required for Phase 2 construction of a drainage layer two feet thick. This would require that 3.5 years of bottom ash be stockpiled for use. Given the timeframe for construction, this could be achieved. If the expansion occurs later, then there should be sufficient material available over the next 10 years.

Total Build Out for Initial Construction

The total tonnage of bottom ash needed for total build out is 421,400 tons. This would require that 7.5 years of bottom ash be stockpiled. This may be difficult to achieve if total build out would be the option chosen for initial facility construction. However, there is sufficient volume of bottom ash over the 10 year period that the dredge cell will operate. Beyond that, however, expansion of the ash pond will likely require additional bottom ash.

Conclusions

True?

This appendix has discussed various regulatory, technical, and constructability factors to be considered for design of the drainage layer for a gypsum disposal facility located at the peninsula at KIF. In general, a drainage layer is required to be constructed above the liner to minimize the hydrostatic head on the liner, which reduces the seepage flow through the liner during the active life of the facility. Structural stability is also enhanced by use of a drainage layer. Consolidation will occur more rapidly, thus improving strength in the interior portion of the stack, which is vulnerable to wedge-type failures. Constructability issues were also addressed. Use of a "blanket drain" (i.e., drainage media with pipes buried within) provides a constant drainage area over the entire liner, versus discreet drainage "trenches". While drainage trenches may be acceptable for stability considerations (would require confirmation during detail design), constructability needs to be considered and trench construction is difficult unless a thicker liner is used, and the trenches "cut into" the liner. Drainage media can be either the bottom/fly ash media, or crushed limestone. If the "full build out" option is selected, there may not be a sufficient quantity of bottom ash available for construction of a drainage layer at one time. Construction may have to be phased in place to allow a sufficient quantity of bottom ash to be generated. Geonets were also discussed; however, testing should be performed to confirm behavior under the high loads expected in order to verify the application would work in the absence of a geomembrane. Costs should be considered when using crushed limestone, as the bottom ash is readily available for Phase 1 construction free of charge, and has a shorter haul distance.

What do we recommend?

