TENNESSEE VALLEY AUTHORITY

KINGSTON FOSSIL PLANT

OPERATIONS MANUAL
DREDGE CELL LATERAL EXPANSION

VOLUME 1

IDL 73-0094

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TVA

Prepared By

Tennessee Valley Authority
Fossil Engineering Services

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	Plant/Unit: KINGSTON FOSSIL PLANT

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TENNESSEE VALLEY AUTHORITY
FOSSIL POWER GROUP
FOSSIL ENGINEERING SERVICES
SITE AND ENVIRONMENTAL ENGINEERING

	Revision 0	R1	R2	R3
Date	June, 2004	March, 2006	May, 2006	July, 2006
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OPERATIONS MANUAL
DREDGE CELL LATERAL EXPANSION
TENNESSEE VALLEY AUTHORITY
KINGSTON FOSSIL PLANT

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Revision 0
June 7, 2004

Revision 1
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Revision 2
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Revision 3
July 28, 2006

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1 SITE INFORMATION

1.1 Responsible Officials

The following is a list of responsible parties involved with the permitting, design, operation, maintenance, quality control/assurance of the Dredge Cell Lateral Expansion at the Kingston Fossil Plant (KIF).

1. Owner: Tennessee Valley Authority (TVA)
   Contact: Plant Manager
   Tennessee Valley Authority
   Kingston Fossil Plant
   714 Swan Pond Road
   Harriman, Tennessee 37748
   (865) 717-2501

   As of the date of this revision, the plant manager is Mr. Michael T. Beckham.

   Please direct any correspondence in regards to this document to the designated Solid Waste Specialist. The Solid Waste Specialist for Kingston Fossil Plant is:

   Larry C. Bowers
   1101 Market Street, LP 5D-C
   Chattanooga, Tennessee 37402-2801
   Phone:(423)751-4947
   Fax:(423)751-7011

2. State: Tennessee Department of Environment and Conservation
   Division of Solid Waste Management
   Tennessee Department of Environment and Conservation
   2700 Middlebrook Pike, Suite 220
   Knoxville, Tennessee 37921-5602
   Phone:(865) 594-6035
   Fax:(865) 594-6115

   Contact as of the date of this manual is Mr. Larry Cook, Environmental Field Office Manager.

   Tennessee Department of Conservation
   Division of Solid Waste Management
   Central Office
   401 Church Street
   5th Floor, L&C Tower
   Nashville, Tennessee 37243-1535
   Phone:(615) 532-0780
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   Contact as of the date of this manual is Mr. Mike Apple, Division Director.

1.2 Site Location

The TVA KIF is located near the confluence of the Clinch and Emory Rivers (Watts Bar Lake) at Clinch River mile 2 (Emory River mile 2) in Roane Co. Tennessee, approximately 1 mi northwest of the City of Kingston. Access to the site is by state Highway 70 and Swan Pond Road. Refer to drawing 10W425-21, which depicts the plant layout and location of the existing dredge cells, and proposed dredge cell expansion.

1.3 Site Description

The site selected for the disposal facility is the existing fly ash pond, and is an expansion of the existing dredge cells, as shown on drawing 10W425-21. The ash pond is entirely within the KIF Reservation. Existing benchmarks are located as shown on the drawings.

The area surrounding the KIF is primarily agricultural, industrial, and rural in nature (refer to Drawing 10W425-21). The fossil plant powerhouse is just south of the proposed location for this disposal facility.

The methods of placement of gypsum and coal ash in this facility are discussed in subsequent sections of this operations manual. Ash conveyance to the pond is by sluicing from the plant, and ash is dredged from the pond to the dredge cells. Dikes are progressively raised as cells are filled with waste material. Gypsum will be sluiced to the dredge cell lateral expansion area from the plant or a proposed drying facility, depending on future circumstances regarding the market for gypsum.

1.4 Site Geology and Hydrogeology

The following section briefly summarizes the geology and hydrogeology for this site. Additional detailed information is contained in the hydrogeologic investigation contained in Appendix E. The plant site is located in the Valley and Ridge physiographic province of the Appalachian Highland region. The ash pond area is underlain by the Conasauga Group (middle to upper Cambrian Age) with the exception of the northern tip of the area, where the Rome formation (lower Cambrian Age) is present. Specific geologic groups within the Conasauga Group represented at the site include the Maynardville, Nolichucky, Maryville, Rogersville, Rutledge, and Pumpkin Valley formations. These formations are locally of low water-producing capacity, and predominantly consist of shale with interbedded siltstones, limestones, and conglomerates. Total thickness of the Conasauga Group beneath the site is unknown, but is estimated to be approximately 1500 ft. Pine Ridge, which borders the ash pond area to the northwest, is underlain by interbedded shale, sandstone, and siltstone of the Rome formation.

Field and laboratory measurements of hydraulic conductivity for soil, ash, and shallow bedrock were performed for this site and are summarized in Appendix E. In general, the field conductivity measurements are about an order of magnitude larger than the laboratory estimates for the same material. Such differences between field and laboratory measures are commonly observed and are attributed to differences in measurement scale.

The upper weathered bedrock zone exhibited the highest field-measured horizontal hydraulic conductivity (K_h), with values averaging about 2×10^{-5} cm/s. Field estimates of K_h for the "silty clay" alluvium averaged approximately 7×10^{-7} cm/s. A conductivity of approximately 2×10^{-5} cm/s was indicated for the permeameter-tested fly ash sample. During the recent geotechnical investigation for the lateral expansion, field hydraulic conductivity testing was conducted for in-situ ash in the outer dike at two locations (B-1 and B-2) near the area that experienced seepage in November 2003. For both locations, vertical hydraulic conductivity was measured at 5.13×10^{-6} cm/s and 3.59×10^{-6} cm/s respectively. Horizontal hydraulic conductivity was measured at 1.42×10^{-5} cm/s and 3.67×10^{-6} cm/s respectively. Laboratory hydraulic conductivity testing was also performed on remolded samples, with hydraulic conductivities ranging from 1.67×10^{-5} to 1.87×10^{-5} cm/s.

Groundwater movement at the plant is generally eastward and southeastward from Pine Ridge toward the reservoir. Because the ash pond area is bounded on two sides by the reservoir, groundwater originating on or upgradient ultimately discharges to the reservoir. Recently acquired potentiometric head data from the interior of the existing dredge cell, along with groundwater level data from MW 16A seem to indicated that the continuous recharge by ash sluice water in the active ash pond produces local on-site mounding of the water table. Similarly, temporary local mounding of the water table may occur during periodic sluicing/dredging of ash to the dredge cells.

1.5 Buffer Zone Compliance

The dredge cell lateral expansion is in compliance with all applicable buffer zone standards listed in Tennessee Rule 1200-1-7-.04(3). Reference is made to drawing 10W425-24. Specifically, the lateral expansion is at least 100 feet from the TVA reservation boundary, and at least 500 ft from any residences. The lateral expansion is more than 200 ft from the normal boundary of any stream or lake, although the ash pond itself is adjacent to Watts Bar Lake, because the facility was built in the 1950's. No constructed appurtenances for the fill area are located within 50 ft of the TVA reservation boundary. No private water-supply wells exist down-gradient of the site. Furthermore, there is no potential for development of such wells because Watts Bar Lake bounds the ash pond on two sides. Water wells within a two-mile radius of the proposed disposal facility are listed in the hydrogeological evaluation for this facility (see Appendix E).

1.6 Geologic Buffer System

A mantle of predominantly alluvial soils generally lies above the bedrock in the ash pond area, as described in Appendix E. Soil thickness is highly variable, ranging from about 5 feet along a portion of the northern perimeter of the site to a maximum of 65 feet on the western boundary. The alluvial deposits are unconsolidated and lenticular, and consist of clay, silt, and sand with occasional gravel. A thin layer of residuum is occasionally present directly above the bedrock. The residuum is composed of clay and silt with weathered shale fragments.

The ash and ash-soil fill materials present above the alluvium/bedrock ranged up to 70 feet in thickness at the time Appendix E was prepared (June 1995). Presently the thickness ranges up to 90 feet in thickness, as ash has continued to be dredged into the dredge cells.

On April 26, 2005 TVA received a notice from TDEC that a waiver from the geologic buffer requirements, Rule 12-1-7-.04(4)(b), would be required. On May 10, 2005 TVA requested this wavier. Following this request, TDEC issued a Notice of Completeness on May 13, 2005.

1.7 Access Control

The Dredge Cell Lateral Expansion is located within the TVA KIF Reservation. Access to this facility is via internal plant roads. During normal operating hours, operations personnel are at the site performing dredging operations, maintenance, and inspections as required. TVA security maintains 24-hour surveillance at the plant. The Dredge Cell Lateral Expansion will only be used for disposal of gypsum and coal combustion ash at the KIF or from other TVA fossil generation facilities. Shipments of non-waste will not be accepted for disposal at this facility.

2 DESCRIPTION OF SOLID WASTES, DISPOSAL CAPACITY, AND FACILITY LIFE

2.1 Types of Waste

The plant consists of nine coal-fired units with a maximum generating capacity of approximately 1600 megawatts (MW). The only wastes that will be disposed of in the dredge cells/dredge cell expansion are ash and gypsum from coal combustion at the KIF or other TVA fossil generation facilities. Bottom ash from the Bull Run Fossil Plant (BRF) may be used if necessary in constructing drains and as filter material as shown on the drawings. This facility may also accept gypsum byproduct material from BRF or dispose of ash from other TVA plants if TVA needs additional disposal capacity. No other waste materials from any non-TVA sources or plants will be accepted for disposal.

Coal combustion ash is composed of the non-combustible mineral components contained within the coal during its formation. Fly ash is inert, non-combustible, and does not decay biologically. This ash is sluiced to the ash pond, and then dredged into the dredge cells located within the ash pond. The ash sluiced to the ash pond from the plant consists of about 100 percent fly ash (fine particles removed from the flue gases). Bottom ash is sluiced to a separate pond, and is used to construct dikes as the dredge cells are raised. As the facility is operated (see the following section), the ash will eventually dry into a relatively inert, structurally stable material. Additional data regarding the typical characteristics of fly ash and testing of KIF ash pond samples is included in Appendix A.

TVA is proposing to construct and operate a wet scrubber system to remove SO_3 emissions from the flue gas emissions from the plant. This system is expected to become operational in FY 2009. Wet gypsum will be sluiced to the ash pond where the Phase 2 and 3 disposal cells will be constructed as depicted on the 10W425 series drawings. Depending on market availability, TVA may be able to market up to 50% of the wet gypsum generated at KIF to private companies involved in the manufacture of various products. It is uncertain as to the actual percentage of gypsum that can be marketed; therefore, life projections will be made for worst case (no marketing) and best case (50% marketing). Gypsum is inert, non-combustible, and does not decay biologically. It is utilized in the manufacture of gypsum wallboard. Additional data regarding the typical characteristics of gypsum and typical chemical composition (based on TVA's Cumberland Fossil Plant Gypsum) is included in Appendix A.

It should also be noted that this facility is also designed to accept fly ash only without gypsum. The stability analysis (Appendix G) analyzed the facility for both gypsum and ash, or ash only. Stacking configurations and limitations are discussed in Appendix G, and herein.

Since wet sluicing of gypsum is integral to TVA's gypsum disposal practices, TVA requests a waiver of Tennessee Rule 1200-1-7-.04 (2), regarding disposal of bulk or non-containerized liquids in a landfill. TVA would also like to point out that slurried coal ash is managed using the same procedures in an adjacent, permitted landfill; and that slurried gypsum is also managed in other permitted landfills in Tennessee.

2.2 Anticipated Volumes and Facility Life

Fly and Bottom Ash

The KIF produces approximately 360,000 tons of fly ash annually (398,000 cubic yards (cy) based on an average of 67 lbs/cubic foot (cf) density). For planning purposes, gypsum production for KIF is expected to be 372,000 tons (327,360 cy) per year, based on a density of 0.88 tons/cy. This is the best available information that TVA has for KIF at this time, as the fuel supply for future years has not yet been determined. Depending on the sulfur content of coal, gypsum production could vary from the estimates presented here. KIF also generates 88,000 tons/year of bottom ash (77,600 cy/year). Bottom ash is used along with fly ash to construct the outer ash dikes when they are raised. TVA has not yet established a start date for gypsum disposal operations, but will notify TDEC at least 180 days before a planned start date for operation. For facility life projections, the scrubber is assumed to become operational in 2009. As described in the attached Closure/Post Closure Plan, TDEC will be notified prior to TVA undertaking any closure activities. Closure is expected to be completed within about two years.

Gypsum

For planning purposes, gypsum production for KIF is expected to be 372,000 tons (327,360 cy) per year. The following sections discuss disposal of each waste stream individually with respect to expansion, and the last section presents projections for facility life using the worst- and best-case waste disposal scenarios.

2.2.1 Existing Dredge Cells

Drawings for the dredge cells have been revised for this permit application. The dredge cells are currently built to elevation 805-810. As-built topography was used for revising these drawings. The final grade is shown on the 10W425 series drawings with the revised as-built topography. The closure contour elevations for the existing dredge cells are unchanged from the last revision, and projected volumes are based on the as-built topography dated October 2003, and the revised final cover design. As of October 2003, there are 4,985,355 cy of disposal capacity available. Assuming a disposal rate of 475,600 cy annually (including bottom and fly ash), there are 10.5 years of capacity remaining.

2.2.2 Phase 1 Lateral Expansion

In order to provide additional fly ash disposal capacity, TVA is constructing an additional dredge cell (Phase 1 expansion) south of the existing dredge cells into the main ash pond. This dredge cell is expected to have 1,169,563 cy of disposal capacity available, and should provide an additional 2.5 years of disposal capacity for fly and bottom ash.

2.2.3 Phase 2 & 3 Lateral Expansion

The disposal capacity of both Phase 2 and 3 are summarized here. Initially, Phase 1 will be constructed, and Phase 2 will be constructed at a later date as determined by TVA. Table 2.1 presents the disposal volume and area of each stage for both Phases 2 and 3.

Table 2.1

Stage	Volume (cy)[1]
Stage 1	2,431,261
Stage 2	3,097,708
Stage 3	3,170,647
Stage 4	2,660897
Stage 5	1,718,399
Stage 6	1,291,505
Total	14,370,417

[1]Capacity includes approximately 148,178 cy for a 1.5 ft thick cover

2.2.4 Projections for Facility Life

The following table depicts the overall life of the facility over time. Table 2.2 assumes 100 percent gypsum disposal and continued fly and bottom ash disposal. Table 2.2 includes the annual gypsum production volumes currently available. The type of coal burned for power production can affect the amount of gypsum produced, and is not finalized at this time. TVA will provide revised waste generation estimates from KIF in the near future, and will advise TDEC DSWM of any significant changes.

Table 2.2

Phase	*Facility*	*Waste*	*Start Date*	*End Date*	*Comments*
1	Existing ash dredge cells 1-3	Sluiced ash to el. 844	2004	2015	
		Dry ash above 844	2015	2017	
	Ash dredge cell expansion	Wet sluiced ash	2004	2015	
	Ash dredge cell expansion	Dry stacked ash	2015	2017	
2	Gypsum areas A and B	Wet gypsum to el. 870	2009	2019	Initial filling will be gypsum - assume all gypsum until 2017
		Wet ash until 870	2017	2020	Wet ash disposal in Phase 2
2&3	Gypsum and ash disposal	Wet gypsum/dry ash	2020	2029	Wet gypsum fill to elev 930
	Gypsum and ash disposal	Dry gypsum/dry ash	2029	2030	Dry waste above elev 930
NA	Wet ash disposal Phase 2	Wet ash	2017	2029	Wet ash disposal Phase 2 only to el 870
	Dry ash disposal Phase 2/3	Dry ash	2029	2047	Dry ash disposal
Closure	Entire disposal area	Ash, gypsum	2047	2077	

2.3 Permitted Area

The area within the ash disposal boundary is depicted on drawing 10W425-23, and is approximately 244 acres overall, not including the stilling basin. The stilling pond occupies an approximate 25-acre area. The existing dredge cells occupy approximately 129 acres, Phase 1 approximately 13.5 acres, and Phases 2 and 3 approximately 64 acres. Existing dredge cell areas and lateral expansion areas do not sum to the total area because the remaining ash pond area is not fully developed for the lateral expansion, allowing for an approximate 200-foot setback from the outer dike at elevation 765. The groundwater compliance boundary is defined by the monitoring wells shown on the drawings included in this permit application.

3 WASTE HANDLING

3.1 Waste Handling Operations

3.1.1 Current Ash Handling Operations

Existing Dredge Cells

Bottom ash and fly ash are sluiced through a series of pipes to a point southwest of the active ash pond. Bottom ash is sluiced through separate pipes to a long channel that drains to the active ash pond. The heavier bottom ash settles out in this channel prior to reaching the active ash pond. The bottom ash is removed from the pond using draglines, long reach trackhoes, and scrapers on a continuous basis to be used to construct the dredge cells. Lighter fly ash continues to be sluiced to the active ash pond through a lined channel.

The fly ash and bottom ash effluent drain to the active ash pond. In this area a series of divider dikes and spillway skimmers separate the sluicing effluent from the transported ash. Fly ash is transported to the active ash pond, along with finer particles of bottom ash. Lime can be added to effluent discharging from the active ash pond to the stilling basin when required for pH adjustment. The sluicing effluent is discharged through weirs to the stilling basin, where it is discharged to the intake channel. Recent modifications were made to this discharge due to the construction of the selective catalytic reduction (SCR) system currently being installed at KIF. Ductile iron pipes equipped with spargers have been attached to the existing discharge pipe from the stilling basin to dissipate ammonia concentrations during times when ash comes in contact with ammonia from the SCR process.

During normal operations, a portable-floating dredge is located in the active ash pond. During normal operation, the dredge is connected to piping that conveys ash to the existing dredge cells located at the north end of the ash pond. Approximately 360,000 tons (398,000 cy) of fly ash are generated annually. The slurry will enter the dredge cells at the northern end, and will flow through the pond. The ash will settle out, and excess water will flow out of the diked area through a spillway. All dredge water and storm water will exit the facility through this spillway (or the underdrain system) and is directed to the stilling basin located south of the ash pond. The stilling basin discharges to an NPDES permitted out fall as discussed in Section 3.10.

The water level in the dredge cells will be maintained at an elevation at least four ft below the dike elevation. This freeboard will ensure that rainfall and wave action can be contained. The 25-year, 24-hour storm event is estimated to raise the water elevation only 5.5 inches, if no water is discharged from the pond. As the initial volume of ash is conveyed to the facility, water will decant through the metal spillway, and drain to allow ash consolidation.

The dredge cell dikes are constructed out of bottom ash material collected from the bottom ash channel and fly ash. This ash is collected and transported by scrapers to the dredge cell area. Dry fly ash is removed from the active ash pond and also hauled to the dredge cell area. Scrapers, dozers, backhoe/loaders, front-end loaders, and dump trucks are used to place and compact the fly and bottom ash, and shape the ash as shown on the drawings included with this permit application. Construction of the dikes is in accordance with the attached QA/QC Plan. Dust is controlled by utilizing a water truck as required on the haul roads and dikes.

During periods of time when dredging not possible, fly ash is removed from the active ash pond by excavators, draglines or other appropriate equipment, hauled to the dredge cell area by use of pans or dump trucks, and compacted by use of appropriate equipment.

The disposal process is an essentially continuous incremental procedure. No daily earth cover will be required. Intermediate cover may be placed and vegetation established in areas (typically the outer slopes) of the dredge cell that do not achieve final contours during inactive phases of operation. The ash is physically stable, nonputrescible, and does not attract animal vectors or diseases.

3.1.2 Additional Fly Ash Dredge Cell (Phase 1)

The additional fly ash dredge cell is located as shown on the 10W425 series drawings. A dike consisting of bottom and fly ash is constructed along the southern boundary of the dredge cells. The construction methods are the same as those described in Section 3.1.1. As ash is dredged into each cell, bottom and fly ash will be used to raise the dikes to create the cell to the next stage. The height of each cell is as shown on the drawings, and has terraces that roughly coincide with the existing dredge cells for ease of construction.

3.1.3 Installation of Slope Drains and Toe Drain for Existing Dredge Cells

As part of the permit application, TVA has investigated causes of the recent seepage in the existing dredge cells. Based on review of groundwater data, and a seepage analysis (see Appendix K), the hydrostatic head has been raised in the dredge cells as the height of the dredge cells has increased. A model was constructed to simulate conditions at the time the seepage occurred using recently acquired data as part of the geotechnical field program. The model was then used to simulate future conditions to determine a suitable remedy. Slope drains can be retrofitted on the slopes of the existing dredge cells at terrace elevations (approximately) 775, 783, and 795 on three sides. In addition, a toe drain is proposed to intercept seepage at the base of the slope in the ditch adjacent to Swan Pond Road (Detail A73 on 10W425-73 depicts this installation). Initially, the underdrain will be constructed along the dike (original Dike B) parallel to Swan Pond Road. This segment will drain to a manhole/lift station installed at the northeast corner of the dredge cells. Effluent collected in the manhole/lift station will be pumped to the main ash pond.

TVA FES is currently evaluating the financial impacts of this and other options for controlling seepage within the existing dredge cell. TVA will make a final determination and discuss with TDEC DSWM prior to TDEC's completion of this permit application. Dredging of wet ash from the ash pond to the existing dredge cells can resume pending review and concurrence by TDEC on the final approach to be taken.

3.1.4 Gypsum Handling Operations and Construction of Phases 2 and 3

Initial Construction of the Phase 2 Expansion

The following discussion is an approximate sequence of activities that will occur in the construction of the Phase 2 expansion. Because the scrubber is not expected to become operational until about FY2009, detailed schedules for construction have not yet been developed. However, this Operation Plan outlines the sequence of construction activities required, and TVA will develop a schedule in concert with Plant Operations staff and TVA Yard Operations/Heavy Equipment Division, the organization that will oversee and implement construction.

The Phase 2 expansion will be initially constructed as shown on the drawings. Detail A65 on 10W425-65 depicts a typical cross-section for construction of the expansion. New weirs will be installed at the southeast corner of the main ash pond, and the existing discharge weirs will be plugged and abandoned in place. The discharge pipes from the weirs will be equipped with valves so that the water level in the ash pond can be temporarily raised to elevation 760 as part of normal dredging operations. A metal spillway will be installed with stoplogs set at elevation 760. The pond can then be raised by closing the valves and allowing the water to rise to elevation 760, where it will overflow into the metal spillway.

In order to maintain the required free water volume, the dredge located in the main ash pond will deepen the western half of the remaining main ash pond area (drawing 10W425-22 and 24). The dredge will discharge this ash in the eastern area of the main ash pond until the elevation of the ash is raised at or above the pond elevation. Trackhoes will also excavate fly ash out of the pond along the western side as ash is continuously sluiced from the plant. This ash will be dried to a moisture content suitable for placement in dry form. Fly ash will be loaded into dump trucks or scrapers and hauled to the Phase 2 construction area. A base of fly ash will be constructed to form the base of the Phase 2 lateral expansion. The QA/QC plan (Appendix I) contains requirements for construction of the base. The base will slope at a grade less that 1% from the existing dredge cells towards the stilling basin. Initially, bottom ash may be used to create access ramps out into the pond to support equipment. Fly ash will be placed in approximately 6-7 inch loose lifts and compacted using compactors and/or other suitable equipment to achieve the required density as described in the QA/QC Plan. Water trucks will provide moisture control to achieve the desired density as well as suppress dust during construction. The boundary of the Phase 2 expansion is set back 200 feet from existing dikes, as was done for the existing dredge cells.

Upon completion of construction of the fly ash base, a drainage filter layer will be constructed on top of the fly ash base. A two and one half-foot thick layer of bottom ash will be placed, with the lower two feet functioning as a drainage layer. The drainage layer will be placed in 6-7 inch thick loose lifts and lightly compacted with a roller. A six-inch layer of fly ash will then be placed on top of the bottom ash and the fly ash will then be mixed with the uppermost six-inches of bottom ash to form a 1-foot thick filter layer. The bottom ash will also be utilized to construct starter dikes to enclose the Phase 2 area to allow later disposal of gypsum, as described in subsequent paragraphs. A testing program was initiated to study the use of existing materials (fly and bottom ash) as drainage and filter media (Boschuk, 2004). This testing program utilized fly and bottom ash samples taken from KIF, as well as gypsum slurry from TVA's Cumberland Fossil Plant (CUF) to evaluate the drainage characteristics each material, to ensure the filter drainage layer will not clog, yet will retain the gypsum particles while allowing water to drain from the stack. Channels will be constructed to allow the facility to receive gypsum sluiced from the dewatering facility without eroding the filter drainage layer. Metal spillways will be installed as shown on the drawings.

Initial Gypsum Placement into Phase 2/Stage 1

Gypsum slurry will be sluiced from the dewatering facility to the Phase 2 expansion area, and allowed to settle. Decant structures (metal spillways) will be installed to maintain the water surfaced at an appropriate level. Because the bottom will slope, initial filling operations may only partially fill Phase 2 area. Construction of the wet cast gypsum dikes will utilize the upstream method of construction. This method has been employed at other TVA plants for gypsum disposal. Trackhoes will excavate the gypsum from the ponded area and stack the gypsum on the outer slope of the bottom ash starter dike. As the outer dike is constructed, a rim ditch and inner dike will be constructed. The outer dike and rim ditch will be constructed around a portion of the periphery of the Phase 2 expansion area, as shown on drawings 10W425-28 through 31, and –34 through -37. A perimeter underdrain will be installed in each 10-foot lift when the outer dikes are raised as shown on drawing 10W425-68. The perimeter drain will be fitted with outlets spaced throughout the circumference of the drain. The drain will be constructed with a nominal one percent slope with the outlets located at low points. After sufficient gypsum is sluiced into the pond, the Phase 2 Area will be subdivided into three distinct ponds, to allow gypsum sluicing operations to continue in one pond while stacking can continue in the inactive pond. The third (center) pond can be used for ash and/or gypsum disposal, once dikes separating the three ponds are completed. The rim ditches surrounding the gypsum disposal ponds will be elevated above the ponded area to allow the coarser-sized particles to settle out in the rim ditch. It is important that the outlet of the rim ditch remain above the level of the pond. The nominal slope of the rim ditch is 0.25 percent (2.5 feet vertical per 1000 feet horizontal). The ditch will be constructed to the dimensions shown on the drawings. Gypsum sluicing will continue to be sluiced into the rim ditch and allowed to decant into the ponded area. The rim ditch can be operated by allowing gypsum to flow along the entire ditch, or the inner wall of the ditch can be breached (sluice cuts) sequentially at various points along the ditch to allow more even distribution of gypsum into the pond. This can be accomplished by plugging existing sluice cuts, and opening new ones opened sequentially throughout the length of the ditch. Another option would be to allow gypsum entry at both the north and south ends of the gypsum area. At the completion of the Stage 1 dikes, the nominal elevation will be 780, less the thickness of the final cover, expected to be between one and one-half and two feet thick.

As an alternative to the rim ditch operation, TVA can provide multiple ports to introduce gypsum along various points along the periphery of the Phase 2 expansion.

Dike Raising in Phase 2/Stage 2

After a sufficient amount of gypsum is placed in the pond, the outer dike of the entire Phase 2 area will be raised in five-foot increments along with the rim ditch and inner dike until the top of the dike is at elevation 810, as shown on 10W425-38 through 41. The metal spillways will be raised and rim ditching activities will continue. After the invert elevation of the rim ditch is above elevation 780, the rim ditch can be constructed completely around the periphery of both gypsum ponds A&B. The subsequent operations will involve continued gypsum sluicing into the pond through the rim ditch and construction of divider dikes to maintain three separate ponds. Ash or gypsum can be dredged into the center area.

After the wet-cast outer dikes have been raised to approximately elevation 790, TVA may decide to sluice fly ash into Phase 2, or continue to sluice into the existing dredge cells and Phase 1 until they are filled. Fly ash will be sluiced into the center pond cell for fly ash disposal. This will ensure that gypsum is segregated from the fly ash so that pure gypsum can be utilized for construction of the wet cast outer dikes.

Dike Raising in Phase 2/Stage 3

Stage 3 operations for Phase 2 will likely transition into Phase 3 development, because Gypsum Area B continues to shrink in area due to dike raising. This is evident from examining the plan drawings for the various stages, as well as the cross section shown on 10W425-63. For continued operation of Phase 2 without Phase 3, Gypsum Area A will have to be subdivided to maintain separate filling and dike raising activities. The exact sequence of this transition depends on the ultimate rate of gypsum production from the scrubber, the ability of TVA to market gypsum at KIF, and also the ability to market fly and/or bottom ash. The decision as to when to build Phase 3 will also depend on the need for additional fly ash disposal capacity versus the production of gypsum. For instance, if 50 percent of gypsum is marketed over a consistent timeframe, construction of wet cast outer dikes may not keep pace with ash production.

Alternative internal configurations for separate or combined gypsum and ash disposal are currently being studied by TVA FES and Yard Operations group, in an effort to simplify operational aspects yet allow a flexible disposal facility capable of managing differing waste streams and volumes.

Dike Raising in Phase 3/Stages 1-3

Construction and operation of Phase 3 will be accomplished in a manner similar to that previously discussed for Phase 2. Gypsum disposal areas are located along the outer dike to provide wet gypsum for stacking operations. The only difference is that once Phase 3 is under construction, the plant will have had to convert to dry fly ash disposal due to the loss of free water volume from the ash pond. Dry fly ash can be stacked by using dump truck or scrapers and dozers. Material will be placed in thin lifts and compacted using vehicular traffic from hauling operations. Supplemental compaction can be provided if necessary to obtain the desired compactive effort, which is 90 percent standard proctor density as a minimum.

Subsequent Dike Raising and Stages 4 Through 6

Wet cast dikes will continue to be raised in 5-foot increments, and will be fitted with the peripheral underdrain system, as shown on 10W425-68. At every 30 feet in vertical elevation, the dikes will be constructed with a 15-foot wide (after final cover construction) bench for stability and equipment access.

At 60-foot intervals (nominal elevations 840 and 900), bottom ash horizontal blanket drains will be constructed to provide vertical and lateral drainage within the stack and to keep the phreatic surface as low as possible within the stack. The blanket drains will tie to the perimeter drain, and cross sections for stack development are shown on drawings 10W425-62 through 10W425-64.

3.1.5 Fly Ash Disposal in Phases 2 and 3

Phases 2 and 3 have been designed to dispose of fly ash only, if TVA decides not to dispose of gypsum within the dredge cell area expansion. Briefly, Phase 2 can be constructed in a similar manner described for dike raising and operation of the existing dredge cells and Phase 1. Ash can be disposed of in Phase 2 up to elevation 870. At that point, Phase 3 must become operational and dry fly ash disposal would begin. Dry fly ash only must be placed above elevation 870.

3.2 Covering Program

3.2.1 Daily and Intermediate Cover

No daily or intermediate cover will be required for this facility. The fly ash and gypsum are inert, physically stable, do not biodegrade, and do not attract animals. Therefore, vector control is not needed.

3.2.2 Final Cover

Final closure of the disposal facility will be undertaken as described in the Closure Plan for this facility (Parsons E&C, 2004a). Drawing 10W425-48, 49, and 58-61 depict final closure contours (including the thickness of the final cover). The fill contours of the ash are at 1.5 to 2 ft below the contours shown.

The final cover will consist of a one foot layer of low-permeability soil compacted to achieve a maximum hydraulic conductivity of 1×10^{-6} cm/s overlain by a one foot thick soil layer suitable for sustaining vegetation, as shown on drawing 10W425-74, if a compacted clay liner is constructed. Another option for the final cover consists of the following components (see drawing 10W425-75) placed on top of the final ash and/or gypsum grade: 1) a low density polyethylene geomembrane, 40 mil thick; 2) a geocomposite drainage layer (consisting of an extruded polyethylene net heat bonded on both sides to a non-woven, needle punched geotextile); 3) a one foot thick layer of soil placed above the geocomposite drainage layer; and 4) a one-half ft thick vegetative soil layer. Material and installation specifications geocomposite materials for the final cover are included as Appendix J to this document.

The design of the final cover meets or exceeds the requirements contained in TDEC Policy Memorandum SW-93 (formerly Policy Memorandum SW-91-2) for coal ash disposal facilities. TVA can obtain soil for the low-permeability soil layer construction from suitable, on-reservation borrow areas. The vegetative soil layer will also be constructed using locally available soil from the KIF TVA reservation, or from off-reservation material provided the soil meets the requirements contained in the drawings. Upon placement of the vegetative layer, the soil will be prepared and seeded using the appropriate methods outlined in Appendix B. Additional provisions for quality assurance and quality control are contained in the QA/QC plan for this facility (Parsons, 2004b).

3.3 Operating Equipment

Operating equipment for ash disposal operations is as follows:

- long-reach track-hoes (excavators);
- Hydraulic dredge. The dredge pump is a 14-inch discharge trash pump rated at 15,000 gpm;
- bulldozers;
- scrapers (pans);
- water trucks.

Ash is sluiced from the powerhouse with solids content approximately 60 to 70 percent. TVA currently conducts dredging with in-house dredging operations. TVA may also supplement disposal operations by contracting with a private company. TVA can provide additional equipment within 24 hours for disposal operations in the event of equipment breakdown.

Operating equipment for gypsum stacking operations consists of:
- long-reach trackhoes;
- bulldozers;
- water trucks.

Gypsum will be sluiced to the dredge cell expansion area using pumps located at the proposed dewatering facility. The solids content of gypsum sluice will be approximately 30 percent.

3.4 Dust and Litter Control

Litter control is not applicable to this disposal facility. Ash will not generate litter. During normal dredging operations, dust will not be generated. If fly or bottom ash is hauled to the facility for disposal at any time, dust control measures are provided at the JOF to prevent a nuisance to adjacent landowners and TVA employees/operations. Water will be used for providing dust suppression when needed. No oil or other chemical substances will be used for dust suppression. Temporary soil cover may be used as needed for dust control. Chemical binding agents, such as Soil Cement or Posi-Shell, may also be used as needed.

3.5 Erosion Control

This site is an existing ash pond and construction of the dredge cell expansion will occur within the pond itself. Therefore, all runoff is directed to the existing stilling basin. Storm water controls to be utilized during construction and operation of the dredge cell lateral expansion are limited to the northeast area where runoff is diverted offsite. Otherwise, stormwater controls used to prevent erosion of soils (i.e., silt fences, etc) are not required during the construction and operation phase of this project. However, during closure activities, when soil is brought to the site for final cover construction, erosion controls may be utilized to reduce sediment loading to the stilling basin, as described in Appendix H.

3.6 Leachate Control and Management System

A mantle of predominantly alluvial soils generally lies above the bedrock in the ash pond area, as described in Appendix E. Soil thickness is highly variable, ranging from about 5 feet along a portion of the northern perimeter of the site to a maximum of 65 feet on the western boundary. The alluvial deposits are unconsolidated and lenticular, and consist of clay, silt, and sand with occasional gravel. A thin layer of residuum is occasionally present directly above the bedrock. The residuum is composed of clay and silt with weathered shale fragments.

The ash and ash-soil fill materials present above the alluvium/bedrock ranged up to 70 feet in thickness at the time Appendix E was prepared (June 1995). Presently the thickness ranges up to 90 feet in thickness, as ash has continued to be dredged into the dredge cells. The construction of the new facility will incorporate blanket drains which will collect and channel drainage from within the stack area. Based upon the results and conclusions presented in the Hydrogeologic Evaluation Report dated June 1995 (Report No. WR28-2-36-124) and submitted as Appendix D of the Dredge Cell Closure Plan, it is anticipated that the development and closure of the proposed dry fly ash and gypsum stacks will ultimately result in a significant reduction of leachate quantity from current conditions. The Hydrogeologic Evaluation Report dated June 1995 (Report No. WR28-2-36-124) is being revised and will address this issue more thoroughly.

3.7 Safety Precautions

Ash from the KIF is a by-product produced by the combustion of coal, and therefore poses no threat as a potential fire hazard. Gypsum likewise is an inert material derived from limestone used in the scrubber process, and also poses no threat as a potential fire hazard. However, properly maintained fire suppression equipment will be provided for all ash disposal equipment and vehicles. This will consist of fire extinguishers of the size and type required extinguish the type of fire that may potentially occur in the types of equipment and vehicles required for conducting disposal operations.

3.8 Personnel Facilities

The following personnel facilities are available at the KIF plant site:
- A utility building is on-site for equipment maintenance and yard operations personnel that is accessible by any facility personnel and has adequate screening, heating facilities, and lighting.
- Safe drinking water.
- Sanitary hand-washing facilities.
- Toilet facilities.
- A two-way radio and/or telephone for communications.
- A first aid kit.

All of the above services and facilities are readily available for operations personnel at the KIF.

3.9 Containment of Explosive Gas

Gas collection for coal combustion ash disposal facilities is not applicable per DSWM Policy, February 27, 1991, Item 3 (Appendix C).

3.10 Surface Water Management System

The surface water management system for final closure is depicted on drawings 10W425-48, 49 and 58 through 61. Drawing 10W425-77 depicts an overall view with references to ditch details. During operations, all storm water and dredge water will collect and discharge through a temporary metal spillway to the sediment pond. When sediment within the sediment pond accumulates to the clean-out elevation shown on the drawings, it will be removed and disposed as directed by TVA. The KIF currently discharges various effluents generated during plant operations under NPDES permit number TN0005452 DSN001. Ash pond effluent is discharged from the disposal facility to the Stilling Basin, then through 36-in diameter and 24-in diameter pipes through an NPDES permitted outfall. The outfall was recently modified to include a sparger system recently constructed as part of the SCR modifications at KIF.

3.10.1 Existing Dredge Cell Surface Water Management System

The existing dredge cells are constructed with outer dikes consisting of a mixture of bottom and fly ashes. The exterior dikes form the interior dredge cells. Temporary spillways are constructed as shown on 10W425-27 and 27 to control the height of water over dredged ash, and maintain the maximum water surface within the cell below the elevation of the outer dikes.

The exterior portion of the existing dredge cells are constructed with terrace ditches every 30 feet in vertical height. Terrace ditches are sloped from high to low elevation, and riprap-lined let down channels are provided as shown on 10W425-48 and 49, to allow surface water to drain to collector channels at the base of the dredge cells, and on to the main ash pond and stilling basin.

3.10.2 Phase 1 Lateral Expansion Surface Water Management System

The same concept used for the existing dredge cells will be applied to the Phase 1 Lateral Expansion. The initial dike will be constructed to elevation 780, and ash dredged inside. Temporary spillways will be utilized to maintain the surface water level below the elevation of the top of dike. As the cells are filled, the outer dikes will be raised using a mixture of bottom and fly ashes. Terraces will be constructed every 30 feet in height, and drainage channels constructed to convey stormwater to low point along the terrace ditches.

3.10.3 Phase 2 Lateral Expansion Surface Water Management System

After completion of the initial Stage 1 dike construction to elevation 775, dredging activities for gypsum disposal for the lateral expansion will commence, and the temporary spillway will be abandoned or removed, and constructed (or relocated) as shown on drawings 10W425-28-31. A temporary let down channel will be constructed to receive discharge from the temporary metal spillway to prevent erosion of the dike slope constructed for Stage 1. Wet gypsum stacking operations will raise this dike to elevation 780 to complete Stage 1 dike construction. As the Stage 1 dredging operation is completed, the initial Stage 2 dike will be constructed using the wet cast method of construction. This process will be repeated for subsequent stages. Terraces will be constructed at the beginning of each new stage, as discussed earlier. The terraces will be graded to covey storm water to additional let down channels away from dredging operations.

Drawings 10W425-48, 49, and 58-61 show the final configuration of the closed facility, including drainage features. Terrace ditches will covey storm water from the uppermost portion of the facility to the base of the facility by use of riprap-lined letdown channels, and on to the stilling basin. Surface water drainage was designed in accordance with Rule 1200-1-7, and calculations are included in Appendix D.

4 PLANNED GROUNDWATER MONITORING PROGRAM

4.1 Compliance Monitoring Boundary and Monitoring Program

The groundwater compliance monitoring boundary is defined by the segment of the ash pond area perimeter lying between the three down-gradient monitoring wells. The approximate location of the groundwater monitoring wells is shown on 10W425-26-33, and in Appendix E. The approach to the detection groundwater monitoring program is a conventional program of monitoring one up-gradient and three down-gradient wells. The up-gradient monitoring well is 16A. The down-gradient monitoring wells are 4B, and 6A, and 13B. Other wells that have been monitored groundwater levels include 13A, 13B, 16B, and 6B. Construction logs for all wells constructed for this facility are in Appendix E.

4.2 Detection Monitoring Program

4.2.1 Monitoring Well Design and Construction

All monitoring wells for this facility were installed, developed, and sampled previously prior to submittal of the Closure/Post Closure Plan for the existing dredge cells. Monitoring wells were drilled with hollow stem auger and constructed of two-inch diameter PVC casing. Wells generally have a 10 ft length slotted PVC well screen (0.1 in slots) installed in 11inch diameter boreholes, packed with filter sand and sealed with bentonite and grout. All wells have vented PVC caps, lockable steel outer casing secured in a concrete pad, and are protected with steel bollards set in concrete. Construction logs for monitoring wells are included in Appendix E.

4.2.2 Sampling and Analysis Program

The sampling and analysis program will be conducted at the following frequencies:

Preconstruction – Four independent samples have been collected and analyzed from each monitoring well for the constituents listed below. The results are listed in Appendix E.

Operation, closure, and post-closure period – collect and analyze one sample from each monitoring well for the constituents listed below, on a semi-annual basis.

Should a statistically significant increase in constituent concentrations be observed, TDEC will be contacted in accordance with Rule 1200-1-7-.04 (7).

The samples will be analyzed for the following constituents listed in Tables 1 and 2:

Table 1 - Groundwater Parameter List

Field Analyses

Acidity	Dissolved Oxygen
Alkalinity	Temperature
Conductivity	pH
Depth to Water	ORP

Laboratory Analyses - Unfiltered samples

ICP2: Copper, zinc;
ICP: Barium, beryllium, silver, vanadium;
GFAA: Antimony, arsenic, cadmium, chromium, cobalt, lead, nickel, selenium, thallium;
OTHER: Fluoride, mercury.

Table 2 - Analytical Methods For Specific Parameters

Parameter	Instrument	Method
Fluoride	ISE	1-EPA 340.2
Ag, Ba, Be, Cu, V, Zn	ICP	2-EPA 6010B
As	ICP-MS	2-EPA 6020
Sb	ICP-MS	2-EPA 6020
Cd	ICP-MS	2-EPA 6020
Co	ICP-MS	2-EPA 6020
Cr	ICP-MS	2-EPA 6020
Pb	ICP-MS	2-EPA 6020
Se	ICP-MS	2-EPA 6020
Tl	ICP-MS	2-EPA 6020
Ni	ICP-MS	2-EPA 6020
Hg	CVAA	2-EPA 7470A

Method Key

Code	Reference
1-EPA	Methods for Chemical Analysis of Water and Wastes, EPS-600/4-79-020, Revised March 1983.
2-EPA	Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW-846, Revision 3, May, 1997.

Samples will be collected according to procedures detailed in TVA's Quality Assurance Procedure *Groundwater Sample Collection Techniques* (See Appendix F). It contains requirements for sample collection, preservation, shipment, chain of custody, and quality assurance and quality control.

4.2.3 Recordkeeping and Reporting

Results for each sample, including analysts' initials, date of analysis, and method number for each parameter will be reported. Records of compliance groundwater sample results will be kept at the facility. Results will be submitted to the Tennessee Division of Solid Waste Management within 30 days after all analyses are completed.

5 ENVIRONMENTAL PROTECTION STATEMENTS

5.1 Floodplain

This facility is not in a 100-year floodplain. The toe of the outermost slope adjacent is elevation XXX. The 100-year flood elevation taken from TVA data is 746 feet above mean sea level, and is lower than the top of the outer dike (elevation 765).

5.2 Other Environmental Impacts

Because construction activities on this project would occur within the existing footprint of the ash pond, which is sufficiently removed from the Clinch River/Watts Bar Lake and Emory River, as well as any tributary streams, there would be no adverse impacts to sensitive aquatic animals from this proposed project. Environmental impacts to groundwater are addressed in Appendix E.

The construction of this lateral expansion of the dredge cells and the associated operational activities are not expected to have negative effects on any federal- or state-listed plant species or sensitive habitat for such species.

6 RANDOM INSPECTION PROGRAM

A random inspection program for this facility is not required. This is because the disposal facility will only dispose of ash and gypsum from TVA facilities. In addition, minor quantities of bottom ash (for use in constructing drainage filters and gypsum from BRF may be co-disposed with KIF waste streams, in the event additional bottom ash is needed for KIF, or due to lack of disposal space at BRF. Therefore, a random inspection program for unauthorized wastes is not required. See DSWM Policy, February 27, 1991 Item 5 (Appendix C).

7 CLOSURE AND POST CLOSURE

Closure and post-closure provisions for this facility are discussed in the Closure Plan (Parsons, 2004a) appended to this Operations Manual (see Appendix H).

8 QUALITY ASSURANCE/QUALITY CONTROL

Quality assurance and quality control for construction and closure of this facility are addressed in the Quality Assurance and Quality Control Plan for the KIF Dredge Cell Lateral Expansion Quality Assurance and Quality Control Plan (Parsons, 2004b) appended to this Operations Manual (see Appendix I).

9 REFERENCES

Parsons2004a, *Closure/Post-Closure Plan Dredge Cell Lateral Expansion, Kingston Fossil Plant*, June 2004

Parsons2004b, *Construction Quality Assurance/Quality Control Plan, Closure Plan Dredge Cell Lateral Expansion, Kingston Fossil Plant*, June 2004

TVA 2004, *Kingston Fossil Plant Hydrogeologic Evaluation of Dredge Cell Lateral Expansion*, River System Operations and Environment, Norris, TN (Currently being prepared for delivery to TDEC in July 2004).