ATTACHMENT 1

DRAINAGE SYSTEM COMPUTER MODEL RUNS FOR KIF GYPSUM DISPOSAL FACILITY

ATTACHMENT 2

SKETCHES FOR VARIOUS DRAINAGE LAYER OPTIONS FOR GYPSUM DISPOSAL FACILITY AT KIF PENINSULA

ATTACHMENT 3

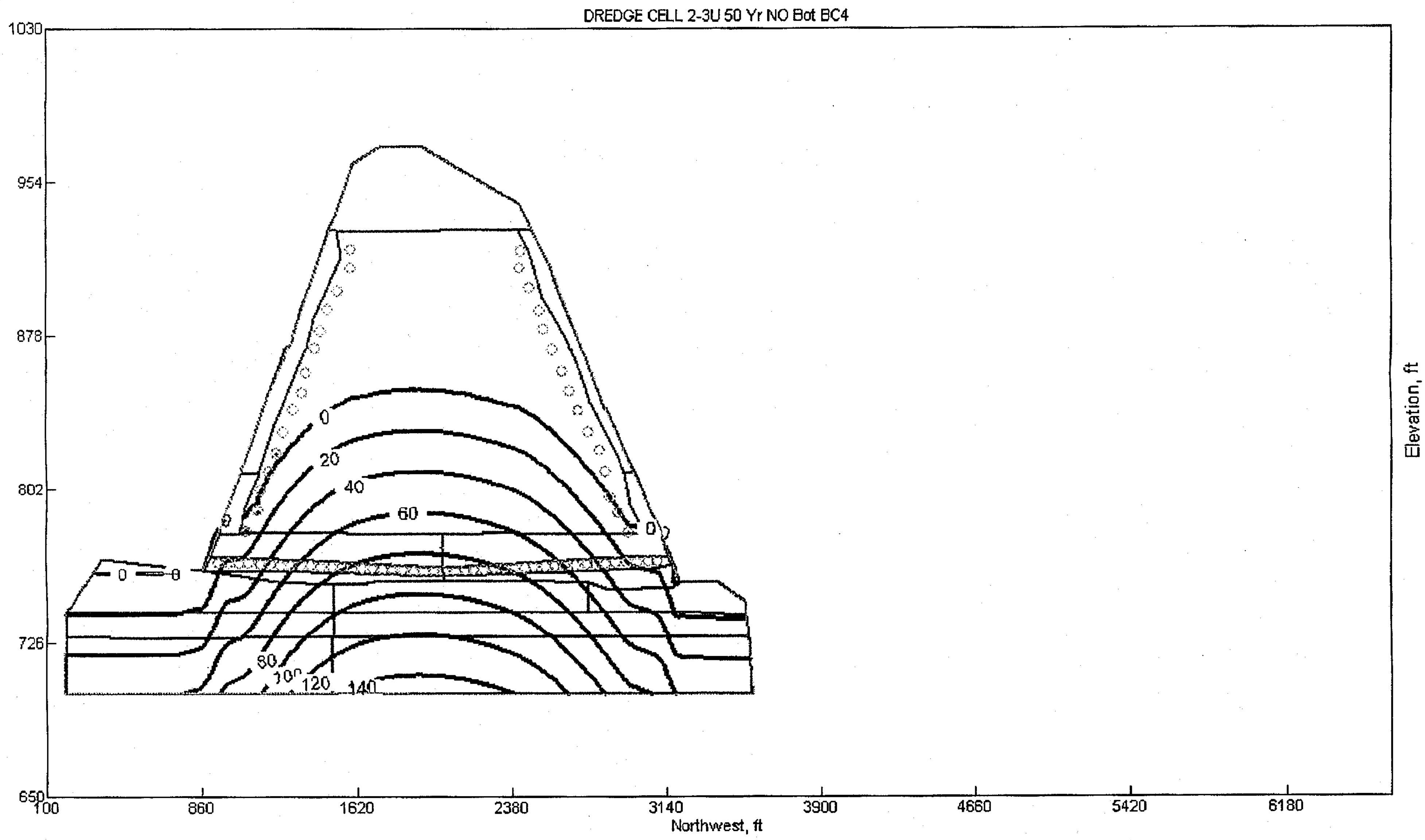
TENAX COMPOSITE GEONET

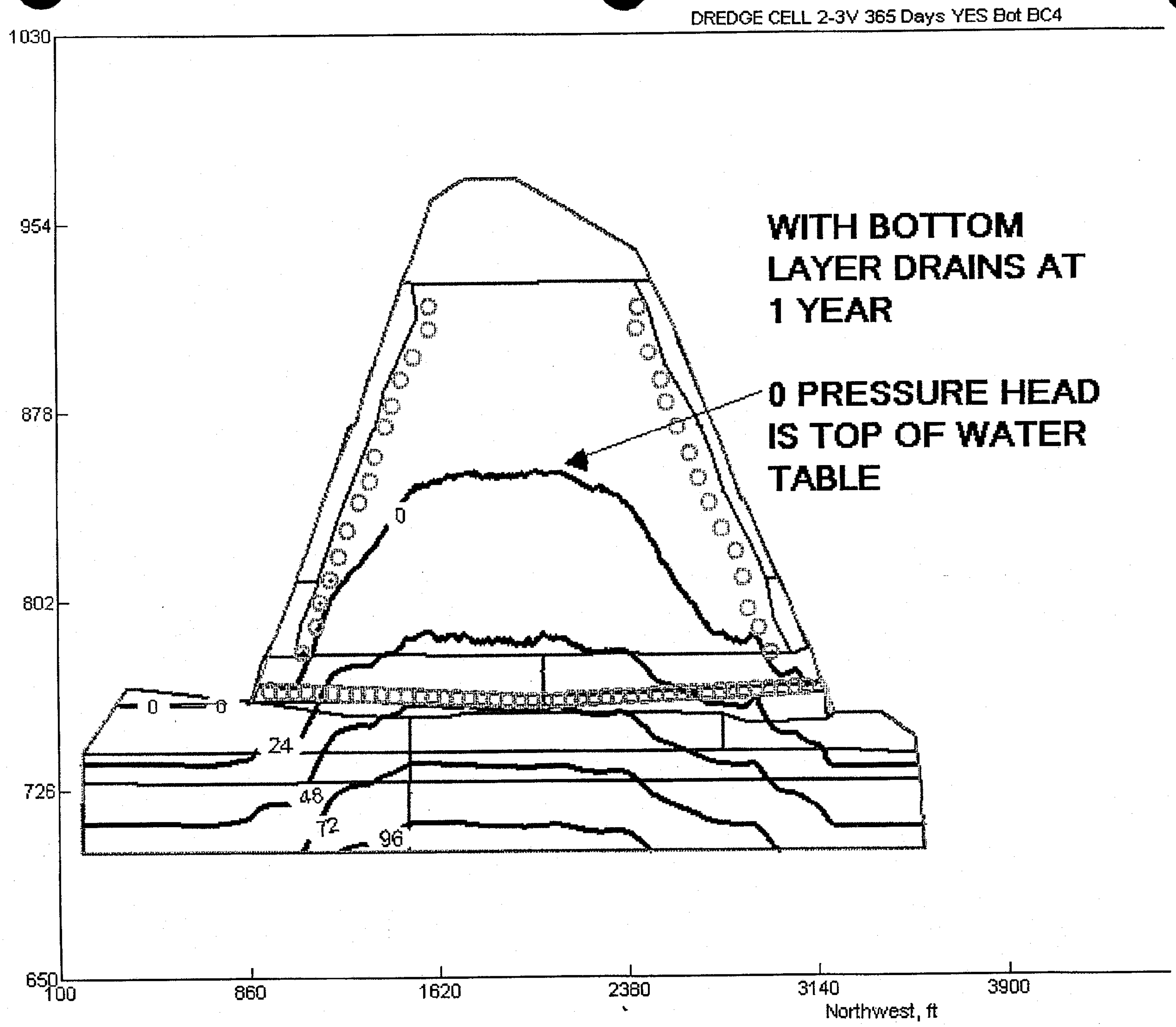
ATTACHMENT 4

AVAILABILITY OF BOTTOM ASH FOR CONSTRUCTION OF DRAINGE LAYER FOR GYPSUM DISPOSAL FACILITY AT KIF

ATTACHMENT 1

DRAINAGE SYSTEM COMPUTER MODEL RUNS FOR KIF GYPSUM DISPOSAL FACILITY


DREDGE CELL 2-3U 50 Yr NO Bot BC4
1030
954
878
802
726
650
100
860
1620
2380
3140
3900
4660
5420
6180
Northwest, ft
Elevation, ft
0
20
40
60
80
100
120
140
0
0
0