Boschuk, John 2004, *TVA Kingston Fossil Plant - Dredge Cell Lateral Expansion - Bottom Ash Filter Drain Study, JLT Laboratories*

APPENDIX A

Ash and Gypsum Testing

Lab Sample Number :92/01018 Project Leader :David M. Varnell

Sample ID Information :KIF-92-1
Sample comments :KINGSTON DREDGED ASH
Sample type/matrix :WASTE
Sample login date :920129 Sample received by lab :920128
Sample account number :8616-767000-X1340H

Alt. IDC	Analysis Performed	result	units
D004'AS	Arsenic, TCLP Extract	230.	ug/L
D010'SE	Selenium, TCLP Extract	11.	ug/L
D006'CD	Cadmium, TCLP Extract	5.	ug/L
D008'PB	Lead, TCLP Extract	25.	ug/L
D007'CR	Chromium, TCLP Extract	5.	ug/L
D005'BA	Barium, TCLP Extract	2100.	ug/L
D011'AG	Silver, TCLP Extract	< 10.	ug/L
D009'HG	Mercury, TCLP Extract	< 2.0	ug/L
TCLP'MET	Tox. Char. Leach. Metals	02/04/92	
RES'RCRA	Residue, RCRA Waste	980000.	mg/L
PH'RCRA	pH on RCRA Waste	7.6	pH Units

KINGSTON FOSSIL PLANT
ASH ANALYSIS

CHEMICAL ANALYSIS	FLY ASH 01/10/92 UNIT 5	FLY ASH 03/10/88 UNIT 7	FLY ASH 02/19/81 UNIT 6
SiO2	49.45	69.29	55.73
Al2O3	27.83	17.01	26.19
Fe2O3	13.16	7.15	6.53
CaO	2.29	1.2	2.72
MgO	0.88	1.66	1.11
SO3	0.03	0.36	0.29
Na2O	0.74	0.12	
K2O	2.32	1.2	
L.O.I.	5.35	0.04	

KINGSTON FOSSIL PLANT
BY-PRODUCT TCLP ANALYSIS

PARAMETER	DRINKING WATER STANDARD	TCLP BOTTOM ASH 12/90 5-SAMPLES	TCLP DREDGED ASH 03/92 KIF-92-1	TCLP FLY ASH 10/93 KFP FA 93
ARSENIC, (mg/L)	0.05	<0.05	0.23	2.2
BARIUM, (mg/L)	1	0.31-0.91	2.1	0.72
CADMIUM,(mg/L)	0.01	<0.01	0.005	0.001
CHROMIUM,(mg/L)	0.05	<0.01	0.005	<0.01
LEAD, (mg/L)	0.05	<0.05	0.025	0.002
MERCURY, (mg/L)	0.002	<0.0005	<0.002	<0.0002
SELENIUM, (mg/L)	0.01	<0.01	0.011	0.049
SILVER, (mg/L)	0.05	<0.01	<0.01	<0.01
pH		7.6		

Data Report Number: 020531-73830
Report of Results: Environmental

TENNESSEE VALLEY AUTHORITY
CENTRAL LABORATORIES SERVICES
1101 Market Street, PSC 1B-C
Chattanooga, Tennessee 37402-2801
Phone: (423) 697 - 4318 • Fax: (423) 697 - 4137

Shipping Address:
Chickamauga Power Service Center
North Side Chickamauga
Reservation
Chattanooga, Tennessee 37415

Customer Address: Kathy Harper
LP 5H-C
Phone: 751-2634
Fax : 751-6619
E-Mail: kharper@tva.gov
Location Code: MISC
Field ID: 257745
Sample Description: CUF SCRUBBER GYPSUM FROM POND

Sample ID: AC04193 **LRF ID:** 02020235
Matrix: Solids **Reg:** RCRA
Date Collected: 02/05/2002
Time Collected: 0:00 EST
Date Received: 02/05/2002
Time Received: 10:40
Project Manager: Pamela L. Whitt

Analyte	CAS Number[1]	Result	Units	MDL[2]	Analysis Date	Analysis Time	Analyst	Method Reference
Barium, TCLP Extract	7440-39-3	0.036	mg/L	0.01	03/02/2002	16:17	LRP	EPA 6010B
Cadmium, TCLP Extract	7440-43-9	< MDL	mg/L	0.005	03/02/2002	16:17	LRP	EPA 6010B
Chromium, TCLP Extract	7440-47-3	< MDL	mg/L	0.05	03/02/2002	16:17	LRP	EPA 6010B
Lead, TCLP Extract	7439-92-1	< MDL	mg/L	0.05	03/02/2002	16:17	LRP	EPA 6010B
Silver, TCLP Extract	7440-22-4	< MDL	mg/L	0.01	03/02/2002	16:17	LRP	EPA 6010B
Mercury , TCLP Extract	7439-97-6	< MDL	mg/L	0.002	03/02/2002	14:19	ALB	EPA 7470
Aluminum, Total	7429-90-5	140	mg/Kg	5.0	03/04/2002	14:15	LRP	EPA 6010B
Antimony, Total	7440-36-0	< MDL	mg/Kg	10.0	03/04/2002	14:15	LRP	EPA 6010B
Barium, Total	7440-39-3	11	mg/Kg	1.0	03/04/2002	14:15	LRP	EPA 6010B
Beryllium, Total	7440-41-7	< MDL	mg/Kg	0.1	03/04/2002	14:15	LRP	EPA 6010B
Cadmium, Total	7440-43-9	< MDL	mg/Kg	0.5	03/04/2002	14:15	LRP	EPA 6010B
Calcium, Total	7440-70-2	220000	mg/Kg	10.0	03/04/2002	14:15	LRP	EPA 6010B
Chromium, Total	7440-47-3	< MDL	mg/Kg	5.0	03/04/2002	14:15	LRP	EPA 6010B
Cobalt, Total	7440-48-4	< MDL	mg/Kg	5.0	03/04/2002	14:15	LRP	EPA 6010B
Copper, Total	7440-50-8	1.6	mg/Kg	1.0	03/04/2002	14:15	LRP	EPA 6010B
Iron, Total	7439-89-6	300	mg/Kg	1.0	03/04/2002	14:15	LRP	EPA 6010B
Lead, Total	7439-92-1	< MDL	mg/Kg	5.0	03/04/2002	14:15	LRP	EPA 6010B
Magnesium, Total	7439-95-4	2500	mg/Kg	1.0	03/04/2002	14:15	LRP	EPA 6010B
Manganese, Total	7439-96-5	11	mg/Kg	0.5	03/04/2002	14:15	LRP	EPA 6010B
Molybdenum, Total	7439-98-7	< MDL	mg/Kg	2.0	03/04/2002	14:15	LRP	EPA 6010B
Nickel, Total	7440-02-0	< MDL	mg/Kg	5.0	03/04/2002	14:15	LRP	EPA 6010B
Silver, Total	7440-22-4	< MDL	mg/Kg	1.0	03/04/2002	14:15	LRP	EPA 6010B
Strontium, Total	7440-24-6	280	mg/Kg	5.0	03/04/2002	14:15	LRP	EPA 6010B
Tin, Total	7440-31-5	< MDL	mg/Kg	5.0	03/04/2002	14:15	LRP	EPA 6010B
Titanium, Total	7440-32-6	< MDL	mg/Kg	0.5	03/04/2002	14:15	LRP	EPA 6010B
Vanadium, Total	7440-62-2	< MDL	mg/Kg	1.0	03/04/2002	14:15	LRP	EPA 6010B
Zinc, Total	7440-66-6	11	mg/Kg	1.0	03/04/2002	14:15	LRP	EPA 6010B
Arsenic, Total	7440-38-2	< MDL	mg/Kg	10.0	03/04/2002	14:15	LRP	EPA 6010B
Selenium, Total	7782-49-2	< MDL	mg/Kg	10.0	03/04/2002	14:15	LRP	EPA 6010B
Thallium, Total	7440-28-0	< MDL	mg/Kg	10.0	03/04/2002	14:15	LRP	EPA 6010B
Lithium, Total	7439-93-2	0.8	mg/Kg	0.5	04/10/2002	14:40	ALP	
Selenium, TCLP Extract	7782-49-2	< MDL	mg/L	0.001	04/10/2002	22:21	ALP	EPA 7740
Asrenic, TCLP Extract	7440-38-2	0.0082	mg/L	0.001	04/10/2002	8:44	ALP	EPA 7060A
Mercury, RCRA Total	7439-97-6	0.10	mg/Kg	0.1	04/25/2002	15:06	ALB	EPA 7470

[1] Chemical Abstracts Service Registry Number [2] Method Detection Limit

TVA

TENNESSEE VALLEY AUTHORITY
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Customer Address: Kathy Harper
LP 5H-C
Phone: 751-2634
Fax : 751-6619
E-Mail: kharper@tva.gov

Location Code: MISC

Field ID: 257745

Sample Description: CUF SCRUBBER GYPSUM FROM POND

Sample ID: AC04193 **LRF ID:** 02020235

Matrix: Solids **Reg:** RCRA

Date Collected: 02/05/2002

Time Collected: 0:00 EST

Date Received: 02/05/2002

Time Received: 10:40

Project Manager: Pamela L. Whitt

Analyte	CAS Number[1]	Result	Units	MDL[2]	Analysis Date	Analysis Time	Analyst	Method Reference

Sample Comments: No collection date or time documented. Received date used.

[1] Chemical Abstracts Service Registry Number [2] Method Detection Limit

Environmental Chemistry Laboratory data report number 020531-73830 was electronically approved using Labworks Enterprise Version 4.6, Build 253 on 05/07/2002 at 15:19 by Pamela L. Whitt.

Vanessa L. Ramey, Lab Director
Pamela L. Whitt, Project Manager
Scott R. McNabb, Project Manager
Lisabeth R. Pearson, Quality Assurance Specialist
Ricardo I. Gilbert, Senior Analytical Chemist

This report contains sample results for the following samples, Login Reference File number: 02020235

AC04193

[1] Chemical Abstracts Service Registry Number [2] Method Detection Limit

CUF gypsum

COMMERCIAL TESTING & ENGINEERING CO.

GENERAL OFFICES: 1919 SOUTH HIGHLAND AVE., SUITE 210-B, LOMBARD, ILLINOIS 60148 • TEL: 630-953-9300 FAX: 630-953-9306

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SGS Member of the SGS Group (Société Générale de Surveillance)

ADDRESS ALL CORRESPONDENCE TO:
4665 PARIS STREET
SUITE B-200
DENVER, CO 80239
TEL: (303) 373-4772
FAX: (303) 373-4791
www.comteco.com

May 30, 2002

TENNESSEE VALLEY AUTHORITY
1101 Market Street PSC 1A
Chattanooga TN 37402
RENEE B. MERRELL

Sample identification by
TENNESSEE VALLEY AUTHORITY

SAMPLE No.: 257745
SAMPLE TYPE: SCRUBBER GYPSUM
REMARKS: SPC

Kind of sample SPC

Sample taken by TENNESSEE VALLEY AUTHORITY

Date received March 5, 2002

Analysis report no. 72-470142

PARAMETER	RESULTS
Calcium, Ca	28.90
Magnesium, Mg	0.51
Acid Insolubles	0.91

Procedure: Acid Insoluble was analyzed per ASTM Volume 04.01, Method C25.

Calcium & Magnesium were analyzed by X-ray Fluorescence Spectrometry.

Results: Results are reported in weight percent (Wt.%), on a dry basis.

NQA ISO9002 REGISTERED COMPANY
Certificate No. 7061/1

Respectfully submitted,
COMMERCIAL TESTING & ENGINEERING CO.

Denver Laboratory

MEMBER ACIL

F-465

TERMS AND CONDITIONS ON REVERSE

cuf gypsum

COMMERCIAL TESTING & ENGINEERING CO.

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May 31, 2002

TENNESSEE VALLEY AUTHORITY
1101 Market Street PSC 1A
Chattanooga TN 37402
RENEE B. MERRELL

SAMPLE No.: 257745
SAMPLE TYPE: SCRUBBER GYPSUM
REMARKS: SPC

Kind of Sample SPC
Date Received March 5, 2002
Analysis report no. 72-470142

PROXIMATE ANALYSIS

	As Received	Dry Basis
% Moisture	9.40	xxxxxx
% Ash	74.84	82.60
% Volatile	9.42	10.40
% Fixed Carbon	6.34	7.00
	100.00	100.00
Btu/lb	< 91	< 100
% Sulfur	14.11	15.57
MAF Btu/lb	575	

ULTIMATE ANALYSIS

	As Received	Dry Basis
% Moisture	9.40	xxxxxx
% Carbon	0.45	0.50
% Hydrogen	1.16	1.28
% Nitrogen	0.03	0.03
% Sulfur	14.11	15.57
% Ash	74.84	82.60
% Oxygen	0.01	0.02
	100.00	100.00

ALYSIS OF ASH	% Weight Ignited Basis
Silica, SiO_2	1.12
Alumina, Al_2O_3	0.33
Titania, TiO_2	0.06
Ferric Oxide, Fe_2O_3	0.17
Lime, CaO	40.48
Magnesia, MgO	0.85
Potassium Oxide, K_2O	0.02
Sodium Oxide, Na_2O	0.05
Sulfur Trioxide, SO_3	56.71
Phosphorous Pentoxide, P_2O_5	0.03
Strontium Oxide, SrO	0.08
Barium Oxide, BaO	0.03
Manganese Oxide, Mn_3O_4	0.07
Undetermined	0.00
Alks. as Na_2O,Dry Coal Basis	0.05
Base:Acid Ratio	27.53
T250 Temperature	2447

Silica Value	2.63
Type of Ash	LIGNITIC
Fouling Index	0.05
% MAF Fixed Carbon	40.23
% MAF Volatile	59.77

NQA
S09002
REGISTERED COMPANY
Certificate No. 7061/1

Respectfully submitted,
COMMERCIAL TESTING & ENGINEERING CO.

Denver Laboratory

MEMBER ACIL

F-465

TERMS AND CONDITIONS ON REVERSE

TVA-00014977

APPENDIX B

TVA Vegetation Specifications

SECTION 580A – Seeding for Gypsum and Ash Disposal Facility Closure

580.1 – Description

This specification consists of furnishing and placing seed, commercial fertilizer, and agricultural limestone on roadway slopes, shoulders, borrow pits, channel banks, waste areas, lawns, meadows, beaches, open play areas, and other areas specified by the plans or the Engineer and in accordance with the methods outlined by these specifications.

580.2 – Materials

1. Seeds

   Seeds shall meet the requirements of applicable seed laws and shall be tested in accordance with the most current edition of the U.S. Department of Agriculture Handbook No. 30, Testing Agricultural and Vegetable Seed. Seeds shall be from the last preceding crop and comply with the requirements outlined below for purity and germination. Each variety of seed shall be furnished in separate, strong bags with each bag being fully tagged or labeled to show the variety, weight, purity, germination, and test data prescribed by law. All test results shall be fully certified by the vendor or by a recognized seed testing agency. TVA reserves the right to require that samples be furnished, and to inspect and test the seeds after delivery. Seeds found not to comply with specification requirements shall be subject to rejection.

When mixing or forming seed mixtures, the seeds shall be carefully and uniformly mixed. Seeds shall not be mixed until each variety of seed to be used in the mix has been inspected and/or tested separately and approved.

580.2 – Materials (Continued)

Rebel Fescue (Festuca arundinacea, variety Rebel)	95	85
Hard Fescue (Festuca ovina, durinuscula)	95	85
Kentucky Bluegrass (Poa pratensis)	95	90
Creeping Red Fescue (Festuca rubra)	95	90
Centipede Grass (Eremochloa ophiuroides)	90	75
eping Lovegrass (Eragrostis curvula)	95	90
Switchgrass (Panicum virgatum)	80	75
Zoysia Grass (Zoysia japonica)	95	80
Little Bluestem Grass (Andropogon scoporius)	40	60
Bahia Grass (Paspalum notatum)	75	80

Seeding materials shall be free from seeds or bulbets of Wild Onion (Allium vineale), Canada Thistle (Cirsium arvense), and Johnson Grass (Sorghum halepense).

Seed species shall not contain more than six seeds per ounce of the seed of any of the following noxious weeds or the seeds of any other weed specifically listed as noxious:

Bindweed (Convolvulus arvensis)
Buckthorn (Plantago lanceolata)
Corncockle (Agrostemmo githago)
Dodder (Cuscuta species)
Oxeyedaisy (Chrysanthemum leucantheumum)
Quackgrass (Agropyron repens)
Sorrel (Rumex acetosella)

Seed species shall not contain an excess of 2 percent by weight of weed seeds, noxious or otherwise.

2. Seed or seed mixtures, rates, and seasons

Seeding mixtures, rates, and seasons shall be those specified herein. The types to be used for each area or project will be specified by the drawing or by memorandum. Mixtures or rates of application other than those specified shall be used only when specified by the plans or the Engineer. Seeding shall be planted during the season and between the dates specified. Temporary cover shall be planted when it is required during seasons not suitable for planting the seed specified by the plans.

a. Lawns

Type 1: Spring or fall seeding (Plant between March 15 and May 1, or between August 15 and October 15).

(1) Kentucky 31 Fescue	120 pounds per acre
(2) Rebel Fescue	120 pounds per acre
(3) Creeping Red Fescue	80 pounds per acre

Type 2: Fall seeding (Plant between August 15 and October 15).

580.2 – Materials (Continued)

Type 3: Spring seeding (Plant between March 15 and May 1).

Bermuda Grass	40 pounds per acre

b. Meadows

Type 4: Spring seeding (Plant between March 15 and May 1).

Mixture:

(1)	Kentucky 31 Fescue	50 pounds per acre
	Alsike Clover	20 pounds per acre
	Total mixture	70 pounds per acre
(2)	Bermuda Grass (hulled)	50 pounds per acre
(3)	Mix Deleted	
(4)	Mix Deleted	
(5)	Crownvetch (inoculated and scarified)	30 pounds per acre
	Kentucky 31 Fescue	30 pounds per acre
	Total mixture	60 pounds per acre

580.2 -- Materials (Continued)

Type 5: Fall seeding (Plant between August 15 and October 15).

Mixture:

(1)	Kentucky 31 Fescue	50 pounds per acre
	White Clover	15 pounds per acre
	Total mixture	65 pounds per acre
(2)	Bluegrass	50 pounds per acre
	White Clover	15 pounds per acre
	Total mixture	65 pounds per acre

c. Channel Banks, Cuts, Fill Slopes, Waste Areas, and Other Disturbed Areas

Type 6: Spring seeding only (Plant between March 15 and May 15).

Mixture:

(1)	Kentucky 31 Fescue	60 pounds per acre
(2)	Bermuda Grass (hulled)	40 pounds per acre
(3)	Creeping Red Fescue (Shaded slopes only)	80 pounds per acre
(4)	Weeping Lovegrass	25 pounds per acre
(5)	Mix Deleted	
(6)	Mix Deleted	

580.2 -- Materials (Continued)

(7)	Crownvetch (scarified and inoculated)	30 pounds per acre
	Kentucky 31 Fescue	30 pounds per acre
	Total mixture	60 pounds per acre
(8)	Bahia Grass	40 pounds per acre
	Bermuda Grass	20 pounds per acre
	Switch Grass	10 pounds per acre
	Total mixture	70 pounds per acre
(9)	Rebel Fescue	40 pounds per acre
	Hard Fescue	10 pounds per acre
	White Clover	5 pounds per acre
	Total mixture	55 pounds per acre

Type 7: Summer seeding (Plant between May 15 and July 15).

Mixture:

(1)	Bermuda Grass (hulled)	50 pounds per acre
(2)	Buffalo Grass	50 pounds per acre

580.2 – Materials (Continued)

Type 8: Fall seeding (Plant between August 15 and October 15).

(1)	Kentucky 31 Fescue	60 pounds per acre
	White Clover	15 pounds per acre
	Total mixture	75 pounds per acre
(2)	Hard Fescue	10 pounds per acre
	Rebel Fescue	40 pounds per acre
	White Clover	5 pounds per acre
	Total mixture	55 pounds per acre
(3)	Rebel Fescue	40 pounds per acre
	Hard Fescue	10 pounds per acre
	White Clover	5 pounds per acre
	Total mixture	55 pounds per acre

d. Highway Shoulders

The planting dates and seed mixtures for each type listed here are described above.

Type 6: Spring seeding [Mixture (1), (2), (3) or (9)]

Type 7: Summer seeding [Mixture (1) or (3)]

Type 8: Fall seeding [Mixture (2)]

e. Temporary Cover

Type 9: Temporary winter seeding (Plant between October 15 and March 15).

Type 10: Temporary summer seeding (Plant between May 1 and August 15).

Mixture:

(1)	Foxtail Millet	40 pounds per acre
(2)	Red Clover	20 pounds per acre
	Weeping Lovegrass	10 pounds per acre
	Total mixture	30 pounds per acre

3. Fertilizer

Fertilizers shall be those readily available commercially. The application of fertilizer shall be at a rate of 200 pounds Ureaform (38-0-0) per acre with either 400 pounds of 15-15-15 per acre or 600 pounds of 6-12-12, unless specified otherwise by the drawings or memorandum.

Ammonium nitrate (NH_4NO_3) may be used for supplemental fertilization when specified by the Engineer.

4. Agricultural Limestone

Limestone shall contain no less than 85 percent calcium carbonate by weight. It shall be crushed so that at least 85 percent will pass a No. 10 sieve. The application of limestone shall be at the rate of 2 tons per acre unless specified otherwise by the drawings or memorandum. Hydrated lime may be substituted at a rate of 1 ton per acre.

580.3 -- Topsoil

All lawn areas to be seeded shall have a 2-inch minimum depth of topsoil immediately below finish grade. Topsoil requirements for other areas, if any, will be determined by field inspection and shall comply with FP-96 Section 624.

580.4 -- Soil Preparation

Areas to be seeded shall have approved cross sections and grades. Objects such as large roots, stones, stumps, coarse vegetation, debris, or any other items that might impede mechanical mowing shall be removed and disposed of satisfactorily.

Seedbeds shall be plowed, disked, harrowed, scarified, or cultivated to the approved depth. In areas where it is practical, this work shall be done with farm-type equipment. On steep slopes, preparation of seedbeds shall be done with the tools and methods specified by the Engineer. It is strongly recommended that scarifying and preparation on cut and fill slopes be accomplished with tools or equipment specially designed for this purpose. Small furrows or grooves formed in the slopes shall be horizontal or as nearly horizontal as practical. The work shall be performed only when the ground is in a workable and tillable condition as determined by good farming practices.

580.5 -- Special Hydroseeding Equipment

Equipment to be used for the hydraulic application of planting materials shall be a Finn Hydro-Seeder, Bowie Hydro Mulcher, Toro Environmental Control Unit, or an approved equal. The equipment shall have mixing tanks with built-in -itators having operating capacities sufficient to agitate, suspend, and homogenously mix slurries of water and planting .erials. Tanks shall have capacities of 1000 gallons or more, and shall be mounted on traveling units that can be either self-propelled or towed by a separate vehicle. The slurry distribution lines shall be large enough to prevent clogging or stoppage. Discharge lines shall be equipped with sets of different sized hydraulic spray nozzles capable of providing for even distribution of varying slurry mixtures on areas to be seeded. Slurry mixture rates are described in Section 580.6.

580.6 -- Seeding Methods

Seeds shall be sown with approved mechanical power-drawn drills or seeders, hand cyclone seeders, or with special hydroseeding equipment. Rates specified in Section 580.2 shall be maintained in a manner that will guarantee uniform coverage. Seeding operations shall not be performed when drought, high winds, and excessive moisture or other factors may defer satisfactory results.

On slopes where the use of drills or seeders is not practical and in other areas specified by plans or by memorandum, seeding shall be accomplished using hydroseeding equipment.

Drill seeding shall be performed in rows with spacing suitable for the type of seed or mixture used. Fertilizer may be drilled simultaneously if drills are equipped for this type of operation. Where fertilizer is not drilled, it may be applied during the cultivation operation described in Section 580.4. When fertilizer and seed are applied separately, the fertilizer shall be spread uniformed over the prepared seedbeds prior to final filling. Rates of application shall be those specified by the plans or the Engineer or those specified in this section. It shall be thoroughly mixed with soil for a depth of 1/2-inch.

Care shall be taken to ensure that seed and fertilizer remain uniformly and thoroughly mixed in the seeding equipment. Additional mixing shall be performed if necessary to avoid segregation of the seed or seed and fertilizer.

580.6 -- Seeding Methods (Continued)

Hydroseeding is the method of applying lime, fertilizer, seed, and mulch combined with water in a single operation. Using the equipment described in Section 580.5, mixing tanks shall be filled with water to the level indicated inside of the tanks. With the engines turned on and the agitators running, the following materials shall be added: (1) limestone at the specified rate of 1/5 per acre (finely ground); (2) fertilizer; (3) seed (Section 580.2); and (4) wood fiber mulch (FP-96 Section 625), for each 1000 gallons of water. The resulting slurries shall be applied to seedbeds at a rate of 5000 gallons per acre.

en hydroseeding slopes are 2:1 or steeper, a vinyl or plastic mulch (FP-96 Section 625) shall be added to the slurries at ue rate specified by the manufacturer.

Discharge lines are activated by opening bypass valves with hand levers that allow the slurries to spray through the nozzles. Slurries shall be sprayed on the seedbeds as the spraying vehicles move slowly across the area. Care shall be taken to ensure that all areas are evenly covered. If wind or rough terrain causes skips to occur, additional applications shall be made before moving to other areas. To provide for the even distribution of a slurry, hydroseeding should be performed with the wind or preferably with no wind at all.

For steep slopes, even coverage is best obtained when an application is begun at the top and worked down a slope with successive overlapping passes. When a hydroseeder is located on top of a slope, the reverse is true.

Seed not sown by drills or hydroseeders shall be covered to a depth of approximately 1/4-inch by lightly harrowing or raking. Raking or harrowing shall follow contours as closely as practical.

Where mulching is to be done, the mulch shall be applied immediately after the seeding is completed to avoid the loss of soil moisture or possible erosion. Mulching shall comply with FP-96 Section 625.

When specified by the Engineer, one or more applications of fertilizer shall be made after a stand of grass has been obtained and allowed to grow for a period of from 3 to 6 weeks. The grade and rate of application of the fertilizer will be specified by the Engineer. When ammonium nitrate or a similar soluble fertilizer is used alone, areas shall be thoroughly soaked as soon as an application is completed.

580.7 -- Maintenance

Seeded areas shall be maintained until a satisfactory cover of plant material is secured, unless stipulated otherwise. All areas shall be preserved, repaired, and protected as specified for this purpose. Areas having poor stands of plant material shall be seeded again and fertilized at the proper rates.

Watering shall be accomplished during the maintenance period to the extent necessary.

580.8 -- Method of Measurement

ded areas will be measured in square yard units and include the seeded areas along slopes.

APPENDIX C

DSWM Policy Memorandum SW-91-2

TENNESSEE DEPARTMENT OF ENVIRONMENT AND CONSERVATION

DIVISION OF SOLID WASTE MANAGEMENT

DATE: February 27, 1991

TO: DSWM Staff

FROM: Tom Tiesler, Director, Division of Solid Waste Management

SUBJECT: Variance Agreement for Fossil Fuel Fly Ash and Bottom Ash Disposal Within a Class II Facility

The purpose of this memorandum is to establish the criteria by which a fossil fuel fly and bottom ash disposal facility will be permitted as a Class II facility with the following variances:

1. The geologic buffer required will be 3 fuel in total thickness with a maximum hydraulic conductivity of 1×10^{-6} cm/sec. The thickness will be measured from the base of the fill to the seasonal high water table of the uppermost unconfined aquifer, or the top of the formation aquifer;
2. No leachate migration control system will be required;
3. No gas migration control system will be required;
4. The final cover shall be 24 inches of compacted soil with a minimum of 6 inches which shall support vegetative cover; and
5. No random inspection program will be required.

Any other variances to the Class II facility permit criteria will require the Commissioner's approval.

POLICY/notebook/93

APPENDIX D

Stormwater And Pond Design Calculations

TVA 30494A [8/95]

PARSONS

CALCULATION COVER SHEET

CLIENT	Tennessee Valley Authority – Fossil Engineering Services
PROJECT	Kingston Fossil Plant – Solid Waste Permit Application for Dredge Cell Lateral Expansion
SUBJECT	Stormwater Calculations
JOB NUMBER	55090501 WBS NUMBER NA
CALCULATION NO.:	

DESCRIPTION/PURPOSE

Design stormwater drainage system to comply with the requirements of the State of Tennessee. The pond is existing but will provide detention for the 25-year storm and can discharge the 100-year storm.

METHOD OF ANALYSIS

Use TR-55 to generate runoff. Use Haestad Methods', "Pondpack" and Flowmaster" to design the system. Design soil erosion and sedimentation control measures in accordance with manuals.

CODES AND STANDARDS

1. " Rules of Tennessee Dept. Of Health and Environment, Chapter 1200-7, Solid Waste Processing and Disposal" Regulations.

INFORMATION SOURCES

1. Design Drawings
2.

ASSUMPTIONS

Contained in body of calculations

CONCLUSIONS OR RESULTS

Ditches are capable of discharging the 25- year 24- hour storm event as required by TDEC rules. The Ash pond and stilling basin are capable of discharging the 100-year storm event.

REV	DATE	DESCRIPTION	PAGES REVISED	PAGES ADDED	PAGES DELETED	BY/DATE	REV/DATE	LDE/DATE
4								
3								
2								
1								
0	6/9/04	ORIGINAL	BY: DRS	REV'D: WPT	——	—/—	—/—	—/—

THIS IS A DESIGN RECORD Form EP3-1 12/96

PARSONS	CLIENT NAME: Tennessee Valley Authority PROJECT NAME:					JOB NO.: 55090501
STANDARD CALCULATION SHEET	SUBJECT: Stormwater Calculations for KIF Dredge Cell Lateral Expansion					CALC NO.:
	REVISION	0	1	2	3	PAGE 2 OF 3
	ORIGINATOR	DRS				
	REVIEWER	WPT				
	DATE:	06/09/04				

STORMWATER DRAINAGE DESIGN CRITERIA

1. Use TR-55 for runoff calculation (Pond Pack version 8).
2. Use the existing stilling basin to detain the 25-year storm event and discharge the 100-year storm event per Tennessee Rule Chapter 1200-7.

STORMWATER DRAINAGE CALCULATIONS

1. General Approach: Design the facility to drain to the south to the existing stilling basin. The vast majority of areas within the outer dikes (at elevation 765) drain to the stilling basin, with exceptions as noted in the calculations. Design perimeter ditches to intercept flow and convey to the stilling basin. Ditches shall be designed with a minimum slope of 0.5% in most cases, with 0.25% slope in one case. The site will be graded so that no run-on is accepted from the adjacent areas.
2. Runoff Curve Numbers: See Attachments 1 and 2 to these calculations.
3. Drainage Areas: See Attachment 3.
4. Time of Concentration and Rainfall Intensity: A time of concentration has been determined for the post development conditions (see Attachment 1). Post developed conditions assume that 3:1 slopes are covered with soil and vegetated, and flatter slopes at the top of the stack (5% and 10% approximately for the existing dredge cell and Phase 2&3 areas respectively) are conservatively assumed to be unvegetated. Ditch flows were calculated using TR-55 with T_c derived from the post-developed watershed model.
5. Letdown Channel and Rock Chute Design: Letdown channels have been designed for a 25-year storm.

List of Attachments:

1 Pond Routing - Pond Pack Version 8 output, including runoff CN, time of concentration calculations to stilling basin, synthetic rainfall generated for the 25 and 100 year storm events. Drawing 10W425-34 F (Attachment 3) depicts the drainage areas used for this model.

2 Ditch Flow Calculations

2.1 Ditch 1 Model for Ditch Flows (Drawing 10W425-34E [Attachment 3] depicts the drainage areas used for ditches)

2.2 Ditch 2 Model for Ditch Flows

2.3 Offsite Ditch Flows – Model

Appendix A – Ditch Hydraulic Design

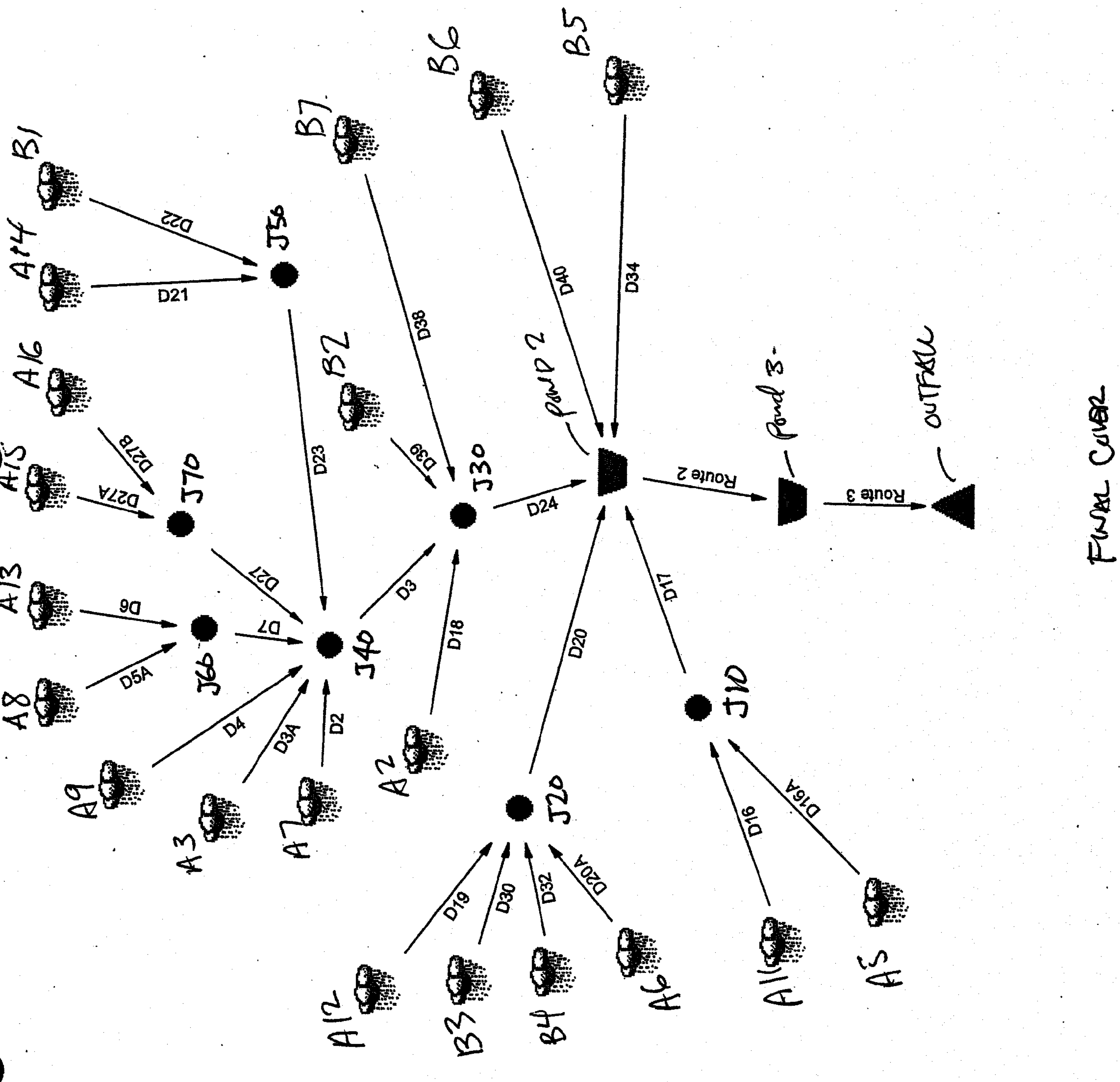
Appendix B – Riprap

Appendix C – Rock Chute Design

3 Drainage area maps.

THIS IS A DESIGN RECORD

ATTACHMENT 1 – POND ROUTING


B1
A14
D22
D21
J56
A16
D27B
A15
D27A
J70
A13
D6
J66
A8
D5A
D27
D7
J40
D23
D4
D3A
D2
A9
A3
A7
B7
D38
B2
D39
J30
D3
D18
A2
B6
B5
D40
D34
Pond 2
D24
Route 2
Pond 3
Route 3
OUTFALL
D20
D17
J10
J20
D19
D30
D32
D20A
D16
D16A
A12
B3
B4
A6
A11
A5
FINAL COVER

==========================
JOB TITLE
==========================

Project Date: 5/3/2004
Project Engineer: Daniel R. Smith
Project Title: KIF Lat Exp Interim Operation w/phase2&3 pond
Project Comments:
This model analyzes the cond of the expan during operation, while Phase 2/3 has a pond. The time of concentration is minimized due to the pond.

Table of Contents

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Table of Contents (continued)

Table of Contents (continued)

MASTER DESIGN STORM SUMMARY

Network Storm Collection: KIF

Return Event	Total Depth in	Rainfall Type	RNF ID
2yr	3.2500	Synthetic Curve	TypeII 24hr
10yr	3.6000	Synthetic Curve	TypeII 24hr
25yr	5.5000	Synthetic Curve	TypeII 24hr
100yr	6.5000	Synthetic Curve	TypeII 24hr

ICPM CALCULATION TOLERANCES

Target Convergence= .000 cfs +/-
Max. Iterations = 35 loops
ICPM Time Step = .0400 hrs
Output Time Step = .0400 hrs
ICPM Ending Time = 35.0000 hrs

MASTER NETWORK SUMMARY
SCS Unit Hydrograph Method

(*Node=Outfall; +Node=Diversion;)
(Trun= HYG Truncation: Blank=None; L=Left; R=Rt; LR=Left&Rt)

Node ID	Type	Return Event	HYG Vol ac-ft	Trun	Qpeak hrs	Qpeak cfs	Max WSEL ft	Max Pond Storage ac-ft
JUNC 10	JCT	2	.987		12.1200	11.59		
JUNC 10	JCT	10	1.225		12.1200	14.74		
JUNC 10	JCT	25	2.718		12.0800	34.40		
JUNC 10	JCT	100	3.593		12.0800	45.81		
JUNC 20	JCT	2	4.997		12.0000	79.74		
JUNC 20	JCT	10	5.904		12.0000	94.34		
JUNC 20	JCT	25	11.212		12.0000	177.59		
JUNC 20	JCT	100	14.174		12.0000	222.80		
JUNC 30	JCT	2	13.350		12.1200	116.50		
JUNC 30	JCT	10	15.794		12.1200	138.85		
JUNC 30	JCT	25	30.189		12.1200	268.50		
JUNC 30	JCT	100	38.259		12.1200	339.91		
JUNC 40	JCT	2	8.913		12.1600	66.32		
JUNC 40	JCT	10	10.519		12.1600	78.74		
JUNC 40	JCT	25	19.952		12.1600	150.69		
JUNC 40	JCT	100	25.229		12.1600	190.34		
JUNC 50	JCT	2	2.278		12.1200	27.34		
JUNC 50	JCT	10	2.624		12.1200	31.35		
JUNC 50	JCT	25	4.554		12.0800	53.43		
JUNC 50	JCT	100	5.591		12.0800	65.00		

ICPM CALCULATION TOLERANCES

```
Target Convergence=     .000 cfs +/-
Max. Iterations    =      35 loops
ICPM   Time Step   =    .0400 hrs
Output Time Step   =    .0400 hrs
ICPM Ending Time   =  35.0000 hrs
```

MASTER NETWORK SUMMARY
SCS Unit Hydrograph Method

(*Node=Outfall; +Node=Diversion;)
(Trun= HYG Truncation: Blank=None; L=Left; R=Rt; LR=Left&Rt)

Node ID		Type	Return Event	HYG Vol ac-ft	Trun	Qpeak hrs	Qpeak cfs	Max WSEL ft	Max Pond Storage ac-ft
JUNC 60		JCT	2	1.744		12.3200	12.89		
JUNC 60		JCT	10	2.055		12.3200	15.36		
JUNC 60		JCT	25	3.876		12.3200	29.60		
JUNC 60		JCT	100	4.892		12.3200	37.43		
JUNC 70		JCT	2	1.410		12.1600	14.20		
JUNC 70		JCT	10	1.693		12.1600	17.26		
JUNC 70		JCT	25	3.398		12.1600	35.41		
JUNC 70		JCT	100	4.371		12.1600	45.61		
*OUT 20		T-E	2	21.305		12.5600	91.71	746.00	
*OUT 20		T-E	10	25.360		12.5200	117.41	746.00	
*OUT 20		T-E	25	49.422		12.5200	200.47	746.00	
*OUT 20		T-E	100	63.029		12.6000	226.84	746.00	
POND 2		POND	2	21.241		12.0400	203.56		
POND 2		POND	10	25.291		12.0400	245.16		
POND 2		POND	25	49.370		12.0400	489.25		
POND 2		POND	100	62.967		12.0400	624.90		
POND 2	OUT	POND	2	21.295		12.4800	92.23	758.54	13.932
POND 2	OUT	POND	10	25.349		12.4400	118.19	758.63	14.813
POND 2	OUT	POND	25	49.413		12.4800	200.74	759.29	21.436
POND 2	OUT	POND	100	63.018		12.5200	227.14	759.75	26.263
POND 3		POND	2	21.295		12.4800	92.23		
POND 3		POND	10	25.349		12.4400	118.19		
POND 3		POND	25	49.413		12.4800	200.74		
POND 3		POND	100	63.018		12.5200	227.14		
POND 3	OUT	POND	2	21.305		12.5600	91.71	757.54	24.995
POND 3	OUT	POND	10	25.360		12.5200	117.41	757.62	25.020
POND 3	OUT	POND	25	49.422		12.5200	200.47	757.90	25.102
POND 3	OUT	POND	100	63.029		12.6000	226.84	757.99	25.127
SUBAREA 15		AREA	2	.643		12.1200	7.57		
SUBAREA 15		AREA	10	.741		12.1200	8.69		
SUBAREA 15		AREA	25	1.286		12.1200	14.77		
SUBAREA 15		AREA	100	1.579		12.1200	17.95		
SUBAREA 16		AREA	2	.767		12.2000	7.11		
SUBAREA 16		AREA	10	.952		12.2000	9.11		
SUBAREA 16		AREA	25	2.112		12.2000	21.44		
SUBAREA 16		AREA	100	2.791		12.2000	28.55		

ICPM CALCULATION TOLERANCES

Target Convergence=	.000	cfs +/-
Max. Iterations =	35	loops
ICPM Time Step =	.0400	hrs
Output Time Step =	.0400	hrs
ICPM Ending Time =	35.0000	hrs

MASTER NETWORK SUMMARY
SCS Unit Hydrograph Method

(*Node=Outfall; +Node=Diversion;)
(Trun= HYG Truncation: Blank=None; L=Left; R=Rt; LR=Left&Rt)

Node ID	Type	Return Event	HYG Vol ac-ft	Trun	Qpeak hrs	Qpeak cfs	Max WSEL ft	Max Pond Storage ac-ft
SUBAREA A11	AREA	2	.289		12.1200	3.43		
SUBAREA A11	AREA	10	.358		12.1200	4.36		
SUBAREA A11	AREA	25	.795		12.0800	10.20		
SUBAREA A11	AREA	100	1.050		12.0800	13.57		
SUBAREA A12	AREA	2	1.592		11.9600	26.27		
SUBAREA A12	AREA	10	1.847		11.9600	30.41		
SUBAREA A12	AREA	25	3.284		11.9600	53.08		
SUBAREA A12	AREA	100	4.062		11.9600	65.01		
SUBAREA A13	AREA	2	1.227		12.4000	8.76		
SUBAREA A13	AREA	10	1.413		12.4000	10.07		
SUBAREA A13	AREA	25	2.452		12.3200	17.28		
SUBAREA A13	AREA	100	3.011		12.3200	21.07		
SUBAREA A14	AREA	2	1.241		12.0800	15.43		
SUBAREA A14	AREA	10	1.429		12.0800	17.71		
SUBAREA A14	AREA	25	2.481		12.0800	30.14		
SUBAREA A14	AREA	100	3.046		12.0800	36.64		
SUBAREA A2	AREA	2	.281		12.1600	2.84		
SUBAREA A2	AREA	10	.349		12.1600	3.63		
SUBAREA A2	AREA	25	.773		12.1600	8.51		
SUBAREA A2	AREA	100	1.022		12.1200	11.34		
SUBAREA A3	AREA	2	.807		12.5200	4.88		
SUBAREA A3	AREA	10	1.002		12.5200	6.25		
SUBAREA A3	AREA	25	2.222		12.4400	14.92		
SUBAREA A3	AREA	100	2.937		12.4000	19.96		
SUBAREA A5	AREA	2	.698		12.1200	8.16		
SUBAREA A5	AREA	10	.867		12.1200	10.38		
SUBAREA A5	AREA	25	1.923		12.0800	24.20		
SUBAREA A5	AREA	100	2.542		12.0800	32.24		
SUBAREA A6	AREA	2	.157		11.9600	2.69		
SUBAREA A6	AREA	10	.195		11.9200	3.41		
SUBAREA A6	AREA	25	.432		11.9200	7.99		
SUBAREA A6	AREA	100	.570		11.9200	10.62		
SUBAREA A7	AREA	2	.738		12.5200	4.08		
SUBAREA A7	AREA	10	.916		12.5200	5.26		
SUBAREA A7	AREA	25	2.032		12.5200	12.59		
SUBAREA A7	AREA	100	2.687		12.5200	16.85		

ICPM CALCULATION TOLERANCES

Target Convergence= .000 cfs +/-
Max. Iterations = 35 loops
ICPM Time Step = .0400 hrs
Output Time Step = .0400 hrs
ICPM Ending Time = 35.0000 hrs

MASTER NETWORK SUMMARY
SCS Unit Hydrograph Method

(*Node=Outfall; +Node=Diversion;)
(Trun= HYG Truncation: Blank=None; L=Left; R=Rt; LR=Left&Rt)

Node ID	Type	Return Event	HYG Vol ac-ft	Trun	Qpeak hrs	Qpeak cfs	Max WSEL ft	Max Pond Storage ac-ft
SUBAREA A8	AREA	2	.517		12.2800	4.22		
SUBAREA A8	AREA	10	.642		12.2800	5.41		
SUBAREA A8	AREA	25	1.423		12.2400	12.85		
SUBAREA A8	AREA	100	1.882		12.2400	17.16		
SUBAREA A9	AREA	2	1.936		12.4000	13.88		
SUBAREA A9	AREA	10	2.229		12.4000	15.95		
SUBAREA A9	AREA	25	3.870		12.4000	27.28		
SUBAREA A9	AREA	100	4.751		12.4000	33.22		
SUBAREA B1	AREA	2	1.037		12.1200	12.13		
SUBAREA B1	AREA	10	1.194		12.1200	13.92		
SUBAREA B1	AREA	25	2.073		12.1200	23.66		
SUBAREA B1	AREA	100	2.545		12.1200	28.76		
SUBAREA B2	AREA	2	2.867		12.1200	33.69		
SUBAREA B2	AREA	10	3.326		12.1200	39.00		
SUBAREA B2	AREA	25	5.913		12.1200	68.19		
SUBAREA B2	AREA	100	7.313		12.1200	83.57		
SUBAREA B3	AREA	2	2.095		12.0000	32.64		
SUBAREA B3	AREA	10	2.430		12.0000	37.74		
SUBAREA B3	AREA	25	4.320		12.0000	65.71		
SUBAREA B3	AREA	100	5.343		12.0000	80.41		
SUBAREA B4	AREA	2	1.154		12.0000	18.38		
SUBAREA B4	AREA	10	1.433		12.0000	23.23		
SUBAREA B4	AREA	25	3.177		12.0000	52.83		
SUBAREA B4	AREA	100	4.200		12.0000	69.71		
SUBAREA B5	AREA	2	.161		12.0400	2.48		
SUBAREA B5	AREA	10	.200		12.0000	3.14		
SUBAREA B5	AREA	25	.444		12.0000	7.22		
SUBAREA B5	AREA	100	.587		12.0000	9.55		
SUBAREA B6	AREA	2	1.745		12.1600	17.39		
SUBAREA B6	AREA	10	2.167		12.1600	22.27		
SUBAREA B6	AREA	25	4.806		12.1600	52.39		
SUBAREA B6	AREA	100	6.354		12.1600	69.77		
SUBAREA B7	AREA	2	1.290		12.0800	15.68		
SUBAREA B7	AREA	10	1.601		12.0800	20.01		
SUBAREA B7	AREA	25	3.551		12.0800	46.67		
SUBAREA B7	AREA	100	4.695		12.0800	62.00		

Type.... Executive Summary (Links) Page 2.01
Name.... Watershed Event: 25 yr
File.... C:\Haestad\PPKW\KIF\KIF LAT EXP PHASE2_FINAL COVER_A.PPW
Storm... TypeII 24hr Tag: 25yr

NETWORK SUMMARY -- LINKS
(UN=Upstream Node; DL=DNstream End of Link; DN=DNstream Node)
(Trun.= HYG Truncation: Blank=None; L=Left; R=Rt; LR=Left & Rt)

DEFAULT Design Storm File,ID = KIF

Storm Tag Name = 25yr

Data Type, File, ID = Synthetic Storm TypeII 24hr
Storm Frequency = 25 yr
Total Rainfall Depth= 5.5000 in
Duration Multiplier = 1
Resulting Duration = 24.0000 hrs
Resulting Start Time= .0000 hrs Step= .1000 hrs End= 24.0000 hrs

ICPM CALCULATION TOLERANCES

Target Convergence= .000 cfs +/-
Max. Iterations = 35 loops
ICPM Time Step = .0400 hrs
Output Time Step = .0400 hrs
ICPM Ending Time = 35.0000 hrs

Link ID	Type		HYG Vol ac-ft	Trun.	Peak Time hrs	Peak Q cfs	End Points
D16	ADD	UN	.795		12.0800	10.20	SUBAREA A11

		DL	.795	12.0800	10.20	
		DN	2.718	12.0800	34.40	JUNC 10
D16A	ADD	UN	1.923	12.0800	24.20	SUBAREA A5
		DL	1.923	12.0800	24.20	
		DN	2.718	12.0800	34.40	JUNC 10
D17	ADD	UN	2.718	12.0800	34.40	JUNC 10
		DL	2.718	12.0800	34.40	
		DN	49.370	12.0400	489.25	POND 2
D18	ADD	UN	.773	12.1600	8.51	SUBAREA A2
		DL	.773	12.1600	8.51	
		DN	30.189	12.1200	268.50	JUNC 30
D19	ADD	UN	3.284	11.9600	53.08	SUBAREA A12
		DL	3.284	11.9600	53.08	
		DN	11.212	12.0000	177.59	JUNC 20

NETWORK SUMMARY -- LINKS
(UN=Upstream Node; DL=DNstream End of Link; DN=DNstream Node)
(Trun.= HYG Truncation: Blank=None; L=Left; R=Rt; LR=Left & Rt)

Link ID	Type		HYG Vol ac-ft	Trun.	Peak Time hrs	Peak Q cfs	End Points
D2	ADD	UN	2.032		12.5200	12.59	SUBAREA A7
		DL	2.032		12.5200	12.59	
		DN	19.952		12.1600	150.69	JUNC 40
D20	ADD	UN	11.212		12.0000	177.59	JUNC 20
		DL	11.212		12.0000	177.59	
		DN	49.370		12.0400	489.25	POND 2
D20A	ADD	UN	.432		11.9200	7.99	SUBAREA A6
		DL	.432		11.9200	7.99	
		DN	11.212		12.0000	177.59	JUNC 20
D21	ADD	UN	2.481		12.0800	30.14	SUBAREA A14
		DL	2.481		12.0800	30.14	
		DN	4.554		12.0800	53.43	JUNC 50
D22	ADD	UN	2.073		12.1200	23.66	SUBAREA B1
		DL	2.073		12.1200	23.66	
		DN	4.554		12.0800	53.43	JUNC 50
D23	ADD	UN	4.554		12.0800	53.43	JUNC 50
		DL	4.554		12.0800	53.43	
		DN	19.952		12.1600	150.69	JUNC 40
D24	ADD	UN	30.189		12.1200	268.50	JUNC 30
		DL	30.189		12.1200	268.50	
		DN	49.370		12.0400	489.25	POND 2
D27	ADD	UN	3.398		12.1600	35.41	JUNC 70
		DL	3.398		12.1600	35.41	
		DN	19.952		12.1600	150.69	JUNC 40
D27A	ADD	UN	1.286		12.1200	14.77	SUBAREA 15
		DL	1.286		12.1200	14.77	
		DN	3.398		12.1600	35.41	JUNC 70
D27B	ADD	UN	2.112		12.2000	21.44	SUBAREA 16
		DL	2.112		12.2000	21.44	
		DN	3.398		12.1600	35.41	JUNC 70

NETWORK SUMMARY -- LINKS
(UN=Upstream Node; DL=DNstream End of Link; DN=DNstream Node)
(Trun.= HYG Truncation: Blank=None; L=Left; R=Rt; LR=Left & Rt)

Link ID	Type		HYG Vol ac-ft	Trun.	Peak Time hrs	Peak Q cfs	End Points
D3	ADD	UN	19.952		12.1600	150.69	JUNC 40
		DL	19.952		12.1600	150.69	
		DN	30.189		12.1200	268.50	JUNC 30
D30	ADD	UN	4.320		12.0000	65.71	SUBAREA B3
		DL	4.320		12.0000	65.71	
		DN	11.212		12.0000	177.59	JUNC 20
D32	ADD	UN	3.177		12.0000	52.83	SUBAREA B4
		DL	3.177		12.0000	52.83	
		DN	11.212		12.0000	177.59	JUNC 20
D34	ADD	UN	.444		12.0000	7.22	SUBAREA B5
		DL	.444		12.0000	7.22	
		DN	49.370		12.0400	489.25	POND 2
D38	ADD	UN	3.551		12.0800	46.67	SUBAREA B7
		DL	3.551		12.0800	46.67	
		DN	30.189		12.1200	268.50	JUNC 30
D39	ADD	UN	5.913		12.1200	68.19	SUBAREA B2
		DL	5.913		12.1200	68.19	
		DN	30.189		12.1200	268.50	JUNC 30
D3A	ADD	UN	2.222		12.4400	14.92	SUBAREA A3
		DL	2.222		12.4400	14.92	
		DN	19.952		12.1600	150.69	JUNC 40
D4	ADD	UN	3.870		12.4000	27.28	SUBAREA A9
		DL	3.870		12.4000	27.28	
		DN	19.952		12.1600	150.69	JUNC 40
D40	ADD	UN	4.806		12.1600	52.39	SUBAREA B6
		DL	4.806		12.1600	52.39	
		DN	49.370		12.0400	489.25	POND 2
D5A	ADD	UN	1.423		12.2400	12.85	SUBAREA A8
		DL	1.423		12.2400	12.85	
		DN	3.876		12.3200	29.60	JUNC 60

NETWORK SUMMARY -- LINKS
(UN=Upstream Node; DL=DNstream End of Link; DN=DNstream Node)
(Trun.= HYG Truncation: Blank=None; L=Left; R=Rt; LR=Left & Rt)

Link ID	Type		HYG Vol ac-ft	Trun.	Peak Time hrs	Peak Q cfs	End Points	
D6	ADD	UN	2.452		12.3200	17.28	SUBAREA A13	
		DL	2.452		12.3200	17.28		
		DN	3.876		12.3200	29.60	JUNC 60	
D7	ADD	UN	3.876		12.3200	29.60	JUNC 60	
		DL	3.876		12.3200	29.60		
		DN	19.952		12.1600	150.69	JUNC 40	
ROUTE 2	PONDrt	UN	49.370		12.0400	489.25	POND 2	IN
ROUTE 2			49.413		12.4800	200.74	POND 2	OUT
		DL	49.413		12.4800	200.74		
		DN	49.413		12.4800	200.74	POND 3	
ROUTE 3	PONDrt	UN	49.413		12.4800	200.74	POND 3	IN
ROUTE 3			49.422		12.5200	200.47	POND 3	OUT
		DL	49.422		12.5200	200.47		
		DN	49.422		12.5200	200.47	OUT 20	

NETWORK SUMMARY -- LINKS
(UN=Upstream Node; DL=DNstream End of Link; DN=DNstream Node)
(Trun.= HYG Truncation: Blank=None; L=Left; R=Rt; LR=Left & Rt)

DEFAULT Design Storm File,ID = KIF

Storm Tag Name = 100yr

Data Type, File, ID = Synthetic Storm TypeII 24hr
Storm Frequency = 100 yr
Total Rainfall Depth= 6.5000 in
Duration Multiplier = 1
Resulting Duration = 24.0000 hrs
Resulting Start Time= .0000 hrs Step= .1000 hrs End= 24.0000 hrs

ICPM CALCULATION TOLERANCES

Target Convergence= .000 cfs +/-
Max. Iterations = 35 loops
ICPM Time Step = .0400 hrs
Output Time Step = .0400 hrs
ICPM Ending Time = 35.0000 hrs

Link ID	Type		HYG Vol ac-ft	Trun.	Peak Time hrs	Peak Q cfs	End Points
D16	ADD	UN	1.050		12.0800	13.57	SUBAREA A11
		DL	1.050		12.0800	13.57	
		DN	3.593		12.0800	45.81	JUNC 10
D16A	ADD	UN	2.542		12.0800	32.24	SUBAREA A5
		DL	2.542		12.0800	32.24	
		DN	3.593		12.0800	45.81	JUNC 10
D17	ADD	UN	3.593		12.0800	45.81	JUNC 10
		DL	3.593		12.0800	45.81	
		DN	62.967		12.0400	624.90	POND 2
D18	ADD	UN	1.022		12.1200	11.34	SUBAREA A2
		DL	1.022		12.1200	11.34	
		DN	38.259		12.1200	339.91	JUNC 30
D19	ADD	UN	4.062		11.9600	65.01	SUBAREA A12
		DL	4.062		11.9600	65.01	
		DN	14.174		12.0000	222.80	JUNC 20

NETWORK SUMMARY -- LINKS
(UN=Upstream Node; DL=DNstream End of Link; DN=DNstream Node)
(Trun.= HYG Truncation: Blank=None; L=Left; R=Rt; LR=Left & Rt)

Link ID	Type		HYG Vol ac-ft	Trun.	Peak Time hrs	Peak Q cfs	End Points
D2	ADD	UN	2.687		12.5200	16.85	SUBAREA A7
		DL	2.687		12.5200	16.85	
		DN	25.229		12.1600	190.34	JUNC 40
D20	ADD	UN	14.174		12.0000	222.80	JUNC 20
		DL	14.174		12.0000	222.80	
		DN	62.967		12.0400	624.90	POND 2
D20A	ADD	UN	.570		11.9200	10.62	SUBAREA A6
		DL	.570		11.9200	10.62	
		DN	14.174		12.0000	222.80	JUNC 20
D21	ADD	UN	3.046		12.0800	36.64	SUBAREA A14
		DL	3.046		12.0800	36.64	
		DN	5.591		12.0800	65.00	JUNC 50
D22	ADD	UN	2.545		12.1200	28.76	SUBAREA B1
		DL	2.545		12.1200	28.76	
		DN	5.591		12.0800	65.00	JUNC 50
D23	ADD	UN	5.591		12.0800	65.00	JUNC 50
		DL	5.591		12.0800	65.00	
		DN	25.229		12.1600	190.34	JUNC 40
D24	ADD	UN	38.259		12.1200	339.91	JUNC 30
		DL	38.259		12.1200	339.91	
		DN	62.967		12.0400	624.90	POND 2
D27	ADD	UN	4.371		12.1600	45.61	JUNC 70
		DL	4.371		12.1600	45.61	
		DN	25.229		12.1600	190.34	JUNC 40
D27A	ADD	UN	1.579		12.1200	17.95	SUBAREA 15
		DL	1.579		12.1200	17.95	
		DN	4.371		12.1600	45.61	JUNC 70
D27B	ADD	UN	2.791		12.2000	28.55	SUBAREA 16
		DL	2.791		12.2000	28.55	
		DN	4.371		12.1600	45.61	JUNC 70

NETWORK SUMMARY -- LINKS
(UN=Upstream Node; DL=DNstream End of Link; DN=DNstream Node)
(Trun.= HYG Truncation: Blank=None; L=Left; R=Rt; LR=Left & Rt)

Link ID	Type		HYG Vol ac-ft	Trun.	Peak Time hrs	Peak Q cfs	End Points
D3	ADD	UN	25.229		12.1600	190.34	JUNC 40
		DL	25.229		12.1600	190.34	
		DN	38.259		12.1200	339.91	JUNC 30
D30	ADD	UN	5.343		12.0000	80.41	SUBAREA B3
		DL	5.343		12.0000	80.41	
		DN	14.174		12.0000	222.80	JUNC 20
D32	ADD	UN	4.200		12.0000	69.71	SUBAREA B4
		DL	4.200		12.0000	69.71	
		DN	14.174		12.0000	222.80	JUNC 20
D34	ADD	UN	.587		12.0000	9.55	SUBAREA B5
		DL	.587		12.0000	9.55	
		DN	62.967		12.0400	624.90	POND 2
D38	ADD	UN	4.695		12.0800	62.00	SUBAREA B7
		DL	4.695		12.0800	62.00	
		DN	38.259		12.1200	339.91	JUNC 30
D39	ADD	UN	7.313		12.1200	83.57	SUBAREA B2
		DL	7.313		12.1200	83.57	
		DN	38.259		12.1200	339.91	JUNC 30
D3A	ADD	UN	2.937		12.4000	19.96	SUBAREA A3
		DL	2.937		12.4000	19.96	
		DN	25.229		12.1600	190.34	JUNC 40
D4	ADD	UN	4.751		12.4000	33.22	SUBAREA A9
		DL	4.751		12.4000	33.22	
		DN	25.229		12.1600	190.34	JUNC 40
D40	ADD	UN	6.354		12.1600	69.77	SUBAREA B6
		DL	6.354		12.1600	69.77	
		DN	62.967		12.0400	624.90	POND 2
D5A	ADD	UN	1.882		12.2400	17.16	SUBAREA A8
		DL	1.882		12.2400	17.16	
		DN	4.892		12.3200	37.43	JUNC 60

NETWORK SUMMARY -- LINKS

(UN=Upstream Node; DL=DNstream End of Link; DN=DNstream Node)
(Trun.= HYG Truncation: Blank=None; L=Left; R=Rt; LR=Left & Rt)

Link ID	Type		HYG Vol ac-ft	Trun.	Peak Time hrs	Peak Q cfs	End Points	
D6	ADD	UN	3.011		12.3200	21.07	SUBAREA A13	
		DL	3.011		12.3200	21.07		
		DN	4.892		12.3200	37.43	JUNC 60	
D7	ADD	UN	4.892		12.3200	37.43	JUNC 60	
		DL	4.892		12.3200	37.43		
		DN	25.229		12.1600	190.34	JUNC 40	
ROUTE 2	PONDrt	UN	62.967		12.0400	624.90	POND 2	IN
ROUTE 2			63.018		12.5200	227.14	POND 2	OUT
		DL	63.018		12.5200	227.14		
		DN	63.018		12.5200	227.14	POND 3	
ROUTE 3	PONDrt	UN	63.018		12.5200	227.14	POND 3	IN
ROUTE 3			63.029		12.6000	226.84	POND 3	OUT
		DL	63.029		12.6000	226.84		
		DN	63.029		12.6000	226.84	OUT 20	

File.... C:\Haestad\PPKW\KIF\
Title... Project Date: 5/3/2004
Project Engineer: Daniel R. Smith
Project Title: KIF Lat Exp Interim Operation w/phase2&3 pond
Project Comments:
This model analyzes the cond of the expan during operation, while Phase 2/3 has a pond. The time of concentration is minimized due to the pond.

DESIGN STORMS SUMMARY

Design Storm File,ID =   KIF

Storm Tag Name   = 2yr

Data Type, File, ID = Synthetic Storm   TypeII 24hr
Storm Frequency   = 2 yr
Total Rainfall Depth= 3.2500 in
Duration Multiplier = 1
Resulting Duration = 24.0000 hrs
Resulting Start Time= .0000 hrs Step= .1000 hrs End= 24.0000 hrs

Storm Tag Name   = 10yr

Data Type, File, ID = Synthetic Storm   TypeII 24hr
Storm Frequency   = 10 yr
Total Rainfall Depth= 3.6000 in
Duration Multiplier = 1
Resulting Duration = 24.0000 hrs
Resulting Start Time= .0000 hrs Step= .1000 hrs End= 24.0000 hrs

Storm Tag Name   = 25yr

Data Type, File, ID = Synthetic Storm   TypeII 24hr
Storm Frequency   = 25 yr
Total Rainfall Depth= 5.5000 in
Duration Multiplier = 1
Resulting Duration = 24.0000 hrs
Resulting Start Time= .0000 hrs Step= .1000 hrs End= 24.0000 hrs

Storm Tag Name   = 100yr

Data Type, File, ID = Synthetic Storm   TypeII 24hr
Storm Frequency   = 100 yr
Total Rainfall Depth= 6.5000 in
Duration Multiplier = 1
Resulting Duration = 24.0000 hrs
Resulting Start Time= .0000 hrs Step= .1000 hrs End= 24.0000 hrs

CUMULATIVE RAINFALL FRACTIONS
Output Time increment = .1000 hrs
Time on left represents time for first value in each row.

Time hrs					
.0000	.000	.001	.002	.003	.004
.5000	.005	.006	.007	.008	.009
1.0000	.011	.012	.013	.014	.015
1.5000	.016	.017	.018	.020	.021
2.0000	.022	.023	.024	.026	.027
2.5000	.028	.029	.031	.032	.033
3.0000	.035	.036	.037	.038	.040
3.5000	.041	.042	.044	.045	.047
4.0000	.048	.049	.051	.052	.054
4.5000	.055	.057	.058	.060	.061
5.0000	.063	.065	.066	.068	.070
5.5000	.071	.073	.075	.076	.078
6.0000	.080	.082	.084	.085	.087
6.5000	.089	.091	.093	.095	.097
7.0000	.099	.101	.103	.105	.107
7.5000	.109	.111	.113	.116	.118
8.0000	.120	.122	.125	.127	.130
8.5000	.132	.135	.138	.141	.144
9.0000	.147	.150	.153	.157	.160
9.5000	.163	.166	.170	.173	.177
10.0000	.181	.185	.189	.194	.199
10.5000	.204	.209	.215	.221	.228
11.0000	.235	.243	.251	.261	.271
11.5000	.283	.307	.354	.431	.568
12.0000	.663	.682	.699	.713	.725
12.5000	.735	.743	.751	.759	.766
13.0000	.772	.778	.784	.789	.794
13.5000	.799	.804	.808	.812	.816
14.0000	.820	.824	.827	.831	.834
14.5000	.838	.841	.844	.847	.850
15.0000	.854	.856	.859	.862	.865
15.5000	.868	.870	.873	.875	.878
16.0000	.880	.882	.885	.887	.889
16.5000	.891	.893	.895	.898	.900
17.0000	.902	.904	.906	.908	.910
17.5000	.912	.914	.915	.917	.919
18.0000	.921	.923	.925	.926	.928
18.5000	.930	.931	.933	.935	.936
19.0000	.938	.939	.941	.942	.944
19.5000	.945	.947	.948	.949	.951
20.0000	.952	.953	.955	.956	.957
20.5000	.958	.960	.961	.962	.964
21.0000	.965	.966	.967	.968	.970
21.5000	.971	.972	.973	.975	.976
22.0000	.977	.978	.979	.981	.982
22.5000	.983	.984	.985	.986	.988

CUMULATIVE RAINFALL FRACTIONS
Output Time increment = .1000 hrs
Time on left represents time for first value in each row.

Time hrs					
23.0000	.989	.990	.991	.992	.993
23.5000	.994	.996	.997	.998	.999
24.0000	1.000				

CUMULATIVE RAINFALL FRACTIONS
Output Time increment = .1000 hrs
Time on left represents time for first value in each row.

Time hrs					
.0000	.000	.001	.002	.003	.004
.5000	.005	.006	.007	.008	.009
1.0000	.011	.012	.013	.014	.015
1.5000	.016	.017	.018	.020	.021
2.0000	.022	.023	.024	.026	.027
2.5000	.028	.029	.031	.032	.033
3.0000	.035	.036	.037	.038	.040
3.5000	.041	.042	.044	.045	.047
4.0000	.048	.049	.051	.052	.054
4.5000	.055	.057	.058	.060	.061
5.0000	.063	.065	.066	.068	.070
5.5000	.071	.073	.075	.076	.078
6.0000	.080	.082	.084	.085	.087
6.5000	.089	.091	.093	.095	.097
7.0000	.099	.101	.103	.105	.107
7.5000	.109	.111	.113	.116	.118
8.0000	.120	.122	.125	.127	.130
8.5000	.132	.135	.138	.141	.144
9.0000	.147	.150	.153	.157	.160
9.5000	.163	.166	.170	.173	.177
10.0000	.181	.185	.189	.194	.199
10.5000	.204	.209	.215	.221	.228
11.0000	.235	.243	.251	.261	.271
11.5000	.283	.307	.354	.431	.568
12.0000	.663	.682	.699	.713	.725
12.5000	.735	.743	.751	.759	.766
13.0000	.772	.778	.784	.789	.794
13.5000	.799	.804	.808	.812	.816
14.0000	.820	.824	.827	.831	.834
14.5000	.838	.841	.844	.847	.850
15.0000	.854	.856	.859	.862	.865
15.5000	.868	.870	.873	.875	.878
16.0000	.880	.882	.885	.887	.889
16.5000	.891	.893	.895	.898	.900
17.0000	.902	.904	.906	.908	.910
17.5000	.912	.914	.915	.917	.919
18.0000	.921	.923	.925	.926	.928
18.5000	.930	.931	.933	.935	.936
19.0000	.938	.939	.941	.942	.944
19.5000	.945	.947	.948	.949	.951
20.0000	.952	.953	.955	.956	.957
20.5000	.958	.960	.961	.962	.964
21.0000	.965	.966	.967	.968	.970
21.5000	.971	.972	.973	.975	.976
22.0000	.977	.978	.979	.981	.982
22.5000	.983	.984	.985	.986	.988

CUMULATIVE RAINFALL FRACTIONS
Output Time increment = .1000 hrs
Time on left represents time for first value in each row.

Time hrs					
23.0000	.989	.990	.991	.992	.993
23.5000	.994	.996	.997	.998	.999
24.0000	1.000				

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP PHASE2_FINAL COVER_A.PPW

TIME OF CONCENTRATION CALCULATOR

Segment #1: Tc: TR-55 Sheet

Mannings n	.0600	
Hydraulic Length	100.00	ft
2yr, 24hr P	3.2500	in
Slope	.050000	ft/ft
Avg.Velocity	.51	ft/sec

Segment #1 Time: .0540 hrs

Segment #2: Tc: TR-55 Shallow

Hydraulic Length	200.00	ft
Slope	.050000	ft/ft
Unpaved		
Avg.Velocity	3.61	ft/sec

Segment #2 Time: .0154 hrs

Segment #3: Tc: TR-55 Channel

Flow Area	1.7500	sq.ft
Wetted Perimeter	5.16	ft
Hydraulic Radius	.34	ft
Slope	.330000	ft/ft
Mannings n	.0350	
Hydraulic Length	200.00	ft
Avg.Velocity	11.89	ft/sec

Segment #3 Time: .0047 hrs

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Segment #4: Tc: TR-55 Channel

Flow Area	35.3500 sq.ft
Wetted Perimeter	53.00 ft
Hydraulic Radius	.67 ft
Slope	.005000 ft/ft
Mannings n	.0350
Hydraulic Length	2600.00 ft
Avg.Velocity	2.30 ft/sec

Segment #4 Time: .3143 hrs

Total Tc: .3883 hrs

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Tc Equations used...

==== SCS TR-55 Sheet Flow ====

```
Tc = (.007 * ((n * Lf)**0.8)) / ((P**.5) * (Sf**.4))

Where:  Tc = Time of concentration, hrs
        n  = Mannings n
        Lf = Flow length, ft
        P  = 2yr, 24hr Rain depth, inches
        Sf = Slope, %
```

==== SCS TR-55 Shallow Concentrated Flow ====

```
Unpaved surface:
V  = 16.1345 * (Sf**0.5)

Paved surface:
V  = 20.3282 * (Sf**0.5)

Tc = (Lf / V) / (3600sec/hr)

Where:  V  = Velocity, ft/sec
        Sf = Slope, ft/ft
        Tc = Time of concentration, hrs
        Lf = Flow length, ft
```

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==== SCS Channel Flow ==

```
R  = Aq / Wp
V  = (1.49 * (R**(2/3)) * (Sf**-0.5)) / n

Tc = (Lf / V) / (3600sec/hr)

Where:  R  = Hydraulic radius
        Aq = Flow area, sq.ft.
        Wp = Wetted perimeter, ft
        V  = Velocity, ft/sec
        Sf = Slope, ft/ft
        n  = Mannings n
        Tc = Time of concentration, hrs
        Lf = Flow length, ft
```

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TIME OF CONCENTRATION CALCULATOR

Segment #1: Tc: TR-55 Sheet

Mannings n	.2400
Hydraulic Length	100.00 ft
2yr, 24hr P	3.2500 in
Slope	.330000 ft/ft
Avg.Velocity	.36 ft/sec

Segment #1 Time: .0769 hrs

Segment #2: Tc: TR-55 Channel

Flow Area	1.1500 sq.ft
Wetted Perimeter	6.81 ft
Hydraulic Radius	.17 ft
Slope	.005000 ft/ft
Mannings n	.0350
Hydraulic Length	300.00 ft
Avg.Velocity	.92 ft/sec

Segment #2 Time: .0906 hrs

Segment #3: Tc: TR-55 Channel

Flow Area	1.7500 sq.ft
Wetted Perimeter	5.16 ft
Hydraulic Radius	.34 ft
Slope	.330000 ft/ft
Mannings n	.0350
Hydraulic Length	300.00 ft
Avg.Velocity	11.89 ft/sec

Segment #3 Time: .0070 hrs

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Segment #4: Tc: TR-55 Channel

Flow Area	35.3500	sq.ft
Wetted Perimeter	53.00	ft
Hydraulic Radius	.67	ft
Slope	.005000	ft/ft
Mannings n	.0350	
Hydraulic Length	2600.00	ft
Avg.Velocity	2.30	ft/sec

Segment #4 Time: .3143 hrs

Total Tc: .4888 hrs

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP PHASE2_FINAL COVER_A.PPW

Tc Equations used...

==== SCS TR-55 Sheet Flow ====

```
Tc = (.007 * ((n * Lf)**0.8)) / ((P**.5) * (Sf**.4))

Where:  Tc = Time of concentration, hrs
        n  = Mannings n
        Lf = Flow length, ft
        P  = 2yr, 24hr Rain depth, inches
        Sf = Slope, %
```

==== SCS Channel Flow ====

```
R  = Aq / Wp
V  = (1.49 * (R**(2/3)) * (Sf**-0.5)) / n

Tc = (Lf / V) / (3600sec/hr)

Where:  R  = Hydraulic radius
        Aq = Flow area, sq.ft.
        Wp = Wetted perimeter, ft
        V  = Velocity, ft/sec
        Sf = Slope, ft/ft
        n  = Mannings n
        Tc = Time of concentration, hrs
        Lf = Flow length, ft
```

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::
TIME OF CONCENTRATION CALCULATOR
::

Segment #1: Tc: TR-55 Sheet

Mannings n	.0600	
Hydraulic Length	100.00	ft
2yr, 24hr P	3.2500	in
Slope	.050000	ft/ft
Avg.Velocity	.51	ft/sec

Segment #1 Time: .0540 hrs

Segment #2: Tc: TR-55 Shallow

Hydraulic Length	300.00	ft
Slope	.050000	ft/ft
Unpaved		
Avg.Velocity	3.61	ft/sec

Segment #2 Time: .0231 hrs

Segment #3: Tc: TR-55 Channel

Flow Area	1.7500	sq.ft
Wetted Perimeter	5.16	ft
Hydraulic Radius	.34	ft
Slope	.330000	ft/ft
Mannings n	.0350	
Hydraulic Length	400.00	ft
Avg.Velocity	11.89	ft/sec

Segment #3 Time: .0093 hrs

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Segment #4: Tc: TR-55 Channel

Flow Area	1.1500	sq.ft
Wetted Perimeter	6.81	ft
Hydraulic Radius	.17	ft
Slope	.005000	ft/ft
Mannings n	.0350	
Hydraulic Length	300.00	ft
Avg.Velocity	.92	ft/sec

Segment #4 Time: .0906 hrs

Segment #5: Tc: TR-55 Channel

Flow Area	1.7500	sq.ft
Wetted Perimeter	5.16	ft
Hydraulic Radius	.34	ft
Slope	.010000	ft/ft
Mannings n	.0350	
Hydraulic Length	1100.00	ft
Avg.Velocity	2.07	ft/sec

Segment #5 Time: .1476 hrs

Total Tc: .3246 hrs

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Tc Equations used...

==== SCS TR-55 Sheet Flow ====

Tc = (.007 * ((n * Lf)**0.8)) / ((P**.5) * (Sf**.4))

Where: Tc = Time of concentration, hrs
n = Mannings n
Lf = Flow length, ft
P = 2yr, 24hr Rain depth, inches
Sf = Slope, %

==== SCS TR-55 Shallow Concentrated Flow ====

Unpaved surface:
V = 16.1345 * (Sf**0.5)

Paved surface:
V = 20.3282 * (Sf**0.5)

Tc = (Lf / V) / (3600sec/hr)

Where: V = Velocity, ft/sec
Sf = Slope, ft/ft
Tc = Time of concentration, hrs
Lf = Flow length, ft

==== SCS Channel Flow ==

```
R  = Aq / Wp
V  = (1.49 * (R**(2/3)) * (Sf**-0.5)) / n

Tc = (Lf / V) / (3600sec/hr)

Where:  R  = Hydraulic radius
        Aq = Flow area, sq.ft.
        Wp = Wetted perimeter, ft
        V  = Velocity, ft/sec
        Sf = Slope, ft/ft
        n  = Mannings n
        Tc = Time of concentration, hrs
        Lf = Flow length, ft
```

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TIME OF CONCENTRATION CALCULATOR

Segment #1: Tc: TR-55 Sheet

Mannings n	.0600
Hydraulic Length	100.00 ft
2yr, 24hr P	3.2500 in
Slope	.050000 ft/ft
Avg.Velocity	.51 ft/sec

Segment #1 Time: .0540 hrs

Segment #2: Tc: TR-55 Shallow

Hydraulic Length	100.00 ft
Slope	.050000 ft/ft
Unpaved	
Avg.Velocity	3.61 ft/sec

Segment #2 Time: .0077 hrs

Segment #3: Tc: TR-55 Channel

Flow Area	1.1500 sq.ft
Wetted Perimeter	6.81 ft
Hydraulic Radius	.17 ft
Slope	.025000 ft/ft
Mannings n	.0200
Hydraulic Length	400.00 ft
Avg.Velocity	3.60 ft/sec

Segment #3 Time: .0309 hrs

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Segment #4: Tc: TR-55 Channel

Flow Area	8.4000 sq.ft
Wetted Perimeter	22.56 ft
Hydraulic Radius	.37 ft
Slope	.090000 ft/ft
Mannings n	.0350
Hydraulic Length	800.00 ft
Avg.Velocity	6.61 ft/sec

Segment #4 Time: .0336 hrs

Segment #5: Tc: TR-55 Channel

Flow Area	1.3300 sq.ft
Wetted Perimeter	4.29 ft
Hydraulic Radius	.31 ft
Slope	.010000 ft/ft
Mannings n	.0350
Hydraulic Length	200.00 ft
Avg.Velocity	1.95 ft/sec

Segment #5 Time: .0285 hrs

Total Tc: .1546 hrs

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Tc Equations used...

==== SCS TR-55 Sheet Flow ====

```
Tc = (.007 * ((n * Lf)**0.8)) / ((P**.5) * (Sf**.4))

Where:  Tc = Time of concentration, hrs
        n  = Mannings n
        Lf = Flow length, ft
        P  = 2yr, 24hr Rain depth, inches
        Sf = Slope, %
```

==== SCS TR-55 Shallow Concentrated Flow ====

```
Unpaved surface:
V  = 16.1345 * (Sf**0.5)

Paved surface:
V  = 20.3282 * (Sf**0.5)

Tc = (Lf / V) / (3600sec/hr)

Where:  V  = Velocity, ft/sec
        Sf = Slope, ft/ft
        Tc = Time of concentration, hrs
        Lf = Flow length, ft
```

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP PHASE2_FINAL COVER_A.PPW

==== SCS Channel Flow ==

```
R  = Aq / Wp
V  = (1.49 * (R**(2/3)) * (Sf**-0.5)) / n

Tc = (Lf / V) / (3600sec/hr)

Where:  R  = Hydraulic radius
        Aq = Flow area, sq.ft.
        Wp = Wetted perimeter, ft
        V  = Velocity, ft/sec
        Sf = Slope, ft/ft
        n  = Mannings n
        Tc = Time of concentration, hrs
        Lf = Flow length, ft
```

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP PHASE2_FINAL COVER_A.PPW

TIME OF CONCENTRATION CALCULATOR

Segment #1: Tc: User Defined

Segment #1 Time: .8400 hrs

Total Tc: .8400 hrs

Tc Equations used...

==== User Defined ====

Tc = Value entered by user

Where: Tc = Time of concentration

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TIME OF CONCENTRATION CALCULATOR

Segment #1: Tc: User Defined

Segment #1 Time: .1550 hrs

Segment #2: Tc: TR-55 Channel

Flow Area	35.3500	sq.ft
Wetted Perimeter	53.00	ft
Hydraulic Radius	.67	ft
Slope	.005000	ft/ft
Mannings n	.0350	
Hydraulic Length	1600.00	ft
Avg.Velocity	2.30	ft/sec

Segment #2 Time: .1934 hrs

Total Tc: .3484 hrs

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Tc Equations used...

==== User Defined ====

Tc = Value entered by user

Where: Tc = Time of concentration

==== SCS Channel Flow ====

```
R  = Aq / Wp
V  = (1.49 * (R**(2/3)) * (Sf**-0.5)) / n

Tc = (Lf / V) / (3600sec/hr)

Where:  R  = Hydraulic radius
        Aq = Flow area, sq.ft.
        Wp = Wetted perimeter, ft
        V  = Velocity, ft/sec
        Sf = Slope, ft/ft
        n  = Mannings n
        Tc = Time of concentration, hrs
        Lf = Flow length, ft
```

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP PHASE2_FINAL COVER_A.PPW

:::

TIME OF CONCENTRATION CALCULATOR

:::

Segment #1: Tc: TR-55 Sheet

Mannings n	.0240
Hydraulic Length	100.00 ft
2yr, 24hr P	3.2500 in
Slope	.330000 ft/ft
Avg.Velocity	2.28 ft/sec

Segment #1 Time: .0122 hrs

Segment #2: Tc: TR-55 Channel

Flow Area	35.3500 sq.ft
Wetted Perimeter	53.00 ft
Hydraulic Radius	.67 ft
Slope	.005000 ft/ft
Mannings n	.0350
Hydraulic Length	1800.00 ft
Avg.Velocity	2.30 ft/sec

Segment #2 Time: .2176 hrs

Segment #3: Tc: TR-55 Channel

Flow Area	35.3500 sq.ft
Wetted Perimeter	53.00 ft
Hydraulic Radius	.67 ft
Slope	.005000 ft/ft
Mannings n	.0350
Hydraulic Length	1600.00 ft
Avg.Velocity	2.30 ft/sec

Segment #3 Time: .1934 hrs

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Total Tc: .4232 hrs

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```
--------------------------------------------------------------------------
Tc Equations used...
--------------------------------------------------------------------------


==== SCS TR-55 Sheet Flow ================================================

     Tc = (.007 * ((n * Lf)**0.8)) / ((P**.5) * (Sf**.4))

     Where:  Tc = Time of concentration, hrs
             n  = Mannings n
             Lf = Flow length, ft
             P  = 2yr, 24hr Rain depth, inches
             Sf = Slope, %


==== SCS Channel Flow ====================================================

     R  = Aq / Wp
     V  = (1.49 * (R**(2/3)) * (Sf**-0.5)) / n

     Tc = (Lf / V) / (3600sec/hr)

     Where:  R  = Hydraulic radius
             Aq = Flow area, sq.ft.
             Wp = Wetted perimeter, ft
             V  = Velocity, ft/sec
             Sf = Slope, ft/ft
             n  = Mannings n
             Tc = Time of concentration, hrs
             Lf = Flow length, ft
```

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TIME OF CONCENTRATION CALCULATOR

Segment #1: Tc: TR-55 Sheet

Mannings n	.2400
Hydraulic Length	100.00 ft
2yr, 24hr P	3.2500 in
Slope	.005000 ft/ft

Avg.Velocity .07 ft/sec

Segment #1 Time: .4109 hrs

Segment #2: Tc: TR-55 Shallow

Hydraulic Length	300.00 ft
Slope	.005000 ft/ft
Unpaved	

Avg.Velocity 1.14 ft/sec

Segment #2 Time: .0730 hrs

Segment #3: Tc: TR-55 Channel

Flow Area	35.3500 sq.ft
Wetted Perimeter	53.00 ft
Hydraulic Radius	.67 ft
Slope	.005000 ft/ft
Mannings n	.0350
Hydraulic Length	1600.00 ft

Avg.Velocity 2.30 ft/sec

Segment #3 Time: .1934 hrs

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP PHASE2_FINAL COVER_A.PPW

Segment #4: Tc: TR-55 Channel

Flow Area	35.3500	sq.ft
Wetted Perimeter	53.00	ft
Hydraulic Radius	.67	ft
Slope	.005000	ft/ft
Mannings n	.0350	
Hydraulic Length	1800.00	ft

Avg.Velocity 2.30 ft/sec

Segment #4 Time: .2176 hrs

Total Tc: .8949 hrs

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP PHASE2_FINAL COVER_A.PPW

Tc Equations used...

==== SCS TR-55 Sheet Flow ====

```
Tc = (.007 * ((n * Lf)**0.8)) / ((P**.5) * (Sf**.4))

Where:  Tc = Time of concentration, hrs
        n  = Mannings n
        Lf = Flow length, ft
        P  = 2yr, 24hr Rain depth, inches
        Sf = Slope, %
```

==== SCS TR-55 Shallow Concentrated Flow ====

```
Unpaved surface:
V  = 16.1345 * (Sf**0.5)

Paved surface:
V  = 20.3282 * (Sf**0.5)

Tc = (Lf / V) / (3600sec/hr)

Where:  V  = Velocity, ft/sec
        Sf = Slope, ft/ft
        Tc = Time of concentration, hrs
        Lf = Flow length, ft
```

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP PHASE2_FINAL COVER_A.PPW

==== SCS Channel Flow ==

```
R  = Aq / Wp
V  = (1.49 * (R**(2/3)) * (Sf**-0.5)) / n

Tc = (Lf / V) / (3600sec/hr)

Where:  R  = Hydraulic radius
        Aq = Flow area, sq.ft.
        Wp = Wetted perimeter, ft
        V  = Velocity, ft/sec
        Sf = Slope, ft/ft
        n  = Mannings n
        Tc = Time of concentration, hrs
        Lf = Flow length, ft
```

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP PHASE2_FINAL COVER_A.PPW

TIME OF CONCENTRATION CALCULATOR

Segment #1: Tc: TR-55 Sheet

Mannings n	.2400	
Hydraulic Length	100.00	ft
2yr, 24hr P	3.2500	in
Slope	.330000	ft/ft
Avg.Velocity	.36	ft/sec

Segment #1 Time: .0769 hrs

Segment #2: Tc: TR-55 Channel

Flow Area	1.1500	sq.ft
Wetted Perimeter	6.81	ft
Hydraulic Radius	.17	ft
Slope	.005000	ft/ft
Mannings n	.0350	
Hydraulic Length	300.00	ft
Avg.Velocity	.92	ft/sec

Segment #2 Time: .0906 hrs

Segment #3: Tc: TR-55 Channel

Flow Area	1.7500	sq.ft
Wetted Perimeter	5.16	ft
Hydraulic Radius	.34	ft
Slope	.330000	ft/ft
Mannings n	.0350	
Hydraulic Length	400.00	ft
Avg.Velocity	11.89	ft/sec

Segment #3 Time: .0093 hrs

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP PHASE2_FINAL COVER_A.PPW

Segment #4: Tc: TR-55 Channel

Flow Area	1.3300	sq.ft
Wetted Perimeter	4.29	ft
Hydraulic Radius	.31	ft
Slope	.010000	ft/ft
Mannings n	.0350	
Hydraulic Length	1100.00	ft
Avg.Velocity	1.95	ft/sec

Segment #4 Time: .1567 hrs

Total Tc: .3335 hrs

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP PHASE2_FINAL COVER_A.PPW

```
-------------------------------------------------------------------------
Tc Equations used...
-------------------------------------------------------------------------

==== SCS TR-55 Sheet Flow ===============================================

     Tc = (.007 * ((n * Lf)**0.8)) / ((P**.5) * (Sf**.4))

     Where:  Tc = Time of concentration, hrs
             n  = Mannings n
             Lf = Flow length, ft
             P  = 2yr, 24hr Rain depth, inches
             Sf = Slope, %

==== SCS Channel Flow ===================================================

     R  = Aq / Wp
     V  = (1.49 * (R**(2/3)) * (Sf**-0.5)) / n

     Tc = (Lf / V) / (3600sec/hr)

     Where:  R  = Hydraulic radius
             Aq = Flow area, sq.ft.
             Wp = Wetted perimeter, ft
             V  = Velocity, ft/sec
             Sf = Slope, ft/ft
             n  = Mannings n
             Tc = Time of concentration, hrs
             Lf = Flow length, ft
```

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP PHASE2_FINAL COVER_A.PPW

::
TIME OF CONCENTRATION CALCULATOR
::

Segment #1: Tc: TR-55 Sheet

Mannings n	.0600
Hydraulic Length	100.00 ft
2yr, 24hr P	3.2500 in
Slope	.330000 ft/ft

Avg.Velocity 1.10 ft/sec

Segment #1 Time: .0254 hrs

Segment #2: Tc: TR-55 Shallow

Hydraulic Length	300.00 ft
Slope	.330000 ft/ft
Unpaved	

Avg.Velocity 9.27 ft/sec

Segment #2 Time: .0090 hrs

Segment #3: Tc: TR-55 Channel

Flow Area	1.7500 sq.ft
Wetted Perimeter	5.16 ft
Hydraulic Radius	.34 ft
Slope	.010000 ft/ft
Mannings n	.0350
Hydraulic Length	400.00 ft

Avg.Velocity 2.07 ft/sec

Segment #3 Time: .0537 hrs

========================
Total Tc: .0880 hrs
========================

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP PHASE2_FINAL COVER_A.PPW

Tc Equations used...

==== SCS TR-55 Sheet Flow ====

```
Tc = (.007 * ((n * Lf)**0.8)) / ((P**.5) * (Sf**.4))

Where:  Tc = Time of concentration, hrs
        n  = Mannings n
        Lf = Flow length, ft
        P  = 2yr, 24hr Rain depth, inches
        Sf = Slope, %
```

==== SCS TR-55 Shallow Concentrated Flow ====

```
Unpaved surface:
V  = 16.1345 * (Sf**0.5)

Paved surface:
V  = 20.3282 * (Sf**0.5)

Tc = (Lf / V) / (3600sec/hr)

Where:  V  = Velocity, ft/sec
        Sf = Slope, ft/ft
        Tc = Time of concentration, hrs
        Lf = Flow length, ft
```

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP PHASE2_FINAL COVER_A.PPW

==== SCS Channel Flow ==

```
R  = Aq / Wp
V  = (1.49 * (R**(2/3)) * (Sf**-0.5)) / n

Tc = (Lf / V) / (3600sec/hr)

Where:  R  = Hydraulic radius
        Aq = Flow area, sq.ft.
        Wp = Wetted perimeter, ft
        V  = Velocity, ft/sec
        Sf = Slope, ft/ft
        n  = Mannings n
        Tc = Time of concentration, hrs
        Lf = Flow length, ft
```

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP PHASE2_FINAL COVER_A.PPW

TIME OF CONCENTRATION CALCULATOR

Segment #1: Tc: TR-55 Sheet

Mannings n	.2400
Hydraulic Length	100.00 ft
2yr, 24hr P	3.2500 in
Slope	.330000 ft/ft
Avg.Velocity	.36 ft/sec

Segment #1 Time: .0769 hrs

Segment #2: Tc: TR-55 Channel

Flow Area	1.1500 sq.ft
Wetted Perimeter	6.81 ft
Hydraulic Radius	.17 ft
Slope	.005000 ft/ft
Mannings n	.0350
Hydraulic Length	300.00 ft
Avg.Velocity	.92 ft/sec

Segment #2 Time: .0906 hrs

Segment #3: Tc: TR-55 Channel

Flow Area	1.7500 sq.ft
Wetted Perimeter	5.16 ft
Hydraulic Radius	.34 ft
Slope	.330000 ft/ft
Mannings n	.0350
Hydraulic Length	350.00 ft
Avg.Velocity	11.89 ft/sec

Segment #3 Time: .0082 hrs

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP PHASE2_FINAL COVER_A.PPW

Segment #4: Tc: TR-55 Channel

Flow Area	1.1500	sq.ft
Wetted Perimeter	6.81	ft
Hydraulic Radius	.17	ft
Slope	.005000	ft/ft
Mannings n	.0350	
Hydraulic Length	1400.00	ft
Avg.Velocity	.92	ft/sec

Segment #4 Time: .4229 hrs

Segment #5: Tc: TR-55 Channel

Flow Area	35.3500	sq.ft
Wetted Perimeter	53.00	ft
Hydraulic Radius	.67	ft
Slope	.005000	ft/ft
Mannings n	.0350	
Hydraulic Length	3400.00	ft
Avg.Velocity	2.30	ft/sec

Segment #5 Time: .4110 hrs

Total Tc: 1.0095 hrs

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP PHASE2_FINAL COVER_A.PPW

Tc Equations used...

==== SCS TR-55 Sheet Flow ====

```
Tc = (.007 * ((n * Lf)**0.8)) / ((P**.5) * (Sf**.4))

Where:  Tc = Time of concentration, hrs
        n  = Mannings n
        Lf = Flow length, ft
        P  = 2yr, 24hr Rain depth, inches
        Sf = Slope, %
```

==== SCS Channel Flow ====

```
R  = Aq / Wp
V  = (1.49 * (R**(2/3)) * (Sf**-0.5)) / n

Tc = (Lf / V) / (3600sec/hr)

Where:  R  = Hydraulic radius
        Aq = Flow area, sq.ft.
        Wp = Wetted perimeter, ft
        V  = Velocity, ft/sec
        Sf = Slope, ft/ft
        n  = Mannings n
        Tc = Time of concentration, hrs
        Lf = Flow length, ft
```

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP PHASE2_FINAL COVER_A.PPW

::
TIME OF CONCENTRATION CALCULATOR
::

Segment #1: Tc: TR-55 Sheet

Mannings n	.2400	
Hydraulic Length	100.00	ft
2yr, 24hr P	3.2500	in
Slope	.330000	ft/ft
Avg.Velocity	.36	ft/sec

Segment #1 Time: .0769 hrs

Segment #2: Tc: TR-55 Channel

Flow Area	1.1500	sq.ft
Wetted Perimeter	6.81	ft
Hydraulic Radius	.17	ft
Slope	.005000	ft/ft
Mannings n	.0350	
Hydraulic Length	300.00	ft
Avg.Velocity	.92	ft/sec

Segment #2 Time: .0906 hrs

Segment #3: Tc: TR-55 Channel

Flow Area	1.7500	sq.ft
Wetted Perimeter	5.16	ft
Hydraulic Radius	.34	ft
Slope	.330000	ft/ft
Mannings n	.0350	
Hydraulic Length	300.00	ft
Avg.Velocity	11.89	ft/sec

Segment #3 Time: .0070 hrs

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP PHASE2_FINAL COVER_A.PPW

Segment #4: Tc: TR-55 Channel

Flow Area	35.3500	sq.ft
Wetted Perimeter	53.00	ft
Hydraulic Radius	.67	ft
Slope	.005000	ft/ft
Mannings n	.0350	
Hydraulic Length	3400.00	ft
Avg.Velocity	2.30	ft/sec

Segment #4 Time: .4110 hrs

Total Tc: .5855 hrs

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP PHASE2_FINAL COVER_A.PPW

Tc Equations used...

==== SCS TR-55 Sheet Flow ====

Tc = (.007 * ((n * Lf)**0.8)) / ((P**.5) * (Sf**.4))

Where: Tc = Time of concentration, hrs
n = Mannings n
Lf = Flow length, ft
P = 2yr, 24hr Rain depth, inches
Sf = Slope, %

==== SCS Channel Flow ====

R = Aq / Wp
V = (1.49 * (R**(2/3)) * (Sf**-0.5)) / n

Tc = (Lf / V) / (3600sec/hr)

Where: R = Hydraulic radius
Aq = Flow area, sq.ft.
Wp = Wetted perimeter, ft
V = Velocity, ft/sec
Sf = Slope, ft/ft
n = Mannings n
Tc = Time of concentration, hrs
Lf = Flow length, ft

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP PHASE2_FINAL COVER_A.PPW

TIME OF CONCENTRATION CALCULATOR

Segment #1: Tc: TR-55 Sheet

Mannings n	.0600	
Hydraulic Length	100.00	ft
2yr, 24hr P	3.2500	in
Slope	.050000	ft/ft
Avg.Velocity	.51	ft/sec

Segment #1 Time: .0540 hrs

Segment #2: Tc: TR-55 Channel

Flow Area	1.1500	sq.ft
Wetted Perimeter	6.81	ft
Hydraulic Radius	.17	ft
Slope	.005000	ft/ft
Mannings n	.0350	
Hydraulic Length	1100.00	ft
Avg.Velocity	.92	ft/sec

Segment #2 Time: .3322 hrs

Segment #3: Tc: TR-55 Channel

Flow Area	1.1500	sq.ft
Wetted Perimeter	6.81	ft
Hydraulic Radius	.17	ft
Slope	.100000	ft/ft
Mannings n	.0350	
Hydraulic Length	700.00	ft
Avg.Velocity	4.11	ft/sec

Segment #3 Time: .0473 hrs

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Segment #4: Tc: TR-55 Channel

Flow Area	35.3500 sq.ft
Wetted Perimeter	53.00 ft
Hydraulic Radius	.67 ft
Slope	.005000 ft/ft
Mannings n	.0350
Hydraulic Length	3400.00 ft
Avg.Velocity	2.30 ft/sec

Segment #4 Time: .4110 hrs

Total Tc: .8445 hrs

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Tc Equations used...

==== SCS TR-55 Sheet Flow ====

```
Tc = (.007 * ((n * Lf)**0.8)) / ((P**.5) * (Sf**.4))

Where:  Tc = Time of concentration, hrs
        n  = Mannings n
        Lf = Flow length, ft
        P  = 2yr, 24hr Rain depth, inches
        Sf = Slope, %
```

==== SCS Channel Flow ====

```
R  = Aq / Wp
V  = (1.49 * (R**(2/3)) * (Sf**-0.5)) / n

Tc = (Lf / V) / (3600sec/hr)

Where:  R  = Hydraulic radius
        Aq = Flow area, sq.ft.
        Wp = Wetted perimeter, ft
        V  = Velocity, ft/sec
        Sf = Slope, ft/ft
        n  = Mannings n
        Tc = Time of concentration, hrs
        Lf = Flow length, ft
```

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP PHASE2_FINAL COVER_A.PPW

::

TIME OF CONCENTRATION CALCULATOR

::

Segment #1: Tc: User Defined

Segment #1 Time: .1980 hrs

Segment #2: Tc: TR-55 Channel

Flow Area	35.3500	sq.ft
Wetted Perimeter	53.00	ft
Hydraulic Radius	.67	ft
Slope	.005000	ft/ft
Mannings n	.0350	
Hydraulic Length	1600.00	ft

Avg.Velocity 2.30 ft/sec

Segment #2 Time: .1934 hrs

========================

Total Tc: .3914 hrs

========================

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP PHASE2_FINAL COVER_A.PPW

Tc Equations used...

==== User Defined ====

Tc = Value entered by user

Where: Tc = Time of concentration

==== SCS Channel Flow ====

```
R  = Aq / Wp
V  = (1.49 * (R**(2/3)) * (Sf**-0.5)) / n

Tc = (Lf / V) / (3600sec/hr)

Where:  R  = Hydraulic radius
        Aq = Flow area, sq.ft.
        Wp = Wetted perimeter, ft
        V  = Velocity, ft/sec
        Sf = Slope, ft/ft
        n  = Mannings n
        Tc = Time of concentration, hrs
        Lf = Flow length, ft
```

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TIME OF CONCENTRATION CALCULATOR

Segment #1: Tc: User Defined

Segment #1 Time: .1980 hrs

Segment #2: Tc: TR-55 Channel

Flow Area	35.3500	sq.ft
Wetted Perimeter	53.00	ft
Hydraulic Radius	.67	ft
Slope	.005000	ft/ft
Mannings n	.0350	
Hydraulic Length	1600.00	ft
Avg.Velocity	2.30	ft/sec

Segment #2 Time: .1934 hrs

Total Tc: .3914 hrs

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP PHASE2_FINAL COVER_A.PPW

Tc Equations used...

==== User Defined ====

Tc = Value entered by user

Where: Tc = Time of concentration

==== SCS Channel Flow ====