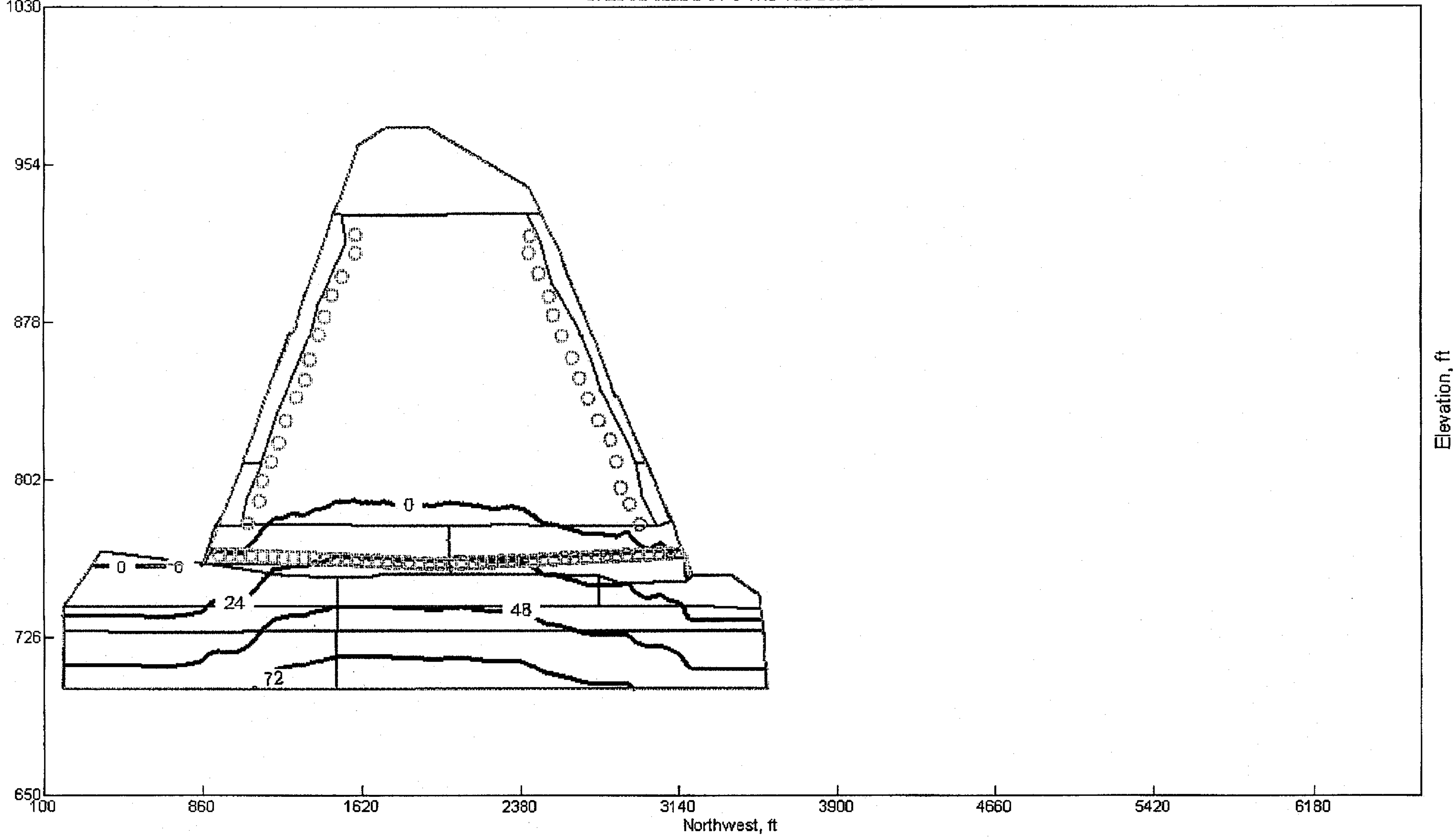


DREDGE CELL 2-3V 365 Days YES Bot BC4

WITH BOTTOM LAYER DRAINS AT 1 YEAR

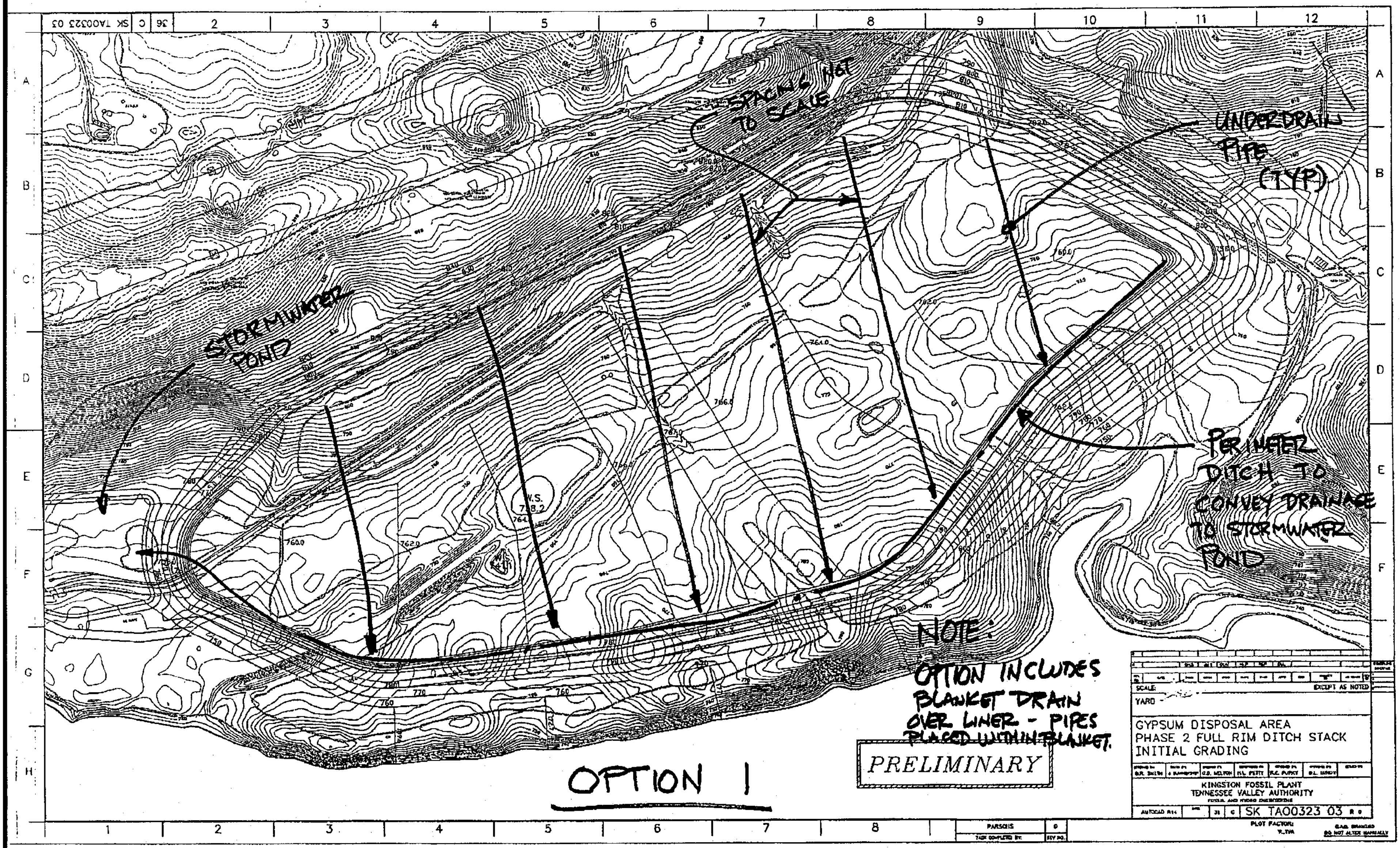
0 PRESSURE HEAD IS TOP OF WATER TABLE

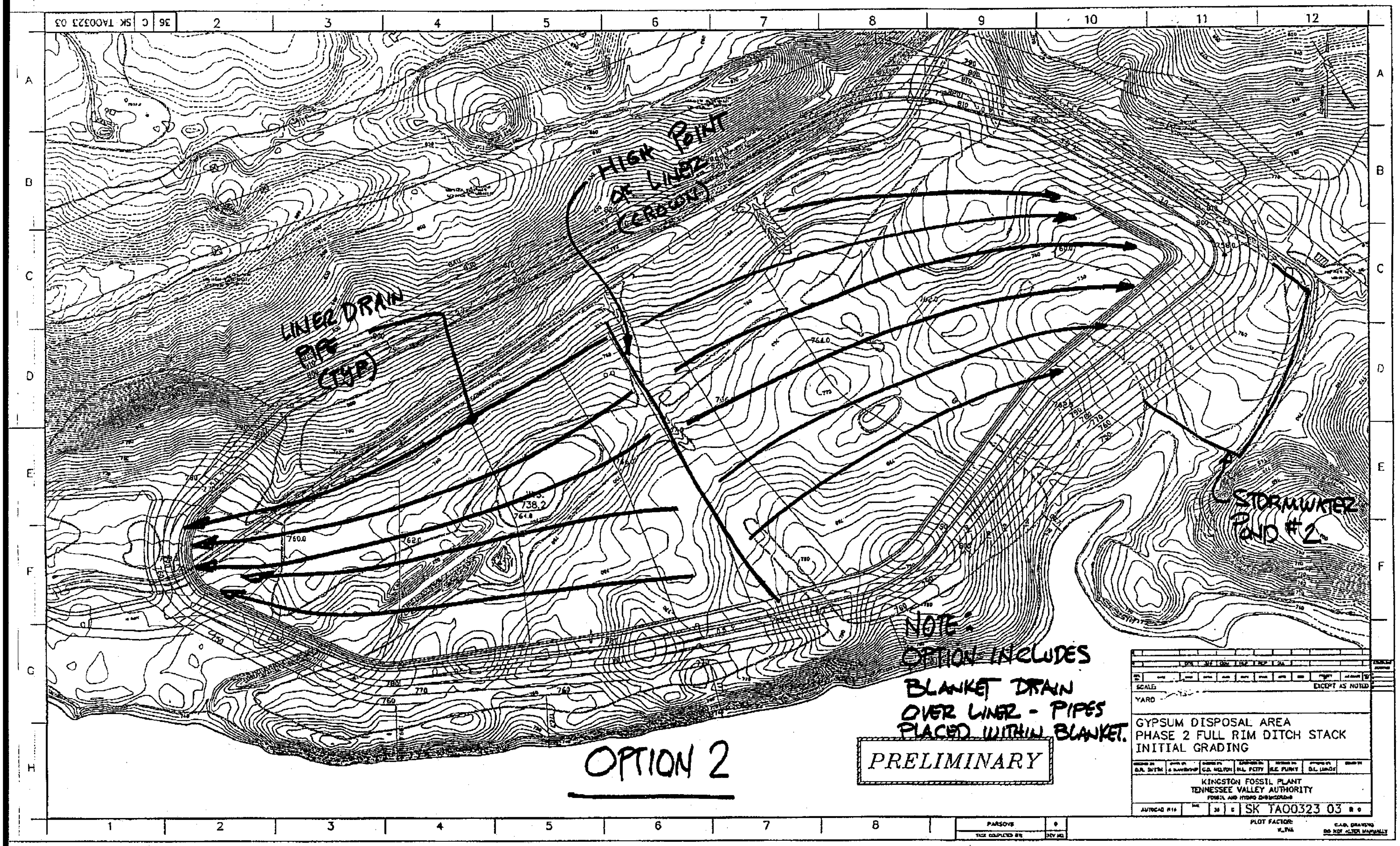
DREDGE CELL 2-3V 5 YRS YES Bot BC4



ATTACHMENT 2

SKETCHES FOR VARIOUS DRAINAGE LAYER OPTIONS FOR GYPSUM DISPOSAL FACILITY AT KIF PENINSULA

SPACING NOT TO SCALE
UNDERDRAIN PIPE (TYP)
STORMWATER POND
PERIMETER DITCH TO CONVEY DRAINAGE TO STORMWATER POND
W.S. 758.2
NOTE:
OPTION INCLUDES BLANKET DRAIN OVER LINER - PIPES PLACED WITHIN BLANKET.
PRELIMINARY
OPTION 1
SCALE: EXCEPT AS NOTED
YARD
GYPSUM DISPOSAL AREA
PHASE 2 FULL RIM DITCH STACK
INITIAL GRADING
KINGSTON FOSSIL PLANT
TENNESSEE VALLEY AUTHORITY
FOSSIL AND HYDRO ENGINEERING
AUTOCAD R14
SK TA00323 03
PLOT FACTOR:
C.A.D. DRAWING
DO NOT ALTER MANUALLY
PARSONS
SK TA00323 03



NOTE:
OPTION INCLUDES
BLANKET DRAIN
OVER LINER - PIPES
PLACED WITHIN BLANKET.