```
R  = Aq / Wp
V  = (1.49 * (R**(2/3)) * (Sf**-0.5)) / n

Tc = (Lf / V) / (3600sec/hr)

Where:  R  = Hydraulic radius
        Aq = Flow area, sq.ft.
        Wp = Wetted perimeter, ft
        V  = Velocity, ft/sec
        Sf = Slope, ft/ft
        n  = Mannings n
        Tc = Time of concentration, hrs
        Lf = Flow length, ft
```

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP PHASE2_FINAL COVER_A.PPW

::
TIME OF CONCENTRATION CALCULATOR
::

Segment #1: Tc: TR-55 Sheet

Mannings n	.0600	
Hydraulic Length	100.00	ft
2yr, 24hr P	3.2500	in
Slope	.010000	ft/ft
Avg.Velocity	.27	ft/sec

Segment #1 Time: .1027 hrs

Segment #2: Tc: TR-55 Channel

Flow Area	1.1500	sq.ft
Wetted Perimeter	6.81	ft
Hydraulic Radius	.17	ft
Slope	.025000	ft/ft
Mannings n	.0200	
Hydraulic Length	400.00	ft
Avg.Velocity	3.60	ft/sec

Segment #2 Time: .0309 hrs

Segment #3: Tc: TR-55 Channel

Flow Area	1.7500	sq.ft
Wetted Perimeter	5.16	ft
Hydraulic Radius	.34	ft
Slope	.330000	ft/ft
Mannings n	.0350	
Hydraulic Length	800.00	ft
Avg.Velocity	11.89	ft/sec

Segment #3 Time: .0187 hrs

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP PHASE2_FINAL COVER_A.PPW

Segment #4: Tc: TR-55 Channel

Flow Area	1.3300	sq.ft
Wetted Perimeter	4.29	ft
Hydraulic Radius	.31	ft
Slope	.010000	ft/ft
Mannings n	.0350	
Hydraulic Length	200.00	ft
Avg.Velocity	1.95	ft/sec

Segment #4 Time: .0285 hrs

Segment #5: Tc: TR-55 Shallow

Hydraulic Length	100.00	ft
Slope	.010000	ft/ft
Unpaved		
Avg.Velocity	1.61	ft/sec

Segment #5 Time: .0172 hrs

Total Tc: .1980 hrs

```
-----------------------------------------------------------------------------
Tc Equations used...
-----------------------------------------------------------------------------


==== SCS TR-55 Sheet Flow ===================================================

     Tc = (.007 * ((n * Lf)**0.8)) / ((P**.5) * (Sf**.4))

     Where:  Tc = Time of concentration, hrs
             n  = Mannings n
             Lf = Flow length, ft
             P  = 2yr, 24hr Rain depth, inches
             Sf = Slope, %


==== SCS TR-55 Shallow Concentrated Flow ====================================

     Unpaved surface:
     V  = 16.1345 * (Sf**0.5)

     Paved surface:
     V  = 20.3282 * (Sf**0.5)

     Tc = (Lf / V) / (3600sec/hr)

     Where:  V  = Velocity, ft/sec
             Sf = Slope, ft/ft
             Tc = Time of concentration, hrs
             Lf = Flow length, ft
```

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP PHASE2_FINAL COVER_A.PPW

==== SCS Channel Flow ==

```
R  = Aq / Wp
V  = (1.49 * (R**(2/3)) * (Sf**-0.5)) / n

Tc = (Lf / V) / (3600sec/hr)

Where:  R  = Hydraulic radius
        Aq = Flow area, sq.ft.
        Wp = Wetted perimeter, ft
        V  = Velocity, ft/sec
        Sf = Slope, ft/ft
        n  = Mannings n
        Tc = Time of concentration, hrs
        Lf = Flow length, ft
```

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP PHASE2_FINAL COVER_A.PPW

::
TIME OF CONCENTRATION CALCULATOR
::

Segment #1: Tc: TR-55 Sheet

Mannings n	.0600
Hydraulic Length	100.00 ft
2yr, 24hr P	3.2500 in
Slope	.330000 ft/ft
Avg.Velocity	1.10 ft/sec

Segment #1 Time: .0254 hrs

Segment #2: Tc: TR-55 Channel

Flow Area	1.1500 sq.ft
Wetted Perimeter	6.81 ft
Hydraulic Radius	.17 ft
Slope	.005000 ft/ft
Mannings n	.0350
Hydraulic Length	300.00 ft
Avg.Velocity	.92 ft/sec

Segment #2 Time: .0906 hrs

Segment #3: Tc: TR-55 Channel

Flow Area	1.7500 sq.ft
Wetted Perimeter	5.16 ft
Hydraulic Radius	.34 ft
Slope	.330000 ft/ft
Mannings n	.0350
Hydraulic Length	400.00 ft
Avg.Velocity	11.89 ft/sec

Segment #3 Time: .0093 hrs

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP PHASE2_FINAL COVER_A.PPW

Segment #4: Tc: TR-55 Channel

Flow Area	1.3300	sq.ft
Wetted Perimeter	4.29	ft
Hydraulic Radius	.31	ft
Slope	.010000	ft/ft
Mannings n	.0350	
Hydraulic Length	200.00	ft

Avg.Velocity 1.95 ft/sec

Segment #4 Time: .0285 hrs

Total Tc: .1538 hrs

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP PHASE2_FINAL COVER_A.PPW

Tc Equations used...

==== SCS TR-55 Sheet Flow ====

```
Tc = (.007 * ((n * Lf)**0.8)) / ((P**.5) * (Sf**.4))

Where:  Tc = Time of concentration, hrs
        n  = Mannings n
        Lf = Flow length, ft
        P  = 2yr, 24hr Rain depth, inches
        Sf = Slope, %
```

==== SCS Channel Flow ====

```
R  = Aq / Wp
V  = (1.49 * (R**(2/3)) * (Sf**-0.5)) / n

Tc = (Lf / V) / (3600sec/hr)

Where:  R  = Hydraulic radius
        Aq = Flow area, sq.ft.
        Wp = Wetted perimeter, ft
        V  = Velocity, ft/sec
        Sf = Slope, ft/ft
        n  = Mannings n
        Tc = Time of concentration, hrs
        Lf = Flow length, ft
```

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP PHASE2_FINAL COVER_A.PPW

::

TIME OF CONCENTRATION CALCULATOR

::

Segment #1: Tc: TR-55 Sheet

Mannings n	.2400	
Hydraulic Length	100.00	ft
2yr, 24hr P	3.2500	in
Slope	.330000	ft/ft
Avg.Velocity	.36	ft/sec

Segment #1 Time: .0769 hrs

Segment #2: Tc: TR-55 Channel

Flow Area	1.1500	sq.ft
Wetted Perimeter	6.81	ft
Hydraulic Radius	.17	ft
Slope	.005000	ft/ft
Mannings n	.0350	
Hydraulic Length	300.00	ft
Avg.Velocity	.92	ft/sec

Segment #2 Time: .0906 hrs

Segment #3: Tc: TR-55 Channel

Flow Area	1.7500	sq.ft
Wetted Perimeter	5.16	ft
Hydraulic Radius	.34	ft
Slope	.330000	ft/ft
Mannings n	.0350	
Hydraulic Length	250.00	ft
Avg.Velocity	11.89	ft/sec

Segment #3 Time: .0058 hrs

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Total Tc: .1733 hrs

========================

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP PHASE2_FINAL COVER_A.PPW

```
----------------------------------------------------------------------------
Tc Equations used...
----------------------------------------------------------------------------

==== SCS TR-55 Sheet Flow ==================================================

     Tc = (.007 * ((n * Lf)**0.8)) / ((P**.5) * (Sf**.4))

     Where:  Tc = Time of concentration, hrs
             n  = Mannings n
             Lf = Flow length, ft
             P  = 2yr, 24hr Rain depth, inches
             Sf = Slope, %

==== SCS Channel Flow ======================================================

     R  = Aq / Wp
     V  = (1.49 * (R**(2/3)) * (Sf**-0.5)) / n

     Tc = (Lf / V) / (3600sec/hr)

     Where:  R  = Hydraulic radius
             Aq = Flow area, sq.ft.
             Wp = Wetted perimeter, ft
             V  = Velocity, ft/sec
             Sf = Slope, ft/ft
             n  = Mannings n
             Tc = Time of concentration, hrs
             Lf = Flow length, ft
```

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP PHASE2_FINAL COVER_A.PPW

::

TIME OF CONCENTRATION CALCULATOR

::

Segment #1: Tc: TR-55 Sheet

Mannings n	.2400	
Hydraulic Length	100.00	ft
2yr, 24hr P	3.2500	in
Slope	.010000	ft/ft
Avg.Velocity	.09	ft/sec

Segment #1 Time: .3114 hrs

Segment #2: Tc: TR-55 Shallow

Hydraulic Length	100.00	ft
Slope	.010000	ft/ft
Unpaved		
Avg.Velocity	1.61	ft/sec

Segment #2 Time: .0172 hrs

Segment #3: Tc: TR-55 Channel

Flow Area	1.1500	sq.ft
Wetted Perimeter	6.81	ft
Hydraulic Radius	.17	ft
Slope	.005000	ft/ft
Mannings n	.0350	
Hydraulic Length	300.00	ft
Avg.Velocity	.92	ft/sec

Segment #3 Time: .0906 hrs

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP PHASE2_FINAL COVER_A.PPW

Segment #4: Tc: TR-55 Channel

Flow Area	1.7500 sq.ft
Wetted Perimeter	6.81 ft
Hydraulic Radius	.26 ft
Slope	.330000 ft/ft
Mannings n	.0350
Hydraulic Length	600.00 ft
Avg.Velocity	9.88 ft/sec

Segment #4 Time: .0169 hrs

Total Tc: .4361 hrs

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Tc Equations used...

==== SCS TR-55 Sheet Flow ====

```
Tc = (.007 * ((n * Lf)**0.8)) / ((P**.5) * (Sf**.4))

Where:  Tc = Time of concentration, hrs
        n  = Mannings n
        Lf = Flow length, ft
        P  = 2yr, 24hr Rain depth, inches
        Sf = Slope, %
```

==== SCS TR-55 Shallow Concentrated Flow ====

```
Unpaved surface:
V  = 16.1345 * (Sf**0.5)

Paved surface:
V  = 20.3282 * (Sf**0.5)

Tc = (Lf / V) / (3600sec/hr)

Where:  V  = Velocity, ft/sec
        Sf = Slope, ft/ft
        Tc = Time of concentration, hrs
        Lf = Flow length, ft
```

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==== SCS Channel Flow ==

```
R  = Aq / Wp
V  = (1.49 * (R**(2/3)) * (Sf**-0.5)) / n

Tc = (Lf / V) / (3600sec/hr)

Where:  R  = Hydraulic radius
        Aq = Flow area, sq.ft.
        Wp = Wetted perimeter, ft
        V  = Velocity, ft/sec
        Sf = Slope, ft/ft
        n  = Mannings n
        Tc = Time of concentration, hrs
        Lf = Flow length, ft
```

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TIME OF CONCENTRATION CALCULATOR

Segment #1: Tc: TR-55 Sheet

Mannings n	.0240	
Hydraulic Length	100.00	ft
2yr, 24hr P	3.2500	in
Slope	.330000	ft/ft
Avg.Velocity	2.28	ft/sec

Segment #1 Time: .0122 hrs

Segment #2: Tc: TR-55 Channel

Flow Area	1.1500	sq.ft
Wetted Perimeter	6.81	ft
Hydraulic Radius	.17	ft
Slope	.005000	ft/ft
Mannings n	.0350	
Hydraulic Length	300.00	ft
Avg.Velocity	.92	ft/sec

Segment #2 Time: .0906 hrs

Segment #3: Tc: TR-55 Channel

Flow Area	1.7500	sq.ft
Wetted Perimeter	5.16	ft
Hydraulic Radius	.34	ft
Slope	.330000	ft/ft
Mannings n	.0350	
Hydraulic Length	450.00	ft
Avg.Velocity	11.89	ft/sec

Segment #3 Time: .0105 hrs

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Segment #4: Tc: TR-55 Channel

Flow Area	35.3500	sq.ft
Wetted Perimeter	53.00	ft
Hydraulic Radius	.67	ft
Slope	.005000	ft/ft
Mannings n	.0350	
Hydraulic Length	1600.00	ft
Avg.Velocity	2.30	ft/sec

Segment #4 Time: .1934 hrs

Total Tc: .3067 hrs

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```
-----------------------------------------------------------------------------
Tc Equations used...
-----------------------------------------------------------------------------


==== SCS TR-55 Sheet Flow ==============================================

     Tc = (.007 * ((n * Lf)**0.8)) / ((P**.5) * (Sf**.4))

     Where:  Tc = Time of concentration, hrs
             n  = Mannings n
             Lf = Flow length, ft
             P  = 2yr, 24hr Rain depth, inches
             Sf = Slope, %


==== SCS Channel Flow ==================================================

     R  = Aq / Wp
     V  = (1.49 * (R**(2/3)) * (Sf**-0.5)) / n

     Tc = (Lf / V) / (3600sec/hr)

     Where:  R  = Hydraulic radius
             Aq = Flow area, sq.ft.
             Wp = Wetted perimeter, ft
             V  = Velocity, ft/sec
             Sf = Slope, ft/ft
             n  = Mannings n
             Tc = Time of concentration, hrs
             Lf = Flow length, ft
```

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP PHASE2_FINAL COVER_A.PPW

RUNOFF CURVE NUMBER DATA

Soil/Surface Description	CN	Area acres	Impervious Adjustment %C	Impervious Adjustment %UC	Adjusted CN
Uncovered slope exist dredge cl	89	3.630			89.00
COMPOSITE AREA & WEIGHTED CN --->		3.630			89.00 (89)

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RUNOFF CURVE NUMBER DATA

Soil/Surface Description	CN	Area acres	Impervious Adjustment %C	Impervious Adjustment %UC	Adjusted CN
N slope exist dredge cell w/terr	71	10.130			71.00
COMPOSITE AREA & WEIGHTED CN --->		10.130			71.00 (71)

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RUNOFF CURVE NUMBER DATA

Soil/Surface Description	CN	Area acres	Impervious Adjustment %C	Impervious Adjustment %UC	Adjusted CN
Exist dredge cell 5% slope	71	3.810			71.00

COMPOSITE AREA & WEIGHTED CN ---> 3.810 71.00 (71)

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP PHASE2_FINAL COVER_A.PPW

RUNOFF CURVE NUMBER DATA

Soil/Surface Description	CN	Area acres	Impervious Adjustment %C	Impervious Adjustment %UC	Adjusted CN
Exposed ash/gypsum	87	9.750			87.00
COMPOSITE AREA & WEIGHTED CN --->		9.750			87.00 (87)

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RUNOFF CURVE NUMBER DATA

Soil/Surface Description	CN	Area acres	Impervious Adjustment %C	Impervious Adjustment %UC	Adjusted CN
Uncovered dredge cell 5% slope	89	6.920			89.00
COMPOSITE AREA & WEIGHTED CN --->		6.920			89.00 (89)

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP PHASE2_FINAL COVER_A.PPW

RUNOFF CURVE NUMBER DATA

::

Soil/Surface Description	CN	Area acres	Impervious Adjustment %C	Impervious Adjustment %UC	Adjusted CN
S. Slope Exist dredge cell unvd	89	7.000			89.00
COMPOSITE AREA & WEIGHTED CN --->		7.000			89.00 (89)

::

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RUNOFF CURVE NUMBER DATA

Soil/Surface Description	CN	Area acres	Impervious Adjustment %C	Impervious Adjustment %UC	Adjusted CN
Outer area along outer dike	71	3.710			71.00
COMPOSITE AREA & WEIGHTED CN --->		3.710			71.00 (71)

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RUNOFF CURVE NUMBER DATA

Soil/Surface Description	CN	Area acres	Impervious Adjustment %C	Impervious Adjustment %UC	Adjusted CN
Flat area for north drainage ditch	71	10.660			71.00
COMPOSITE AREA & WEIGHTED CN --->		10.660			71.00 (71)

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP PHASE2_FINAL COVER_A.PPW

RUNOFF CURVE NUMBER DATA

Soil/Surface Description	CN	Area acres	Impervious Adjustment %C	Impervious Adjustment %UC	Adjusted CN
Grassed 3:1 Slope w/Terraces	71	9.230			71.00
COMPOSITE AREA & WEIGHTED CN --->		9.230			71.00 (71)

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP PHASE2_FINAL COVER_A.PPW

RUNOFF CURVE NUMBER DATA

Soil/Surface Description	CN	Area acres	Impervious Adjustment %C	Impervious Adjustment %UC	Adjusted CN
SE Corner of exist dredge cell	71	2.070			71.00
COMPOSITE AREA & WEIGHTED CN --->		2.070			71.00 (71)

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RUNOFF CURVE NUMBER DATA

Soil/Surface Description	CN	Area acres	Impervious Adjustment %C	Impervious Adjustment %UC	Adjusted CN
3:1 slopes w/terrace ditches	71	9.750			71.00
COMPOSITE AREA & WEIGHTED CN --->		9.750			71.00 (71)

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP PHASE2_FINAL COVER_A.PPW

RUNOFF CURVE NUMBER DATA

Soil/Surface Description	CN	Area acres	Impervious Adjustment %C	Impervious Adjustment %UC	Adjusted CN
3:1 slope w/terraces NW Drdg cl	71	6.830			71.00
COMPOSITE AREA & WEIGHTED CN --->		6.830			71.00 (71)

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RUNOFF CURVE NUMBER DATA

Soil/Surface Description	CN	Area acres	Impervious Adjustment %C	Impervious Adjustment %UC	Adjusted CN
NE slope of exist dredge cell	89	10.920			89.00
COMPOSITE AREA & WEIGHTED CN --->		10.920			89.00 (89)

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP PHASE2_FINAL COVER_A.PPW

RUNOFF CURVE NUMBER DATA

Soil/Surface Description	CN	Area acres	Impervious Adjustment %C	Impervious Adjustment %UC	Adjusted CN
Uncovered gypsum	89	5.850			89.00
COMPOSITE AREA & WEIGHTED CN --->		5.850			89.00 (89)

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP PHASE2_FINAL COVER_A.PPW

RUNOFF CURVE NUMBER DATA

Soil/Surface Description	CN	Area acres	Impervious Adjustment %C	Impervious Adjustment %UC	Adjusted CN
uncovered gypsum area	87	17.560			87.00
COMPOSITE AREA & WEIGHTED CN --->		17.560			87.00 (87)

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP PHASE2_FINAL COVER_A.PPW

RUNOFF CURVE NUMBER DATA

Soil/Surface Description	CN	Area acres	Impervious Adjustment %C	Impervious Adjustment %UC	Adjusted CN
Exposed area w/o final cover	87	12.830			87.00
COMPOSITE AREA & WEIGHTED CN --->		12.830			87.00 (87)

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP PHASE2_FINAL COVER_A.PPW

RUNOFF CURVE NUMBER DATA

Soil/Surface Description	CN	Area acres	Impervious Adjustment %C	Impervious Adjustment %UC	Adjusted CN
3:1 slope - gypsum stack	71	15.240			71.00
COMPOSITE AREA & WEIGHTED CN --->		15.240			71.00 (71)

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP PHASE2_FINAL COVER_A.PPW

RUNOFF CURVE NUMBER DATA

Soil/Surface Description	CN	Area acres	Impervious Adjustment %C	Impervious Adjustment %UC	Adjusted CN
3:1 gypsum SW corner	71	2.130			71.00
COMPOSITE AREA & WEIGHTED CN --->		2.130			71.00 (71)

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP PHASE2_FINAL COVER_A.PPW

RUNOFF CURVE NUMBER DATA

Soil/Surface Description	CN	Area acres	Impervious Adjustment %C	Impervious Adjustment %UC	Adjusted CN
3:1 slope south face gypsum	71	23.060			71.00
COMPOSITE AREA & WEIGHTED CN --->		23.060			71.00 (71)

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP PHASE2_FINAL COVER_A.PPW

RUNOFF CURVE NUMBER DATA

Soil/Surface Description	CN	Area acres	Impervious Adjustment %C	Impervious Adjustment %UC	Adjusted CN
3:1 slope gypsum area	71	17.040			71.00
COMPOSITE AREA & WEIGHTED CN --->		17.040			71.00 (71)

ICPM HYDROGRAPH...
HYG file =
HYG ID = POND 2 IN
HYG Tag = 25yr

Peak Discharge = 489.25 cfs
Time to Peak = 12.0400 hrs
HYG Volume = 49.370 ac-ft

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
.0000	.00	.00	.00	.00	.00
.2000	.00	.00	.00	.00	.00
.4000	.00	.00	.00	.00	.00
.6000	.00	.00	.00	.00	.00
.8000	.00	.00	.00	.00	.00
1.0000	.00	.00	.00	.00	.00
1.2000	.00	.00	.00	.00	.00
1.4000	.00	.00	.00	.00	.00
1.6000	.00	.00	.00	.00	.00
1.8000	.00	.00	.00	.00	.00
2.0000	.00	.00	.00	.00	.00
2.2000	.00	.00	.00	.00	.00
2.4000	.00	.00	.00	.00	.00
2.6000	.00	.00	.00	.00	.00
2.8000	.00	.00	.00	.00	.00
3.0000	.00	.00	.00	.00	.00
3.2000	.00	.00	.00	.00	.00
3.4000	.00	.00	.00	.00	.00
3.6000	.00	.00	.00	.00	.00
3.8000	.00	.00	.00	.00	.00
4.0000	.00	.01	.01	.02	.02
4.2000	.03	.04	.04	.05	.06
4.4000	.07	.08	.09	.10	.12
4.6000	.14	.16	.18	.20	.23
4.8000	.25	.28	.30	.33	.36
5.0000	.39	.42	.45	.48	.51
5.2000	.54	.57	.60	.64	.67
5.4000	.70	.73	.77	.80	.83
5.6000	.87	.90	.93	.97	1.00
5.8000	1.04	1.07	1.11	1.14	1.18
6.0000	1.21	1.25	1.28	1.32	1.36
6.2000	1.39	1.43	1.47	1.50	1.54
6.4000	1.58	1.61	1.65	1.69	1.73

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
6.6000	1.77	1.80	1.84	1.88	1.92
6.8000	1.96	2.00	2.04	2.08	2.12
7.0000	2.16	2.20	2.24	2.28	2.32
7.2000	2.36	2.40	2.44	2.48	2.52
7.4000	2.56	2.60	2.64	2.68	2.72
7.6000	2.77	2.81	2.85	2.89	2.93
7.8000	2.97	3.02	3.06	3.10	3.14
8.0000	3.19	3.23	3.28	3.33	3.38
8.2000	3.44	3.51	3.58	3.65	3.73
8.4000	3.81	3.90	3.99	4.08	4.17
8.6000	4.27	4.37	4.47	4.57	4.68
8.8000	4.78	4.89	5.00	5.11	5.23
9.0000	5.34	5.46	5.57	5.68	5.79
9.2000	5.90	6.01	6.12	6.23	6.35
9.4000	6.46	6.57	6.68	6.80	6.91
9.6000	7.04	7.18	7.34	7.51	7.70
9.8000	7.90	8.12	8.34	8.58	8.83
10.0000	9.09	9.35	9.64	9.93	10.25
10.2000	10.58	10.93	11.29	11.67	12.07
10.4000	12.48	12.90	13.34	13.79	14.26
10.6000	14.76	15.28	15.85	16.44	17.07
10.8000	17.73	18.42	19.15	19.89	20.67
11.0000	21.47	22.32	23.24	24.24	25.35
11.2000	26.58	27.92	29.38	30.93	32.59
11.4000	34.35	36.18	38.14	40.65	45.05
11.6000	52.20	62.76	78.83	100.15	128.24
11.8000	163.31	210.08	274.16	347.67	414.04
12.0000	462.57	489.25	484.44	458.98	425.68
12.2000	389.72	355.27	322.76	292.43	265.91
12.4000	243.52	223.33	205.80	190.42	176.02
12.6000	163.13	151.45	140.72	131.07	122.49
12.8000	114.74	107.66	101.40	95.86	90.79
13.0000	86.22	82.06	78.27	74.81	71.64
13.2000	68.72	66.12	63.71	61.49	59.44
13.4000	57.53	55.74	54.06	52.49	51.00
13.6000	49.57	48.26	47.01	45.81	44.69
13.8000	43.63	42.60	41.63	40.70	39.79
14.0000	38.91	38.09	37.29	36.54	35.85
14.2000	35.20	34.61	34.06	33.55	33.08
14.4000	32.63	32.21	31.81	31.43	31.07
14.6000	30.73	30.39	30.08	29.78	29.49
14.8000	29.19	28.92	28.65	28.38	28.12
15.0000	27.86	27.61	27.35	27.11	26.86
15.2000	26.61	26.37	26.13	25.90	25.66
15.4000	25.42	25.18	24.94	24.71	24.48
15.6000	24.24	24.00	23.77	23.54	23.30
15.8000	23.06	22.83	22.59	22.36	22.13

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
16.0000	21.89	21.66	21.43	21.22	21.02
16.2000	20.84	20.66	20.50	20.35	20.21
16.4000	20.08	19.95	19.83	19.72	19.61
16.6000	19.50	19.40	19.30	19.20	19.10
16.8000	19.01	18.91	18.82	18.73	18.64
17.0000	18.55	18.46	18.37	18.29	18.20
17.2000	18.11	18.03	17.94	17.86	17.77
17.4000	17.69	17.60	17.52	17.44	17.35
17.6000	17.27	17.18	17.10	17.02	16.93
17.8000	16.85	16.76	16.68	16.60	16.51
18.0000	16.43	16.34	16.26	16.18	16.09
18.2000	16.01	15.92	15.84	15.76	15.67
18.4000	15.59	15.50	15.42	15.34	15.25
18.6000	15.17	15.08	15.00	14.91	14.83
18.8000	14.74	14.66	14.57	14.49	14.41
19.0000	14.32	14.23	14.15	14.07	13.98
19.2000	13.89	13.81	13.72	13.64	13.56
19.4000	13.47	13.38	13.30	13.21	13.13
19.6000	13.04	12.95	12.87	12.78	12.70
19.8000	12.61	12.53	12.44	12.36	12.27
20.0000	12.18	12.10	12.02	11.94	11.87
20.2000	11.81	11.75	11.70	11.65	11.61
20.4000	11.57	11.53	11.50	11.47	11.44
20.6000	11.41	11.38	11.36	11.33	11.31
20.8000	11.29	11.26	11.24	11.22	11.21
21.0000	11.18	11.16	11.15	11.13	11.11
21.2000	11.09	11.07	11.06	11.04	11.02
21.4000	11.00	10.99	10.97	10.95	10.94
21.6000	10.92	10.90	10.88	10.87	10.85
21.8000	10.83	10.82	10.80	10.79	10.77
22.0000	10.75	10.73	10.72	10.70	10.69
22.2000	10.67	10.65	10.64	10.62	10.60
22.4000	10.59	10.57	10.55	10.54	10.52
22.6000	10.50	10.49	10.47	10.46	10.44
22.8000	10.42	10.40	10.39	10.37	10.36
23.0000	10.34	10.32	10.30	10.29	10.27
23.2000	10.26	10.24	10.22	10.21	10.19
23.4000	10.17	10.15	10.14	10.12	10.11
23.6000	10.09	10.07	10.06	10.04	10.02
23.8000	10.01	9.99	9.97	9.96	9.94
24.0000	9.90	9.67	9.03	8.13	7.17
24.2000	6.29	5.47	4.73	4.08	3.52
24.4000	3.05	2.64	2.31	2.02	1.77
24.6000	1.56	1.37	1.20	1.06	.93
24.8000	.82	.72	.63	.55	.49
25.0000	.43	.38	.34	.30	.27
25.2000	.24	.21	.19	.17	.15

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
25.4000	.13	.12	.11	.10	.08
25.6000	.08	.07	.06	.05	.05
25.8000	.04	.04	.03	.03	.03
26.0000	.02	.02	.02	.02	.01
26.2000	.01	.01	.01	.01	.01
26.4000	.01	.00	.00	.00	.00
26.6000	.00	.00	.00	.00	.00
26.8000	.00	.00	.00	.00	.00
27.0000	.00	.00	.00	.00	.00
27.2000	.00	.00	.00	.00	.00
27.4000	.00	.00	.00	.00	.00
27.6000	.00	.00	.00	.00	.00
27.8000	.00	.00	.00	.00	.00
28.0000	.00	.00	.00	.00	.00
28.2000	.00	.00	.00	.00	.00
28.4000	.00	.00	.00	.00	.00
28.6000	.00	.00	.00	.00	.00
28.8000	.00	.00	.00	.00	.00
29.0000	.00	.00	.00	.00	.00
29.2000	.00	.00	.00	.00	.00
29.4000	.00	.00	.00	.00	.00
29.6000	.00	.00	.00	.00	.00
29.8000	.00	.00	.00	.00	.00
30.0000	.00	.00	.00	.00	.00
30.2000	.00	.00	.00	.00	.00
30.4000	.00	.00	.00	.00	.00
30.6000	.00	.00	.00	.00	.00
30.8000	.00	.00	.00	.00	.00
31.0000	.00	.00	.00	.00	.00
31.2000	.00	.00	.00	.00	.00
31.4000	.00	.00	.00	.00	.00
31.6000	.00	.00	.00	.00	.00
31.8000	.00	.00	.00	.00	.00
32.0000	.00	.00	.00	.00	.00
32.2000	.00	.00	.00	.00	.00
32.4000	.00	.00	.00	.00	.00
32.6000	.00	.00	.00	.00	.00
32.8000	.00	.00	.00	.00	.00
33.0000	.00	.00	.00	.00	.00
33.2000	.00	.00	.00	.00	.00
33.4000	.00	.00	.00	.00	.00
33.6000	.00	.00	.00	.00	.00
33.8000	.00	.00	.00	.00	.00
34.0000	.00	.00	.00	.00	.00
34.2000	.00	.00	.00	.00	.00
34.4000	.00	.00	.00	.00	.00
34.6000	.00	.00	.00	.00	.00

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
34.8000	.00	.00	.00	.00	.00
35.0000	.00				

ICPM HYDROGRAPH...
HYG file =
HYG ID = POND 2 IN
HYG Tag = 100yr

Peak Discharge = 624.90 cfs
Time to Peak = 12.0400 hrs
HYG Volume = 62.967 ac-ft

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
.0000	.00	.00	.00	.00	.00
.2000	.00	.00	.00	.00	.00
.4000	.00	.00	.00	.00	.00
.6000	.00	.00	.00	.00	.00
.8000	.00	.00	.00	.00	.00
1.0000	.00	.00	.00	.00	.00
1.2000	.00	.00	.00	.00	.00
1.4000	.00	.00	.00	.00	.00
1.6000	.00	.00	.00	.00	.00
1.8000	.00	.00	.00	.00	.00
2.0000	.00	.00	.00	.00	.00
2.2000	.00	.00	.00	.00	.00
2.4000	.00	.00	.00	.00	.00
2.6000	.00	.00	.00	.00	.00
2.8000	.00	.00	.00	.00	.00
3.0000	.00	.00	.00	.00	.00
3.2000	.00	.00	.00	.00	.00
3.4000	.00	.00	.01	.01	.01
3.6000	.02	.03	.04	.05	.06
3.8000	.07	.08	.09	.10	.12
4.0000	.14	.16	.18	.21	.24
4.2000	.27	.30	.33	.36	.40
4.4000	.43	.47	.50	.54	.57
4.6000	.61	.65	.68	.72	.76
4.8000	.80	.84	.88	.91	.95
5.0000	.99	1.03	1.07	1.12	1.16
5.2000	1.20	1.24	1.28	1.32	1.37
5.4000	1.41	1.45	1.49	1.54	1.58
5.6000	1.62	1.67	1.71	1.76	1.80
5.8000	1.85	1.89	1.94	1.98	2.03
6.0000	2.07	2.12	2.17	2.21	2.26
6.2000	2.31	2.35	2.40	2.45	2.49
6.4000	2.54	2.59	2.64	2.69	2.73

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
6.6000	2.78	2.83	2.88	2.93	2.98
6.8000	3.03	3.08	3.13	3.17	3.22
7.0000	3.27	3.32	3.37	3.42	3.47
7.2000	3.53	3.58	3.63	3.68	3.73
7.4000	3.78	3.83	3.88	3.93	3.98
7.6000	4.04	4.09	4.14	4.19	4.24
7.8000	4.30	4.35	4.40	4.45	4.50
8.0000	4.56	4.61	4.67	4.73	4.80
8.2000	4.88	4.96	5.05	5.15	5.26
8.4000	5.38	5.51	5.65	5.80	5.95
8.6000	6.12	6.29	6.47	6.65	6.85
8.8000	7.05	7.25	7.46	7.67	7.89
9.0000	8.12	8.35	8.57	8.79	9.01
9.2000	9.21	9.41	9.60	9.78	9.96
9.4000	10.13	10.29	10.45	10.61	10.78
9.6000	10.96	11.15	11.37	11.60	11.86
9.8000	12.14	12.43	12.74	13.07	13.41
10.0000	13.76	14.13	14.51	14.92	15.34
10.2000	15.80	16.27	16.77	17.28	17.82
10.4000	18.38	18.95	19.54	20.14	20.78
10.6000	21.45	22.15	22.91	23.71	24.55
10.8000	25.44	26.36	27.33	28.32	29.35
11.0000	30.42	31.54	32.77	34.09	35.56
11.2000	37.20	38.97	40.90	42.95	45.15
11.4000	47.47	49.88	52.46	55.75	61.59
11.6000	71.09	85.07	106.26	134.19	170.79
11.8000	216.11	276.07	357.54	450.18	532.98
12.0000	592.77	624.90	617.50	584.35	541.45
12.2000	495.32	451.10	409.42	370.57	336.65
12.4000	307.98	282.12	259.72	240.10	221.73
12.6000	205.33	190.48	176.85	164.60	153.70
12.8000	143.87	134.90	126.95	119.93	113.52
13.0000	107.73	102.46	97.67	93.30	89.29
13.2000	85.62	82.34	79.29	76.49	73.91
13.4000	71.50	69.25	67.13	65.16	63.29
13.6000	61.49	59.85	58.28	56.77	55.38
13.8000	54.05	52.76	51.54	50.38	49.24
14.0000	48.15	47.12	46.12	45.19	44.32
14.2000	43.51	42.77	42.08	41.45	40.86
14.4000	40.30	39.77	39.28	38.81	38.36
14.6000	37.93	37.51	37.11	36.74	36.38
14.8000	36.01	35.67	35.33	35.00	34.68
15.0000	34.35	34.03	33.72	33.41	33.11
15.2000	32.80	32.50	32.20	31.91	31.61
15.4000	31.31	31.02	30.72	30.44	30.14
15.6000	29.85	29.56	29.26	28.98	28.69
15.8000	28.40	28.10	27.81	27.53	27.24

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
16.0000	26.94	26.66	26.38	26.12	25.87
16.2000	25.64	25.42	25.22	25.04	24.87
16.4000	24.70	24.54	24.40	24.26	24.12
16.6000	23.98	23.85	23.73	23.61	23.49
16.8000	23.37	23.25	23.14	23.03	22.91
17.0000	22.80	22.69	22.58	22.48	22.37
17.2000	22.26	22.15	22.05	21.94	21.84
17.4000	21.73	21.63	21.52	21.42	21.32
17.6000	21.21	21.11	21.00	20.90	20.80
17.8000	20.69	20.59	20.48	20.38	20.28
18.0000	20.17	20.07	19.96	19.86	19.76
18.2000	19.65	19.55	19.44	19.34	19.24
18.4000	19.13	19.03	18.92	18.82	18.72
18.6000	18.61	18.51	18.40	18.30	18.20
18.8000	18.09	17.98	17.88	17.78	17.67
19.0000	17.57	17.46	17.36	17.25	17.15
19.2000	17.04	16.94	16.83	16.73	16.63
19.4000	16.52	16.41	16.31	16.20	16.10
19.6000	15.99	15.89	15.78	15.68	15.57
19.8000	15.46	15.36	15.25	15.15	15.04
20.0000	14.94	14.83	14.73	14.64	14.55
20.2000	14.47	14.40	14.34	14.28	14.23
20.4000	14.18	14.13	14.09	14.05	14.02
20.6000	13.98	13.95	13.92	13.89	13.86
20.8000	13.83	13.80	13.78	13.75	13.73
21.0000	13.70	13.68	13.65	13.63	13.61
21.2000	13.59	13.56	13.54	13.52	13.50
21.4000	13.48	13.46	13.44	13.42	13.40
21.6000	13.37	13.35	13.33	13.31	13.29
21.8000	13.27	13.25	13.23	13.21	13.19
22.0000	13.17	13.14	13.12	13.11	13.09
22.2000	13.06	13.04	13.02	13.00	12.98
22.4000	12.96	12.94	12.92	12.90	12.88
22.6000	12.86	12.84	12.82	12.80	12.78
22.8000	12.76	12.73	12.71	12.70	12.68
23.0000	12.65	12.63	12.61	12.59	12.57
23.2000	12.55	12.53	12.51	12.49	12.47
23.4000	12.45	12.42	12.40	12.39	12.37
23.6000	12.34	12.32	12.30	12.28	12.26
23.8000	12.24	12.22	12.20	12.18	12.16
24.0000	12.11	11.83	11.05	9.94	8.77
24.2000	7.70	6.70	5.79	5.00	4.31
24.4000	3.73	3.24	2.82	2.47	2.17
24.6000	1.91	1.67	1.47	1.29	1.13
24.8000	1.00	.88	.77	.68	.60
25.0000	.53	.47	.42	.37	.33
25.2000	.29	.26	.23	.21	.18

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
25.4000	.16	.14	.13	.12	.10
25.6000	.09	.08	.07	.07	.06
25.8000	.05	.05	.04	.04	.03
26.0000	.03	.03	.02	.02	.02
26.2000	.02	.01	.01	.01	.01
26.4000	.01	.01	.00	.00	.00
26.6000	.00	.00	.00	.00	.00
26.8000	.00	.00	.00	.00	.00
27.0000	.00	.00	.00	.00	.00
27.2000	.00	.00	.00	.00	.00
27.4000	.00	.00	.00	.00	.00
27.6000	.00	.00	.00	.00	.00
27.8000	.00	.00	.00	.00	.00
28.0000	.00	.00	.00	.00	.00
28.2000	.00	.00	.00	.00	.00
28.4000	.00	.00	.00	.00	.00
28.6000	.00	.00	.00	.00	.00
28.8000	.00	.00	.00	.00	.00
29.0000	.00	.00	.00	.00	.00
29.2000	.00	.00	.00	.00	.00
29.4000	.00	.00	.00	.00	.00
29.6000	.00	.00	.00	.00	.00
29.8000	.00	.00	.00	.00	.00
30.0000	.00	.00	.00	.00	.00
30.2000	.00	.00	.00	.00	.00
30.4000	.00	.00	.00	.00	.00
30.6000	.00	.00	.00	.00	.00
30.8000	.00	.00	.00	.00	.00
31.0000	.00	.00	.00	.00	.00
31.2000	.00	.00	.00	.00	.00
31.4000	.00	.00	.00	.00	.00
31.6000	.00	.00	.00	.00	.00
31.8000	.00	.00	.00	.00	.00
32.0000	.00	.00	.00	.00	.00
32.2000	.00	.00	.00	.00	.00
32.4000	.00	.00	.00	.00	.00
32.6000	.00	.00	.00	.00	.00
32.8000	.00	.00	.00	.00	.00
33.0000	.00	.00	.00	.00	.00
33.2000	.00	.00	.00	.00	.00
33.4000	.00	.00	.00	.00	.00
33.6000	.00	.00	.00	.00	.00
33.8000	.00	.00	.00	.00	.00
34.0000	.00	.00	.00	.00	.00
34.2000	.00	.00	.00	.00	.00
34.4000	.00	.00	.00	.00	.00
34.6000	.00	.00	.00	.00	.00

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
34.8000	.00	.00	.00	.00	.00
35.0000	.00				

ICPM HYDROGRAPH...
HYG file =
HYG ID = POND 2 OUT
HYG Tag = 25yr

Peak Discharge =	200.74	cfs
Time to Peak =	12.4800	hrs
HYG Volume =	49.413	ac-ft

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
.0000	.00	.00	.00	.00	.00
.2000	.00	.00	.00	.00	.00
.4000	.00	.00	.00	.00	.00
.6000	.00	.00	.00	.00	.00
.8000	.00	.00	.00	.00	.00
1.0000	.00	.00	.00	.00	.00
1.2000	.00	.00	.00	.00	.00
1.4000	.00	.00	.00	.00	.00
1.6000	.00	.00	.00	.00	.00
1.8000	.00	.00	.00	.00	.00
2.0000	.00	.00	.00	.00	.00
2.2000	.00	.00	.00	.00	.00
2.4000	.00	.00	.00	.00	.00
2.6000	.00	.00	.00	.00	.00
2.8000	.00	.00	.00	.00	.00
3.0000	.00	.00	.00	.00	.00
3.2000	.00	.00	.00	.00	.00
3.4000	.00	.00	.00	.00	.00
3.6000	.00	.00	.00	.00	.00
3.8000	.00	.00	.00	.00	.00
4.0000	.00	.00	.00	.00	.00
4.2000	.00	.00	.00	.00	.00
4.4000	.00	.00	.00	.01	.02
4.6000	.03	.04	.05	.06	.07
4.8000	.08	.09	.10	.11	.12
5.0000	.13	.14	.16	.18	.20
5.2000	.22	.24	.26	.28	.30
5.4000	.32	.34	.36	.38	.40
5.6000	.42	.44	.46	.49	.52
5.8000	.54	.57	.60	.63	.66
6.0000	.69	.72	.75	.78	.81
6.2000	.84	.87	.90	.93	.96
6.4000	.99	1.02	1.05	1.08	1.11

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
6.6000	1.14	1.17	1.20	1.23	1.26
6.8000	1.30	1.34	1.38	1.42	1.46
7.0000	1.50	1.54	1.57	1.61	1.65
7.2000	1.69	1.73	1.77	1.81	1.85
7.4000	1.89	1.93	1.97	2.01	2.05
7.6000	2.09	2.13	2.17	2.21	2.25
7.8000	2.29	2.33	2.37	2.41	2.45
8.0000	2.49	2.53	2.57	2.61	2.64
8.2000	2.68	2.72	2.76	2.80	2.85
8.4000	2.90	2.95	3.00	3.05	3.11
8.6000	3.17	3.23	3.29	3.35	3.42
8.8000	3.49	3.56	3.63	3.69	3.77
9.0000	3.85	3.93	4.01	4.09	4.18
9.2000	4.27	4.36	4.45	4.54	4.63
9.4000	4.72	4.80	4.89	4.99	5.09
9.6000	5.19	5.29	5.39	5.50	5.61
9.8000	5.72	5.83	5.95	6.08	6.22
10.0000	6.36	6.51	6.67	6.82	6.99
10.2000	7.17	7.36	7.55	7.75	7.95
10.4000	8.17	8.40	8.65	8.91	9.17
10.6000	9.45	9.74	10.03	10.35	10.68
10.8000	11.02	11.39	11.77	12.16	12.58
11.0000	13.02	13.47	13.95	14.44	14.97
11.2000	15.52	16.12	16.75	17.43	18.17
11.4000	18.95	19.78	20.66	21.61	22.69
11.6000	24.01	25.71	28.00	31.12	35.34
11.8000	40.96	48.37	58.22	71.06	90.35
12.0000	117.94	144.33	168.12	184.49	191.79
12.2000	192.51	194.25	196.36	198.13	199.40
12.4000	200.22	200.65	200.74	200.54	200.09
12.6000	199.40	198.51	197.45	196.23	194.87
12.8000	193.39	191.82	190.17	188.45	186.68
13.0000	184.87	183.02	179.21	174.87	170.58
13.2000	166.21	161.70	157.05	152.27	147.38
13.4000	142.40	137.34	132.22	127.07	121.90
13.6000	116.73	111.60	106.52	101.52	96.62
13.8000	91.85	87.23	83.26	79.96	76.95
14.0000	74.22	72.37	70.61	68.89	67.23
14.2000	65.61	64.05	62.54	61.09	59.67
14.4000	58.30	56.99	55.72	54.49	53.31
14.6000	52.17	51.07	50.01	48.99	48.01
14.8000	47.06	46.15	45.27	44.42	43.59
15.0000	42.80	42.04	41.30	40.58	39.89
15.2000	39.23	38.58	37.96	37.35	36.77
15.4000	36.19	35.63	35.10	34.57	34.07
15.6000	33.57	33.09	32.63	32.16	31.72
15.8000	31.28	30.86	30.44	30.03	29.64

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
16.0000	29.24	28.85	28.48	28.11	27.76
16.2000	27.41	27.06	26.73	26.40	26.08
16.4000	25.77	25.48	25.19	24.91	24.65
16.6000	24.39	24.13	23.88	23.64	23.42
16.8000	23.19	22.97	22.76	22.56	22.36
17.0000	22.16	21.97	21.79	21.61	21.44
17.2000	21.27	21.10	20.94	20.78	20.63
17.4000	20.48	20.34	20.20	20.06	19.92
17.6000	19.78	19.65	19.52	19.40	19.27
17.8000	19.15	19.03	18.91	18.79	18.67
18.0000	18.56	18.45	18.35	18.24	18.13
18.2000	18.02	17.91	17.80	17.70	17.60
18.4000	17.50	17.40	17.31	17.21	17.11
18.6000	17.01	16.91	16.81	16.71	16.61
18.8000	16.52	16.43	16.34	16.26	16.17
19.0000	16.08	15.99	15.90	15.81	15.72
19.2000	15.63	15.54	15.45	15.36	15.27
19.4000	15.19	15.10	15.01	14.92	14.83
19.6000	14.74	14.65	14.56	14.47	14.38
19.8000	14.29	14.20	14.12	14.03	13.94
20.0000	13.85	13.76	13.67	13.58	13.49
20.2000	13.40	13.32	13.24	13.16	13.09
20.4000	13.01	12.93	12.86	12.79	12.72
20.6000	12.65	12.58	12.52	12.46	12.40
20.8000	12.34	12.28	12.23	12.18	12.13
21.0000	12.08	12.04	11.99	11.95	11.91
21.2000	11.87	11.83	11.79	11.75	11.71
21.4000	11.67	11.64	11.61	11.58	11.55
21.6000	11.52	11.49	11.46	11.43	11.40
21.8000	11.37	11.34	11.31	11.28	11.25
22.0000	11.22	11.20	11.18	11.16	11.14
22.2000	11.12	11.10	11.08	11.06	11.04
22.4000	11.02	11.01	10.99	10.97	10.95
22.6000	10.93	10.91	10.89	10.87	10.85
22.8000	10.83	10.81	10.79	10.77	10.75
23.0000	10.73	10.71	10.69	10.67	10.65
23.2000	10.63	10.61	10.59	10.57	10.55
23.4000	10.53	10.51	10.49	10.47	10.45
23.6000	10.43	10.41	10.39	10.37	10.35
23.8000	10.33	10.31	10.29	10.27	10.25
24.0000	10.23	10.21	10.17	10.09	9.97
24.2000	9.80	9.60	9.37	9.11	8.84
24.4000	8.55	8.25	7.95	7.66	7.36
24.6000	7.06	6.78	6.49	6.21	5.94
24.8000	5.69	5.43	5.18	4.94	4.72
25.0000	4.50	4.29	4.09	3.89	3.70
25.2000	3.53	3.36	3.20	3.04	2.89

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
25.4000	2.75	2.62	2.49	2.37	2.25
25.6000	2.14	2.03	1.93	1.83	1.74
25.8000	1.65	1.57	1.50	1.42	1.35
26.0000	1.28	1.21	1.15	1.09	1.03
26.2000	.98	.93	.88	.83	.79
26.4000	.75	.71	.67	.64	.61
26.6000	.58	.55	.52	.50	.47
26.8000	.45	.43	.41	.39	.37
27.0000	.35	.33	.31	.29	.28
27.2000	.27	.26	.25	.24	.23
27.4000	.22	.21	.20	.19	.18
27.6000	.17	.16	.15	.14	.13
27.8000	.12	.11	.10	.09	.09
28.0000	.09	.09	.09	.09	.09
28.2000	.09	.09	.09	.09	.09
28.4000	.09	.09	.09	.09	.09
28.6000	.09	.09	.09	.09	.09
28.8000	.09	.09	.09	.09	.09
29.0000	.09	.09	.09	.09	.09
29.2000	.09	.09	.09	.09	.09
29.4000	.09	.09	.09	.09	.09
29.6000	.09	.09	.09	.09	.09
29.8000	.09	.09	.09	.09	.09
30.0000	.09	.09	.09	.09	.09
30.2000	.09	.09	.09	.09	.09
30.4000	.09	.09	.09	.09	.09
30.6000	.09	.09	.09	.09	.09
30.8000	.09	.09	.09	.09	.09
31.0000	.09	.09	.09	.09	.09
31.2000	.09	.09	.09	.09	.09
31.4000	.09	.09	.09	.09	.09
31.6000	.09	.09	.09	.09	.09
31.8000	.09	.09	.09	.09	.09
32.0000	.09	.09	.09	.09	.09
32.2000	.09	.09	.09	.09	.09
32.4000	.09	.09	.09	.09	.09
32.6000	.09	.09	.09	.09	.09
32.8000	.09	.09	.09	.09	.09
33.0000	.09	.09	.09	.09	.09
33.2000	.09	.09	.09	.09	.09
33.4000	.09	.09	.09	.09	.09
33.6000	.09	.09	.09	.09	.09
33.8000	.09	.09	.09	.09	.09
34.0000	.09	.09	.09	.09	.09
34.2000	.09	.09	.09	.09	.09
34.4000	.09	.09	.09	.09	.09
34.6000	.09	.09	.09	.09	.09