OPTION 2

PRELIMINARY

SCALE: EXCEPT AS NOTED

YARD

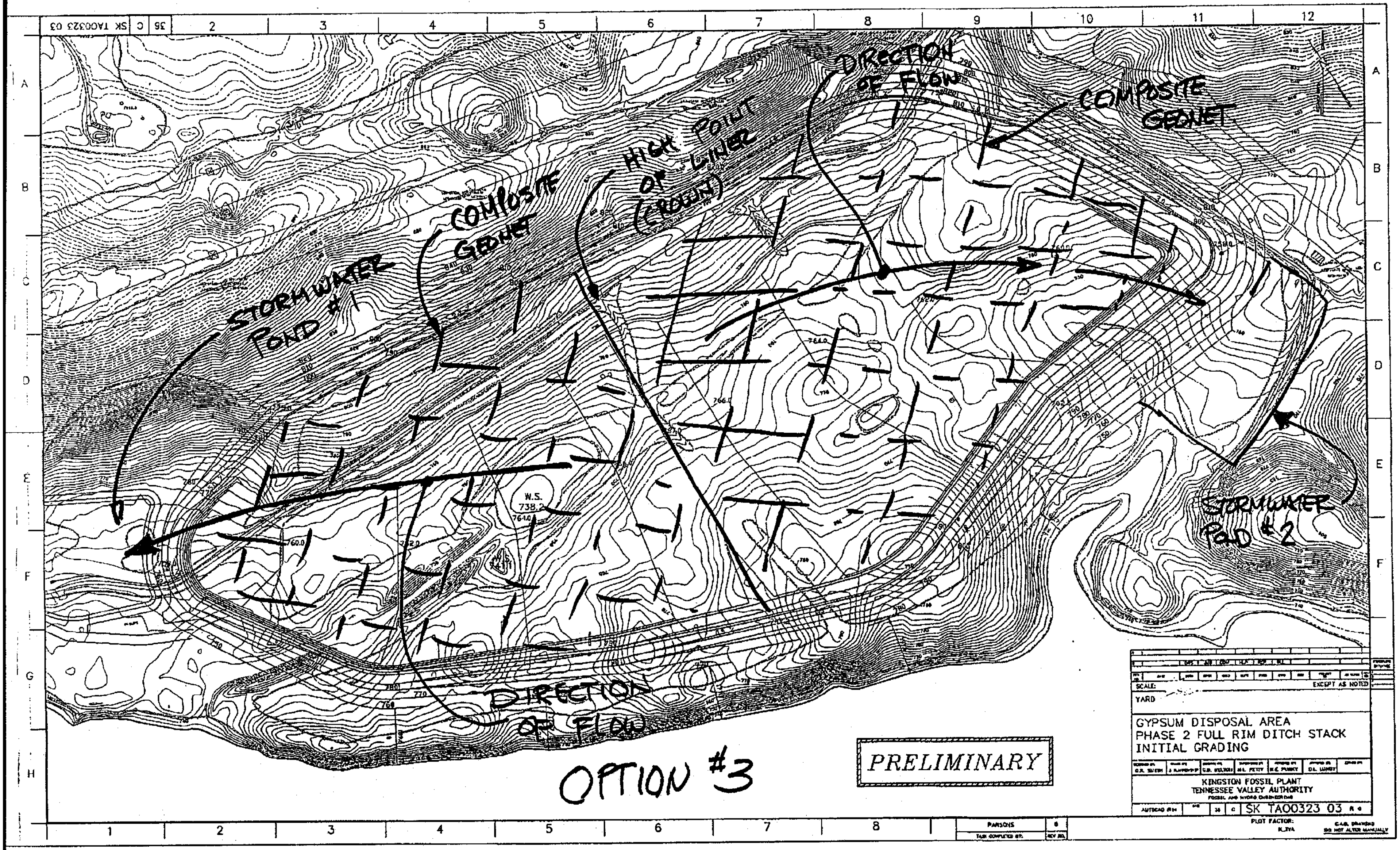
GYPSUM DISPOSAL AREA
PHASE 2 FULL RIM DITCH STACK
INITIAL GRADING

KINGSTON FOSSIL PLANT
TENNESSEE VALLEY AUTHORITY
FOSSIL AND HYDRO ENGINEERING

AUTOCAD R14 | 36 | C | SK TA00323 03

PLOT FACTOR:

C.A.D. DRAWING
DO NOT ALTER MANUALLY



OPTION #3

SCALE: EXCEPT AS NOTED
YARD

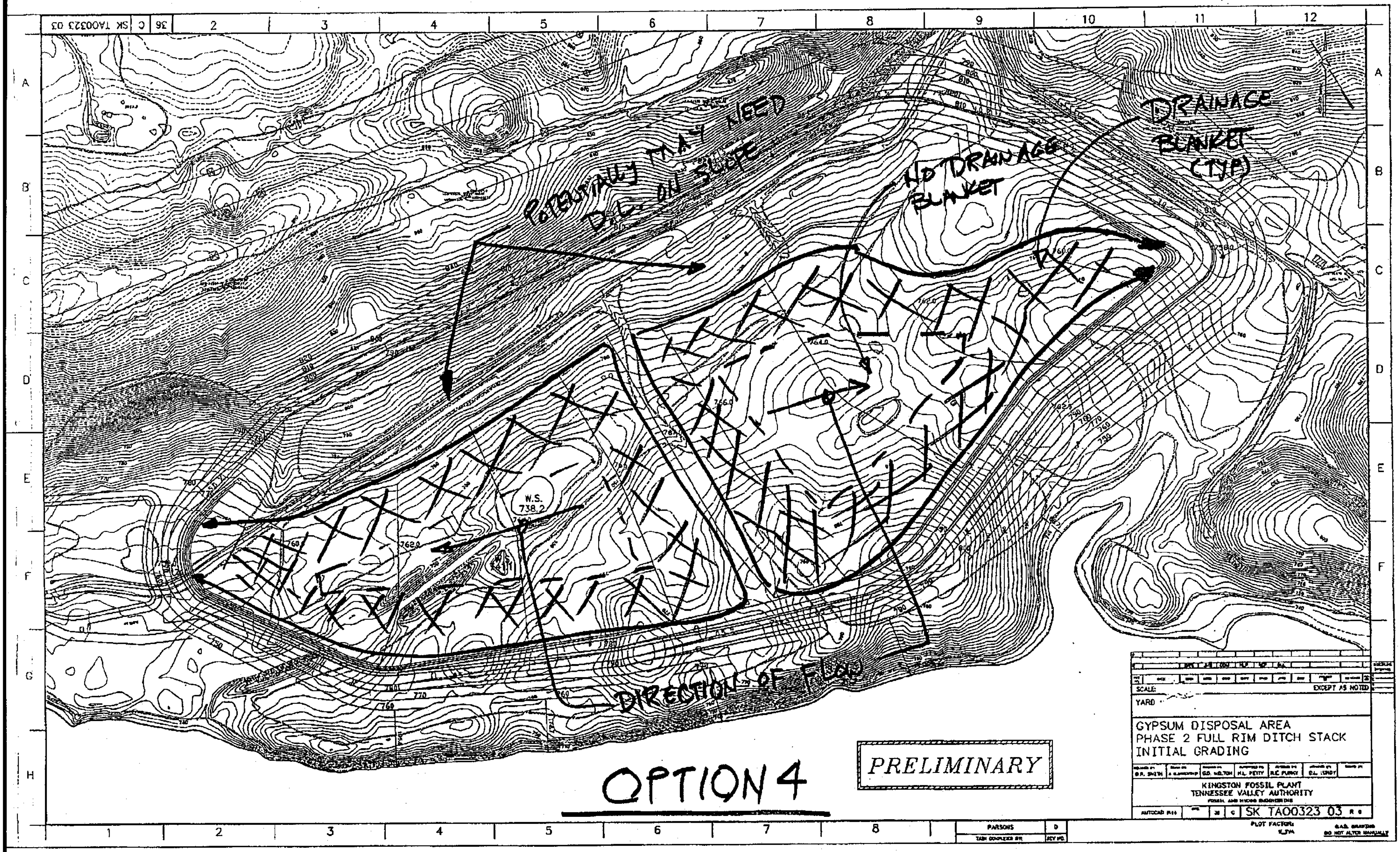
GYPSUM DISPOSAL AREA
PHASE 2 FULL RIM DITCH STACK
INITIAL GRADING

KINGSTON FOSSIL PLANT
TENNESSEE VALLEY AUTHORITY
FOSSIL AND HYDRO ENGINEERING

AUTOCAD R14 | 35 | C | SK TA00323 03

PLOT FACTOR:
K_TVA

C.A.D. DRAWING
DO NOT ALTER MANUALLY



SCALE: EXCEPT AS NOTED

YARD

GYPSUM DISPOSAL AREA
PHASE 2 FULL RIM DITCH STACK
INITIAL GRADING

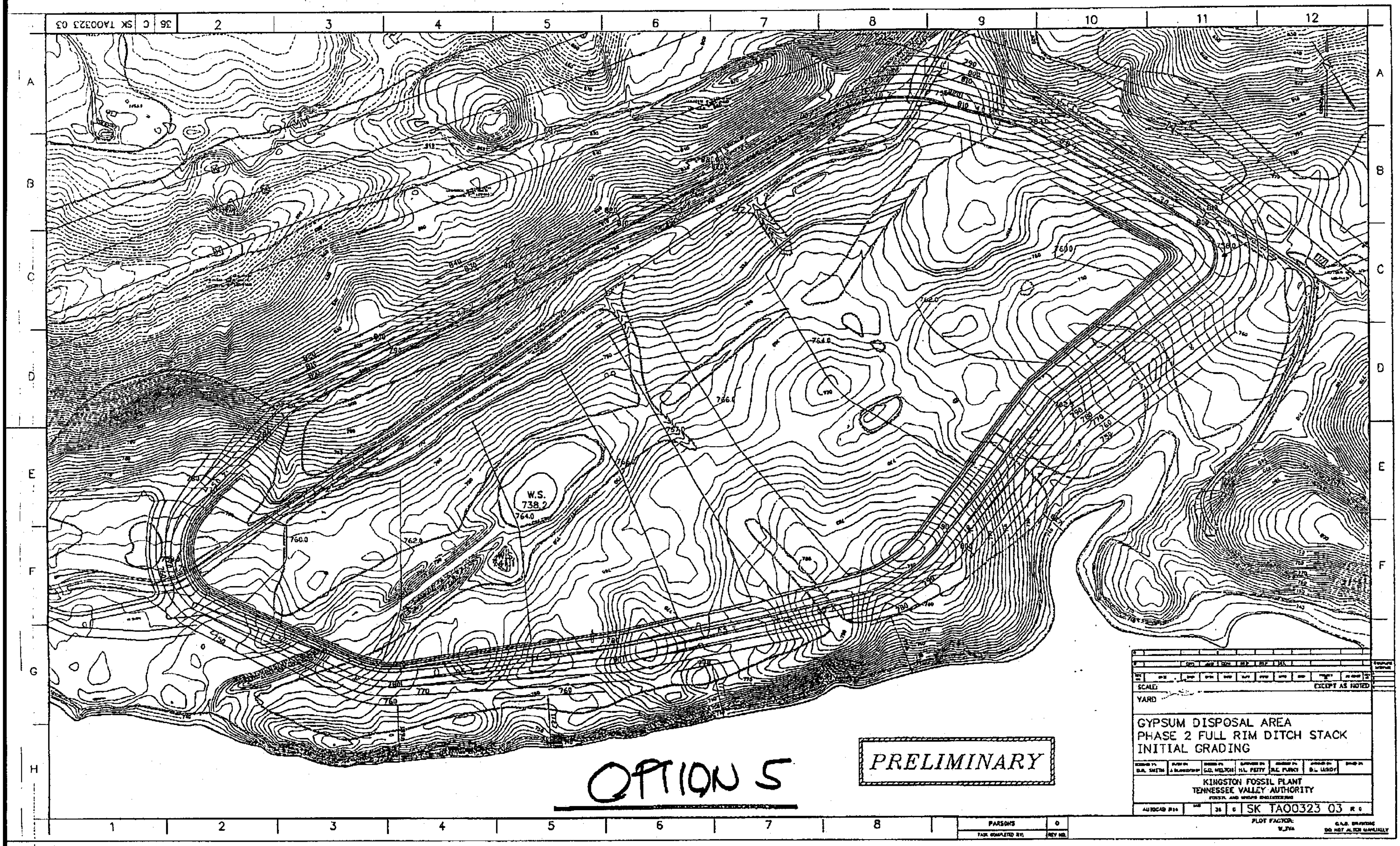
D.R. SMITH | G.D. MELTON | H.L. PETTY | R.E. PURKEY | D.L. LUNDY

KINGSTON FOSSIL PLANT
TENNESSEE VALLEY AUTHORITY
FOSSIL AND HYDRO ENGINEERING

AUTOCAD R14 | 36 | C | SK TA00323 03 | R 0

PLOT FACTOR:

C.A.D. DRAWING
DO NOT ALTER MANUALLY



OPTION 5

SCALE: EXCEPT AS NOTED

YARD

GYPSUM DISPOSAL AREA
PHASE 2 FULL RIM DITCH STACK
INITIAL GRADING

D.R. SMITH | G.D. MELTON | H.L. PETTY | D.L. LUNDY

KINGSTON FOSSIL PLANT
TENNESSEE VALLEY AUTHORITY

AUTOCAD R14 | 36 | C | SK TA00323 03 R 0

PLOT FACTOR:

C.A.D. DRAWING
DO NOT ALTER MANUALLY

PARSONS | 0

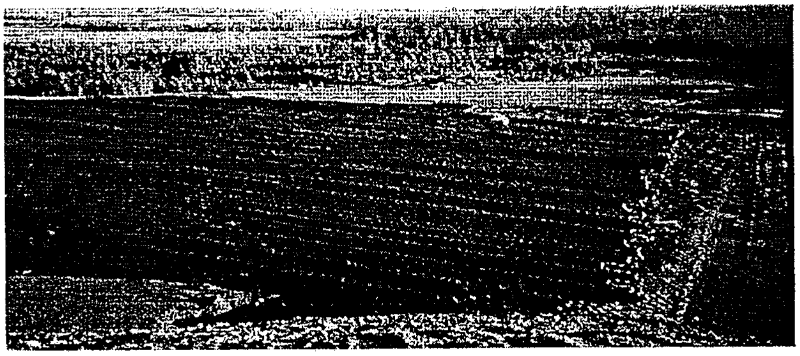
ATTACHMENT 3

TENAX COMPOSITE GEONET

TENAX® Corporation Project Highlight

Tri-Planar Geonet Composite for Leakage Detection under Heavy Compressive Load Atlantic Waste Disposal, VA

The bioreactor municipal solid waste landfill has over 200 acres, and over 300 ft in height upon completion. The wastes are brought into this landfill by truck, railroad car and barge, it closes only five days a year.



Together with this enormous waste pile is the challenge to manage all the liquids in this bioreactor design. The leachate collection and detection system must be capable of taking huge compressive load and still deliver adequate liquid transmission capacity. Because of the height of the waste, injection pipes will be installed while filling the landfill, this to enhance the bio-reaction to start the decomposition faster. Seven different levels of leachate injection pipes will be installed, with a spacing of 40 feet vertical direction, and a horizontal spacing of 100 feet. The injection pipes have a dual purpose and will serve as temporary landfill gas collectors as well.

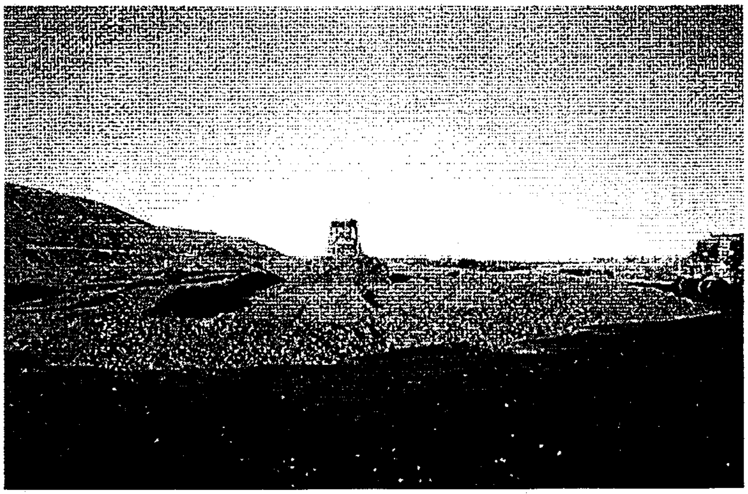
The Leakage Detection System (LDS) must be designed to satisfy the following objectives:

- Provide rapid detection of a major breach in the primary liner system, common requirements are for 24 hour maximum detection time; and

- Limit the head acting on the secondary liner to less than the thickness of the LDS or 0.3m, whichever is less.

Tri-planar geonet composite provides the most efficient material for rapid leakage detection under normal loads of this magnitude. Geonets have very limited fluid storage capacity and much faster fluid transmission speed than granular soil drain. The tri-planar structure of Tendrain was engineered to maintain flow rates under sustained heavy loads. Transmissivity was measured under 45,000psf for this project with deformable boundary conditions. Its structure is capable of taking such a load at 50,000 psf and still maintaining a 50% thickness.

Project Name: Atlantic Waste Disposal
Location: Waverly, VA
Products: Tri-Planar Geonet Composite
Application: Leakage Detection under Heavy Load
Date: 2000
Engineer: G.N. Richardson & Associates



TENAX® Corporation
4800 East Monument Street
Baltimore, Maryland 21205
Office: (410) 522-7000 Order Line: (800) 356-8495
Fax: (410) 522-7016 Waste Mgt: (800) US-GRIDS
Web Site: www.tenaxus.com

ATTACHMENT 4

AVAILABILITY OF BOTTOM ASH FOR CONSTRUCTION OF DRAINGE LAYER FOR GYPSUM DISPOSAL FACILITY AT KIF

p. 1/2

BOTTOM ASH - FOR PENINSULA

SEE ATTACHED CALCS.

Need 282,328 TONS of BA TO BUILD DIKES FOR Dredge Cell.

SAY 300,000 TONS.

THIS WILL LAST 10 YRS. (WILL PROVIDE DISPOSAL CAPACITY FOR 10 YRS)

BA prod @ KIF = 88,000 TPY.

$$\begin{array}{r} 88{,}000 \times 10 = 880{,}000 \text{ TONS} \\ - \underline{300{,}000} \\ 580{,}000 \end{array}$$

580,000 TONS EXCESS OVER NEXT 10 YRS. $\boxed{2006 - 2016}$

FOR PHASE 1

— AREA = 37 Ac.

2.5' THICK Layer

BA Needed = 37 × 2.5 = 92.5 Ac ft. = 149,233 cy.

USE 179,630 cy in COST ESTIMATE —

@ 8.4 pcf 179,630 × 27 = 4,850,010 cf

$$\frac{4{,}850{,}010 \text{ cf} \times 84 \text{ lb/cf}}{2000 \text{ lb/ton}} = 203{,}700 \text{ TONS}$$

FOR TOTAL BUILDOUT

Need 371,620 cy

$$\frac{371{,}620}{179{,}630} = \frac{x}{203{,}700}$$

x = 421,417 TONS FOR TOTAL BUILDOUT