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
34.8000	.09	.09	.09	.09	.09
35.0000	.09				

ICPM HYDROGRAPH...
HYG file =
HYG ID = POND 2 OUT
HYG Tag = 100yr

Peak Discharge = 227.14 cfs
Time to Peak = 12.5200 hrs
HYG Volume = 63.018 ac-ft

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
.0000	.00	.00	.00	.00	.00
.2000	.00	.00	.00	.00	.00
.4000	.00	.00	.00	.00	.00
.6000	.00	.00	.00	.00	.00
.8000	.00	.00	.00	.00	.00
1.0000	.00	.00	.00	.00	.00
1.2000	.00	.00	.00	.00	.00
1.4000	.00	.00	.00	.00	.00
1.6000	.00	.00	.00	.00	.00
1.8000	.00	.00	.00	.00	.00
2.0000	.00	.00	.00	.00	.00
2.2000	.00	.00	.00	.00	.00
2.4000	.00	.00	.00	.00	.00
2.6000	.00	.00	.00	.00	.00
2.8000	.00	.00	.00	.00	.00
3.0000	.00	.00	.00	.00	.00
3.2000	.00	.00	.00	.00	.00
3.4000	.00	.00	.00	.00	.00
3.6000	.00	.00	.00	.00	.00
3.8000	.00	.00	.00	.00	.01
4.0000	.02	.03	.04	.05	.06
4.2000	.07	.08	.09	.10	.11
4.4000	.13	.15	.17	.19	.21
4.6000	.23	.25	.27	.29	.31
4.8000	.33	.36	.39	.42	.45
5.0000	.48	.51	.53	.56	.59
5.2000	.62	.65	.68	.71	.74
5.4000	.77	.80	.83	.87	.91
5.6000	.95	.99	1.03	1.07	1.11
5.8000	1.15	1.19	1.23	1.27	1.31
6.0000	1.35	1.39	1.43	1.47	1.51
6.2000	1.55	1.58	1.62	1.66	1.70
6.4000	1.74	1.78	1.82	1.86	1.90

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
6.6000	1.94	1.98	2.03	2.08	2.13
6.8000	2.18	2.23	2.28	2.33	2.38
7.0000	2.43	2.48	2.53	2.58	2.62
7.2000	2.67	2.72	2.77	2.82	2.87
7.4000	2.92	2.97	3.02	3.07	3.12
7.6000	3.17	3.22	3.27	3.32	3.37
7.8000	3.42	3.47	3.52	3.57	3.62
8.0000	3.67	3.71	3.76	3.81	3.86
8.2000	3.91	3.96	4.01	4.07	4.13
8.4000	4.19	4.26	4.33	4.40	4.48
8.6000	4.56	4.65	4.73	4.82	4.92
8.8000	5.03	5.14	5.25	5.37	5.50
9.0000	5.63	5.77	5.90	6.04	6.19
9.2000	6.34	6.49	6.65	6.81	6.96
9.4000	7.12	7.28	7.44	7.60	7.76
9.6000	7.91	8.07	8.24	8.41	8.58
9.8000	8.76	8.93	9.12	9.32	9.52
10.0000	9.73	9.95	10.17	10.41	10.66
10.2000	10.92	11.18	11.46	11.75	12.05
10.4000	12.35	12.68	13.02	13.36	13.73
10.6000	14.11	14.49	14.91	15.34	15.80
10.8000	16.27	16.76	17.28	17.81	18.37
11.0000	18.96	19.57	20.22	20.89	21.60
11.2000	22.36	23.16	24.01	24.92	25.89
11.4000	26.93	28.04	29.22	30.49	31.93
11.6000	33.68	35.94	38.97	43.10	48.66
11.8000	56.02	65.67	78.43	103.23	132.82
12.0000	164.18	190.82	198.03	201.70	206.92
12.2000	212.23	216.66	219.68	222.10	223.98
12.4000	225.38	226.34	226.91	227.14	227.07
12.6000	226.73	226.14	225.34	224.35	223.19
12.8000	221.89	220.47	218.94	217.32	215.63
13.0000	213.88	211.90	209.67	207.43	205.20
13.2000	202.95	200.70	198.44	196.18	193.92
13.4000	191.68	189.45	187.23	185.02	182.84
13.6000	178.31	173.36	168.50	163.59	158.56
13.8000	153.42	148.18	142.85	137.47	132.04
14.0000	126.59	121.15	115.74	110.38	105.12
14.2000	99.96	94.94	90.08	85.42	81.85
14.4000	78.63	75.74	73.40	71.66	69.97
14.6000	68.36	66.80	65.31	63.86	62.47
14.8000	61.14	59.85	58.61	57.42	56.27
15.0000	55.16	54.09	53.06	52.07	51.11
15.2000	50.19	49.30	48.44	47.61	46.80
15.4000	46.02	45.27	44.54	43.81	43.13
15.6000	42.47	41.82	41.18	40.55	39.96
15.8000	39.37	38.81	38.26	37.72	37.19

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
16.0000	36.67	36.17	35.67	35.19	34.72
16.2000	34.25	33.81	33.37	32.95	32.53
16.4000	32.13	31.75	31.37	31.00	30.66
16.6000	30.32	29.99	29.68	29.37	29.07
16.8000	28.79	28.51	28.23	27.96	27.71
17.0000	27.46	27.22	26.98	26.75	26.53
17.2000	26.31	26.10	25.89	25.70	25.50
17.4000	25.31	25.12	24.94	24.76	24.59
17.6000	24.42	24.25	24.08	23.92	23.76
17.8000	23.60	23.46	23.31	23.16	23.01
18.0000	22.87	22.73	22.59	22.46	22.32
18.2000	22.18	22.05	21.92	21.79	21.66
18.4000	21.53	21.41	21.28	21.16	21.04
18.6000	20.92	20.80	20.68	20.56	20.45
18.8000	20.33	20.21	20.09	19.97	19.85
19.0000	19.73	19.61	19.50	19.40	19.29
19.2000	19.18	19.07	18.96	18.85	18.74
19.4000	18.63	18.52	18.41	18.31	18.20
19.6000	18.09	17.98	17.87	17.76	17.65
19.8000	17.54	17.43	17.32	17.22	17.11
20.0000	17.00	16.89	16.78	16.67	16.56
20.2000	16.45	16.35	16.26	16.16	16.06
20.4000	15.96	15.87	15.78	15.69	15.60
20.6000	15.52	15.44	15.36	15.28	15.21
20.8000	15.15	15.08	15.01	14.95	14.89
21.0000	14.83	14.77	14.71	14.65	14.60
21.2000	14.55	14.50	14.45	14.40	14.35
21.4000	14.31	14.27	14.23	14.19	14.16
21.6000	14.12	14.08	14.04	14.00	13.96
21.8000	13.92	13.89	13.86	13.83	13.80
22.0000	13.77	13.74	13.71	13.68	13.65
22.2000	13.62	13.59	13.56	13.53	13.50
22.4000	13.47	13.44	13.41	13.38	13.35
22.6000	13.32	13.30	13.28	13.26	13.24
22.8000	13.22	13.20	13.18	13.16	13.14
23.0000	13.12	13.10	13.08	13.06	13.04
23.2000	13.02	13.00	12.98	12.96	12.94
23.4000	12.92	12.90	12.87	12.85	12.83
23.6000	12.81	12.79	12.77	12.75	12.73
23.8000	12.71	12.69	12.67	12.65	12.63
24.0000	12.60	12.57	12.51	12.41	12.25
24.2000	12.05	11.80	11.51	11.19	10.86
24.4000	10.50	10.14	9.78	9.41	9.04
24.6000	8.69	8.33	7.98	7.65	7.32
24.8000	6.99	6.69	6.39	6.10	5.82
25.0000	5.56	5.30	5.05	4.81	4.59
25.2000	4.37	4.16	3.96	3.77	3.59

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
25.4000	3.41	3.24	3.08	2.93	2.78
25.6000	2.64	2.52	2.39	2.27	2.16
25.8000	2.05	1.95	1.85	1.76	1.67
26.0000	1.58	1.51	1.43	1.36	1.29
26.2000	1.22	1.16	1.10	1.04	.99
26.4000	.94	.89	.84	.80	.76
26.6000	.72	.68	.64	.61	.58
26.8000	.55	.52	.50	.47	.45
27.0000	.43	.41	.39	.37	.35
27.2000	.33	.31	.29	.28	.27
27.4000	.26	.25	.24	.23	.22
27.6000	.21	.20	.19	.18	.17
27.8000	.16	.15	.14	.13	.12
28.0000	.11	.10	.09	.09	.09
28.2000	.09	.09	.09	.09	.09
28.4000	.09	.09	.09	.09	.09
28.6000	.09	.09	.09	.09	.09
28.8000	.09	.09	.09	.09	.09
29.0000	.09	.09	.09	.09	.09
29.2000	.09	.09	.09	.09	.09
29.4000	.09	.09	.09	.09	.09
29.6000	.09	.09	.09	.09	.09
29.8000	.09	.09	.09	.09	.09
30.0000	.09	.09	.09	.09	.09
30.2000	.09	.09	.09	.09	.09
30.4000	.09	.09	.09	.09	.09
30.6000	.09	.09	.09	.09	.09
30.8000	.09	.09	.09	.09	.09
31.0000	.09	.09	.09	.09	.09
31.2000	.09	.09	.09	.09	.09
31.4000	.09	.09	.09	.09	.09
31.6000	.09	.09	.09	.09	.09
31.8000	.09	.09	.09	.09	.09
32.0000	.09	.09	.09	.09	.09
32.2000	.09	.09	.09	.09	.09
32.4000	.09	.09	.09	.09	.09
32.6000	.09	.09	.09	.09	.09
32.8000	.09	.09	.09	.09	.09
33.0000	.09	.09	.09	.09	.09
33.2000	.09	.09	.09	.09	.09
33.4000	.09	.09	.09	.09	.09
33.6000	.09	.09	.09	.09	.09
33.8000	.09	.09	.09	.09	.09
34.0000	.09	.09	.09	.09	.09
34.2000	.09	.09	.09	.09	.09
34.4000	.09	.09	.09	.09	.09
34.6000	.09	.09	.09	.09	.09

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
34.8000	.09	.09	.09	.09	.09
35.0000	.09				

ICPM HYDROGRAPH...
HYG file =
HYG ID = POND 3 IN
HYG Tag = 25yr

Peak Discharge = 200.74 cfs
Time to Peak = 12.4800 hrs
HYG Volume = 49.413 ac-ft

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
.0000	.00	.00	.00	.00	.00
.2000	.00	.00	.00	.00	.00
.4000	.00	.00	.00	.00	.00
.6000	.00	.00	.00	.00	.00
.8000	.00	.00	.00	.00	.00
1.0000	.00	.00	.00	.00	.00
1.2000	.00	.00	.00	.00	.00
1.4000	.00	.00	.00	.00	.00
1.6000	.00	.00	.00	.00	.00
1.8000	.00	.00	.00	.00	.00
2.0000	.00	.00	.00	.00	.00
2.2000	.00	.00	.00	.00	.00
2.4000	.00	.00	.00	.00	.00
2.6000	.00	.00	.00	.00	.00
2.8000	.00	.00	.00	.00	.00
3.0000	.00	.00	.00	.00	.00
3.2000	.00	.00	.00	.00	.00
3.4000	.00	.00	.00	.00	.00
3.6000	.00	.00	.00	.00	.00
3.8000	.00	.00	.00	.00	.00
4.0000	.00	.00	.00	.00	.00
4.2000	.00	.00	.00	.00	.00
4.4000	.00	.00	.00	.01	.02
4.6000	.03	.04	.05	.06	.07
4.8000	.08	.09	.10	.11	.12
5.0000	.13	.14	.16	.18	.20
5.2000	.22	.24	.26	.28	.30
5.4000	.32	.34	.36	.38	.40
5.6000	.42	.44	.46	.49	.52
5.8000	.54	.57	.60	.63	.66
6.0000	.69	.72	.75	.78	.81
6.2000	.84	.87	.90	.93	.96
6.4000	.99	1.02	1.05	1.08	1.11

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
6.6000	1.14	1.17	1.20	1.23	1.26
6.8000	1.30	1.34	1.38	1.42	1.46
7.0000	1.50	1.54	1.57	1.61	1.65
7.2000	1.69	1.73	1.77	1.81	1.85
7.4000	1.89	1.93	1.97	2.01	2.05
7.6000	2.09	2.13	2.17	2.21	2.25
7.8000	2.29	2.33	2.37	2.41	2.45
8.0000	2.49	2.53	2.57	2.61	2.64
8.2000	2.68	2.72	2.76	2.80	2.85
8.4000	2.90	2.95	3.00	3.05	3.11
8.6000	3.17	3.23	3.29	3.35	3.42
8.8000	3.49	3.56	3.63	3.69	3.77
9.0000	3.85	3.93	4.01	4.09	4.18
9.2000	4.27	4.36	4.45	4.54	4.63
9.4000	4.72	4.80	4.89	4.99	5.09
9.6000	5.19	5.29	5.39	5.50	5.61
9.8000	5.72	5.83	5.95	6.08	6.22
10.0000	6.36	6.51	6.67	6.82	6.99
10.2000	7.17	7.36	7.55	7.75	7.95
10.4000	8.17	8.40	8.65	8.91	9.17
10.6000	9.45	9.74	10.03	10.35	10.68
10.8000	11.02	11.39	11.77	12.16	12.58
11.0000	13.02	13.47	13.95	14.44	14.97
11.2000	15.52	16.12	16.75	17.43	18.17
11.4000	18.95	19.78	20.66	21.61	22.69
11.6000	24.01	25.71	28.00	31.12	35.34
11.8000	40.96	48.37	58.22	71.06	90.35
12.0000	117.94	144.33	168.12	184.49	191.79
12.2000	192.51	194.25	196.36	198.13	199.40
12.4000	200.22	200.65	200.74	200.54	200.09
12.6000	199.40	198.51	197.45	196.23	194.87
12.8000	193.39	191.82	190.17	188.45	186.68
13.0000	184.87	183.02	179.21	174.87	170.58
13.2000	166.21	161.70	157.05	152.27	147.38
13.4000	142.40	137.34	132.22	127.07	121.90
13.6000	116.73	111.60	106.52	101.52	96.62
13.8000	91.85	87.23	83.26	79.96	76.95
14.0000	74.22	72.37	70.61	68.89	67.23
14.2000	65.61	64.05	62.54	61.09	59.67
14.4000	58.30	56.99	55.72	54.49	53.31
14.6000	52.17	51.07	50.01	48.99	48.01
14.8000	47.06	46.15	45.27	44.42	43.59
15.0000	42.80	42.04	41.30	40.58	39.89
15.2000	39.23	38.58	37.96	37.35	36.77
15.4000	36.19	35.63	35.10	34.57	34.07
15.6000	33.57	33.09	32.63	32.16	31.72
15.8000	31.28	30.86	30.44	30.03	29.64

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
16.0000	29.24	28.85	28.48	28.11	27.76
16.2000	27.41	27.06	26.73	26.40	26.08
16.4000	25.77	25.48	25.19	24.91	24.65
16.6000	24.39	24.13	23.88	23.64	23.42
16.8000	23.19	22.97	22.76	22.56	22.36
17.0000	22.16	21.97	21.79	21.61	21.44
17.2000	21.27	21.10	20.94	20.78	20.63
17.4000	20.48	20.34	20.20	20.06	19.92
17.6000	19.78	19.65	19.52	19.40	19.27
17.8000	19.15	19.03	18.91	18.79	18.67
18.0000	18.56	18.45	18.35	18.24	18.13
18.2000	18.02	17.91	17.80	17.70	17.60
18.4000	17.50	17.40	17.31	17.21	17.11
18.6000	17.01	16.91	16.81	16.71	16.61
18.8000	16.52	16.43	16.34	16.26	16.17
19.0000	16.08	15.99	15.90	15.81	15.72
19.2000	15.63	15.54	15.45	15.36	15.27
19.4000	15.19	15.10	15.01	14.92	14.83
19.6000	14.74	14.65	14.56	14.47	14.38
19.8000	14.29	14.20	14.12	14.03	13.94
20.0000	13.85	13.76	13.67	13.58	13.49
20.2000	13.40	13.32	13.24	13.16	13.09
20.4000	13.01	12.93	12.86	12.79	12.72
20.6000	12.65	12.58	12.52	12.46	12.40
20.8000	12.34	12.28	12.23	12.18	12.13
21.0000	12.08	12.04	11.99	11.95	11.91
21.2000	11.87	11.83	11.79	11.75	11.71
21.4000	11.67	11.64	11.61	11.58	11.55
21.6000	11.52	11.49	11.46	11.43	11.40
21.8000	11.37	11.34	11.31	11.28	11.25
22.0000	11.22	11.20	11.18	11.16	11.14
22.2000	11.12	11.10	11.08	11.06	11.04
22.4000	11.02	11.01	10.99	10.97	10.95
22.6000	10.93	10.91	10.89	10.87	10.85
22.8000	10.83	10.81	10.79	10.77	10.75
23.0000	10.73	10.71	10.69	10.67	10.65
23.2000	10.63	10.61	10.59	10.57	10.55
23.4000	10.53	10.51	10.49	10.47	10.45
23.6000	10.43	10.41	10.39	10.37	10.35
23.8000	10.33	10.31	10.29	10.27	10.25
24.0000	10.23	10.21	10.17	10.09	9.97
24.2000	9.80	9.60	9.37	9.11	8.84
24.4000	8.55	8.25	7.95	7.66	7.36
24.6000	7.06	6.78	6.49	6.21	5.94
24.8000	5.69	5.43	5.18	4.94	4.72
25.0000	4.50	4.29	4.09	3.89	3.70
25.2000	3.53	3.36	3.20	3.04	2.89

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
25.4000	2.75	2.62	2.49	2.37	2.25
25.6000	2.14	2.03	1.93	1.83	1.74
25.8000	1.65	1.57	1.50	1.42	1.35
26.0000	1.28	1.21	1.15	1.09	1.03
26.2000	.98	.93	.88	.83	.79
26.4000	.75	.71	.67	.64	.61
26.6000	.58	.55	.52	.50	.47
26.8000	.45	.43	.41	.39	.37
27.0000	.35	.33	.31	.29	.28
27.2000	.27	.26	.25	.24	.23
27.4000	.22	.21	.20	.19	.18
27.6000	.17	.16	.15	.14	.13
27.8000	.12	.11	.10	.09	.09
28.0000	.09	.09	.09	.09	.09
28.2000	.09	.09	.09	.09	.09
28.4000	.09	.09	.09	.09	.09
28.6000	.09	.09	.09	.09	.09
28.8000	.09	.09	.09	.09	.09
29.0000	.09	.09	.09	.09	.09
29.2000	.09	.09	.09	.09	.09
29.4000	.09	.09	.09	.09	.09
29.6000	.09	.09	.09	.09	.09
29.8000	.09	.09	.09	.09	.09
30.0000	.09	.09	.09	.09	.09
30.2000	.09	.09	.09	.09	.09
30.4000	.09	.09	.09	.09	.09
30.6000	.09	.09	.09	.09	.09
30.8000	.09	.09	.09	.09	.09
31.0000	.09	.09	.09	.09	.09
31.2000	.09	.09	.09	.09	.09
31.4000	.09	.09	.09	.09	.09
31.6000	.09	.09	.09	.09	.09
31.8000	.09	.09	.09	.09	.09
32.0000	.09	.09	.09	.09	.09
32.2000	.09	.09	.09	.09	.09
32.4000	.09	.09	.09	.09	.09
32.6000	.09	.09	.09	.09	.09
32.8000	.09	.09	.09	.09	.09
33.0000	.09	.09	.09	.09	.09
33.2000	.09	.09	.09	.09	.09
33.4000	.09	.09	.09	.09	.09
33.6000	.09	.09	.09	.09	.09
33.8000	.09	.09	.09	.09	.09
34.0000	.09	.09	.09	.09	.09
34.2000	.09	.09	.09	.09	.09
34.4000	.09	.09	.09	.09	.09
34.6000	.09	.09	.09	.09	.09

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
34.8000	.09	.09	.09	.09	.09
35.0000	.09				

ICPM HYDROGRAPH...
HYG file =
HYG ID = POND 3 IN
HYG Tag = 100yr

Peak Discharge = 227.14 cfs
Time to Peak = 12.5200 hrs
HYG Volume = 63.018 ac-ft

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
.0000	.00	.00	.00	.00	.00
.2000	.00	.00	.00	.00	.00
.4000	.00	.00	.00	.00	.00
.6000	.00	.00	.00	.00	.00
.8000	.00	.00	.00	.00	.00
1.0000	.00	.00	.00	.00	.00
1.2000	.00	.00	.00	.00	.00
1.4000	.00	.00	.00	.00	.00
1.6000	.00	.00	.00	.00	.00
1.8000	.00	.00	.00	.00	.00
2.0000	.00	.00	.00	.00	.00
2.2000	.00	.00	.00	.00	.00
2.4000	.00	.00	.00	.00	.00
2.6000	.00	.00	.00	.00	.00
2.8000	.00	.00	.00	.00	.00
3.0000	.00	.00	.00	.00	.00
3.2000	.00	.00	.00	.00	.00
3.4000	.00	.00	.00	.00	.00
3.6000	.00	.00	.00	.00	.00
3.8000	.00	.00	.00	.00	.01
4.0000	.02	.03	.04	.05	.06
4.2000	.07	.08	.09	.10	.11
4.4000	.13	.15	.17	.19	.21
4.6000	.23	.25	.27	.29	.31
4.8000	.33	.36	.39	.42	.45
5.0000	.48	.51	.53	.56	.59
5.2000	.62	.65	.68	.71	.74
5.4000	.77	.80	.83	.87	.91
5.6000	.95	.99	1.03	1.07	1.11
5.8000	1.15	1.19	1.23	1.27	1.31
6.0000	1.35	1.39	1.43	1.47	1.51
6.2000	1.55	1.58	1.62	1.66	1.70
6.4000	1.74	1.78	1.82	1.86	1.90

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
6.6000	1.94	1.98	2.03	2.08	2.13
6.8000	2.18	2.23	2.28	2.33	2.38
7.0000	2.43	2.48	2.53	2.58	2.62
7.2000	2.67	2.72	2.77	2.82	2.87
7.4000	2.92	2.97	3.02	3.07	3.12
7.6000	3.17	3.22	3.27	3.32	3.37
7.8000	3.42	3.47	3.52	3.57	3.62
8.0000	3.67	3.71	3.76	3.81	3.86
8.2000	3.91	3.96	4.01	4.07	4.13
8.4000	4.19	4.26	4.33	4.40	4.48
8.6000	4.56	4.65	4.73	4.82	4.92
8.8000	5.03	5.14	5.25	5.37	5.50
9.0000	5.63	5.77	5.90	6.04	6.19
9.2000	6.34	6.49	6.65	6.81	6.96
9.4000	7.12	7.28	7.44	7.60	7.76
9.6000	7.91	8.07	8.24	8.41	8.58
9.8000	8.76	8.93	9.12	9.32	9.52
10.0000	9.73	9.95	10.17	10.41	10.66
10.2000	10.92	11.18	11.46	11.75	12.05
10.4000	12.35	12.68	13.02	13.36	13.73
10.6000	14.11	14.49	14.91	15.34	15.80
10.8000	16.27	16.76	17.28	17.81	18.37
11.0000	18.96	19.57	20.22	20.89	21.60
11.2000	22.36	23.16	24.01	24.92	25.89
11.4000	26.93	28.04	29.22	30.49	31.93
11.6000	33.68	35.94	38.97	43.10	48.66
11.8000	56.02	65.67	78.43	103.23	132.82
12.0000	164.18	190.82	198.03	201.70	206.92
12.2000	212.23	216.66	219.68	222.10	223.98
12.4000	225.38	226.34	226.91	227.14	227.07
12.6000	226.73	226.14	225.34	224.35	223.19
12.8000	221.89	220.47	218.94	217.32	215.63
13.0000	213.88	211.90	209.67	207.43	205.20
13.2000	202.95	200.70	198.44	196.18	193.92
13.4000	191.68	189.45	187.23	185.02	182.84
13.6000	178.31	173.36	168.50	163.59	158.56
13.8000	153.42	148.18	142.85	137.47	132.04
14.0000	126.59	121.15	115.74	110.38	105.12
14.2000	99.96	94.94	90.08	85.42	81.85
14.4000	78.63	75.74	73.40	71.66	69.97
14.6000	68.36	66.80	65.31	63.86	62.47
14.8000	61.14	59.85	58.61	57.42	56.27
15.0000	55.16	54.09	53.06	52.07	51.11
15.2000	50.19	49.30	48.44	47.61	46.80
15.4000	46.02	45.27	44.54	43.81	43.13
15.6000	42.47	41.82	41.18	40.55	39.96
15.8000	39.37	38.81	38.26	37.72	37.19

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
16.0000	36.67	36.17	35.67	35.19	34.72
16.2000	34.25	33.81	33.37	32.95	32.53
16.4000	32.13	31.75	31.37	31.00	30.66
16.6000	30.32	29.99	29.68	29.37	29.07
16.8000	28.79	28.51	28.23	27.96	27.71
17.0000	27.46	27.22	26.98	26.75	26.53
17.2000	26.31	26.10	25.89	25.70	25.50
17.4000	25.31	25.12	24.94	24.76	24.59
17.6000	24.42	24.25	24.08	23.92	23.76
17.8000	23.60	23.46	23.31	23.16	23.01
18.0000	22.87	22.73	22.59	22.46	22.32
18.2000	22.18	22.05	21.92	21.79	21.66
18.4000	21.53	21.41	21.28	21.16	21.04
18.6000	20.92	20.80	20.68	20.56	20.45
18.8000	20.33	20.21	20.09	19.97	19.85
19.0000	19.73	19.61	19.50	19.40	19.29
19.2000	19.18	19.07	18.96	18.85	18.74
19.4000	18.63	18.52	18.41	18.31	18.20
19.6000	18.09	17.98	17.87	17.76	17.65
19.8000	17.54	17.43	17.32	17.22	17.11
20.0000	17.00	16.89	16.78	16.67	16.56
20.2000	16.45	16.35	16.26	16.16	16.06
20.4000	15.96	15.87	15.78	15.69	15.60
20.6000	15.52	15.44	15.36	15.28	15.21
20.8000	15.15	15.08	15.01	14.95	14.89
21.0000	14.83	14.77	14.71	14.65	14.60
21.2000	14.55	14.50	14.45	14.40	14.35
21.4000	14.31	14.27	14.23	14.19	14.16
21.6000	14.12	14.08	14.04	14.00	13.96
21.8000	13.92	13.89	13.86	13.83	13.80
22.0000	13.77	13.74	13.71	13.68	13.65
22.2000	13.62	13.59	13.56	13.53	13.50
22.4000	13.47	13.44	13.41	13.38	13.35
22.6000	13.32	13.30	13.28	13.26	13.24
22.8000	13.22	13.20	13.18	13.16	13.14
23.0000	13.12	13.10	13.08	13.06	13.04
23.2000	13.02	13.00	12.98	12.96	12.94
23.4000	12.92	12.90	12.87	12.85	12.83
23.6000	12.81	12.79	12.77	12.75	12.73
23.8000	12.71	12.69	12.67	12.65	12.63
24.0000	12.60	12.57	12.51	12.41	12.25
24.2000	12.05	11.80	11.51	11.19	10.86
24.4000	10.50	10.14	9.78	9.41	9.04
24.6000	8.69	8.33	7.98	7.65	7.32
24.8000	6.99	6.69	6.39	6.10	5.82
25.0000	5.56	5.30	5.05	4.81	4.59
25.2000	4.37	4.16	3.96	3.77	3.59

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
25.4000	3.41	3.24	3.08	2.93	2.78
25.6000	2.64	2.52	2.39	2.27	2.16
25.8000	2.05	1.95	1.85	1.76	1.67
26.0000	1.58	1.51	1.43	1.36	1.29
26.2000	1.22	1.16	1.10	1.04	.99
26.4000	.94	.89	.84	.80	.76
26.6000	.72	.68	.64	.61	.58
26.8000	.55	.52	.50	.47	.45
27.0000	.43	.41	.39	.37	.35
27.2000	.33	.31	.29	.28	.27
27.4000	.26	.25	.24	.23	.22
27.6000	.21	.20	.19	.18	.17
27.8000	.16	.15	.14	.13	.12
28.0000	.11	.10	.09	.09	.09
28.2000	.09	.09	.09	.09	.09
28.4000	.09	.09	.09	.09	.09
28.6000	.09	.09	.09	.09	.09
28.8000	.09	.09	.09	.09	.09
29.0000	.09	.09	.09	.09	.09
29.2000	.09	.09	.09	.09	.09
29.4000	.09	.09	.09	.09	.09
29.6000	.09	.09	.09	.09	.09
29.8000	.09	.09	.09	.09	.09
30.0000	.09	.09	.09	.09	.09
30.2000	.09	.09	.09	.09	.09
30.4000	.09	.09	.09	.09	.09
30.6000	.09	.09	.09	.09	.09
30.8000	.09	.09	.09	.09	.09
31.0000	.09	.09	.09	.09	.09
31.2000	.09	.09	.09	.09	.09
31.4000	.09	.09	.09	.09	.09
31.6000	.09	.09	.09	.09	.09
31.8000	.09	.09	.09	.09	.09
32.0000	.09	.09	.09	.09	.09
32.2000	.09	.09	.09	.09	.09
32.4000	.09	.09	.09	.09	.09
32.6000	.09	.09	.09	.09	.09
32.8000	.09	.09	.09	.09	.09
33.0000	.09	.09	.09	.09	.09
33.2000	.09	.09	.09	.09	.09
33.4000	.09	.09	.09	.09	.09
33.6000	.09	.09	.09	.09	.09
33.8000	.09	.09	.09	.09	.09
34.0000	.09	.09	.09	.09	.09
34.2000	.09	.09	.09	.09	.09
34.4000	.09	.09	.09	.09	.09
34.6000	.09	.09	.09	.09	.09

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
34.8000	.09	.09	.09	.09	.09
35.0000	.09				

ICPM HYDROGRAPH...
HYG file =
HYG ID = POND 3 OUT
HYG Tag = 25yr

Peak Discharge	=	200.47 cfs
Time to Peak	=	12.5200 hrs
HYG Volume	=	49.422 ac-ft

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
.0000	.00	.00	.00	.00	.00
.2000	.00	.00	.00	.00	.00
.4000	.00	.00	.00	.00	.00
.6000	.00	.00	.00	.00	.00
.8000	.00	.00	.00	.00	.00
1.0000	.00	.00	.00	.00	.00
1.2000	.00	.00	.00	.00	.00
1.4000	.00	.00	.00	.00	.00
1.6000	.00	.00	.00	.00	.00
1.8000	.00	.00	.00	.00	.00
2.0000	.00	.00	.00	.00	.00
2.2000	.00	.00	.00	.00	.00
2.4000	.00	.00	.00	.00	.00
2.6000	.00	.00	.00	.00	.00
2.8000	.00	.00	.00	.00	.00
3.0000	.00	.00	.00	.00	.00
3.2000	.00	.00	.00	.00	.00
3.4000	.00	.00	.00	.00	.00
3.6000	.00	.00	.00	.00	.00
3.8000	.00	.00	.00	.00	.00
4.0000	.00	.00	.00	.00	.00
4.2000	.00	.00	.00	.00	.00
4.4000	.00	.00	.00	.00	.01
4.6000	.02	.03	.04	.05	.06
4.8000	.07	.08	.09	.10	.11
5.0000	.12	.13	.14	.16	.18
5.2000	.20	.22	.24	.26	.28
5.4000	.30	.32	.34	.36	.38
5.6000	.40	.42	.44	.46	.48
5.8000	.51	.53	.56	.59	.62
6.0000	.65	.68	.71	.74	.77
6.2000	.80	.83	.86	.89	.92
6.4000	.95	.98	1.01	1.04	1.07

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
6.6000	1.10	1.13	1.16	1.19	1.22
6.8000	1.25	1.28	1.32	1.36	1.40
7.0000	1.44	1.48	1.52	1.56	1.59
7.2000	1.63	1.67	1.71	1.75	1.79
7.4000	1.83	1.87	1.91	1.95	1.99
7.6000	2.03	2.07	2.11	2.15	2.19
7.8000	2.23	2.27	2.31	2.35	2.39
8.0000	2.43	2.47	2.51	2.55	2.59
8.2000	2.62	2.66	2.70	2.74	2.79
8.4000	2.83	2.88	2.93	2.98	3.04
8.6000	3.09	3.14	3.20	3.26	3.32
8.8000	3.38	3.45	3.52	3.59	3.66
9.0000	3.73	3.81	3.89	3.97	4.05
9.2000	4.13	4.22	4.31	4.40	4.49
9.4000	4.58	4.67	4.75	4.84	4.93
9.6000	5.03	5.13	5.23	5.33	5.44
9.8000	5.55	5.66	5.77	5.88	6.01
10.0000	6.14	6.29	6.43	6.58	6.75
10.2000	6.91	7.09	7.26	7.44	7.63
10.4000	7.85	8.06	8.29	8.53	8.77
10.6000	9.03	9.29	9.59	9.89	10.19
10.8000	10.52	10.86	11.21	11.59	11.98
11.0000	12.38	12.81	13.25	13.72	14.20
11.2000	14.72	15.26	15.84	16.45	17.12
11.4000	17.82	18.57	19.38	20.24	21.18
11.6000	22.24	23.53	25.16	27.31	30.20
11.8000	34.09	39.28	46.15	55.21	67.71
12.0000	86.16	111.19	136.26	158.56	175.02
12.2000	184.56	189.47	192.73	195.23	197.19
12.4000	198.64	199.63	200.23	200.47	200.39
12.6000	200.03	199.43	198.62	197.62	196.46
12.8000	195.18	193.75	192.23	190.61	188.93
13.0000	187.17	185.38	183.01	179.67	175.80
13.2000	171.67	167.36	162.90	158.30	153.57
13.4000	148.74	143.79	138.78	133.69	128.56
13.6000	123.40	118.26	113.13	108.06	103.04
13.8000	98.14	93.34	88.83	84.81	81.29
14.0000	78.47	75.94	73.76	71.80	69.97
14.2000	68.24	66.58	64.97	63.43	61.94
14.4000	60.49	59.10	57.75	56.45	55.20
14.6000	54.00	52.84	51.70	50.63	49.59
14.8000	48.59	47.62	46.68	45.78	44.91
15.0000	44.07	43.26	42.48	41.71	40.98
15.2000	40.29	39.61	38.95	38.30	37.70
15.4000	37.10	36.52	35.95	35.39	34.86
15.6000	34.34	33.85	33.36	32.89	32.42
15.8000	31.97	31.52	31.09	30.67	30.25

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
16.0000	29.85	29.45	29.06	28.69	28.32
16.2000	27.95	27.60	27.25	26.91	26.58
16.4000	26.26	25.94	25.65	25.35	25.07
16.6000	24.79	24.55	24.28	24.04	23.80
16.8000	23.56	23.32	23.11	22.90	22.68
17.0000	22.49	22.28	22.08	21.89	21.72
17.2000	21.53	21.36	21.19	21.03	20.88
17.4000	20.73	20.58	20.44	20.29	20.15
17.6000	20.01	19.86	19.72	19.59	19.46
17.8000	19.35	19.23	19.11	18.99	18.87
18.0000	18.75	18.63	18.52	18.41	18.31
18.2000	18.20	18.09	17.98	17.87	17.77
18.4000	17.67	17.57	17.47	17.37	17.28
18.6000	17.18	17.08	16.98	16.88	16.78
18.8000	16.68	16.58	16.49	16.40	16.31
19.0000	16.23	16.14	16.05	15.96	15.87
19.2000	15.78	15.69	15.60	15.51	15.42
19.4000	15.33	15.24	15.16	15.07	14.98
19.6000	14.89	14.80	14.71	14.62	14.53
19.8000	14.44	14.35	14.26	14.17	14.09
20.0000	14.00	13.91	13.82	13.73	13.64
20.2000	13.55	13.46	13.38	13.30	13.22
20.4000	13.14	13.07	12.99	12.91	12.84
20.6000	12.77	12.70	12.63	12.56	12.50
20.8000	12.44	12.38	12.32	12.26	12.21
21.0000	12.16	12.11	12.06	12.02	11.98
21.2000	11.94	11.90	11.86	11.82	11.78
21.4000	11.74	11.69	11.65	11.62	11.59
21.6000	11.56	11.53	11.50	11.47	11.44
21.8000	11.41	11.38	11.35	11.32	11.29
22.0000	11.26	11.23	11.21	11.19	11.17
22.2000	11.15	11.13	11.11	11.09	11.07
22.4000	11.05	11.03	11.02	11.00	10.98
22.6000	10.96	10.94	10.92	10.90	10.88
22.8000	10.86	10.84	10.82	10.80	10.78
23.0000	10.76	10.74	10.72	10.70	10.68
23.2000	10.66	10.64	10.62	10.60	10.58
23.4000	10.56	10.54	10.52	10.50	10.48
23.6000	10.46	10.44	10.42	10.40	10.38
23.8000	10.36	10.34	10.32	10.30	10.28
24.0000	10.26	10.24	10.21	10.17	10.10
24.2000	9.99	9.86	9.68	9.46	9.22
24.4000	8.96	8.69	8.40	8.10	7.81
24.6000	7.51	7.22	6.93	6.65	6.37
24.8000	6.11	5.85	5.59	5.33	5.08
25.0000	4.84	4.64	4.42	4.22	4.01
25.2000	3.81	3.63	3.47	3.31	3.15

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
25.4000	2.99	2.84	2.69	2.57	2.45
25.6000	2.33	2.21	2.10	2.00	1.90
25.8000	1.80	1.71	1.63	1.56	1.48
26.0000	1.40	1.33	1.26	1.19	1.13
26.2000	1.07	1.01	.96	.91	.85
26.4000	.81	.77	.73	.69	.65
26.6000	.62	.59	.56	.53	.51
26.8000	.48	.46	.44	.42	.40
27.0000	.38	.36	.34	.32	.30
27.2000	.29	.28	.27	.26	.25
27.4000	.24	.23	.22	.21	.20
27.6000	.19	.18	.17	.16	.15
27.8000	.14	.13	.12	.11	.10
28.0000	.10	.10	.10	.10	.10
28.2000	.10	.10	.10	.10	.10
28.4000	.10	.10	.10	.10	.10
28.6000	.10	.10	.10	.10	.10
28.8000	.10	.10	.10	.10	.10
29.0000	.10	.10	.10	.10	.10
29.2000	.10	.10	.10	.10	.10
29.4000	.10	.10	.10	.10	.10
29.6000	.10	.10	.10	.10	.10
29.8000	.10	.10	.10	.10	.10
30.0000	.10	.10	.10	.10	.10
30.2000	.10	.10	.10	.10	.10
30.4000	.10	.10	.10	.10	.10
30.6000	.10	.10	.10	.10	.10
30.8000	.10	.10	.10	.10	.10
31.0000	.10	.10	.10	.10	.10
31.2000	.10	.10	.10	.10	.10
31.4000	.10	.10	.10	.10	.10
31.6000	.10	.10	.10	.10	.10
31.8000	.10	.10	.10	.10	.10
32.0000	.10	.10	.10	.10	.10
32.2000	.10	.10	.10	.10	.10
32.4000	.10	.10	.10	.10	.10
32.6000	.10	.10	.10	.10	.10
32.8000	.10	.10	.10	.10	.10
33.0000	.10	.10	.10	.10	.10
33.2000	.10	.10	.10	.10	.10
33.4000	.10	.10	.10	.10	.10
33.6000	.10	.10	.10	.10	.10
33.8000	.10	.10	.10	.10	.10
34.0000	.10	.10	.10	.10	.10
34.2000	.10	.10	.10	.10	.10
34.4000	.10	.10	.10	.10	.10
34.6000	.10	.10	.10	.10	.10

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
34.8000	.10	.10	.10	.10	.10
35.0000	.10				

ICPM HYDROGRAPH...
HYG file =
HYG ID = POND 3 OUT
HYG Tag = 100yr

Peak Discharge =	226.84	cfs
Time to Peak =	12.6000	hrs
HYG Volume =	63.029	ac-ft

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
.0000	.00	.00	.00	.00	.00
.2000	.00	.00	.00	.00	.00
.4000	.00	.00	.00	.00	.00
.6000	.00	.00	.00	.00	.00
.8000	.00	.00	.00	.00	.00
1.0000	.00	.00	.00	.00	.00
1.2000	.00	.00	.00	.00	.00
1.4000	.00	.00	.00	.00	.00
1.6000	.00	.00	.00	.00	.00
1.8000	.00	.00	.00	.00	.00
2.0000	.00	.00	.00	.00	.00
2.2000	.00	.00	.00	.00	.00
2.4000	.00	.00	.00	.00	.00
2.6000	.00	.00	.00	.00	.00
2.8000	.00	.00	.00	.00	.00
3.0000	.00	.00	.00	.00	.00
3.2000	.00	.00	.00	.00	.00
3.4000	.00	.00	.00	.00	.00
3.6000	.00	.00	.00	.00	.00
3.8000	.00	.00	.00	.00	.00
4.0000	.01	.02	.03	.04	.05
4.2000	.06	.07	.08	.09	.10
4.4000	.11	.13	.15	.17	.19
4.6000	.21	.23	.25	.27	.29
4.8000	.31	.33	.35	.38	.41
5.0000	.44	.47	.50	.52	.55
5.2000	.58	.61	.64	.67	.70
5.4000	.73	.76	.79	.82	.85
5.6000	.89	.93	.97	1.01	1.05
5.8000	1.09	1.13	1.17	1.21	1.25
6.0000	1.29	1.33	1.37	1.41	1.45
6.2000	1.49	1.53	1.57	1.60	1.64
6.4000	1.68	1.72	1.76	1.80	1.84

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
6.6000	1.88	1.92	1.97	2.01	2.06
6.8000	2.11	2.16	2.21	2.26	2.31
7.0000	2.36	2.41	2.46	2.51	2.56
7.2000	2.61	2.65	2.70	2.75	2.80
7.4000	2.85	2.90	2.95	3.00	3.05
7.6000	3.10	3.15	3.20	3.25	3.30
7.8000	3.35	3.40	3.45	3.50	3.55
8.0000	3.60	3.65	3.69	3.74	3.79
8.2000	3.84	3.89	3.94	3.99	4.04
8.4000	4.10	4.16	4.22	4.29	4.36
8.6000	4.44	4.52	4.60	4.69	4.77
8.8000	4.87	4.97	5.08	5.19	5.31
9.0000	5.43	5.56	5.69	5.82	5.97
9.2000	6.12	6.27	6.41	6.56	6.72
9.4000	6.87	7.03	7.19	7.35	7.51
9.6000	7.67	7.83	7.99	8.16	8.33
9.8000	8.50	8.66	8.85	9.03	9.21
10.0000	9.40	9.62	9.84	10.06	10.28
10.2000	10.53	10.79	11.03	11.31	11.60
10.4000	11.88	12.19	12.52	12.85	13.19
10.6000	13.55	13.92	14.30	14.71	15.14
10.8000	15.58	16.05	16.52	17.03	17.55
11.0000	18.11	18.68	19.29	19.91	20.57
11.2000	21.26	21.99	22.78	23.60	24.49
11.4000	25.43	26.44	27.51	28.66	29.90
11.6000	31.32	33.03	35.19	38.05	41.89
11.8000	47.01	53.80	62.75	76.51	98.99
12.0000	126.55	154.92	176.90	189.69	197.84
12.2000	204.38	209.99	214.56	218.09	220.84
12.4000	222.96	224.57	225.71	226.44	226.78
12.6000	226.84	226.62	226.13	225.41	224.50
12.8000	223.41	222.16	220.81	219.32	217.74
13.0000	216.10	214.32	212.37	210.23	208.04
13.2000	205.85	203.62	201.37	199.13	196.86
13.4000	194.62	192.37	190.14	187.91	185.70
13.6000	182.84	178.97	174.49	169.78	164.93
13.8000	159.95	154.84	149.64	144.36	139.00
14.0000	133.60	128.18	122.75	117.35	112.01
14.2000	106.74	101.56	96.52	91.63	87.18
14.4000	83.30	80.05	77.37	75.01	72.95
14.6000	71.10	69.38	67.75	66.21	64.72
14.8000	63.30	61.93	60.61	59.34	58.13
15.0000	56.95	55.82	54.72	53.67	52.64
15.2000	51.67	50.73	49.82	48.92	48.08
15.4000	47.27	46.48	45.69	44.95	44.23
15.6000	43.53	42.85	42.19	41.54	40.91
15.8000	40.31	39.70	39.13	38.56	38.02

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
16.0000	37.48	36.96	36.44	35.95	35.46
16.2000	34.98	34.51	34.06	33.61	33.18
16.4000	32.77	32.36	31.97	31.58	31.21
16.6000	30.86	30.51	30.17	29.86	29.54
16.8000	29.24	28.94	28.66	28.40	28.12
17.0000	27.85	27.62	27.38	27.14	26.89
17.2000	26.66	26.45	26.24	26.02	25.82
17.4000	25.62	25.42	25.24	25.06	24.88
17.6000	24.70	24.53	24.36	24.18	24.01
17.8000	23.85	23.70	23.56	23.41	23.26
18.0000	23.11	22.96	22.82	22.68	22.55
18.2000	22.41	22.26	22.13	21.99	21.86
18.4000	21.73	21.61	21.48	21.36	21.24
18.6000	21.12	21.00	20.88	20.76	20.64
18.8000	20.52	20.41	20.29	20.17	20.05
19.0000	19.93	19.81	19.69	19.57	19.46
19.2000	19.36	19.25	19.14	19.03	18.92
19.4000	18.81	18.70	18.59	18.48	18.37
19.6000	18.27	18.16	18.05	17.94	17.83
19.8000	17.72	17.61	17.50	17.39	17.29
20.0000	17.18	17.07	16.96	16.85	16.74
20.2000	16.63	16.52	16.42	16.32	16.23
20.4000	16.13	16.03	15.93	15.84	15.75
20.6000	15.66	15.58	15.50	15.42	15.34
20.8000	15.26	15.20	15.13	15.06	14.99
21.0000	14.93	14.87	14.81	14.75	14.69
21.2000	14.64	14.58	14.53	14.48	14.43
21.4000	14.37	14.33	14.29	14.25	14.21
21.6000	14.17	14.14	14.10	14.06	14.02
21.8000	13.98	13.94	13.90	13.87	13.84
22.0000	13.81	13.78	13.75	13.72	13.69
22.2000	13.66	13.63	13.60	13.57	13.54
22.4000	13.51	13.48	13.45	13.42	13.39
22.6000	13.36	13.33	13.31	13.29	13.27
22.8000	13.25	13.23	13.21	13.19	13.17
23.0000	13.15	13.13	13.11	13.09	13.07
23.2000	13.05	13.03	13.01	12.99	12.97
23.4000	12.95	12.93	12.91	12.88	12.86
23.6000	12.84	12.82	12.80	12.78	12.76
23.8000	12.74	12.72	12.70	12.68	12.66
24.0000	12.64	12.61	12.58	12.52	12.43
24.2000	12.30	12.11	11.89	11.64	11.33
24.4000	11.01	10.67	10.32	9.97	9.60
24.6000	9.23	8.88	8.52	8.17	7.84
24.8000	7.50	7.17	6.85	6.56	6.26
25.0000	5.98	5.73	5.46	5.20	4.95
25.2000	4.72	4.51	4.30	4.10	3.89

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
25.4000	3.69	3.51	3.35	3.19	3.02
25.6000	2.87	2.72	2.60	2.47	2.35
25.8000	2.23	2.12	2.02	1.92	1.82
26.0000	1.73	1.64	1.57	1.49	1.41
26.2000	1.34	1.27	1.20	1.14	1.08
26.4000	1.02	.97	.92	.86	.82
26.6000	.78	.74	.70	.66	.62
26.8000	.59	.56	.53	.51	.48
27.0000	.46	.44	.42	.40	.38
27.2000	.36	.34	.32	.30	.29
27.4000	.28	.27	.26	.25	.24
27.6000	.23	.22	.21	.20	.19
27.8000	.18	.17	.16	.15	.14
28.0000	.13	.12	.11	.10	.10
28.2000	.10	.10	.10	.10	.10
28.4000	.10	.10	.10	.10	.10
28.6000	.10	.10	.10	.10	.10
28.8000	.10	.10	.10	.10	.10
29.0000	.10	.10	.10	.10	.10
29.2000	.10	.10	.10	.10	.10
29.4000	.10	.10	.10	.10	.10
29.6000	.10	.10	.10	.10	.10
29.8000	.10	.10	.10	.10	.10
30.0000	.10	.10	.10	.10	.10
30.2000	.10	.10	.10	.10	.10
30.4000	.10	.10	.10	.10	.10
30.6000	.10	.10	.10	.10	.10
30.8000	.10	.10	.10	.10	.10
31.0000	.10	.10	.10	.10	.10
31.2000	.10	.10	.10	.10	.10
31.4000	.10	.10	.10	.10	.10
31.6000	.10	.10	.10	.10	.10
31.8000	.10	.10	.10	.10	.10
32.0000	.10	.10	.10	.10	.10
32.2000	.10	.10	.10	.10	.10
32.4000	.10	.10	.10	.10	.10
32.6000	.10	.10	.10	.10	.10
32.8000	.10	.10	.10	.10	.10
33.0000	.10	.10	.10	.10	.10
33.2000	.10	.10	.10	.10	.10
33.4000	.10	.10	.10	.10	.10
33.6000	.10	.10	.10	.10	.10
33.8000	.10	.10	.10	.10	.10
34.0000	.10	.10	.10	.10	.10
34.2000	.10	.10	.10	.10	.10
34.4000	.10	.10	.10	.10	.10
34.6000	.10	.10	.10	.10	.10

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
34.8000	.10	.10	.10	.10	.10
35.0000	.10				

TIME vs. ELEVATION (ft)

Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
.0000	758.00	758.00	758.00	758.00	758.00
.2000	758.00	758.00	758.00	758.00	758.00
.4000	758.00	758.00	758.00	758.00	758.00
.6000	758.00	758.00	758.00	758.00	758.00
.8000	758.00	758.00	758.00	758.00	758.00
1.0000	758.00	758.00	758.00	758.00	758.00
1.2000	758.00	758.00	758.00	758.00	758.00
1.4000	758.00	758.00	758.00	758.00	758.00
1.6000	758.00	758.00	758.00	758.00	758.00
1.8000	758.00	758.00	758.00	758.00	758.00
2.0000	758.00	758.00	758.00	758.00	758.00
2.2000	758.00	758.00	758.00	758.00	758.00
2.4000	758.00	758.00	758.00	758.00	758.00
2.6000	758.00	758.00	758.00	758.00	758.00
2.8000	758.00	758.00	758.00	758.00	758.00
3.0000	758.00	758.00	758.00	758.00	758.00
3.2000	758.00	758.00	758.00	758.00	758.00
3.4000	758.00	758.00	758.00	758.00	758.00
3.6000	758.00	758.00	758.00	758.00	758.00
3.8000	758.00	758.00	758.00	758.00	758.00
4.0000	758.00	758.00	758.00	758.00	758.00
4.2000	758.00	758.00	758.00	758.00	758.00
4.4000	758.00	758.00	758.00	758.00	758.00
4.6000	758.00	758.00	758.00	758.00	758.00
4.8000	758.00	758.00	758.00	758.00	758.00
5.0000	758.00	758.00	758.00	758.00	758.00
5.2000	758.00	758.00	758.00	758.00	758.00
5.4000	758.00	758.00	758.00	758.00	758.00
5.6000	758.00	758.00	758.00	758.00	758.00
5.8000	758.00	758.00	758.00	758.00	758.00
6.0000	758.00	758.00	758.00	758.00	758.01
6.2000	758.01	758.01	758.01	758.01	758.01
6.4000	758.01	758.01	758.01	758.01	758.01
6.6000	758.01	758.01	758.01	758.01	758.01
6.8000	758.01	758.01	758.01	758.01	758.01
7.0000	758.01	758.01	758.01	758.01	758.01
7.2000	758.01	758.01	758.01	758.01	758.01
7.4000	758.01	758.01	758.01	758.01	758.01
7.6000	758.01	758.01	758.01	758.01	758.01
7.8000	758.01	758.01	758.01	758.01	758.02
8.0000	758.02	758.02	758.02	758.02	758.02
8.2000	758.02	758.02	758.02	758.02	758.02
8.4000	758.02	758.02	758.02	758.02	758.02
8.6000	758.02	758.02	758.02	758.02	758.02
8.8000	758.02	758.02	758.02	758.02	758.02

TIME vs. ELEVATION (ft)

Time hrs	Output Time increment = .0400 hrs Time on left represents time for first value in each row.				
9.0000	758.02	758.02	758.02	758.03	758.03
9.2000	758.03	758.03	758.03	758.03	758.03
9.4000	758.03	758.03	758.03	758.03	758.03
9.6000	758.03	758.03	758.03	758.03	758.03
9.8000	758.04	758.04	758.04	758.04	758.04
10.0000	758.04	758.04	758.04	758.04	758.04
10.2000	758.04	758.05	758.05	758.05	758.05
10.4000	758.05	758.05	758.05	758.05	758.06
10.6000	758.06	758.06	758.06	758.06	758.07
10.8000	758.07	758.07	758.07	758.08	758.08
11.0000	758.08	758.08	758.09	758.09	758.09
11.2000	758.10	758.10	758.10	758.11	758.11
11.4000	758.12	758.12	758.13	758.13	758.14
11.6000	758.15	758.16	758.17	758.19	758.22
11.8000	758.25	758.30	758.36	758.44	758.53
12.0000	758.64	758.74	758.85	758.94	759.03
12.2000	759.09	759.15	759.20	759.23	759.26
12.4000	759.27	759.28	759.29	759.29	759.28
12.6000	759.27	759.26	759.24	759.22	759.20
12.8000	759.18	759.15	759.13	759.10	759.07
13.0000	759.04	759.01	758.97	758.94	758.91
13.2000	758.88	758.85	758.82	758.79	758.76
13.4000	758.73	758.70	758.68	758.65	758.63
13.6000	758.61	758.59	758.57	758.55	758.54
13.8000	758.52	758.51	758.49	758.48	758.47
14.0000	758.46	758.45	758.44	758.42	758.41
14.2000	758.40	758.39	758.39	758.38	758.37
14.4000	758.36	758.35	758.34	758.34	758.33
14.6000	758.32	758.31	758.31	758.30	758.30
14.8000	758.29	758.28	758.28	758.27	758.27
15.0000	758.26	758.26	758.25	758.25	758.25
15.2000	758.24	758.24	758.23	758.23	758.23
15.4000	758.22	758.22	758.22	758.21	758.21
15.6000	758.21	758.20	758.20	758.20	758.20
15.8000	758.19	758.19	758.19	758.19	758.18
16.0000	758.18	758.18	758.18	758.17	758.17
16.2000	758.17	758.17	758.16	758.16	758.16
16.4000	758.16	758.16	758.16	758.15	758.15
16.6000	758.15	758.15	758.15	758.15	758.14
16.8000	758.14	758.14	758.14	758.14	758.14
17.0000	758.14	758.14	758.13	758.13	758.13
17.2000	758.13	758.13	758.13	758.13	758.13
17.4000	758.13	758.13	758.12	758.12	758.12
17.6000	758.12	758.12	758.12	758.12	758.12
17.8000	758.12	758.12	758.12	758.12	758.12
18.0000	758.11	758.11	758.11	758.11	758.11

TIME vs. ELEVATION (ft)

Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
18.2000	758.11	758.11	758.11	758.11	758.11
18.4000	758.11	758.11	758.11	758.11	758.11
18.6000	758.10	758.10	758.10	758.10	758.10
18.8000	758.10	758.10	758.10	758.10	758.10
19.0000	758.10	758.10	758.10	758.10	758.10
19.2000	758.10	758.10	758.10	758.09	758.09
19.4000	758.09	758.09	758.09	758.09	758.09
19.6000	758.09	758.09	758.09	758.09	758.09
19.8000	758.09	758.09	758.09	758.09	758.09
20.0000	758.09	758.08	758.08	758.08	758.08
20.2000	758.08	758.08	758.08	758.08	758.08
20.4000	758.08	758.08	758.08	758.08	758.08
20.6000	758.08	758.08	758.08	758.08	758.08
20.8000	758.08	758.08	758.08	758.08	758.07
21.0000	758.07	758.07	758.07	758.07	758.07
21.2000	758.07	758.07	758.07	758.07	758.07
21.4000	758.07	758.07	758.07	758.07	758.07
21.6000	758.07	758.07	758.07	758.07	758.07
21.8000	758.07	758.07	758.07	758.07	758.07
22.0000	758.07	758.07	758.07	758.07	758.07
22.2000	758.07	758.07	758.07	758.07	758.07
22.4000	758.07	758.07	758.07	758.07	758.07
22.6000	758.07	758.07	758.07	758.07	758.07
22.8000	758.07	758.07	758.07	758.07	758.07
23.0000	758.07	758.07	758.07	758.07	758.07
23.2000	758.07	758.07	758.07	758.07	758.07
23.4000	758.06	758.06	758.06	758.06	758.06
23.6000	758.06	758.06	758.06	758.06	758.06
23.8000	758.06	758.06	758.06	758.06	758.06
24.0000	758.06	758.06	758.06	758.06	758.06
24.2000	758.06	758.06	758.06	758.06	758.05
24.4000	758.05	758.05	758.05	758.05	758.05
24.6000	758.04	758.04	758.04	758.04	758.04
24.8000	758.04	758.03	758.03	758.03	758.03
25.0000	758.03	758.03	758.03	758.02	758.02
25.2000	758.02	758.02	758.02	758.02	758.02
25.4000	758.02	758.02	758.02	758.01	758.01
25.6000	758.01	758.01	758.01	758.01	758.01
25.8000	758.01	758.01	758.01	758.01	758.01
26.0000	758.01	758.01	758.01	758.01	758.01
26.2000	758.01	758.01	758.01	758.01	758.00
26.4000	758.00	758.00	758.00	758.00	758.00
26.6000	758.00	758.00	758.00	758.00	758.00
26.8000	758.00	758.00	758.00	758.00	758.00
27.0000	758.00	758.00	758.00	758.00	758.00
27.2000	758.00	758.00	758.00	758.00	758.00

TIME vs. ELEVATION (ft)

Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
27.4000	758.00	758.00	758.00	758.00	758.00
27.6000	758.00	758.00	758.00	758.00	758.00
27.8000	758.00	758.00	758.00	758.00	758.00
28.0000	758.00	758.00	758.00	758.00	758.00
28.2000	758.00	758.00	758.00	758.00	758.00
28.4000	758.00	758.00	758.00	758.00	758.00
28.6000	758.00	758.00	758.00	758.00	758.00
28.8000	758.00	758.00	758.00	758.00	758.00
29.0000	758.00	758.00	758.00	758.00	758.00
29.2000	758.00	758.00	758.00	758.00	758.00
29.4000	758.00	758.00	758.00	758.00	758.00
29.6000	758.00	758.00	758.00	758.00	758.00
29.8000	758.00	758.00	758.00	758.00	758.00
30.0000	758.00	758.00	758.00	758.00	758.00
30.2000	758.00	758.00	758.00	758.00	758.00
30.4000	758.00	758.00	758.00	758.00	758.00
30.6000	758.00	758.00	758.00	758.00	758.00
30.8000	758.00	758.00	758.00	758.00	758.00
31.0000	758.00	758.00	758.00	758.00	758.00
31.2000	758.00	758.00	758.00	758.00	758.00
31.4000	758.00	758.00	758.00	758.00	758.00
31.6000	758.00	758.00	758.00	758.00	758.00
31.8000	758.00	758.00	758.00	758.00	758.00
32.0000	758.00	758.00	758.00	758.00	758.00
32.2000	758.00	758.00	758.00	758.00	758.00
32.4000	758.00	758.00	758.00	758.00	758.00
32.6000	758.00	758.00	758.00	758.00	758.00
32.8000	758.00	758.00	758.00	758.00	758.00
33.0000	758.00	758.00	758.00	758.00	758.00
33.2000	758.00	758.00	758.00	758.00	758.00
33.4000	758.00	758.00	758.00	758.00	758.00
33.6000	758.00	758.00	758.00	758.00	758.00
33.8000	758.00	758.00	758.00	758.00	758.00
34.0000	758.00	758.00	758.00	758.00	758.00
34.2000	758.00	758.00	758.00	758.00	758.00
34.4000	758.00	758.00	758.00	758.00	758.00
34.6000	758.00	758.00	758.00	758.00	758.00
34.8000	758.00	758.00	758.00	758.00	758.00
35.0000	758.00				

TIME vs. ELEVATION (ft)

Time hrs	Output Time increment = .0400 hrs Time on left represents time for first value in each row.				
.0000	758.00	758.00	758.00	758.00	758.00
.2000	758.00	758.00	758.00	758.00	758.00
.4000	758.00	758.00	758.00	758.00	758.00
.6000	758.00	758.00	758.00	758.00	758.00
.8000	758.00	758.00	758.00	758.00	758.00
1.0000	758.00	758.00	758.00	758.00	758.00
1.2000	758.00	758.00	758.00	758.00	758.00
1.4000	758.00	758.00	758.00	758.00	758.00
1.6000	758.00	758.00	758.00	758.00	758.00
1.8000	758.00	758.00	758.00	758.00	758.00
2.0000	758.00	758.00	758.00	758.00	758.00
2.2000	758.00	758.00	758.00	758.00	758.00
2.4000	758.00	758.00	758.00	758.00	758.00
2.6000	758.00	758.00	758.00	758.00	758.00
2.8000	758.00	758.00	758.00	758.00	758.00
3.0000	758.00	758.00	758.00	758.00	758.00
3.2000	758.00	758.00	758.00	758.00	758.00
3.4000	758.00	758.00	758.00	758.00	758.00
3.6000	758.00	758.00	758.00	758.00	758.00
3.8000	758.00	758.00	758.00	758.00	758.00
4.0000	758.00	758.00	758.00	758.00	758.00
4.2000	758.00	758.00	758.00	758.00	758.00
4.4000	758.00	758.00	758.00	758.00	758.00
4.6000	758.00	758.00	758.00	758.00	758.00
4.8000	758.00	758.00	758.00	758.00	758.00
5.0000	758.00	758.00	758.00	758.00	758.00
5.2000	758.00	758.00	758.00	758.00	758.00
5.4000	758.00	758.00	758.01	758.01	758.01
5.6000	758.01	758.01	758.01	758.01	758.01
5.8000	758.01	758.01	758.01	758.01	758.01
6.0000	758.01	758.01	758.01	758.01	758.01
6.2000	758.01	758.01	758.01	758.01	758.01
6.4000	758.01	758.01	758.01	758.01	758.01
6.6000	758.01	758.01	758.01	758.01	758.01
6.8000	758.01	758.01	758.01	758.01	758.01
7.0000	758.02	758.02	758.02	758.02	758.02
7.2000	758.02	758.02	758.02	758.02	758.02
7.4000	758.02	758.02	758.02	758.02	758.02
7.6000	758.02	758.02	758.02	758.02	758.02
7.8000	758.02	758.02	758.02	758.02	758.02
8.0000	758.02	758.02	758.02	758.02	758.02
8.2000	758.02	758.02	758.02	758.03	758.03
8.4000	758.03	758.03	758.03	758.03	758.03
8.6000	758.03	758.03	758.03	758.03	758.03
8.8000	758.03	758.03	758.03	758.03	758.03

TIME vs. ELEVATION (ft)

Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
9.0000	758.03	758.04	758.04	758.04	758.04
9.2000	758.04	758.04	758.04	758.04	758.04
9.4000	758.04	758.04	758.05	758.05	758.05
9.6000	758.05	758.05	758.05	758.05	758.05
9.8000	758.05	758.06	758.06	758.06	758.06
10.0000	758.06	758.06	758.06	758.06	758.07
10.2000	758.07	758.07	758.07	758.07	758.07
10.4000	758.08	758.08	758.08	758.08	758.08
10.6000	758.09	758.09	758.09	758.09	758.10
10.8000	758.10	758.10	758.11	758.11	758.11
11.0000	758.12	758.12	758.12	758.13	758.13
11.2000	758.14	758.14	758.15	758.15	758.16
11.4000	758.17	758.17	758.18	758.19	758.20
11.6000	758.21	758.22	758.24	758.27	758.30
11.8000	758.35	758.40	758.48	758.58	758.70
12.0000	758.83	758.96	759.10	759.23	759.34
12.2000	759.44	759.52	759.58	759.64	759.68
12.4000	759.71	759.73	759.74	759.75	759.75
12.6000	759.75	759.74	759.73	759.71	759.69
12.8000	759.67	759.64	759.61	759.58	759.55
13.0000	759.52	759.48	759.45	759.41	759.38
13.2000	759.34	759.31	759.27	759.23	759.19
13.4000	759.16	759.12	759.08	759.04	759.01
13.6000	758.97	758.93	758.90	758.86	758.83
13.8000	758.79	758.76	758.73	758.70	758.68
14.0000	758.65	758.63	758.61	758.58	758.56
14.2000	758.55	758.53	758.51	758.50	758.49
14.4000	758.48	758.46	758.45	758.44	758.43
14.6000	758.42	758.41	758.40	758.39	758.38
14.8000	758.38	758.37	758.36	758.35	758.35
15.0000	758.34	758.33	758.33	758.32	758.31
15.2000	758.31	758.30	758.30	758.29	758.29
15.4000	758.28	758.28	758.27	758.27	758.27
15.6000	758.26	758.26	758.25	758.25	758.25
15.8000	758.24	758.24	758.24	758.23	758.23
16.0000	758.23	758.22	758.22	758.22	758.21
16.2000	758.21	758.21	758.21	758.20	758.20
16.4000	758.20	758.20	758.19	758.19	758.19
16.6000	758.19	758.18	758.18	758.18	758.18
16.8000	758.18	758.18	758.17	758.17	758.17
17.0000	758.17	758.17	758.17	758.16	758.16
17.2000	758.16	758.16	758.16	758.16	758.16
17.4000	758.16	758.15	758.15	758.15	758.15
17.6000	758.15	758.15	758.15	758.15	758.15
17.8000	758.15	758.14	758.14	758.14	758.14
18.0000	758.14	758.14	758.14	758.14	758.14

TIME vs. ELEVATION (ft)

Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
18.2000	758.14	758.14	758.14	758.13	758.13
18.4000	758.13	758.13	758.13	758.13	758.13
18.6000	758.13	758.13	758.13	758.13	758.13
18.8000	758.13	758.12	758.12	758.12	758.12
19.0000	758.12	758.12	758.12	758.12	758.12
19.2000	758.12	758.12	758.12	758.12	758.12
19.4000	758.11	758.11	758.11	758.11	758.11
19.6000	758.11	758.11	758.11	758.11	758.11
19.8000	758.11	758.11	758.11	758.11	758.11
20.0000	758.10	758.10	758.10	758.10	758.10
20.2000	758.10	758.10	758.10	758.10	758.10
20.4000	758.10	758.10	758.10	758.10	758.10
20.6000	758.10	758.10	758.09	758.09	758.09
20.8000	758.09	758.09	758.09	758.09	758.09
21.0000	758.09	758.09	758.09	758.09	758.09
21.2000	758.09	758.09	758.09	758.09	758.09
21.4000	758.09	758.09	758.09	758.09	758.09
21.6000	758.09	758.09	758.09	758.09	758.09
21.8000	758.09	758.09	758.09	758.09	758.09
22.0000	758.08	758.08	758.08	758.08	758.08
22.2000	758.08	758.08	758.08	758.08	758.08
22.4000	758.08	758.08	758.08	758.08	758.08
22.6000	758.08	758.08	758.08	758.08	758.08
22.8000	758.08	758.08	758.08	758.08	758.08
23.0000	758.08	758.08	758.08	758.08	758.08
23.2000	758.08	758.08	758.08	758.08	758.08
23.4000	758.08	758.08	758.08	758.08	758.08
23.6000	758.08	758.08	758.08	758.08	758.08
23.8000	758.08	758.08	758.08	758.08	758.08
24.0000	758.08	758.08	758.08	758.08	758.08
24.2000	758.07	758.07	758.07	758.07	758.07
24.4000	758.06	758.06	758.06	758.06	758.06
24.6000	758.05	758.05	758.05	758.05	758.05
24.8000	758.04	758.04	758.04	758.04	758.04
25.0000	758.03	758.03	758.03	758.03	758.03
25.2000	758.03	758.03	758.02	758.02	758.02
25.4000	758.02	758.02	758.02	758.02	758.02
25.6000	758.02	758.02	758.01	758.01	758.01
25.8000	758.01	758.01	758.01	758.01	758.01
26.0000	758.01	758.01	758.01	758.01	758.01
26.2000	758.01	758.01	758.01	758.01	758.01
26.4000	758.01	758.01	758.01	758.00	758.00
26.6000	758.00	758.00	758.00	758.00	758.00
26.8000	758.00	758.00	758.00	758.00	758.00
27.0000	758.00	758.00	758.00	758.00	758.00
27.2000	758.00	758.00	758.00	758.00	758.00

TIME vs. ELEVATION (ft)

Time hrs	Output Time increment = .0400 hrs Time on left represents time for first value in each row.				
27.4000	758.00	758.00	758.00	758.00	758.00
27.6000	758.00	758.00	758.00	758.00	758.00
27.8000	758.00	758.00	758.00	758.00	758.00
28.0000	758.00	758.00	758.00	758.00	758.00
28.2000	758.00	758.00	758.00	758.00	758.00
28.4000	758.00	758.00	758.00	758.00	758.00
28.6000	758.00	758.00	758.00	758.00	758.00
28.8000	758.00	758.00	758.00	758.00	758.00
29.0000	758.00	758.00	758.00	758.00	758.00
29.2000	758.00	758.00	758.00	758.00	758.00
29.4000	758.00	758.00	758.00	758.00	758.00
29.6000	758.00	758.00	758.00	758.00	758.00
29.8000	758.00	758.00	758.00	758.00	758.00
30.0000	758.00	758.00	758.00	758.00	758.00
30.2000	758.00	758.00	758.00	758.00	758.00
30.4000	758.00	758.00	758.00	758.00	758.00
30.6000	758.00	758.00	758.00	758.00	758.00
30.8000	758.00	758.00	758.00	758.00	758.00
31.0000	758.00	758.00	758.00	758.00	758.00
31.2000	758.00	758.00	758.00	758.00	758.00
31.4000	758.00	758.00	758.00	758.00	758.00
31.6000	758.00	758.00	758.00	758.00	758.00
31.8000	758.00	758.00	758.00	758.00	758.00
32.0000	758.00	758.00	758.00	758.00	758.00
32.2000	758.00	758.00	758.00	758.00	758.00
32.4000	758.00	758.00	758.00	758.00	758.00
32.6000	758.00	758.00	758.00	758.00	758.00
32.8000	758.00	758.00	758.00	758.00	758.00
33.0000	758.00	758.00	758.00	758.00	758.00
33.2000	758.00	758.00	758.00	758.00	758.00
33.4000	758.00	758.00	758.00	758.00	758.00
33.6000	758.00	758.00	758.00	758.00	758.00
33.8000	758.00	758.00	758.00	758.00	758.00
34.0000	758.00	758.00	758.00	758.00	758.00
34.2000	758.00	758.00	758.00	758.00	758.00
34.4000	758.00	758.00	758.00	758.00	758.00
34.6000	758.00	758.00	758.00	758.00	758.00
34.8000	758.00	758.00	758.00	758.00	758.00
35.0000	758.00				

TIME vs. ELEVATION (ft)

Time hrs	Output Time increment = .0400 hrs Time on left represents time for first value in each row.				
.0000	757.00	757.00	757.00	757.00	757.00
.2000	757.00	757.00	757.00	757.00	757.00
.4000	757.00	757.00	757.00	757.00	757.00
.6000	757.00	757.00	757.00	757.00	757.00
.8000	757.00	757.00	757.00	757.00	757.00
1.0000	757.00	757.00	757.00	757.00	757.00
1.2000	757.00	757.00	757.00	757.00	757.00
1.4000	757.00	757.00	757.00	757.00	757.00
1.6000	757.00	757.00	757.00	757.00	757.00
1.8000	757.00	757.00	757.00	757.00	757.00
2.0000	757.00	757.00	757.00	757.00	757.00
2.2000	757.00	757.00	757.00	757.00	757.00
2.4000	757.00	757.00	757.00	757.00	757.00
2.6000	757.00	757.00	757.00	757.00	757.00
2.8000	757.00	757.00	757.00	757.00	757.00
3.0000	757.00	757.00	757.00	757.00	757.00
3.2000	757.00	757.00	757.00	757.00	757.00
3.4000	757.00	757.00	757.00	757.00	757.00
3.6000	757.00	757.00	757.00	757.00	757.00
3.8000	757.00	757.00	757.00	757.00	757.00
4.0000	757.00	757.00	757.00	757.00	757.00
4.2000	757.00	757.00	757.00	757.00	757.00
4.4000	757.00	757.00	757.00	757.00	757.00
4.6000	757.00	757.00	757.00	757.00	757.00
4.8000	757.00	757.00	757.00	757.00	757.00
5.0000	757.00	757.00	757.00	757.00	757.00
5.2000	757.00	757.00	757.00	757.00	757.00
5.4000	757.00	757.00	757.00	757.00	757.00
5.6000	757.00	757.00	757.00	757.00	757.00
5.8000	757.00	757.00	757.00	757.00	757.00
6.0000	757.00	757.00	757.00	757.00	757.00
6.2000	757.00	757.01	757.01	757.01	757.01
6.4000	757.01	757.01	757.01	757.01	757.01
6.6000	757.01	757.01	757.01	757.01	757.01
6.8000	757.01	757.01	757.01	757.01	757.01
7.0000	757.01	757.01	757.01	757.01	757.01
7.2000	757.01	757.01	757.01	757.01	757.01
7.4000	757.01	757.01	757.01	757.01	757.01
7.6000	757.01	757.01	757.01	757.01	757.01
7.8000	757.01	757.01	757.01	757.01	757.01
8.0000	757.02	757.02	757.02	757.02	757.02
8.2000	757.02	757.02	757.02	757.02	757.02
8.4000	757.02	757.02	757.02	757.02	757.02
8.6000	757.02	757.02	757.02	757.02	757.02
8.8000	757.02	757.02	757.02	757.02	757.02

TIME vs. ELEVATION (ft)

Time hrs	Output Time increment = .0400 hrs Time on left represents time for first value in each row.				
9.0000	757.02	757.02	757.02	757.02	757.03
9.2000	757.03	757.03	757.03	757.03	757.03
9.4000	757.03	757.03	757.03	757.03	757.03
9.6000	757.03	757.03	757.03	757.03	757.03
9.8000	757.03	757.03	757.04	757.04	757.04
10.0000	757.04	757.04	757.04	757.04	757.04
10.2000	757.04	757.04	757.04	757.05	757.05
10.4000	757.05	757.05	757.05	757.05	757.05
10.6000	757.06	757.06	757.06	757.06	757.06
10.8000	757.06	757.07	757.07	757.07	757.07
11.0000	757.08	757.08	757.08	757.08	757.09
11.2000	757.09	757.09	757.10	757.10	757.11
11.4000	757.11	757.11	757.12	757.12	757.13
11.6000	757.14	757.15	757.16	757.17	757.19
11.8000	757.21	757.24	757.28	757.34	757.42
12.0000	757.52	757.60	757.69	757.76	757.82
12.2000	757.85	757.87	757.88	757.88	757.89
12.4000	757.90	757.90	757.90	757.90	757.90
12.6000	757.90	757.90	757.90	757.89	757.89
12.8000	757.88	757.88	757.87	757.87	757.86
13.0000	757.86	757.85	757.84	757.83	757.82
13.2000	757.81	757.79	757.78	757.76	757.74
13.4000	757.73	757.71	757.69	757.68	757.66
13.6000	757.64	757.63	757.61	757.59	757.57
13.8000	757.56	757.54	757.53	757.51	757.50
14.0000	757.48	757.47	757.45	757.44	757.43
14.2000	757.42	757.41	757.40	757.39	757.38
14.4000	757.37	757.36	757.36	757.35	757.34
14.6000	757.33	757.33	757.32	757.31	757.31
14.8000	757.30	757.29	757.29	757.28	757.28
15.0000	757.27	757.27	757.26	757.26	757.25
15.2000	757.25	757.24	757.24	757.24	757.23
15.4000	757.23	757.23	757.22	757.22	757.21
15.6000	757.21	757.21	757.21	757.20	757.20
15.8000	757.20	757.19	757.19	757.19	757.19
16.0000	757.18	757.18	757.18	757.18	757.17
16.2000	757.17	757.17	757.17	757.17	757.16
16.4000	757.16	757.16	757.16	757.16	757.15
16.6000	757.15	757.15	757.15	757.15	757.15
16.8000	757.15	757.14	757.14	757.14	757.14
17.0000	757.14	757.14	757.14	757.13	757.13
17.2000	757.13	757.13	757.13	757.13	757.13
17.4000	757.13	757.13	757.13	757.13	757.12
17.6000	757.12	757.12	757.12	757.12	757.12
17.8000	757.12	757.12	757.12	757.12	757.12
18.0000	757.12	757.11	757.11	757.11	757.11

TIME vs. ELEVATION (ft)

Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
18.2000	757.11	757.11	757.11	757.11	757.11
18.4000	757.11	757.11	757.11	757.11	757.11
18.6000	757.11	757.11	757.10	757.10	757.10
18.8000	757.10	757.10	757.10	757.10	757.10
19.0000	757.10	757.10	757.10	757.10	757.10
19.2000	757.10	757.10	757.10	757.10	757.10
19.4000	757.09	757.09	757.09	757.09	757.09
19.6000	757.09	757.09	757.09	757.09	757.09
19.8000	757.09	757.09	757.09	757.09	757.09
20.0000	757.09	757.09	757.09	757.08	757.08
20.2000	757.08	757.08	757.08	757.08	757.08
20.4000	757.08	757.08	757.08	757.08	757.08
20.6000	757.08	757.08	757.08	757.08	757.08
20.8000	757.08	757.08	757.08	757.08	757.08
21.0000	757.08	757.07	757.07	757.07	757.07
21.2000	757.07	757.07	757.07	757.07	757.07
21.4000	757.07	757.07	757.07	757.07	757.07
21.6000	757.07	757.07	757.07	757.07	757.07
21.8000	757.07	757.07	757.07	757.07	757.07
22.0000	757.07	757.07	757.07	757.07	757.07
22.2000	757.07	757.07	757.07	757.07	757.07
22.4000	757.07	757.07	757.07	757.07	757.07
22.6000	757.07	757.07	757.07	757.07	757.07
22.8000	757.07	757.07	757.07	757.07	757.07
23.0000	757.07	757.07	757.07	757.07	757.07
23.2000	757.07	757.07	757.07	757.07	757.07
23.4000	757.07	757.06	757.06	757.06	757.06
23.6000	757.06	757.06	757.06	757.06	757.06
23.8000	757.06	757.06	757.06	757.06	757.06
24.0000	757.06	757.06	757.06	757.06	757.06
24.2000	757.06	757.06	757.06	757.06	757.06
24.4000	757.06	757.05	757.05	757.05	757.05
24.6000	757.05	757.04	757.04	757.04	757.04
24.8000	757.04	757.04	757.03	757.03	757.03
25.0000	757.03	757.03	757.03	757.03	757.02
25.2000	757.02	757.02	757.02	757.02	757.02
25.4000	757.02	757.02	757.02	757.02	757.02
25.6000	757.01	757.01	757.01	757.01	757.01
25.8000	757.01	757.01	757.01	757.01	757.01
26.0000	757.01	757.01	757.01	757.01	757.01
26.2000	757.01	757.01	757.01	757.01	757.01
26.4000	757.01	757.00	757.00	757.00	757.00
26.6000	757.00	757.00	757.00	757.00	757.00
26.8000	757.00	757.00	757.00	757.00	757.00
27.0000	757.00	757.00	757.00	757.00	757.00
27.2000	757.00	757.00	757.00	757.00	757.00

TIME vs. ELEVATION (ft)

Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
27.4000	757.00	757.00	757.00	757.00	757.00
27.6000	757.00	757.00	757.00	757.00	757.00
27.8000	757.00	757.00	757.00	757.00	757.00
28.0000	757.00	757.00	757.00	757.00	757.00
28.2000	757.00	757.00	757.00	757.00	757.00
28.4000	757.00	757.00	757.00	757.00	757.00
28.6000	757.00	757.00	757.00	757.00	757.00
28.8000	757.00	757.00	757.00	757.00	757.00
29.0000	757.00	757.00	757.00	757.00	757.00
29.2000	757.00	757.00	757.00	757.00	757.00
29.4000	757.00	757.00	757.00	757.00	757.00
29.6000	757.00	757.00	757.00	757.00	757.00
29.8000	757.00	757.00	757.00	757.00	757.00
30.0000	757.00	757.00	757.00	757.00	757.00
30.2000	757.00	757.00	757.00	757.00	757.00
30.4000	757.00	757.00	757.00	757.00	757.00
30.6000	757.00	757.00	757.00	757.00	757.00
30.8000	757.00	757.00	757.00	757.00	757.00
31.0000	757.00	757.00	757.00	757.00	757.00
31.2000	757.00	757.00	757.00	757.00	757.00
31.4000	757.00	757.00	757.00	757.00	757.00
31.6000	757.00	757.00	757.00	757.00	757.00
31.8000	757.00	757.00	757.00	757.00	757.00
32.0000	757.00	757.00	757.00	757.00	757.00
32.2000	757.00	757.00	757.00	757.00	757.00
32.4000	757.00	757.00	757.00	757.00	757.00
32.6000	757.00	757.00	757.00	757.00	757.00
32.8000	757.00	757.00	757.00	757.00	757.00
33.0000	757.00	757.00	757.00	757.00	757.00
33.2000	757.00	757.00	757.00	757.00	757.00
33.4000	757.00	757.00	757.00	757.00	757.00
33.6000	757.00	757.00	757.00	757.00	757.00
33.8000	757.00	757.00	757.00	757.00	757.00
34.0000	757.00	757.00	757.00	757.00	757.00
34.2000	757.00	757.00	757.00	757.00	757.00
34.4000	757.00	757.00	757.00	757.00	757.00
34.6000	757.00	757.00	757.00	757.00	757.00
34.8000	757.00	757.00	757.00	757.00	757.00
35.0000	757.00				

TIME vs. ELEVATION (ft)

Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
.0000	757.00	757.00	757.00	757.00	757.00
.2000	757.00	757.00	757.00	757.00	757.00
.4000	757.00	757.00	757.00	757.00	757.00
.6000	757.00	757.00	757.00	757.00	757.00
.8000	757.00	757.00	757.00	757.00	757.00
1.0000	757.00	757.00	757.00	757.00	757.00
1.2000	757.00	757.00	757.00	757.00	757.00
1.4000	757.00	757.00	757.00	757.00	757.00
1.6000	757.00	757.00	757.00	757.00	757.00
1.8000	757.00	757.00	757.00	757.00	757.00
2.0000	757.00	757.00	757.00	757.00	757.00
2.2000	757.00	757.00	757.00	757.00	757.00
2.4000	757.00	757.00	757.00	757.00	757.00
2.6000	757.00	757.00	757.00	757.00	757.00
2.8000	757.00	757.00	757.00	757.00	757.00
3.0000	757.00	757.00	757.00	757.00	757.00
3.2000	757.00	757.00	757.00	757.00	757.00
3.4000	757.00	757.00	757.00	757.00	757.00
3.6000	757.00	757.00	757.00	757.00	757.00
3.8000	757.00	757.00	757.00	757.00	757.00
4.0000	757.00	757.00	757.00	757.00	757.00
4.2000	757.00	757.00	757.00	757.00	757.00
4.4000	757.00	757.00	757.00	757.00	757.00
4.6000	757.00	757.00	757.00	757.00	757.00
4.8000	757.00	757.00	757.00	757.00	757.00
5.0000	757.00	757.00	757.00	757.00	757.00
5.2000	757.00	757.00	757.00	757.00	757.00
5.4000	757.00	757.00	757.00	757.01	757.01
5.6000	757.01	757.01	757.01	757.01	757.01
5.8000	757.01	757.01	757.01	757.01	757.01
6.0000	757.01	757.01	757.01	757.01	757.01
6.2000	757.01	757.01	757.01	757.01	757.01
6.4000	757.01	757.01	757.01	757.01	757.01
6.6000	757.01	757.01	757.01	757.01	757.01
6.8000	757.01	757.01	757.01	757.01	757.01
7.0000	757.01	757.01	757.02	757.02	757.02
7.2000	757.02	757.02	757.02	757.02	757.02
7.4000	757.02	757.02	757.02	757.02	757.02
7.6000	757.02	757.02	757.02	757.02	757.02
7.8000	757.02	757.02	757.02	757.02	757.02
8.0000	757.02	757.02	757.02	757.02	757.02
8.2000	757.02	757.02	757.02	757.02	757.02
8.4000	757.03	757.03	757.03	757.03	757.03
8.6000	757.03	757.03	757.03	757.03	757.03
8.8000	757.03	757.03	757.03	757.03	757.03

TIME vs. ELEVATION (ft)

Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
9.0000	757.03	757.03	757.04	757.04	757.04
9.2000	757.04	757.04	757.04	757.04	757.04
9.4000	757.04	757.04	757.04	757.05	757.05
9.6000	757.05	757.05	757.05	757.05	757.05
9.8000	757.05	757.05	757.05	757.06	757.06
10.0000	757.06	757.06	757.06	757.06	757.06
10.2000	757.06	757.07	757.07	757.07	757.07
10.4000	757.07	757.08	757.08	757.08	757.08
10.6000	757.08	757.09	757.09	757.09	757.09
10.8000	757.10	757.10	757.10	757.10	757.11
11.0000	757.11	757.12	757.12	757.12	757.13
11.2000	757.13	757.14	757.14	757.15	757.15
11.4000	757.16	757.16	757.17	757.18	757.18
11.6000	757.19	757.20	757.22	757.23	757.26
11.8000	757.29	757.33	757.39	757.47	757.56
12.0000	757.65	757.75	757.82	757.87	757.89
12.2000	757.92	757.93	757.95	757.96	757.97
12.4000	757.98	757.98	757.99	757.99	757.99
12.6000	757.99	757.99	757.99	757.99	757.98
12.8000	757.98	757.98	757.97	757.97	757.96
13.0000	757.95	757.95	757.94	757.94	757.93
13.2000	757.92	757.91	757.91	757.90	757.89
13.4000	757.88	757.87	757.87	757.86	757.85
13.6000	757.84	757.83	757.81	757.80	757.78
13.8000	757.77	757.75	757.73	757.71	757.69
14.0000	757.68	757.66	757.64	757.62	757.60
14.2000	757.59	757.57	757.55	757.54	757.52
14.4000	757.51	757.49	757.48	757.46	757.45
14.6000	757.44	757.43	757.42	757.41	757.40
14.8000	757.39	757.38	757.37	757.37	757.36
15.0000	757.35	757.34	757.34	757.33	757.32
15.2000	757.32	757.31	757.31	757.30	757.30
15.4000	757.29	757.29	757.28	757.28	757.27
15.6000	757.27	757.26	757.26	757.26	757.25
15.8000	757.25	757.24	757.24	757.24	757.23
16.0000	757.23	757.23	757.22	757.22	757.22
16.2000	757.22	757.21	757.21	757.21	757.20
16.4000	757.20	757.20	757.20	757.19	757.19
16.6000	757.19	757.19	757.19	757.18	757.18
16.8000	757.18	757.18	757.18	757.18	757.17
17.0000	757.17	757.17	757.17	757.17	757.17
17.2000	757.16	757.16	757.16	757.16	757.16
17.4000	757.16	757.16	757.16	757.15	757.15
17.6000	757.15	757.15	757.15	757.15	757.15
17.8000	757.15	757.15	757.15	757.14	757.14
18.0000	757.14	757.14	757.14	757.14	757.14

TIME vs. ELEVATION (ft)

Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
18.2000	757.14	757.14	757.14	757.14	757.13
18.4000	757.13	757.13	757.13	757.13	757.13
18.6000	757.13	757.13	757.13	757.13	757.13
18.8000	757.13	757.13	757.13	757.12	757.12
19.0000	757.12	757.12	757.12	757.12	757.12
19.2000	757.12	757.12	757.12	757.12	757.12
19.4000	757.12	757.12	757.11	757.11	757.11
19.6000	757.11	757.11	757.11	757.11	757.11
19.8000	757.11	757.11	757.11	757.11	757.11
20.0000	757.11	757.11	757.10	757.10	757.10
20.2000	757.10	757.10	757.10	757.10	757.10
20.4000	757.10	757.10	757.10	757.10	757.10
20.6000	757.10	757.10	757.10	757.10	757.09
20.8000	757.09	757.09	757.09	757.09	757.09
21.0000	757.09	757.09	757.09	757.09	757.09
21.2000	757.09	757.09	757.09	757.09	757.09
21.4000	757.09	757.09	757.09	757.09	757.09
21.6000	757.09	757.09	757.09	757.09	757.09
21.8000	757.09	757.09	757.09	757.09	757.09
22.0000	757.09	757.08	757.08	757.08	757.08
22.2000	757.08	757.08	757.08	757.08	757.08
22.4000	757.08	757.08	757.08	757.08	757.08
22.6000	757.08	757.08	757.08	757.08	757.08
22.8000	757.08	757.08	757.08	757.08	757.08
23.0000	757.08	757.08	757.08	757.08	757.08
23.2000	757.08	757.08	757.08	757.08	757.08
23.4000	757.08	757.08	757.08	757.08	757.08
23.6000	757.08	757.08	757.08	757.08	757.08
23.8000	757.08	757.08	757.08	757.08	757.08
24.0000	757.08	757.08	757.08	757.08	757.08
24.2000	757.08	757.07	757.07	757.07	757.07
24.4000	757.07	757.07	757.06	757.06	757.06
24.6000	757.06	757.05	757.05	757.05	757.05
24.8000	757.05	757.04	757.04	757.04	757.04
25.0000	757.04	757.04	757.03	757.03	757.03
25.2000	757.03	757.03	757.03	757.03	757.02
25.4000	757.02	757.02	757.02	757.02	757.02
25.6000	757.02	757.02	757.02	757.02	757.01
25.8000	757.01	757.01	757.01	757.01	757.01
26.0000	757.01	757.01	757.01	757.01	757.01
26.2000	757.01	757.01	757.01	757.01	757.01
26.4000	757.01	757.01	757.01	757.01	757.01
26.6000	757.00	757.00	757.00	757.00	757.00
26.8000	757.00	757.00	757.00	757.00	757.00
27.0000	757.00	757.00	757.00	757.00	757.00
27.2000	757.00	757.00	757.00	757.00	757.00

TIME vs. ELEVATION (ft)

Time hrs	Output Time increment = .0400 hrs Time on left represents time for first value in each row.				
27.4000	757.00	757.00	757.00	757.00	757.00
27.6000	757.00	757.00	757.00	757.00	757.00
27.8000	757.00	757.00	757.00	757.00	757.00
28.0000	757.00	757.00	757.00	757.00	757.00
28.2000	757.00	757.00	757.00	757.00	757.00
28.4000	757.00	757.00	757.00	757.00	757.00
28.6000	757.00	757.00	757.00	757.00	757.00
28.8000	757.00	757.00	757.00	757.00	757.00
29.0000	757.00	757.00	757.00	757.00	757.00
29.2000	757.00	757.00	757.00	757.00	757.00
29.4000	757.00	757.00	757.00	757.00	757.00
29.6000	757.00	757.00	757.00	757.00	757.00
29.8000	757.00	757.00	757.00	757.00	757.00
30.0000	757.00	757.00	757.00	757.00	757.00
30.2000	757.00	757.00	757.00	757.00	757.00
30.4000	757.00	757.00	757.00	757.00	757.00
30.6000	757.00	757.00	757.00	757.00	757.00
30.8000	757.00	757.00	757.00	757.00	757.00
31.0000	757.00	757.00	757.00	757.00	757.00
31.2000	757.00	757.00	757.00	757.00	757.00
31.4000	757.00	757.00	757.00	757.00	757.00
31.6000	757.00	757.00	757.00	757.00	757.00
31.8000	757.00	757.00	757.00	757.00	757.00
32.0000	757.00	757.00	757.00	757.00	757.00
32.2000	757.00	757.00	757.00	757.00	757.00
32.4000	757.00	757.00	757.00	757.00	757.00
32.6000	757.00	757.00	757.00	757.00	757.00
32.8000	757.00	757.00	757.00	757.00	757.00
33.0000	757.00	757.00	757.00	757.00	757.00
33.2000	757.00	757.00	757.00	757.00	757.00
33.4000	757.00	757.00	757.00	757.00	757.00
33.6000	757.00	757.00	757.00	757.00	757.00
33.8000	757.00	757.00	757.00	757.00	757.00
34.0000	757.00	757.00	757.00	757.00	757.00
34.2000	757.00	757.00	757.00	757.00	757.00
34.4000	757.00	757.00	757.00	757.00	757.00
34.6000	757.00	757.00	757.00	757.00	757.00
34.8000	757.00	757.00	757.00	757.00	757.00
35.0000	757.00				

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Elevation (ft)	Planimeter (sq.in)	Area (acres)	A1+A2+sqr(A1*A2) (acres)	Volume (ac-ft)	Volume Sum (ac-ft)
757.00	-----	8.0100	.0000	.000	.000
758.00	-----	9.4200	26.1164	8.705	8.705
759.00	-----	10.0800	29.2444	9.748	18.454
760.00	-----	10.7100	31.1802	10.393	28.847
761.00	-----	11.2700	32.9664	10.989	39.836
762.00	-----	12.3100	35.3585	11.786	51.622
763.00	-----	13.7800	39.1143	13.038	64.660

POND VOLUME EQUATIONS

* Incremental volume computed by the Conic Method for Reservoir Volumes.

Volume = (1/3) * (EL2-EL1) * (Area1 + Area2 + sq.rt.(Area1*Area2))

where: EL1, EL2 = Lower and upper elevations of the increment
Area1,Area2 = Areas computed for EL1, EL2, respectively
Volume = Incremental volume between EL1 and EL2

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP PHASE2_FINAL COVER_A.PPW

USER DEFINED VOLUME RATING TABLE

Elevation (ft)	Volume (ac-ft)
747.00	.640
748.00	4.880
749.00	17.040
750.00	20.560
751.00	21.750
752.00	22.530
753.00	23.190
754.00	23.700
755.00	24.170
756.00	24.550
757.00	24.840
758.00	25.130
759.00	25.410
760.00	25.650
761.00	25.910
762.00	26.200
763.00	26.460
764.00	26.760
765.00	27.060

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP PHASE2_FINAL COVER_A.PPW

REQUESTED POND WS ELEVATIONS:

Min. Elev.= 757.00 ft
Increment = .50 ft
Max. Elev.= 763.00 ft

****
OUTLET CONNECTIVITY
****

---> Forward Flow Only (UpStream to DnStream)
<--- Reverse Flow Only (DnStream to UpStream)
<---> Forward and Reverse Both Allowed

Structure	No.		Outfall	E1, ft	E2, ft
Stand Pipe	SP	--->	CV	758.000	763.000
Stand Pipe	SP	--->	CV	758.000	763.000
Stand Pipe	SP	--->	CV	758.000	763.000
Stand Pipe	SP	--->	CV	758.000	763.000
Stand Pipe	SP	--->	CV	758.000	763.000
Culvert-Circular	CV	--->	TW	752.000	763.000
TW SETUP, DS Channel					

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP PHASE2_FINAL COVER_A.PPW

OUTLET STRUCTURE INPUT DATA

```
Structure ID       = SP
Structure Type     = Stand Pipe
------------------------------------
# of Openings      =        1
Invert Elev.       =    758.00 ft
Diameter           =    4.5000 ft
Orifice Area       =   15.9043 sq.ft
Orifice Coeff.     =      .600
Weir Length        =     14.14 ft
Weir Coeff.        =     3.247
K, Submerged       =      .000
K, Reverse         =     1.000
Kb,Barrel          =   .000000  (per ft of full flow)
Barrel Length      =       .00 ft
Mannings n         =     .0000
```

```
Structure ID       = SP
Structure Type     = Stand Pipe
------------------------------------
# of Openings      =        1
Invert Elev.       =    758.00 ft
Diameter           =    4.5000 ft
Orifice Area       =   15.9043 sq.ft
Orifice Coeff.     =      .600
Weir Length        =     14.14 ft
Weir Coeff.        =     3.247
K, Submerged       =      .000
K, Reverse         =     1.000
Kb,Barrel          =   .000000  (per ft of full flow)
Barrel Length      =       .00 ft
Mannings n         =     .0000
```

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP PHASE2_FINAL COVER_A.PPW

OUTLET STRUCTURE INPUT DATA

```
Structure ID       = SP
Structure Type     = Stand Pipe
------------------------------------
# of Openings      =        1
Invert Elev.       =    758.00 ft
Diameter           =    4.5000 ft
Orifice Area       =   15.9043 sq.ft
Orifice Coeff.     =      .600
Weir Length        =     14.14 ft
Weir Coeff.        =     3.247
K, Submerged       =      .000
K, Reverse         =     1.000
Kb,Barrel          =   .000000  (per ft of full flow)
Barrel Length      =       .00 ft
Mannings n         =     .0000
```

```
Structure ID       = SP
Structure Type     = Stand Pipe
------------------------------------
# of Openings      =        1
Invert Elev.       =    758.00 ft
Diameter           =    4.5000 ft
Orifice Area       =   15.9043 sq.ft
Orifice Coeff.     =      .600
Weir Length        =     14.14 ft
Weir Coeff.        =     3.247
K, Submerged       =      .000
K, Reverse         =     1.000
Kb,Barrel          =   .000000  (per ft of full flow)
Barrel Length      =       .00 ft
Mannings n         =     .0000
```

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP PHASE2_FINAL COVER_A.PPW

OUTLET STRUCTURE INPUT DATA

```
Structure ID       = SP
Structure Type     = Stand Pipe
------------------------------------
# of Openings      =        1
Invert Elev.       =   758.00 ft
Diameter           =   4.5000 ft
Orifice Area       =  15.9043 sq.ft
Orifice Coeff.     =     .600
Weir Length        =    14.14 ft
Weir Coeff.        =    3.247
K, Submerged       =     .000
K, Reverse         =    1.000
Kb,Barrel          =  .000000  (per ft of full flow)
Barrel Length      =      .00 ft
Mannings n         =    .0000
```

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP PHASE2_FINAL COVER_A.PPW

OUTLET STRUCTURE INPUT DATA

```
Structure ID       = CV
Structure Type     = Culvert-Circular
------------------------------------
No. Barrels        =        5
Barrel Diameter    =   3.0000 ft
Upstream Invert    =   752.00 ft
Dnstream Invert    =   751.00 ft
Horiz. Length      =   200.00 ft
Barrel Length      =   200.00 ft
Barrel Slope       =   .00500 ft/ft

OUTLET CONTROL DATA...
Mannings n         =    .0120
Ke                 =    .5000  (forward entrance loss)
Kb                 =  .006159  (per ft of full flow)
Kr                 =    .5000  (reverse entrance loss)
HW Convergence     =     .001  +/- ft

INLET CONTROL DATA...
Equation form      =        1
Inlet Control K    =    .0098
Inlet Control M    =   2.0000
Inlet Control c    =   .03980
Inlet Control Y    =    .6700
T1 ratio (HW/D)    =    1.158
T2 ratio (HW/D)    =    1.304
Slope Factor       =    -.500
```

Use unsubmerged inlet control Form 1 equ. below T1 elev.
Use   submerged inlet control Form 1 equ. above T2 elev.

In transition zone between unsubmerged and submerged inlet control,
interpolate between flows at T1 & T2...
At T1 Elev =   755.47 ft ---> Flow =   42.85 cfs
At T2 Elev =   755.91 ft ---> Flow =   48.97 cfs

Index of Starting Page Numbers for ID Names

ATTACHMENT 2.1 – DITCH 1 MODEL FOR DITCH FLOWS

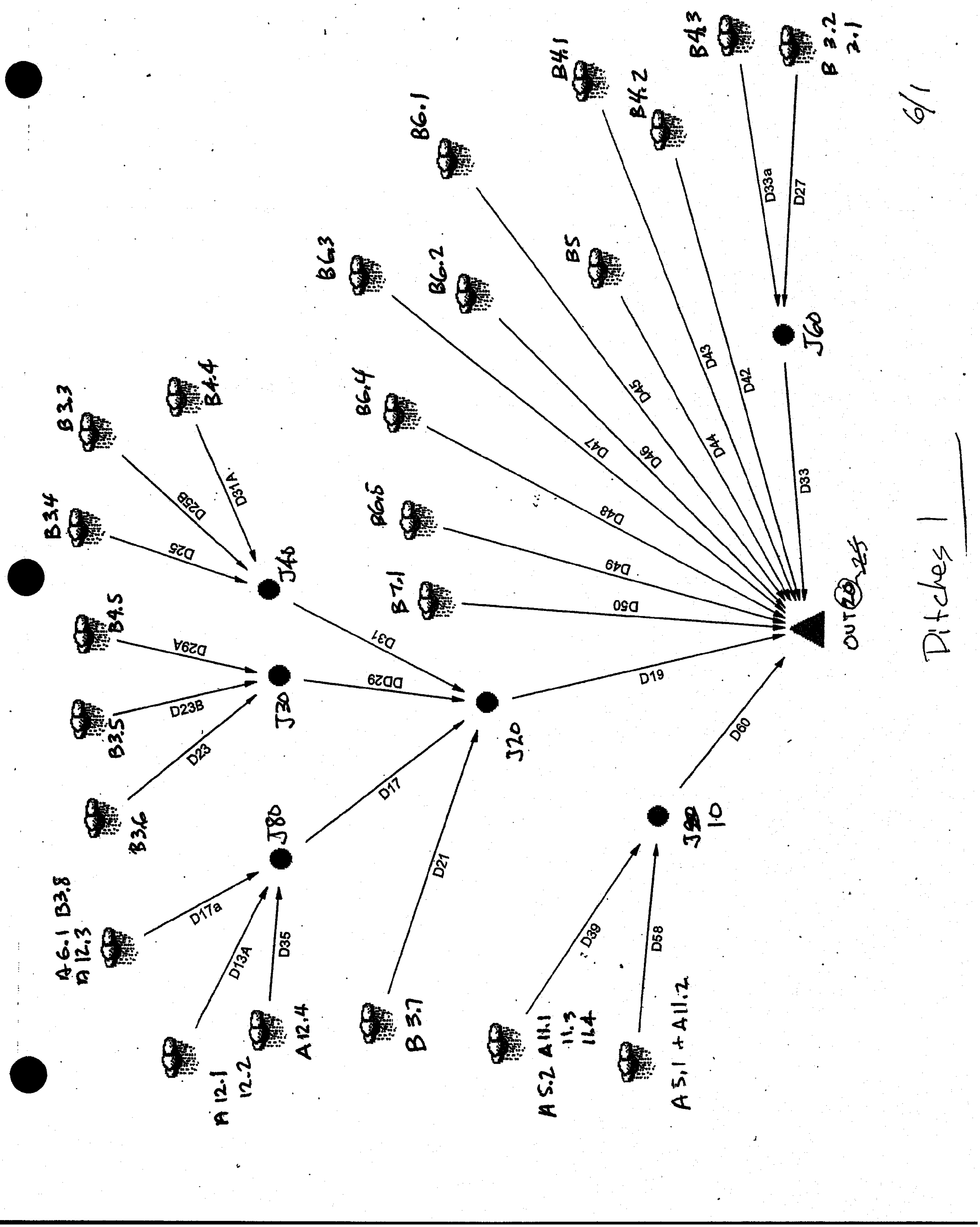
Ditches 1
6/1
OUT
J40
J30
J20
J80
J60
J10
B3.3
B4.4
B3.4
B4.5
B3.5
B3.6
A6.1 B3.8
A12.3
A12.1
12.2
A12.4
B3.7
A5.2 A11.1
11.3
11.4
A5.1 + A11.2
B6.3
B6.2
B6.4
B6.5
B7.1
B6.1
B5
B4.1
B4.2
B4.3
B3.2
3.1
D25B
D31A
D25
D29A
D23B
D23
DD29
D31
D17
D17a
D13A
D35
D21
D39
D58
D60
D19
D50
D49
D48
D47
D46
D45
D44
D43
D42
D33
D33a
D27

Table of Contents

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Table of Contents (continued)

Table of Contents (continued)

NETWORK SUMMARY -- LINKS
(UN=Upstream Node; DL=DNstream End of Link; DN=DNstream Node)
(Trun.= HYG Truncation: Blank=None; L=Left; R=Rt;.LR=Left & Rt)

DEFAULT Design Storm File,ID = KIF

Storm Tag Name = 25yr

Data Type, File, ID = Synthetic Storm TypeII 24hr
Storm Frequency = 25 yr
Total Rainfall Depth= 5.5000 in
Duration Multiplier = 1
Resulting Duration = 24.0000 hrs
Resulting Start Time= .0000 hrs Step= .1000 hrs End= 24.0000 hrs

ICPM CALCULATION TOLERANCES

Target Convergence= .000 cfs +/-
Max. Iterations = 35 loops
ICPM Time Step = .0400 hrs
Output Time Step = .0400 hrs
ICPM Ending Time = 35.0000 hrs

Link ID	Type		HYG Vol ac-ft	Trun.	Peak Time hrs	Peak Q cfs	End Points
D13A	ADD	UN	1.928		12.0800	24.12	SUB12.1&12.2
		DL	1.928		12.0800	24.12	
		DN	3.962		12.0000	52.43	JUNC 80
D17	ADD	UN	3.962		12.0000	52.43	JUNC 80
		DL	3.962		12.0000	52.43	
		DN	8.058		12.0000	117.68	JUNC 20
D17A	ADD	UN	1.677		11.9600	27.68	SUBA12.36.1B3.8
		DL	1.677		11.9600	27.68	
		DN	3.962		12.0000	52.43	JUNC 80
D19	ADD	UN	8.058		12.0000	117.68	JUNC 20
		DL	8.058		12.0000	117.68	
		DN	18.636		11.9600	301.52	OUT 20
D21	ADD	UN	.838		11.9600	13.37	SUB B3.7
		DL	.838		11.9600	13.37	
		DN	8.058		12.0000	117.68	JUNC 20

NETWORK SUMMARY -- LINKS
(UN=Upstream Node; DL=DNstream End of Link; DN=DNstream Node)
(Trun.= HYG Truncation: Blank=None; L=Left; R=Rt; LR=Left & Rt)

Link ID	Type		HYG Vol ac-ft	Trun.	Peak Time hrs	Peak Q cfs	End Points
D23	ADD	UN	.744		11.9600	12.17	SUBB3.6
		DL	.744		11.9600	12.17	
		DN	1.656		11.9600	27.42	JUNC 30
D23B	ADD	UN	.643		11.9600	10.52	SUBB3.5
		DL	.643		11.9600	10.52	
		DN	1.656		11.9600	27.42	JUNC 30
D25	ADD	UN	.542		11.9600	8.87	SUBB3.4
		DL	.542		11.9600	8.87	
		DN	1.602		11.9600	26.86	JUNC 40
D25B	ADD	UN	.522		11.9600	8.54	SUBB3.3
		DL	.522		11.9600	8.54	
		DN	1.602		11.9600	26.86	JUNC 40
D27	ADD	UN	.744		11.9600	12.17	SUB B3.2&3.1
		DL	.744		11.9600	12.17	
		DN	1.426		11.9600	24.15	JUNC 60
D29A	ADD	UN	.269		11.9200	5.04	SUB B4.5
		DL	.269		11.9200	5.04	
		DN	1.656		11.9600	27.42	JUNC 30
D31	ADD	UN	1.602		11.9600	26.86	JUNC 40
		DL	1.602		11.9600	26.86	
		DN	8.058		12.0000	117.68	JUNC 20
D31A	ADD	UN	.538		11.9200	10.08	SUBB4.4
		DL	.538		11.9200	10.08	
		DN	1.602		11.9600	26.86	JUNC 40
D33	ADD	UN	1.426		11.9600	24.15	JUNC 60
		DL	1.426		11.9600	24.15	
		DN	18.636		11.9600	301.52	OUT 20
D33A	ADD	UN	.682		11.9200	12.77	SUBB4.3
		DL	.682		11.9200	12.77	
		DN	1.426		11.9600	24.15	JUNC 60

NETWORK SUMMARY -- LINKS
(UN=Upstream Node; DL=DNstream End of Link; DN=DNstream Node)
(Trun.= HYG Truncation: Blank=None; L=Left; R=Rt; LR=Left & Rt)

Link ID	Type		HYG Vol ac-ft	Trun.	Peak Time hrs	Peak Q cfs	End Points
D35	ADD	UN	.357		12.0800	4.46	SUB A12.4
		DL	.357		12.0800	4.46	
		DN	3.962		12.0000	52.43	JUNC 80
D39	ADD	UN	1.328		11.9600	22.56	SUBA5.2A11.1.3.4
		DL	1.328		11.9600	22.56	
		DN	2.130		11.9600	36.59	JUNC 10
D42	ADD	UN	.940		11.9200	17.62	SUBB4.2
		DL	.940		11.9200	17.62	
		DN	18.636		11.9600	301.52	OUT 20
D43	ADD	UN	.457		11.9200	8.55	SUBAREA B4.1
		DL	.457		11.9200	8.55	
		DN	18.636		11.9600	301.52	OUT 20
D44	ADD	UN	.313		11.9200	5.86	SUBAREA B5
		DL	.313		11.9200	5.86	
		DN	18.636		11.9600	301.52	OUT 20
D45	ADD	UN	.611		11.9200	11.44	SUBAREA B6.1
		DL	.611		11.9200	11.44	
		DN	18.636		11.9600	301.52	OUT 20
D46	ADD	UN	.686		11.9200	12.85	SUBAREA B6.2
		DL	.686		11.9200	12.85	
		DN	18.636		11.9600	301.52	OUT 20
D47	ADD	UN	.971		11.9200	18.20	SUBAREA B6.3
		DL	.971		11.9200	18.20	
		DN	18.636		11.9600	301.52	OUT 20
D48	ADD	UN	1.015		11.9200	19.02	SUBAREA B6.4
		DL	1.015		11.9200	19.02	
		DN	18.636		11.9600	301.52	OUT 20
D49	ADD	UN	.996		11.9200	18.67	SUBAREA B6.5
		DL	.996		11.9200	18.67	
		DN	18.636		11.9600	301.52	OUT 20

NETWORK SUMMARY -- LINKS
(UN=Upstream Node; DL=DNstream End of Link; DN=DNstream Node)
(Trun.= HYG Truncation: Blank=None; L=Left; R=Rt; LR=Left & Rt)

Link ID	Type		HYG Vol ac-ft	Trun.	Peak Time hrs	Peak Q cfs	End Points
D50	ADD	UN	1.034		11.9200	19.37	SUBB7.1
		DL	1.034		11.9200	19.37	
		DN	18.636		11.9600	301.52	OUT 20
D58	ADD	UN	.802		11.9600	14.03	SUB A5.1+A11.2
		DL	.802		11.9600	14.03	
		DN	2.130		11.9600	36.59	JUNC 10
D60	ADD	UN	2.130		11.9600	36.59	JUNC 10
		DL	2.130		11.9600	36.59	
		DN	18.636		11.9600	301.52	OUT 20
DD29	ADD	UN	1.656		11.9600	27.42	JUNC 30
		DL	1.656		11.9600	27.42	
		DN	8.058		12.0000	117.68	JUNC 20

File.... C:\Haestad\PPKW\KIF\
Title... Project Date: 5/3/2004
Project Engineer: Daniel R. Smith
Project Title: KIF Lat Exp Interim Operation w/phase2&3 pond
Project Comments:
This model analyzes the cond of the expan during operation, while Phase 2/3 has a pond. The time of concentration is minimized due to the pond.

DESIGN STORMS SUMMARY

Design Storm File,ID = KIF

Storm Tag Name = 2yr

Data Type, File, ID = Synthetic Storm TypeII 24hr
Storm Frequency = 2 yr
Total Rainfall Depth= 3.2500 in
Duration Multiplier = 1
Resulting Duration = 24.0000 hrs
Resulting Start Time= .0000 hrs Step= .1000 hrs End= 24.0000 hrs

Storm Tag Name = 10yr

Data Type, File, ID = Synthetic Storm TypeII 24hr
Storm Frequency = 10 yr
Total Rainfall Depth= 3.6000 in
Duration Multiplier = 1
Resulting Duration = 24.0000 hrs
Resulting Start Time= .0000 hrs Step= .1000 hrs End= 24.0000 hrs

Storm Tag Name = 25yr

Data Type, File, ID = Synthetic Storm TypeII 24hr
Storm Frequency = 25 yr
Total Rainfall Depth= 5.5000 in
Duration Multiplier = 1
Resulting Duration = 24.0000 hrs
Resulting Start Time= .0000 hrs Step= .1000 hrs End= 24.0000 hrs

Storm Tag Name = 100yr

Data Type, File, ID = Synthetic Storm TypeII 24hr
Storm Frequency = 100 yr
Total Rainfall Depth= 6.5000 in
Duration Multiplier = 1
Resulting Duration = 24.0000 hrs
Resulting Start Time= .0000 hrs Step= .1000 hrs End= 24.0000 hrs

CUMULATIVE RAINFALL FRACTIONS
Output Time increment = .1000 hrs
Time on left represents time for first value in each row.

Time hrs					
.0000	.000	.001	.002	.003	.004
.5000	.005	.006	.007	.008	.009
1.0000	.011	.012	.013	.014	.015
1.5000	.016	.017	.018	.020	.021
2.0000	.022	.023	.024	.026	.027
2.5000	.028	.029	.031	.032	.033
3.0000	.035	.036	.037	.038	.040
3.5000	.041	.042	.044	.045	.047
4.0000	.048	.049	.051	.052	.054
4.5000	.055	.057	.058	.060	.061
5.0000	.063	.065	.066	.068	.070
5.5000	.071	.073	.075	.076	.078
6.0000	.080	.082	.084	.085	.087
6.5000	.089	.091	.093	.095	.097
7.0000	.099	.101	.103	.105	.107
7.5000	.109	.111	.113	.116	.118
8.0000	.120	.122	.125	.127	.130
8.5000	.132	.135	.138	.141	.144
9.0000	.147	.150	.153	.157	.160
9.5000	.163	.166	.170	.173	.177
10.0000	.181	.185	.189	.194	.199
10.5000	.204	.209	.215	.221	.228
11.0000	.235	.243	.251	.261	.271
11.5000	.283	.307	.354	.431	.568
12.0000	.663	.682	.699	.713	.725
12.5000	.735	.743	.751	.759	.766
13.0000	.772	.778	.784	.789	.794
13.5000	.799	.804	.808	.812	.816
14.0000	.820	.824	.827	.831	.834
14.5000	.838	.841	.844	.847	.850
15.0000	.854	.856	.859	.862	.865
15.5000	.868	.870	.873	.875	.878
16.0000	.880	.882	.885	.887	.889
16.5000	.891	.893	.895	.898	.900
17.0000	.902	.904	.906	.908	.910
17.5000	.912	.914	.915	.917	.919
18.0000	.921	.923	.925	.926	.928
18.5000	.930	.931	.933	.935	.936
19.0000	.938	.939	.941	.942	.944
19.5000	.945	.947	.948	.949	.951
20.0000	.952	.953	.955	.956	.957
20.5000	.958	.960	.961	.962	.964
21.0000	.965	.966	.967	.968	.970
21.5000	.971	.972	.973	.975	.976
22.0000	.977	.978	.979	.981	.982
22.5000	.983	.984	.985	.986	.988

CUMULATIVE RAINFALL FRACTIONS
Output Time increment = .1000 hrs
Time on left represents time for first value in each row.

Time hrs					
23.0000	.989	.990	.991	.992	.993
23.5000	.994	.996	.997	.998	.999
24.0000	1.000				

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_1A.PPW

::

TIME OF CONCENTRATION CALCULATOR

::

Segment #1: Tc: User Defined

Segment #1 Time: .3300 hrs

Total Tc: .3300 hrs

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_1A.PPW

Tc Equations used...

==== User Defined ==

Tc = Value entered by user

Where: Tc = Time of concentration

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_1A.PPW

TIME OF CONCENTRATION CALCULATOR

Segment #1: Tc: User Defined

Segment #1 Time: .1200 hrs

Total Tc: .1200 hrs

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_1A.PPW

Tc Equations used...

==== User Defined ====

Tc = Value entered by user

Where: Tc = Time of concentration

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_1A.PPW

::
TIME OF CONCENTRATION CALCULATOR
::

Segment #1: Tc: User Defined

Segment #1 Time: .1500 hrs

Total Tc: .1500 hrs

Tc Equations used...

==== User Defined ====

Tc = Value entered by user

Where: Tc = Time of concentration

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_1A.PPW

TIME OF CONCENTRATION CALCULATOR

Segment #1: Tc: User Defined

Segment #1 Time: .1600 hrs

Total Tc: .1600 hrs

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_1A.PPW

Tc Equations used...

==== User Defined ==

Tc = Value entered by user

Where: Tc = Time of concentration

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_1A.PPW

```
::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
TIME OF CONCENTRATION CALCULATOR
::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::


----------------------------------------------------------------------

Segment #1:  Tc: User Defined

                                        Segment #1 Time:     .0800 hrs
----------------------------------------------------------------------

                                                ========================
                                                 Total Tc:     .0800 hrs

                                                 Calculated Tc < Min.Tc:
                                                 Use Minimum Tc...
                                                 Use Tc =      .0833 hrs
                                                ========================
```

Tc Equations used...

==== User Defined ====

Tc = Value entered by user

Where: Tc = Time of concentration

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_1A.PPW

TIME OF CONCENTRATION CALCULATOR

Segment #1: Tc: User Defined

Segment #1 Time: .3300 hrs

Total Tc: .3300 hrs

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_1A.PPW

Tc Equations used...

==== User Defined ====

Tc = Value entered by user

Where: Tc = Time of concentration

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_1A.PPW

::
TIME OF CONCENTRATION CALCULATOR
::

Segment #1: Tc: User Defined

Segment #1 Time: .1500 hrs

Total Tc: .1500 hrs

Tc Equations used...

==== User Defined ====

Tc = Value entered by user

Where: Tc = Time of concentration

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_1A.PPW

```
::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
TIME OF CONCENTRATION CALCULATOR
::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::

------------------------------------------------------------------------

Segment #1:  Tc: User Defined

                                         Segment #1 Time:     .1400 hrs
------------------------------------------------------------------------

                                                ========================
                                                Total Tc:     .1400 hrs
                                                ========================
```

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_1A.PPW

Tc Equations used...

==== User Defined ====

Tc = Value entered by user

Where: Tc = Time of concentration

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_1A.PPW

::

TIME OF CONCENTRATION CALCULATOR

::

Segment #1: Tc: User Defined

Segment #1 Time: .0800 hrs

Total Tc: .0800 hrs

Calculated Tc < Min.Tc:
Use Minimum Tc...
Use Tc = .0833 hrs

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_1A.PPW

Tc Equations used...

==== User Defined ==

Tc = Value entered by user

Where: Tc = Time of concentration

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_1A.PPW

TIME OF CONCENTRATION CALCULATOR

Segment #1: Tc: User Defined

Segment #1 Time: .0800 hrs

Total Tc: .0800 hrs

Calculated Tc < Min.Tc:
Use Minimum Tc...
Use Tc = .0833 hrs

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_1A.PPW

Tc Equations used...

==== User Defined ====

Tc = Value entered by user

Where: Tc = Time of concentration

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_1A.PPW

TIME OF CONCENTRATION CALCULATOR

Segment #1: Tc: User Defined

Segment #1 Time: .0800 hrs

Total Tc: .0800 hrs

Calculated Tc < Min.Tc:
Use Minimum Tc...
Use Tc = .0833 hrs

Tc Equations used...

==== User Defined ====

Tc = Value entered by user

Where: Tc = Time of concentration

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_1A.PPW

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::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
TIME OF CONCENTRATION CALCULATOR
::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::


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Segment #1:  Tc: User Defined

                                        Segment #1 Time:     .0800 hrs
----------------------------------------------------------------------

                                           ========================
                                            Total Tc:      .0800 hrs

                                            Calculated Tc < Min.Tc:
                                            Use Minimum Tc...
                                            Use Tc =       .0833 hrs
                                           ========================
```

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_1A.PPW

Tc Equations used...

==== User Defined ====

Tc = Value entered by user

Where: Tc = Time of concentration

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_1A.PPW

:::

TIME OF CONCENTRATION CALCULATOR

:::

Segment #1: Tc: User Defined

Segment #1 Time: .0800 hrs

========================

Total Tc: .0800 hrs

Calculated Tc < Min.Tc:
Use Minimum Tc...
Use Tc = .0833 hrs

========================

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_1A.PPW

Tc Equations used...

==== User Defined ==

Tc = Value entered by user

Where: Tc = Time of concentration

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_1A.PPW

TIME OF CONCENTRATION CALCULATOR

Segment #1: Tc: User Defined

Segment #1 Time: .0800 hrs

Total Tc: .0800 hrs

Calculated Tc < Min.Tc:
Use Minimum Tc...
Use Tc = .0833 hrs

Tc Equations used...

==== User Defined ====

Tc = Value entered by user

Where: Tc = Time of concentration

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_1A.PPW

::

TIME OF CONCENTRATION CALCULATOR

::

Segment #1: Tc: User Defined

Segment #1 Time: .0800 hrs

========================

Total Tc: .0800 hrs

Calculated Tc < Min.Tc:
Use Minimum Tc...
Use Tc = .0833 hrs

========================

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_1A.PPW

Tc Equations used...

==== User Defined ====

Tc = Value entered by user

Where: Tc = Time of concentration

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_1A.PPW

::
TIME OF CONCENTRATION CALCULATOR
::

Segment #1: Tc: User Defined

Segment #1 Time: .1500 hrs

========================
Total Tc: .1500 hrs
========================

Tc Equations used...

==== User Defined ===

Tc = Value entered by user

Where: Tc = Time of concentration

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_1A.PPW

::

TIME OF CONCENTRATION CALCULATOR

::

Segment #1: Tc: User Defined

Segment #1 Time: .1500 hrs

========================

Total Tc: .1500 hrs

========================

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_1A.PPW

Tc Equations used...

==== User Defined ====

Tc = Value entered by user

Where: Tc = Time of concentration

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_1A.PPW

::
TIME OF CONCENTRATION CALCULATOR
::

Segment #1: Tc: User Defined

Segment #1 Time: .1500 hrs

Total Tc: .1500 hrs

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_1A.PPW

Tc Equations used...

==== User Defined ====

Tc = Value entered by user

Where: Tc = Time of concentration

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_1A.PPW

::
TIME OF CONCENTRATION CALCULATOR
::

Segment #1: Tc: User Defined

Segment #1 Time: .1500 hrs

=========================
Total Tc: .1500 hrs
=========================

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_1A.PPW

Tc Equations used...

==== User Defined ====

Tc = Value entered by user

Where: Tc = Time of concentration

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_1A.PPW

TIME OF CONCENTRATION CALCULATOR

Segment #1: Tc: User Defined

Segment #1 Time: .0800 hrs

Total Tc: .0800 hrs

Calculated Tc < Min.Tc:
Use Minimum Tc...
Use Tc = .0833 hrs

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_1A.PPW

Tc Equations used...

==== User Defined ====

Tc = Value entered by user

Where: Tc = Time of concentration

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_1A.PPW

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::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
TIME OF CONCENTRATION CALCULATOR
::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::

----------------------------------------------------------------------

Segment #1:  Tc: User Defined

                                       Segment #1 Time:     .0800 hrs
----------------------------------------------------------------------

                                             ========================
                                              Total Tc:      .0800 hrs

                                              Calculated Tc < Min.Tc:
                                              Use Minimum Tc...
                                              Use Tc =       .0833 hrs
                                             ========================
```

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_1A.PPW

Tc Equations used...

==== User Defined ====

Tc = Value entered by user

Where: Tc = Time of concentration

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_1A.PPW

TIME OF CONCENTRATION CALCULATOR

Segment #1: Tc: User Defined

Segment #1 Time: .0800 hrs

Total Tc: .0800 hrs

Calculated Tc < Min.Tc:
Use Minimum Tc...
Use Tc = .0833 hrs

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_1A.PPW

Tc Equations used...

==== User Defined ====

Tc = Value entered by user

Where: Tc = Time of concentration

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_1A.PPW

TIME OF CONCENTRATION CALCULATOR

Segment #1: Tc: User Defined

Segment #1 Time: .0800 hrs

Total Tc: .0800 hrs

Calculated Tc < Min.Tc:
Use Minimum Tc...
Use Tc = .0833 hrs

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_1A.PPW

Tc Equations used...

==== User Defined ====

Tc = Value entered by user

Where: Tc = Time of concentration

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_1A.PPW

RUNOFF CURVE NUMBER DATA

Soil/Surface Description	CN	Area acres	Impervious Adjustment %C	Impervious Adjustment %UC	Adjusted CN
A12.4	87	1.060			87.00
COMPOSITE AREA & WEIGHTED CN --->		1.060			87.00 (87)

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_1A.PPW

RUNOFF CURVE NUMBER DATA

Soil/Surface Description	CN	Area acres	Impervious Adjustment %C	Impervious Adjustment %UC	Adjusted CN
A5.1	71	1.950			71.00
A11.2	87	1.210			87.00
COMPOSITE AREA & WEIGHTED CN --->		3.160			77.13 (77)

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_1A.PPW

RUNOFF CURVE NUMBER DATA

Soil/Surface Description	CN	Area acres	Impervious Adjustment %C	Impervious Adjustment %UC	Adjusted CN
B3.2&3.1	87	2.210			87.00
COMPOSITE AREA & WEIGHTED CN --->		2.210			87.00 (87)

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_1A.PPW

RUNOFF CURVE NUMBER DATA

Soil/Surface Description	CN	Area acres	Impervious Adjustment %C	%UC	Adjusted CN
B3.7	87	2.490			87.00
COMPOSITE AREA & WEIGHTED CN --->		2.490			87.00 (87)

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_1A.PPW

RUNOFF CURVE NUMBER DATA

Soil/Surface Description	CN	Area acres	Impervious Adjustment %C	Impervious Adjustment %UC	Adjusted CN
B4.5	71	1.290			71.00
COMPOSITE AREA & WEIGHTED CN --->		1.290			71.00 (71)

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_1A.PPW

RUNOFF CURVE NUMBER DATA

::

Soil/Surface Description	CN	Area acres	Impervious Adjustment %C	Impervious Adjustment %UC	Adjusted CN
12.1 and 12.2	87	5.730			87.00

COMPOSITE AREA & WEIGHTED CN ---> 5.730 87.00 (87)

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File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_1A.PPW

RUNOFF CURVE NUMBER DATA

Soil/Surface Description	CN	Area acres	Impervious Adjustment %C	Impervious Adjustment %UC	Adjusted CN
A12.3&B3.8	87	4.710			87.00
A6.1	71	.540			71.00
COMPOSITE AREA & WEIGHTED CN --->		5.250			85.35 (85)

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_1A.PPW

RUNOFF CURVE NUMBER DATA

Soil/Surface Description	CN	Area acres	Impervious Adjustment %C	Impervious Adjustment %UC	Adjusted CN
A5.2	71	3.170			71.00
A11.1&3&4	87	2.060			87.00

COMPOSITE AREA & WEIGHTED CN ---> 5.230 77.30 (77)

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_1A.PPW

RUNOFF CURVE NUMBER DATA

Soil/Surface Description	CN	Area acres	Impervious Adjustment %C	Impervious Adjustment %UC	Adjusted CN
B4.1	71	2.190			71.00
COMPOSITE AREA & WEIGHTED CN --->		2.190			71.00 (71)

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_1A.PPW

RUNOFF CURVE NUMBER DATA

Soil/Surface Description	CN	Area acres	Impervious Adjustment %C	Impervious Adjustment %UC	Adjusted CN
B5	71	1.500			71.00
COMPOSITE AREA & WEIGHTED CN --->		1.500			71.00 (71)

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_1A.PPW

RUNOFF CURVE NUMBER DATA

Soil/Surface Description	CN	Area acres	Impervious Adjustment %C	Impervious Adjustment %UC	Adjusted CN
B6.1	71	2.930			71.00
COMPOSITE AREA & WEIGHTED CN --->		2.930			71.00 (71)

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_1A.PPW

RUNOFF CURVE NUMBER DATA

Soil/Surface Description	CN	Area acres	Impervious Adjustment %C	Impervious Adjustment %UC	Adjusted CN
B6.2	71	3.290			71.00
COMPOSITE AREA & WEIGHTED CN --->		3.290			71.00 (71)

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_1A.PPW

RUNOFF CURVE NUMBER DATA

Soil/Surface Description	CN	Area acres	Impervious Adjustment %C	Impervious Adjustment %UC	Adjusted CN
B6.3	71	4.660			71.00
COMPOSITE AREA & WEIGHTED CN --->		4.660			71.00 (71)

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_1A.PPW

RUNOFF CURVE NUMBER DATA

Soil/Surface Description	CN	Area acres	Impervious Adjustment %C	Impervious Adjustment %UC	Adjusted CN
B6.4	71	4.870			71.00
COMPOSITE AREA & WEIGHTED CN --->		4.870			71.00 (71)

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_1A.PPW

RUNOFF CURVE NUMBER DATA

Soil/Surface Description	CN	Area acres	Impervious Adjustment %C	Impervious Adjustment %UC	Adjusted CN
B6.5	71	4.780			71.00
COMPOSITE AREA & WEIGHTED CN --->		4.780			71.00 (71)

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_1A.PPW

RUNOFF CURVE NUMBER DATA

Soil/Surface Description	CN	Area acres	Impervious Adjustment %C	Impervious Adjustment %UC	Adjusted CN
B3.3	87	1.550			87.00
COMPOSITE AREA & WEIGHTED CN --->		1.550			87.00 (87)

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_1A.PPW

RUNOFF CURVE NUMBER DATA

Soil/Surface Description	CN	Area acres	Impervious Adjustment %C	Impervious Adjustment %UC	Adjusted CN
B3.4	87	1.610			87.00
COMPOSITE AREA & WEIGHTED CN --->		1.610			87.00 (87)

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_1A.PPW

RUNOFF CURVE NUMBER DATA

Soil/Surface Description	CN	Area acres	Impervious Adjustment %C	Impervious Adjustment %UC	Adjusted CN
B3.5	87	1.910			87.00
COMPOSITE AREA & WEIGHTED CN --->		1.910			87.00 (87)

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_1A.PPW

RUNOFF CURVE NUMBER DATA

Soil/Surface Description	CN	Area acres	Impervious Adjustment %C	Impervious Adjustment %UC	Adjusted CN
B3.6	87	2.210			87.00
COMPOSITE AREA & WEIGHTED CN --->		2.210			87.00 (87)

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_1A.PPW

RUNOFF CURVE NUMBER DATA

Soil/Surface Description	CN	Area acres	Impervious Adjustment %C	Impervious Adjustment %UC	Adjusted CN
B4.2	71	4.510			71.00
COMPOSITE AREA & WEIGHTED CN --->		4.510			71.00 (71)

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_1A.PPW

RUNOFF CURVE NUMBER DATA

Soil/Surface Description	CN	Area acres	Impervious Adjustment %C	Impervious Adjustment %UC	Adjusted CN
B4.3	71	3.270			71.00
COMPOSITE AREA & WEIGHTED CN --->		3.270			71.00 (71)

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_1A.PPW

RUNOFF CURVE NUMBER DATA

Soil/Surface Description	CN	Area acres	Impervious Adjustment %C	Impervious Adjustment %UC	Adjusted CN
B4.4	71	2.580			71.00
COMPOSITE AREA & WEIGHTED CN --->		2.580			71.00 (71)

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_1A.PPW

RUNOFF CURVE NUMBER DATA

Soil/Surface Description	CN	Area acres	Impervious Adjustment %C	Impervious Adjustment %UC	Adjusted CN
B7.1	71	4.960			71.00
COMPOSITE AREA & WEIGHTED CN --->		4.960			71.00 (71)

SUMMARY FOR HYDROGRAPH ADDITION
at Node: JUNC 20

HYG Directory: C:\Haestad\PPKW\KIF\

Upstream Link ID	Upstream Node ID	HYG file	HYG ID	HYG tag
DD29	JUNC 30		JUNC 30	25yr
D17	JUNC 80		JUNC 80	25yr
D31	JUNC 40		JUNC 40	25yr
D21	SUB B3.7		SUB B3.7	25yr

INFLOWS TO: JUNC 20

HYG file	HYG ID	HYG tag	Volume ac-ft	Peak Time hrs	Peak Flow cfs
	JUNC 30	25yr	1.656	11.9600	27.42
	JUNC 80	25yr	3.962	12.0000	52.43
	JUNC 40	25yr	1.602	11.9600	26.86
	SUB B3.7	25yr	.838	11.9600	13.37

TOTAL FLOW INTO: JUNC 20

HYG file	HYG ID	HYG tag	Volume ac-ft	Peak Time hrs	Peak Flow cfs
	JUNC 20	25yr	8.058	12.0000	117.68

TOTAL NODE INFLOW...
HYG file =
HYG ID = JUNC 20
HYG Tag = 25yr

Peak Discharge = 117.68 cfs
Time to Peak = 12.0000 hrs
HYG Volume = 8.058 ac-ft

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
4.5200	.00	.00	.01	.01	.01
4.7200	.02	.02	.03	.04	.04
4.9200	.05	.05	.06	.07	.07
5.1200	.08	.09	.09	.10	.11
5.3200	.12	.13	.14	.15	.16
5.5200	.17	.17	.18	.19	.20
5.7200	.21	.22	.23	.24	.25
5.9200	.26	.27	.28	.29	.30
6.1200	.31	.32	.33	.34	.35
6.3200	.36	.37	.38	.39	.40
6.5200	.41	.42	.43	.45	.46
6.7200	.47	.48	.49	.50	.51
6.9200	.52	.53	.54	.56	.57
7.1200	.58	.59	.60	.61	.62
7.3200	.63	.65	.66	.67	.68
7.5200	.69	.70	.72	.73	.74
7.7200	.75	.76	.78	.79	.80
7.9200	.81	.82	.84	.85	.86
8.1200	.88	.90	.92	.94	.97
8.3200	.99	1.02	1.04	1.07	1.10
8.5200	1.13	1.16	1.19	1.22	1.25
8.7200	1.28	1.31	1.34	1.37	1.40
8.9200	1.44	1.47	1.51	1.54	1.57
9.1200	1.60	1.63	1.65	1.67	1.69
9.3200	1.71	1.73	1.75	1.77	1.78
9.5200	1.80	1.82	1.85	1.88	1.92
9.7200	1.96	2.01	2.06	2.11	2.17
9.9200	2.22	2.28	2.34	2.40	2.46
10.1200	2.53	2.60	2.68	2.76	2.85
10.3200	2.93	3.02	3.11	3.20	3.30
10.5200	3.39	3.49	3.60	3.72	3.85
10.7200	3.99	4.13	4.28	4.43	4.59
10.9200	4.75	4.91	5.08	5.25	5.47

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
11.1200	5.70	5.97	6.28	6.60	6.97
11.3200	7.32	7.70	8.09	8.48	8.90
11.5200	9.47	11.25	14.07	18.02	24.35
11.7200	31.45	40.78	51.66	65.54	86.75
11.9200	107.43	117.35	117.68	110.06	90.57
12.1200	70.32	54.90	44.78	37.44	31.81
12.3200	27.56	24.30	21.73	19.64	17.72
12.5200	16.17	14.80	13.63	12.70	11.95
12.7200	11.37	10.86	10.43	10.05	9.68
12.9200	9.37	9.05	8.76	8.50	8.24
13.1200	8.03	7.82	7.64	7.48	7.32
13.3200	7.17	7.02	6.87	6.73	6.58
13.5200	6.45	6.31	6.18	6.06	5.94
13.7200	5.83	5.72	5.62	5.52	5.41
13.9200	5.31	5.21	5.11	5.02	4.93
14.1200	4.85	4.79	4.73	4.68	4.64
14.3200	4.60	4.56	4.52	4.48	4.44
14.5200	4.41	4.37	4.34	4.30	4.27
14.7200	4.23	4.20	4.16	4.13	4.09
14.9200	4.06	4.02	3.99	3.95	3.92
15.1200	3.88	3.85	3.81	3.78	3.74
15.3200	3.71	3.67	3.63	3.60	3.56
15.5200	3.53	3.50	3.46	3.42	3.39
15.7200	3.35	3.32	3.28	3.24	3.21
15.9200	3.18	3.14	3.10	3.07	3.04
16.1200	3.01	2.99	2.97	2.95	2.94
16.3200	2.92	2.91	2.89	2.88	2.87
16.5200	2.86	2.84	2.83	2.82	2.80
16.7200	2.79	2.78	2.76	2.75	2.74
16.9200	2.73	2.72	2.70	2.69	2.68
17.1200	2.67	2.65	2.64	2.63	2.61
17.3200	2.60	2.59	2.58	2.56	2.55
17.5200	2.54	2.53	2.51	2.50	2.49
17.7200	2.48	2.46	2.45	2.44	2.42
17.9200	2.41	2.40	2.39	2.37	2.36
18.1200	2.35	2.34	2.32	2.31	2.30
18.3200	2.29	2.27	2.26	2.25	2.23
18.5200	2.22	2.21	2.19	2.18	2.17
18.7200	2.16	2.14	2.13	2.12	2.10
18.9200	2.09	2.08	2.07	2.05	2.04
19.1200	2.03	2.02	2.00	1.99	1.98
19.3200	1.97	1.95	1.94	1.93	1.91
19.5200	1.90	1.89	1.87	1.86	1.85
19.7200	1.84	1.82	1.81	1.80	1.78
19.9200	1.77	1.76	1.74	1.73	1.72
20.1200	1.71	1.71	1.70	1.70	1.69
20.3200	1.69	1.69	1.68	1.68	1.68

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
20.5200	1.67	1.67	1.67	1.66	1.66
20.7200	1.66	1.66	1.66	1.65	1.65
20.9200	1.65	1.65	1.64	1.64	1.64
21.1200	1.64	1.63	1.63	1.63	1.63
21.3200	1.62	1.62	1.62	1.61	1.61
21.5200	1.61	1.61	1.61	1.60	1.60
21.7200	1.60	1.60	1.59	1.59	1.59
21.9200	1.59	1.58	1.58	1.58	1.58
22.1200	1.57	1.57	1.57	1.56	1.56
22.3200	1.56	1.56	1.55	1.55	1.55
22.5200	1.55	1.55	1.54	1.54	1.54
22.7200	1.54	1.53	1.53	1.53	1.52
22.9200	1.52	1.52	1.52	1.51	1.51
23.1200	1.51	1.51	1.50	1.50	1.50
23.3200	1.50	1.50	1.49	1.49	1.49
23.5200	1.49	1.48	1.48	1.48	1.47
23.7200	1.47	1.47	1.47	1.46	1.46
23.9200	1.46	1.46	1.45	1.34	1.03
24.1200	.72	.49	.34	.24	.17
24.3200	.12	.09	.06	.04	.03
24.5200	.02	.02	.01	.01	.01
24.7200	.01	.00	.00	.00	.00
24.9200	.00				

SUMMARY FOR HYDROGRAPH ADDITION
at Node: JUNC 30

HYG Directory: C:\Haestad\PPKW\KIF\

Upstream Link ID	Upstream Node ID	HYG file	HYG ID	HYG tag
D29A	SUB B4.5		SUB B4.5	25yr
D23B	SUBB3.5		SUBB3.5	25yr
D23	SUBB3.6		SUBB3.6	25yr

INFLOWS TO: JUNC 30

HYG file	HYG ID	HYG tag	Volume ac-ft	Peak Time hrs	Peak Flow cfs
	SUB B4.5	25yr	.269	11.9200	5.04
	SUBB3.5	25yr	.643	11.9600	10.52
	SUBB3.6	25yr	.744	11.9600	12.17

TOTAL FLOW INTO: JUNC 30

HYG file	HYG ID	HYG tag	Volume ac-ft	Peak Time hrs	Peak Flow cfs
	JUNC 30	25yr	1.656	11.9600	27.42

TOTAL NODE INFLOW...
HYG file =
HYG ID = JUNC 30
HYG Tag = 25yr

Peak Discharge = 27.42 cfs
Time to Peak = 11.9600 hrs
HYG Volume = 1.656 ac-ft

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
4.5600	.00	.00	.00	.00	.01
4.7600	.01	.01	.01	.01	.01
4.9600	.02	.02	.02	.02	.02
5.1600	.02	.03	.03	.03	.03
5.3600	.03	.03	.04	.04	.04
5.5600	.04	.04	.05	.05	.05
5.7600	.05	.05	.05	.06	.06
5.9600	.06	.06	.06	.07	.07
6.1600	.07	.07	.07	.08	.08
6.3600	.08	.08	.08	.09	.09
6.5600	.09	.09	.09	.10	.10
6.7600	.10	.10	.10	.11	.11
6.9600	.11	.11	.12	.12	.12
7.1600	.12	.12	.13	.13	.13
7.3600	.13	.14	.14	.14	.14
7.5600	.14	.15	.15	.15	.15
7.7600	.16	.16	.16	.16	.17
7.9600	.17	.17	.17	.18	.18
8.1600	.18	.19	.19	.20	.20
8.3600	.21	.21	.22	.22	.23
8.5600	.24	.24	.25	.25	.26
8.7600	.27	.27	.28	.28	.29
8.9600	.30	.30	.31	.32	.32
9.1600	.33	.33	.34	.34	.34
9.3600	.35	.35	.35	.36	.36
9.5600	.36	.37	.38	.39	.40
9.7600	.41	.42	.43	.44	.45
9.9600	.47	.48	.49	.50	.52
10.1600	.53	.55	.57	.59	.60
10.3600	.62	.64	.66	.68	.70
10.5600	.72	.74	.77	.80	.83
10.7600	.86	.89	.92	.95	.99
10.9600	1.02	1.06	1.09	1.14	1.19

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_1A.PPW
Storm... TypeII 24hr Tag: 25yr

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
11.1600	1.25	1.32	1.39	1.47	1.55
11.3600	1.63	1.72	1.80	1.89	2.01
11.5600	2.48	3.21	4.20	5.83	7.55
11.7600	9.83	12.43	15.75	21.05	25.89
11.9600	27.42	26.38	23.42	17.42	11.89
12.1600	8.26	6.37	5.29	4.60	4.16
12.3600	3.80	3.51	3.26	3.00	2.79
12.5600	2.59	2.42	2.30	2.20	2.13
12.7600	2.07	2.01	1.96	1.90	1.85
12.9600	1.79	1.74	1.69	1.64	1.61
13.1600	1.57	1.54	1.51	1.47	1.45
13.3600	1.42	1.39	1.36	1.33	1.30
13.5600	1.28	1.25	1.23	1.20	1.18
13.7600	1.16	1.14	1.12	1.10	1.08
13.9600	1.06	1.04	1.02	1.00	.99
14.1600	.97	.96	.96	.95	.94
14.3600	.93	.93	.92	.91	.91
14.5600	.90	.89	.88	.88	.87
14.7600	.86	.86	.85	.84	.83
14.9600	.83	.82	.81	.80	.80
15.1600	.79	.78	.78	.77	.76
15.3600	.75	.75	.74	.73	.73
15.5600	.72	.71	.70	.69	.69
15.7600	.68	.67	.67	.66	.65
15.9600	.64	.64	.63	.62	.62
16.1600	.61	.61	.61	.61	.60
16.3600	.60	.60	.59	.59	.59
16.5600	.59	.58	.58	.58	.58
16.7600	.57	.57	.57	.57	.56
16.9600	.56	.56	.56	.55	.55
17.1600	.55	.55	.54	.54	.54
17.3600	.54	.53	.53	.53	.52
17.5600	.52	.52	.52	.51	.51
17.7600	.51	.51	.50	.50	.50
17.9600	.50	.49	.49	.49	.49
18.1600	.48	.48	.48	.47	.47
18.3600	.47	.47	.46	.46	.46
18.5600	.46	.45	.45	.45	.45
18.7600	.44	.44	.44	.43	.43
18.9600	.43	.43	.42	.42	.42
19.1600	.42	.41	.41	.41	.41
19.3600	.40	.40	.40	.39	.39
19.5600	.39	.39	.38	.38	.38
19.7600	.38	.37	.37	.37	.37
19.9600	.36	.36	.36	.36	.35
20.1600	.35	.35	.35	.35	.35
20.3600	.35	.35	.35	.35	.35

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
20.5600	.35	.35	.35	.35	.34
20.7600	.34	.34	.34	.34	.34
20.9600	.34	.34	.34	.34	.34
21.1600	.34	.34	.34	.34	.34
21.3600	.34	.34	.34	.33	.33
21.5600	.33	.33	.33	.33	.33
21.7600	.33	.33	.33	.33	.33
21.9600	.33	.33	.33	.33	.33
22.1600	.33	.33	.32	.32	.32
22.3600	.32	.32	.32	.32	.32
22.5600	.32	.32	.32	.32	.32
22.7600	.32	.32	.32	.32	.32
22.9600	.32	.31	.31	.31	.31
23.1600	.31	.31	.31	.31	.31
23.3600	.31	.31	.31	.31	.31
23.5600	.31	.31	.31	.31	.31
23.7600	.31	.30	.30	.30	.30
23.9600	.30	.30	.27	.18	.10
24.1600	.05	.03	.01	.01	.00
24.3600	.00				

SUMMARY FOR HYDROGRAPH ADDITION
at Node: JUNC 40

HYG Directory: C:\Haestad\PPKW\KIF\

Upstream Link ID	Upstream Node ID	HYG file	HYG ID	HYG tag
D25	SUBB3.4		SUBB3.4	25yr
D25B	SUBB3.3		SUBB3.3	25yr
D31A	SUBB4.4		SUBB4.4	25yr

INFLOWS TO: JUNC 40

HYG file	HYG ID	HYG tag	Volume ac-ft	Peak Time hrs	Peak Flow cfs
	SUBB3.4	25yr	.542	11.9600	8.87
	SUBB3.3	25yr	.522	11.9600	8.54
	SUBB4.4	25yr	.538	11.9200	10.08

TOTAL FLOW INTO: JUNC 40

HYG file	HYG ID	HYG tag	Volume ac-ft	Peak Time hrs	Peak Flow cfs
	JUNC 40	25yr	1.602	11.9600	26.86

TOTAL NODE INFLOW...
HYG file =
HYG ID = JUNC 40
HYG Tag = 25yr

Peak Discharge = 26.86 cfs
Time to Peak = 11.9600 hrs
HYG Volume = 1.602 ac-ft

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
4.5600	.00	.00	.00	.00	.00
4.7600	.01	.01	.01	.01	.01
4.9600	.01	.01	.01	.02	.02
5.1600	.02	.02	.02	.02	.02
5.3600	.03	.03	.03	.03	.03
5.5600	.03	.03	.03	.04	.04
5.7600	.04	.04	.04	.04	.04
5.9600	.05	.05	.05	.05	.05
6.1600	.05	.06	.06	.06	.06
6.3600	.06	.06	.06	.07	.07
6.5600	.07	.07	.07	.07	.08
6.7600	.08	.08	.08	.08	.08
6.9600	.09	.09	.09	.09	.09
7.1600	.09	.10	.10	.10	.10
7.3600	.10	.10	.11	.11	.11
7.5600	.11	.11	.11	.12	.12
7.7600	.12	.12	.12	.12	.13
7.9600	.13	.13	.13	.13	.14
8.1600	.14	.14	.15	.15	.16
8.3600	.16	.16	.17	.17	.18
8.5600	.18	.19	.19	.19	.20
8.7600	.20	.21	.21	.22	.22
8.9600	.23	.23	.24	.24	.25
9.1600	.25	.26	.26	.26	.27
9.3600	.27	.27	.28	.28	.29
9.5600	.29	.30	.30	.31	.32
9.7600	.33	.34	.35	.36	.37
9.9600	.38	.39	.40	.42	.43
10.1600	.44	.46	.47	.49	.51
10.3600	.52	.54	.56	.58	.59
10.5600	.61	.64	.66	.69	.71
10.7600	.74	.77	.80	.83	.86
10.9600	.89	.93	.96	1.01	1.05

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
11.1600	1.11	1.18	1.24	1.32	1.39
11.3600	1.47	1.55	1.62	1.71	1.84
11.5600	2.35	3.04	4.03	5.68	7.29
11.7600	9.67	12.22	15.74	21.47	26.07
11.9600	26.86	25.65	22.31	15.67	10.58
12.1600	7.48	5.91	5.02	4.42	4.05
12.3600	3.71	3.44	3.20	2.93	2.74
12.5600	2.54	2.39	2.27	2.18	2.12
12.7600	2.06	2.00	1.95	1.89	1.84
12.9600	1.79	1.73	1.69	1.64	1.60
13.1600	1.57	1.53	1.51	1.47	1.45
13.3600	1.42	1.39	1.36	1.33	1.31
13.5600	1.28	1.25	1.23	1.20	1.19
13.7600	1.16	1.14	1.12	1.10	1.08
13.9600	1.06	1.04	1.02	1.00	.99
14.1600	.98	.97	.96	.96	.95
14.3600	.94	.93	.93	.92	.91
14.5600	.91	.90	.89	.88	.88
14.7600	.87	.86	.86	.85	.84
14.9600	.83	.83	.82	.81	.81
15.1600	.80	.79	.78	.77	.77
15.3600	.76	.75	.75	.74	.73
15.5600	.72	.72	.71	.70	.70
15.7600	.69	.68	.67	.66	.66
15.9600	.65	.64	.64	.63	.63
16.1600	.62	.62	.62	.61	.61
16.3600	.61	.60	.60	.60	.60
16.5600	.59	.59	.59	.59	.58
16.7600	.58	.58	.58	.57	.57
16.9600	.57	.57	.56	.56	.56
17.1600	.56	.55	.55	.55	.55
17.3600	.54	.54	.54	.53	.53
17.5600	.53	.53	.52	.52	.52
17.7600	.52	.51	.51	.51	.51
17.9600	.50	.50	.50	.49	.49
18.1600	.49	.49	.48	.48	.48
18.3600	.48	.47	.47	.47	.47
18.5600	.46	.46	.46	.45	.45
18.7600	.45	.45	.44	.44	.44
18.9600	.44	.43	.43	.43	.43
19.1600	.42	.42	.42	.41	.41
19.3600	.41	.41	.40	.40	.40
19.5600	.40	.39	.39	.39	.38
19.7600	.38	.38	.38	.37	.37
19.9600	.37	.37	.36	.36	.36
20.1600	.36	.36	.36	.36	.36
20.3600	.36	.35	.35	.35	.35

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
20.5600	.35	.35	.35	.35	.35
20.7600	.35	.35	.35	.35	.35
20.9600	.35	.35	.35	.35	.35
21.1600	.35	.34	.34	.34	.34
21.3600	.34	.34	.34	.34	.34
21.5600	.34	.34	.34	.34	.34
21.7600	.34	.34	.34	.34	.34
21.9600	.33	.33	.33	.33	.33
22.1600	.33	.33	.33	.33	.33
22.3600	.33	.33	.33	.33	.33
22.5600	.33	.33	.33	.33	.32
22.7600	.32	.32	.32	.32	.32
22.9600	.32	.32	.32	.32	.32
23.1600	.32	.32	.32	.32	.32
23.3600	.32	.32	.31	.31	.31
23.5600	.31	.31	.31	.31	.31
23.7600	.31	.31	.31	.31	.31
23.9600	.31	.31	.27	.16	.09
24.1600	.04	.02	.01	.01	.00
24.3600	.00				

SUMMARY FOR HYDROGRAPH ADDITION
at Node: JUNC 60

HYG Directory: C:\Haestad\PPKW\KIF\

Upstream Link ID	Upstream Node ID	HYG file	HYG ID	HYG tag
D27	SUB B3.2&3.1		SUB B3.2&3.1	25yr
D33A	SUBB4.3		SUBB4.3	25yr

INFLOWS TO: JUNC 60

HYG file	HYG ID	HYG tag	Volume ac-ft	Peak Time hrs	Peak Flow cfs
	SUB B3.2&3.1	25yr	.744	11.9600	12.17
	SUBB4.3	25yr	.682	11.9200	12.77

TOTAL FLOW INTO: JUNC 60

HYG file	HYG ID	HYG tag	Volume ac-ft	Peak Time hrs	Peak Flow cfs
	JUNC 60	25yr	1.426	11.9600	24.15

TOTAL NODE INFLOW...
HYG file =
HYG ID = JUNC 60
HYG Tag = 25yr

Peak Discharge =	24.15 cfs
Time to Peak =	11.9600 hrs
HYG Volume =	1.426 ac-ft

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
4.5600	.00	.00	.00	.00	.00
4.7600	.00	.00	.01	.01	.01
4.9600	.01	.01	.01	.01	.01
5.1600	.01	.01	.01	.02	.02
5.3600	.02	.02	.02	.02	.02
5.5600	.02	.02	.02	.03	.03
5.7600	.03	.03	.03	.03	.03
5.9600	.03	.03	.03	.04	.04
6.1600	.04	.04	.04	.04	.04
6.3600	.04	.04	.05	.05	.05
6.5600	.05	.05	.05	.05	.05
6.7600	.05	.06	.06	.06	.06
6.9600	.06	.06	.06	.06	.06
7.1600	.07	.07	.07	.07	.07
7.3600	.07	.07	.07	.08	.08
7.5600	.08	.08	.08	.08	.08
7.7600	.08	.08	.09	.09	.09
7.9600	.09	.09	.09	.09	.10
8.1600	.10	.10	.10	.11	.11
8.3600	.11	.11	.12	.12	.12
8.5600	.13	.13	.13	.14	.14
8.7600	.14	.15	.15	.15	.16
8.9600	.16	.16	.17	.17	.17
9.1600	.18	.18	.18	.19	.19
9.3600	.20	.20	.20	.21	.21
9.5600	.21	.22	.22	.23	.24
9.7600	.25	.25	.26	.27	.28
9.9600	.29	.30	.31	.32	.33
10.1600	.34	.35	.37	.38	.39
10.3600	.41	.42	.44	.45	.47
10.5600	.49	.50	.52	.55	.57
10.7600	.59	.62	.64	.67	.70
10.9600	.73	.75	.79	.83	.87

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
11.1600	.92	.98	1.03	1.10	1.16
11.3600	1.23	1.30	1.36	1.44	1.56
11.5600	2.06	2.66	3.57	5.09	6.49
11.7600	8.72	11.02	14.39	19.92	23.96
11.9600	24.15	22.92	19.60	13.09	8.74
12.1600	6.29	5.08	4.40	3.92	3.63
12.3600	3.33	3.09	2.89	2.63	2.47
12.5600	2.29	2.15	2.06	1.98	1.93
12.7600	1.87	1.82	1.78	1.72	1.68
12.9600	1.63	1.58	1.54	1.49	1.46
13.1600	1.43	1.40	1.38	1.35	1.33
13.3600	1.30	1.27	1.25	1.22	1.19
13.5600	1.17	1.15	1.13	1.10	1.09
13.7600	1.07	1.05	1.03	1.01	.99
13.9600	.97	.95	.94	.92	.91
14.1600	.90	.89	.89	.88	.87
14.3600	.86	.86	.85	.85	.84
14.5600	.83	.83	.82	.81	.81
14.7600	.80	.79	.79	.78	.77
14.9600	.77	.76	.75	.75	.74
15.1600	.73	.73	.72	.71	.71
15.3600	.70	.69	.69	.68	.67
15.5600	.67	.66	.65	.65	.64
15.7600	.63	.62	.62	.61	.61
15.9600	.60	.59	.59	.58	.58
16.1600	.57	.57	.57	.56	.56
16.3600	.56	.56	.56	.55	.55
16.5600	.55	.55	.54	.54	.54
16.7600	.54	.53	.53	.53	.53
16.9600	.52	.52	.52	.52	.52
17.1600	.51	.51	.51	.51	.50
17.3600	.50	.50	.50	.49	.49
17.5600	.49	.49	.48	.48	.48
17.7600	.48	.47	.47	.47	.47
17.9600	.46	.46	.46	.46	.45
18.1600	.45	.45	.45	.44	.44
18.3600	.44	.44	.43	.43	.43
18.5600	.43	.42	.42	.42	.42
18.7600	.41	.41	.41	.41	.41
18.9600	.40	.40	.40	.40	.39
19.1600	.39	.39	.39	.38	.38
19.3600	.38	.37	.37	.37	.37
19.5600	.37	.36	.36	.36	.36
19.7600	.35	.35	.35	.35	.34
19.9600	.34	.34	.34	.33	.33
20.1600	.33	.33	.33	.33	.33
20.3600	.33	.33	.33	.33	.33

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
20.5600	.33	.33	.33	.33	.33
20.7600	.32	.32	.32	.32	.32
20.9600	.32	.32	.32	.32	.32
21.1600	.32	.32	.32	.32	.32
21.3600	.32	.32	.32	.32	.32
21.5600	.31	.31	.31	.31	.31
21.7600	.31	.31	.31	.31	.31
21.9600	.31	.31	.31	.31	.31
22.1600	.31	.31	.31	.31	.31
22.3600	.31	.30	.30	.30	.30
22.5600	.30	.30	.30	.30	.30
22.7600	.30	.30	.30	.30	.30
22.9600	.30	.30	.30	.30	.30
23.1600	.30	.29	.29	.29	.29
23.3600	.29	.29	.29	.29	.29
23.5600	.29	.29	.29	.29	.29
23.7600	.29	.29	.29	.29	.29
23.9600	.29	.28	.24	.13	.07
24.1600	.03	.02	.01	.00	.00
24.3600	.00				

SUMMARY FOR HYDROGRAPH ADDITION
at Node: JUNC 80

HYG Directory: C:\Haestad\PPKW\KIF\

Upstream Link ID	Upstream Node ID	HYG file	HYG ID	HYG tag
D35	SUB A12.4		SUB A12.4	25yr
D13A	SUB12.1&12.2		SUB12.1&12.2	25yr
D17A	SUBA12.36.1B3.8		SUBA12.36.1B3.8	25yr

INFLOWS TO: JUNC 80

HYG file	HYG ID	HYG tag	Volume ac-ft	Peak Time hrs	Peak Flow cfs
	SUB A12.4	25yr	.357	12.0800	4.46
	SUB12.1&12.2	25yr	1.928	12.0800	24.12
	SUBA12.36.1B3.8	25yr	1.677	11.9600	27.68

TOTAL FLOW INTO: JUNC 80

HYG file	HYG ID	HYG tag	Volume ac-ft	Peak Time hrs	Peak Flow cfs
	JUNC 80	25yr	3.962	12.0000	52.43

TOTAL NODE INFLOW...
HYG file =
HYG ID = JUNC 80
HYG Tag = 25yr

Peak Discharge = 52.43 cfs
Time to Peak = 12.0000 hrs
HYG Volume = 3.962 ac-ft

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
4.6000	.00	.00	.00	.00	.01
4.8000	.01	.01	.01	.01	.02
5.0000	.02	.02	.02	.03	.03
5.2000	.03	.04	.04	.05	.05
5.4000	.06	.06	.07	.07	.08
5.6000	.08	.09	.09	.10	.10
5.8000	.11	.11	.12	.12	.13
6.0000	.13	.14	.14	.15	.15
6.2000	.16	.17	.17	.18	.18
6.4000	.19	.19	.20	.20	.21
6.6000	.22	.22	.23	.23	.24
6.8000	.25	.25	.26	.26	.27
7.0000	.28	.28	.29	.29	.30
7.2000	.31	.31	.32	.32	.33
7.4000	.34	.34	.35	.36	.36
7.6000	.37	.38	.38	.39	.39
7.8000	.40	.41	.41	.42	.43
8.0000	.43	.44	.45	.46	.47
8.2000	.48	.49	.50	.51	.53
8.4000	.54	.55	.57	.58	.60
8.6000	.61	.63	.65	.66	.68
8.8000	.70	.71	.73	.75	.77
9.0000	.78	.80	.82	.84	.85
9.2000	.86	.88	.89	.90	.91
9.4000	.92	.92	.93	.94	.95
9.6000	.96	.98	.99	1.01	1.03
9.8000	1.06	1.08	1.11	1.14	1.16
10.0000	1.19	1.22	1.25	1.29	1.32
10.2000	1.36	1.40	1.44	1.48	1.52
10.4000	1.57	1.61	1.66	1.71	1.76
10.6000	1.81	1.86	1.93	1.99	2.06
10.8000	2.13	2.20	2.28	2.36	2.43
11.0000	2.52	2.60	2.70	2.81	2.93

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

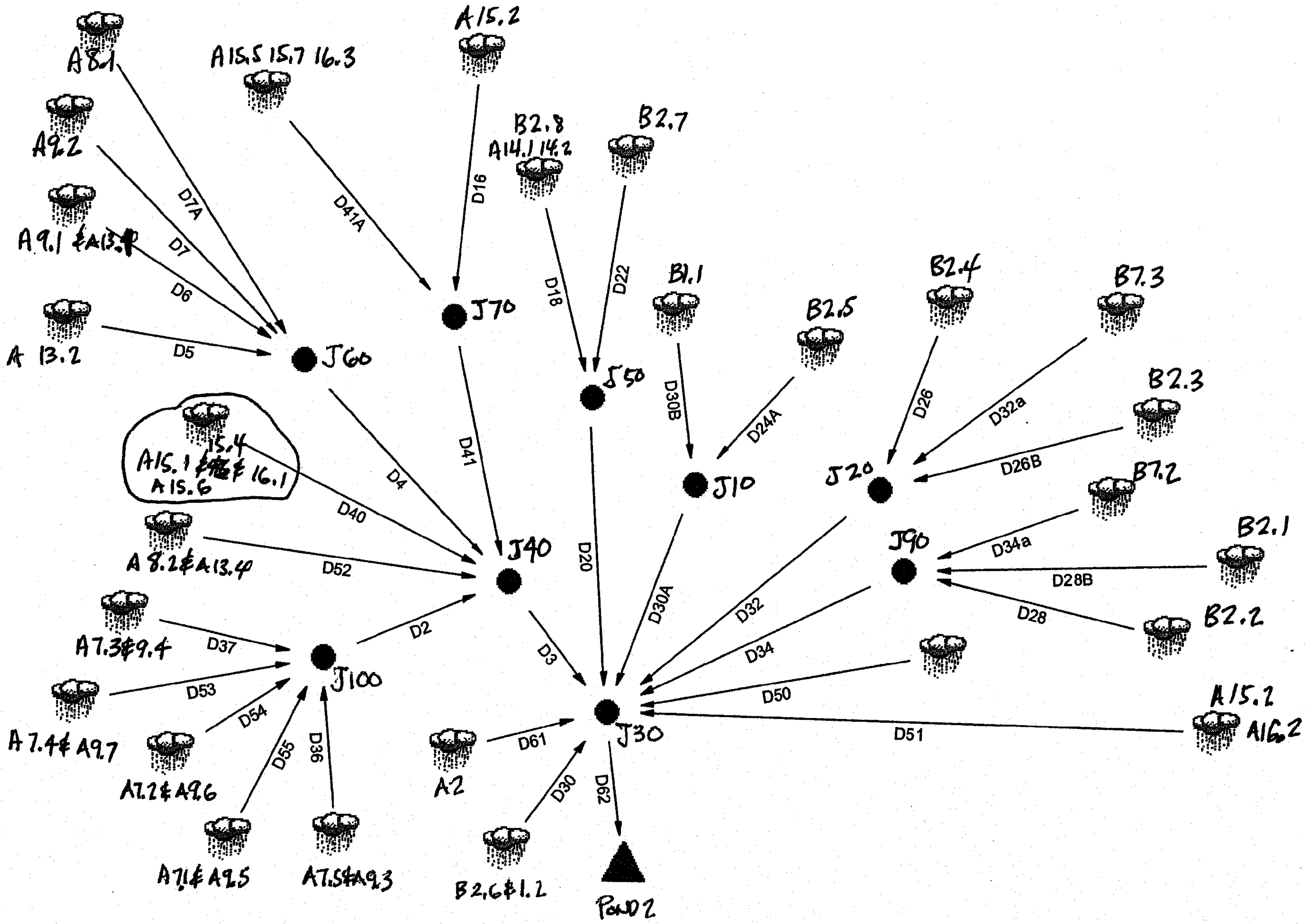
Time hrs					
11.2000	3.07	3.22	3.38	3.55	3.73
11.4000	3.91	4.10	4.30	4.56	5.16
11.6000	6.22	7.70	10.04	12.92	16.56
11.8000	21.06	26.60	34.53	43.39	49.70
12.0000	52.43	52.25	47.72	40.85	34.30
12.2000	28.86	24.21	20.31	17.17	14.82
12.4000	12.99	11.52	10.27	9.23	8.35
12.6000	7.60	6.98	6.47	6.05	5.71
12.8000	5.42	5.17	4.95	4.76	4.58
13.0000	4.42	4.28	4.14	4.02	3.92
13.2000	3.82	3.73	3.64	3.56	3.49
13.4000	3.41	3.34	3.27	3.20	3.13
13.6000	3.06	3.00	2.94	2.89	2.83
13.8000	2.78	2.73	2.67	2.62	2.58
14.0000	2.53	2.48	2.43	2.39	2.36
14.2000	2.32	2.30	2.27	2.25	2.23
14.4000	2.21	2.19	2.17	2.15	2.13
14.6000	2.11	2.10	2.08	2.06	2.05
14.8000	2.03	2.01	1.99	1.98	1.96
15.0000	1.94	1.93	1.91	1.89	1.88
15.2000	1.86	1.84	1.82	1.81	1.79
15.4000	1.77	1.76	1.74	1.72	1.70
15.6000	1.69	1.67	1.65	1.64	1.62
15.8000	1.60	1.58	1.57	1.55	1.53
16.0000	1.52	1.50	1.48	1.47	1.46
16.2000	1.44	1.43	1.43	1.42	1.41
16.4000	1.40	1.40	1.39	1.38	1.38
16.6000	1.37	1.36	1.36	1.35	1.34
16.8000	1.34	1.33	1.33	1.32	1.31
17.0000	1.31	1.30	1.30	1.29	1.28
17.2000	1.28	1.27	1.27	1.26	1.25
17.4000	1.25	1.24	1.23	1.23	1.22
17.6000	1.22	1.21	1.20	1.20	1.19
17.8000	1.19	1.18	1.17	1.17	1.16
18.0000	1.16	1.15	1.14	1.14	1.13
18.2000	1.12	1.12	1.11	1.11	1.10
18.4000	1.09	1.09	1.08	1.08	1.07
18.6000	1.06	1.06	1.05	1.04	1.04
18.8000	1.03	1.03	1.02	1.01	1.01
19.0000	1.00	.99	.99	.98	.98
19.2000	.97	.96	.96	.95	.95
19.4000	.94	.93	.93	.92	.91
19.6000	.91	.90	.90	.89	.88
19.8000	.88	.87	.86	.86	.85
20.0000	.85	.84	.83	.83	.83
20.2000	.82	.82	.82	.81	.81
20.4000	.81	.81	.81	.81	.80

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
20.6000	.80	.80	.80	.80	.80
20.8000	.80	.80	.79	.79	.79
21.0000	.79	.79	.79	.79	.79
21.2000	.78	.78	.78	.78	.78
21.4000	.78	.78	.78	.78	.77
21.6000	.77	.77	.77	.77	.77
21.8000	.77	.76	.76	.76	.76
22.0000	.76	.76	.76	.76	.76
22.2000	.75	.75	.75	.75	.75
22.4000	.75	.75	.75	.74	.74
22.6000	.74	.74	.74	.74	.74
22.8000	.74	.73	.73	.73	.73
23.0000	.73	.73	.73	.73	.73
23.2000	.72	.72	.72	.72	.72
23.4000	.72	.72	.71	.71	.71
23.6000	.71	.71	.71	.71	.71
23.8000	.71	.70	.70	.70	.70
24.0000	.70	.67	.58	.46	.36
24.2000	.28	.21	.15	.11	.08
24.4000	.06	.04	.03	.02	.02
24.6000	.01	.01	.01	.01	.00
24.8000	.00	.00	.00	.00	

Index of Starting Page Numbers for ID Names

ATTACHMENT 2.2 – DITCH 2 MODEL FOR DITCH FLOWS


A8.1
A9.2
A9.1 & A13.?
A 13.2
A15.5 15.7 16.3
A15.2
B2.8
A14.1 14.2
B2.7
B1.1
B2.5
B2.4
B7.3
B2.3
B7.2
B2.1
B2.2
A15.2
A16.2
15.4
A15.1 & 16.1
A15.6
A 8.2 & A13.4
A7.3 & 9.4
A7.4 & A9.7
A7.2 & A9.6
A7.1 & A9.5
A7.5 & A9.3
A2
B2.6 & 1.2
POND 2
J60
J70
J50
J10
J20
J90
J40
J100
J30
D7A
D7
D6
D5
D41A
D16
D18
D22
D30B
D24A
D26
D32a
D26B
D34a
D28B
D28
D4
D41
D40
D52
D20
D30A
D32
D34
D50
D51
D37
D53
D54
D55
D36
D2
D3
D61
D30
D62

DITCHES 2

=========================
JOB TITLE
=========================

Project Date: 5/3/2004
Project Engineer: Daniel R. Smith
Project Title: KIF Lat Exp Interim Operation w/phase2&3 pond
Project Comments:
This model analyzes the cond of the expan during operation, while Phase 2/3 has a pond. The time of concentration is minimized due to the pond.

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Table of Contents (continued)

Table of Contents (continued)

MASTER DESIGN STORM SUMMARY

Network Storm Collection: KIF

Return Event	Total Depth in	Rainfall Type	RNF ID
2yr	3.2500	Synthetic Curve	TypeII 24hr
10yr	3.6000	Synthetic Curve	TypeII 24hr
25yr	5.5000	Synthetic Curve	TypeII 24hr
100yr	6.5000	Synthetic Curve	TypeII 24hr

ICPM CALCULATION TOLERANCES

```
Target Convergence=     .000 cfs +/-
Max. Iterations   =       35 loops
ICPM    Time Step =    .0400 hrs
Output Time Step  =    .0400 hrs
ICPM Ending Time  =  35.0000 hrs
```

MASTER NETWORK SUMMARY
SCS Unit Hydrograph Method

(*Node=Outfall; +Node=Diversion;)
(Trun= HYG Truncation: Blank=None; L=Left; R=Rt; LR=Left&Rt)

Node ID	Type	Return Event	HYG Vol ac-ft	Trun	Qpeak hrs	Qpeak cfs	Max WSEL ft	Max Pond Storage ac-ft
A14.1&14.2&B2.8	AREA	2	1.493		12.0800	19.05		
A14.1&14.2&B2.8	AREA	10	1.732		12.0800	22.05		
A14.1&14.2&B2.8	AREA	25	3.079		12.0800	38.52		
A14.1&14.2&B2.8	AREA	100	3.808		12.0800	47.19		
A15.1.4.6&16.1	AREA	2	.319		12.0000	5.13		
A15.1.4.6&16.1	AREA	10	.397		12.0000	6.48		
A15.1.4.6&16.1	AREA	25	.880		12.0000	14.70		
A15.1.4.6&16.1	AREA	100	1.163		11.9600	19.44		
A15.2&A16.2	AREA	2	.371		12.0000	6.18		
A15.2&A16.2	AREA	10	.448		12.0000	7.48		
A15.2&A16.2	AREA	25	.906		11.9600	15.18		
A15.2&A16.2	AREA	100	1.166		11.9600	19.50		
A15.5&.7&16.3	AREA	2	.242		12.0000	3.89		
A15.5&.7&16.3	AREA	10	.301		12.0000	4.91		
A15.5&.7&16.3	AREA	25	.667		12.0000	11.15		
A15.5&.7&16.3	AREA	100	.882		11.9600	14.74		
A9.2	AREA	2	.522		12.0800	6.66		
A9.2	AREA	10	.606		12.0800	7.71		
A9.2	AREA	25	1.077		12.0800	13.47		
A9.2	AREA	100	1.332		12.0800	16.50		

ICPM CALCULATION TOLERANCES

Target Convergence= .000 cfs +/-
Max. Iterations = 35 loops
ICPM Time Step = .0400 hrs
Output Time Step = .0400 hrs
ICPM Ending Time = 35.0000 hrs

MASTER NETWORK SUMMARY
SCS Unit Hydrograph Method

(*Node=Outfall; +Node=Diversion;)
(Trun= HYG Truncation: Blank=None; L=Left; R=Rt; LR=Left&Rt)

Node ID	Type	Return Event	HYG Vol ac-ft	Trun	Qpeak hrs	Qpeak cfs	Max WSEL ft	Max Pond Storage ac-ft
B2.2	AREA	2	.356		11.9600	5.95		
B2.2	AREA	10	.413		11.9600	6.89		
B2.2	AREA	25	.734		11.9600	12.01		
B2.2	AREA	100	.908		11.9600	14.70		
JUNC 10	JCT	2	.678		11.9200	12.03		
JUNC 10	JCT	10	.796		11.9200	14.16		
JUNC 10	JCT	25	1.478		11.9200	26.22		
JUNC 10	JCT	100	1.855		11.9200	32.72		
JUNC 100	JCT	2	1.816		12.0000	28.90		
JUNC 100	JCT	10	2.191		12.0000	35.08		
JUNC 100	JCT	25	4.443		12.0000	71.14		
JUNC 100	JCT	100	5.719		12.0000	90.98		
JUNC 20	JCT	2	1.066		11.9600	17.87		
JUNC 20	JCT	10	1.249		11.9600	20.97		
JUNC 20	JCT	25	2.309		11.9600	38.40		
JUNC 20	JCT	100	2.894		11.9600	47.77		
JUNC 30	JCT	2	10.659		12.0000	160.17		
JUNC 30	JCT	10	12.655		12.0000	190.71		
JUNC 30	JCT	25	24.420		11.9600	366.27		
JUNC 30	JCT	100	31.011		11.9600	464.59		
JUNC 40	JCT	2	3.981		12.0000	60.34		
JUNC 40	JCT	10	4.793		12.0000	73.22		
JUNC 40	JCT	25	9.661		12.0000	148.56		
JUNC 40	JCT	100	12.427		12.0000	190.16		
JUNC 50	JCT	2	2.037		12.0400	26.53		
JUNC 50	JCT	10	2.362		12.0400	30.69		
JUNC 50	JCT	25	4.200		12.0400	53.56		
JUNC 50	JCT	100	5.195		12.0400	65.59		
JUNC 60	JCT	2	1.200		12.0400	15.76		
JUNC 60	JCT	10	1.419		12.0000	18.73		
JUNC 60	JCT	25	2.701		12.0000	35.92		
JUNC 60	JCT	100	3.415		12.0000	45.25		
JUNC 70	JCT	2	.446		12.0000	7.25		
JUNC 70	JCT	10	.537		12.0000	8.79		
JUNC 70	JCT	25	1.088		11.9600	17.96		
JUNC 70	JCT	100	1.402		11.9600	23.17		

ICPM CALCULATION TOLERANCES

Target Convergence= .000 cfs +/-
Max. Iterations = 35 loops
ICPM Time Step = .0400 hrs
Output Time Step = .0400 hrs
ICPM Ending Time = 35.0000 hrs

MASTER NETWORK SUMMARY
SCS Unit Hydrograph Method

(*Node=Outfall; +Node=Diversion;)
(Trun= HYG Truncation: Blank=None; L=Left; R=Rt; LR=Left&Rt)

Node ID	Type	Return Event	HYG Vol ac-ft	Trun	Qpeak hrs	Qpeak cfs	Max WSEL ft	Max Pond Storage ac-ft
JUNC 90	JCT	2	1.014		11.9600	17.06		
JUNC 90	JCT	10	1.201		11.9600	20.28		
JUNC 90	JCT	25	2.298		11.9600	38.75		
JUNC 90	JCT	100	2.912		11.9600	48.83		
*POND 2	T-E	2	10.659		12.0000	160.17	746.00	
*POND 2	T-E	10	12.655		12.0000	190.71	746.00	
*POND 2	T-E	25	24.420		11.9600	366.27	746.00	
*POND 2	T-E	100	31.012		11.9600	464.59	746.00	
SUBA13.2	AREA	2	.255		12.0800	3.25		
SUBA13.2	AREA	10	.295		12.0800	3.76		
SUBA13.2	AREA	25	.525		12.0800	6.57		
SUBA13.2	AREA	100	.649		12.0800	8.05		
SUBA7.1&A9.5	AREA	2	.254		12.0000	4.22		
SUBA7.1&A9.5	AREA	10	.308		12.0000	5.13		
SUBA7.1&A9.5	AREA	25	.632		11.9600	10.59		
SUBA7.1&A9.5	AREA	100	.817		11.9600	13.68		
SUBA7.2&A9.6	AREA	2	.243		11.9600	4.12		
SUBA7.2&A9.6	AREA	10	.297		11.9600	5.11		
SUBA7.2&A9.6	AREA	25	.628		11.9600	11.00		
SUBA7.2&A9.6	AREA	100	.818		11.9600	14.30		
SUBA7.3&9.4	AREA	2	.497		12.0400	7.68		
SUBA7.3&9.4	AREA	10	.595		12.0000	9.24		
SUBA7.3&9.4	AREA	25	1.171		12.0000	18.27		
SUBA7.3&9.4	AREA	100	1.493		12.0000	23.20		
SUBA7.4&A9.7	AREA	2	.221		11.9600	3.86		
SUBA7.4&A9.7	AREA	10	.271		11.9600	4.77		
SUBA7.4&A9.7	AREA	25	.572		11.9200	10.31		
SUBA7.4&A9.7	AREA	100	.746		11.9200	13.48		
SUBA7.5&A9.3	AREA	2	.600		12.0400	9.26		
SUBA7.5&A9.3	AREA	10	.721		12.0000	11.17		
SUBA7.5&A9.3	AREA	25	1.440		12.0000	22.49		
SUBA7.5&A9.3	AREA	100	1.844		12.0000	28.70		
SUBA8.1	AREA	2	.114		11.9600	1.95		
SUBA8.1	AREA	10	.142		11.9600	2.46		
SUBA8.1	AREA	25	.315		11.9200	5.62		
SUBA8.1	AREA	100	.416		11.9200	7.50		

ICPM CALCULATION TOLERANCES

Target Convergence= .000 cfs +/-
Max. Iterations = 35 loops
ICPM Time Step = .0400 hrs
Output Time Step = .0400 hrs
ICPM Ending Time = 35.0000 hrs

MASTER NETWORK SUMMARY
SCS Unit Hydrograph Method

(*Node=Outfall; +Node=Diversion;)
(Trun= HYG Truncation: Blank=None; L=Left; R=Rt; LR=Left&Rt)

Node ID	Type	Return Event	HYG Vol ac-ft	Trun	Qpeak hrs	Qpeak cfs	Max WSEL ft	Max Pond Storage ac-ft
SUBA8.2&A13.4	AREA	2	.200		11.9200	3.46		
SUBA8.2&A13.4	AREA	10	.248		11.9200	4.42		
SUBA8.2&A13.4	AREA	25	.550		11.9200	10.31		
SUBA8.2&A13.4	AREA	100	.727		11.9200	13.70		
SUBA9.1&A13.1	AREA	2	.309		11.9600	5.43		
SUBA9.1&A13.1	AREA	10	.376		11.9600	6.65		
SUBA9.1&A13.1	AREA	25	.784		11.9200	14.14		
SUBA9.1&A13.1	AREA	100	1.018		11.9200	18.39		
SUBAREA A15.2	AREA	2	.204		11.9600	3.41		
SUBAREA A15.2	AREA	10	.237		11.9600	3.95		
SUBAREA A15.2	AREA	25	.421		11.9600	6.89		
SUBAREA A15.2	AREA	100	.521		11.9600	8.43		
SUBAREA A2	AREA	2	.274		12.1200	3.21		
SUBAREA A2	AREA	10	.340		12.1200	4.09		
SUBAREA A2	AREA	25	.754		12.0800	9.54		
SUBAREA A2	AREA	100	.997		12.0800	12.70		
SUBAREA B1.1	AREA	2	.115		11.9600	1.96		
SUBAREA B1.1	AREA	10	.143		11.9600	2.48		
SUBAREA B1.1	AREA	25	.317		11.9200	5.66		
SUBAREA B1.1	AREA	100	.419		11.9200	7.55		
SUBAREA B2.1	AREA	2	.359		11.9600	6.01		
SUBAREA B2.1	AREA	10	.417		11.9600	6.95		
SUBAREA B2.1	AREA	25	.741		11.9600	12.12		
SUBAREA B2.1	AREA	100	.916		11.9600	14.84		
SUBAREA B2.3	AREA	2	.424		11.9600	7.10		
SUBAREA B2.3	AREA	10	.492		11.9600	8.21		
SUBAREA B2.3	AREA	25	.875		11.9600	14.32		
SUBAREA B2.3	AREA	100	1.083		11.9600	17.54		
SUBAREA B2.4	AREA	2	.480		11.9600	8.03		
SUBAREA B2.4	AREA	10	.557		11.9600	9.29		
SUBAREA B2.4	AREA	25	.990		11.9600	16.20		
SUBAREA B2.4	AREA	100	1.224		11.9600	19.83		
SUBAREA B2.5	AREA	2	.563		11.9200	10.17		
SUBAREA B2.5	AREA	10	.653		11.9200	11.77		
SUBAREA B2.5	AREA	25	1.162		11.9200	20.55		
SUBAREA B2.5	AREA	100	1.437		11.9200	25.17		

ICPM CALCULATION TOLERANCES

```
Target Convergence=     .000 cfs +/-
Max. Iterations   =       35 loops
ICPM   Time Step  =    .0400 hrs
Output Time Step  =    .0400 hrs
ICPM Ending Time  =  35.0000 hrs
```

MASTER NETWORK SUMMARY
SCS Unit Hydrograph Method

(*Node=Outfall; +Node=Diversion;)
(Trun= HYG Truncation: Blank=None; L=Left; R=Rt; LR=Left&Rt)

Node ID	Type	Return Event	HYG Vol ac-ft	Trun	Qpeak hrs	Qpeak cfs	Max WSEL ft	Max Pond Storage ac-ft
SUBAREA B7.1	AREA	2	.375		11.9600	6.40		
SUBAREA B7.1	AREA	10	.466		11.9600	8.09		
SUBAREA B7.1	AREA	25	1.034		11.9200	18.47		
SUBAREA B7.1	AREA	100	1.367		11.9200	24.62		
SUBAREA B7.2	AREA	2	.299		11.9600	5.10		
SUBAREA B7.2	AREA	10	.371		11.9600	6.44		
SUBAREA B7.2	AREA	25	.823		11.9200	14.71		
SUBAREA B7.2	AREA	100	1.088		11.9200	19.61		
SUBAREA B7.3	AREA	2	.161		11.9600	2.75		
SUBAREA B7.3	AREA	10	.200		11.9600	3.47		
SUBAREA B7.3	AREA	25	.444		11.9200	7.93		
SUBAREA B7.3	AREA	100	.587		11.9200	10.57		
SUBB2.6&1.2	AREA	2	.862		11.9600	14.41		
SUBB2.6&1.2	AREA	10	1.000		11.9600	16.68		
SUBB2.6&1.2	AREA	25	1.778		11.9600	29.09		
SUBB2.6&1.2	AREA	100	2.199		11.9600	35.61		
SUBB2.7	AREA	2	.544		11.9600	9.09		
SUBB2.7	AREA	10	.631		11.9600	10.52		
SUBB2.7	AREA	25	1.121		11.9600	18.34		
SUBB2.7	AREA	100	1.387		11.9600	22.46		

NETWORK SUMMARY -- LINKS
(UN=Upstream Node; DL=DNstream End of Link; DN=DNstream Node)
(Trun.= HYG Truncation: Blank=None; L=Left; R=Rt; LR=Left & Rt)

DEFAULT Design Storm File,ID = KIF

Storm Tag Name = 25yr

Data Type, File, ID = Synthetic Storm TypeII 24hr
Storm Frequency = 25 yr
Total Rainfall Depth= 5.5000 in
Duration Multiplier = 1
Resulting Duration = 24.0000 hrs
Resulting Start Time= .0000 hrs Step= .1000 hrs End= 24.0000 hrs

ICPM CALCULATION TOLERANCES

Target Convergence= .000 cfs +/-
Max. Iterations = 35 loops
ICPM Time Step = .0400 hrs
Output Time Step = .0400 hrs
ICPM Ending Time = 35.0000 hrs

Link ID	Type		HYG Vol ac-ft	Trun.	Peak Time hrs	Peak Q cfs	End Points
D16	ADD	UN	.421		11.9600	6.89	SUBAREA A15.2
		DL	.421		11.9600	6.89	
		DN	1.088		11.9600	17.96	JUNC 70
D18	ADD	UN	3.079		12.0800	38.52	A14.1&14.2&B2.8
		DL	3.079		12.0800	38.52	
		DN	4.200		12.0400	53.56	JUNC 50
D2	ADD	UN	4.443		12.0000	71.14	JUNC 100
		DL	4.443		12.0000	71.14	
		DN	9.661		12.0000	148.56	JUNC 40
D20	ADD	UN	4.200		12.0400	53.56	JUNC 50
		DL	4.200		12.0400	53.56	
		DN	24.420		11.9600	366.27	JUNC 30
D22	ADD	UN	1.121		11.9600	18.34	SUBB2.7
		DL	1.121		11.9600	18.34	
		DN	4.200		12.0400	53.56	JUNC 50

NETWORK SUMMARY -- LINKS
(UN=Upstream Node; DL=DNstream End of Link; DN=DNstream Node)
(Trun.= HYG Truncation: Blank=None; L=Left; R=Rt; LR=Left & Rt)

Link ID	Type		HYG Vol ac-ft	Trun.	Peak Time hrs	Peak Q cfs	End Points
D24A	ADD	UN	1.162		11.9200	20.55	SUBAREA B2.5
		DL	1.162		11.9200	20.55	
		DN	1.478		11.9200	26.22	JUNC 10
D26	ADD	UN	.990		11.9600	16.20	SUBAREA B2.4
		DL	.990		11.9600	16.20	
		DN	2.309		11.9600	38.40	JUNC 20
D26B	ADD	UN	.875		11.9600	14.32	SUBAREA B2.3
		DL	.875		11.9600	14.32	
		DN	2.309		11.9600	38.40	JUNC 20
D28	ADD	UN	.734		11.9600	12.01	B2.2
		DL	.734		11.9600	12.01	
		DN	2.298		11.9600	38.75	JUNC 90
D28B	ADD	UN	.741		11.9600	12.12	SUBAREA B2.1
		DL	.741		11.9600	12.12	
		DN	2.298		11.9600	38.75	JUNC 90
D3	ADD	UN	9.661		12.0000	148.56	JUNC 40
		DL	9.661		12.0000	148.56	
		DN	24.420		11.9600	366.27	JUNC 30
D30	ADD	UN	1.778		11.9600	29.09	SUBB2.6&1.2
		DL	1.778		11.9600	29.09	
		DN	24.420		11.9600	366.27	JUNC 30
D30A	ADD	UN	1.478		11.9200	26.22	JUNC 10
		DL	1.478		11.9200	26.22	
		DN	24.420		11.9600	366.27	JUNC 30
D30B	ADD	UN	.317		11.9200	5.66	SUBAREA B1.1
		DL	.317		11.9200	5.66	
		DN	1.478		11.9200	26.22	JUNC 10
D32	ADD	UN	2.309		11.9600	38.40	JUNC 20
		DL	2.309		11.9600	38.40	
		DN	24.420		11.9600	366.27	JUNC 30

NETWORK SUMMARY -- LINKS
(UN=Upstream Node; DL=DNstream End of Link; DN=DNstream Node)
(Trun.= HYG Truncation: Blank=None; L=Left; R=Rt; LR=Left & Rt)

Link ID	Type		HYG Vol ac-ft	Trun.	Peak Time hrs	Peak Q cfs	End Points
D32A	ADD	UN	.444		11.9200	7.93	SUBAREA B7.3
		DL	.444		11.9200	7.93	
		DN	2.309		11.9600	38.40	JUNC 20
D34	ADD	UN	2.298		11.9600	38.75	JUNC 90
		DL	2.298		11.9600	38.75	
		DN	24.420		11.9600	366.27	JUNC 30
D34A	ADD	UN	.823		11.9200	14.71	SUBAREA B7.2
		DL	.823		11.9200	14.71	
		DN	2.298		11.9600	38.75	JUNC 90
D36	ADD	UN	1.440		12.0000	22.49	SUBA7.5&A9.3
		DL	1.440		12.0000	22.49	
		DN	4.443		12.0000	71.14	JUNC 100
D37	ADD	UN	1.171		12.0000	18.27	SUBA7.3&9.4
		DL	1.171		12.0000	18.27	
		DN	4.443		12.0000	71.14	JUNC 100
D4	ADD	UN	2.701		12.0000	35.92	JUNC 60
		DL	2.701		12.0000	35.92	
		DN	9.661		12.0000	148.56	JUNC 40
D40	ADD	UN	.880		12.0000	14.70	A15.1.4.6&16.1
		DL	.880		12.0000	14.70	
		DN	9.661		12.0000	148.56	JUNC 40
D41	ADD	UN	1.088		11.9600	17.96	JUNC 70
		DL	1.088		11.9600	17.96	
		DN	9.661		12.0000	148.56	JUNC 40
D41A	ADD	UN	.667		12.0000	11.15	A15.5&.7&16.3
		DL	.667		12.0000	11.15	
		DN	1.088		11.9600	17.96	JUNC 70
D5	ADD	UN	.525		12.0800	6.57	SUBA13.2
		DL	.525		12.0800	6.57	
		DN	2.701		12.0000	35.92	JUNC 60

NETWORK SUMMARY -- LINKS
(UN=Upstream Node; DL=DNstream End of Link; DN=DNstream Node)
(Trun.= HYG Truncation: Blank=None; L=Left; R=Rt; LR=Left & Rt)

Link ID	Type		HYG Vol ac-ft	Trun.	Peak Time hrs	Peak Q cfs	End Points
D50	ADD	UN	1.034		11.9200	18.47	SUBAREA B7.1
		DL	1.034		11.9200	18.47	
		DN	24.420		11.9600	366.27	JUNC 30
D51	ADD	UN	.906		11.9600	15.18	A15.2&A16.2
		DL	.906		11.9600	15.18	
		DN	24.420		11.9600	366.27	JUNC 30
D52	ADD	UN	.550		11.9200	10.31	SUBA8.2&A13.4
		DL	.550		11.9200	10.31	
		DN	9.661		12.0000	148.56	JUNC 40
D53	ADD	UN	.572		11.9200	10.31	SUBA7.4&A9.7
		DL	.572		11.9200	10.31	
		DN	4.443		12.0000	71.14	JUNC 100
D54	ADD	UN	.628		11.9600	11.00	SUBA7.2&A9.6
		DL	.628		11.9600	11.00	
		DN	4.443		12.0000	71.14	JUNC 100
D55	ADD	UN	.632		11.9600	10.59	SUBA7.1&A9.5
		DL	.632		11.9600	10.59	
		DN	4.443		12.0000	71.14	JUNC 100
D6	ADD	UN	.784		11.9200	14.14	SUBA9.1&A13.1
		DL	.784		11.9200	14.14	
		DN	2.701		12.0000	35.92	JUNC 60
D61	ADD	UN	.754		12.0800	9.54	SUBAREA A2
		DL	.754		12.0800	9.54	
		DN	24.420		11.9600	366.27	JUNC 30
D62	ADD	UN	24.420		11.9600	366.27	JUNC 30
		DL	24.420		11.9600	366.27	
		DN	24.420		11.9600	366.27	POND 2
D7	ADD	UN	1.077		12.0800	13.47	A9.2
		DL	1.077		12.0800	13.47	
		DN	2.701		12.0000	35.92	JUNC 60

NETWORK SUMMARY -- LINKS
(UN=Upstream Node; DL=DNstream End of Link; DN=DNstream Node)
(Trun.= HYG Truncation: Blank=None; L=Left; R=Rt; LR=Left & Rt)

Link ID	Type		HYG Vol ac-ft	Trun.	Peak Time hrs	Peak Q cfs	End Points
D7A	ADD	UN	.315		11.9200	5.62	SUBA8.1
		DL	.315		11.9200	5.62	
		DN	2.701		12.0000	35.92	JUNC 60

Type.... Design Storms
Name.... KIF

File.... C:\Haestad\PPKW\KIF\
Title... Project Date: 5/3/2004
Project Engineer: Daniel R. Smith
Project Title: KIF Lat Exp Interim Operation w/phase2&3 pond
Project Comments:
This model analyzes the cond of the expan during operation, while Phase 2/3 has a pond. The time of concentration is minimized due to the pond.

DESIGN STORMS SUMMARY

Design Storm File,ID = KIF

Storm Tag Name = 2yr

Data Type, File, ID = Synthetic Storm TypeII 24hr
Storm Frequency = 2 yr
Total Rainfall Depth= 3.2500 in
Duration Multiplier = 1
Resulting Duration = 24.0000 hrs
Resulting Start Time= .0000 hrs Step= .1000 hrs End= 24.0000 hrs

Storm Tag Name = 10yr

Data Type, File, ID = Synthetic Storm TypeII 24hr
Storm Frequency = 10 yr
Total Rainfall Depth= 3.6000 in
Duration Multiplier = 1
Resulting Duration = 24.0000 hrs
Resulting Start Time= .0000 hrs Step= .1000 hrs End= 24.0000 hrs

Storm Tag Name = 25yr

Data Type, File, ID = Synthetic Storm TypeII 24hr
Storm Frequency = 25 yr
Total Rainfall Depth= 5.5000 in
Duration Multiplier = 1
Resulting Duration = 24.0000 hrs
Resulting Start Time= .0000 hrs Step= .1000 hrs End= 24.0000 hrs

Storm Tag Name = 100yr

Data Type, File, ID = Synthetic Storm TypeII 24hr
Storm Frequency = 100 yr
Total Rainfall Depth= 6.5000 in
Duration Multiplier = 1
Resulting Duration = 24.0000 hrs
Resulting Start Time= .0000 hrs Step= .1000 hrs End= 24.0000 hrs

CUMULATIVE RAINFALL FRACTIONS
Output Time increment = .1000 hrs
Time on left represents time for first value in each row.

Time hrs					
.0000	.000	.001	.002	.003	.004
.5000	.005	.006	.007	.008	.009
1.0000	.011	.012	.013	.014	.015
1.5000	.016	.017	.018	.020	.021
2.0000	.022	.023	.024	.026	.027
2.5000	.028	.029	.031	.032	.033
3.0000	.035	.036	.037	.038	.040
3.5000	.041	.042	.044	.045	.047
4.0000	.048	.049	.051	.052	.054
4.5000	.055	.057	.058	.060	.061
5.0000	.063	.065	.066	.068	.070
5.5000	.071	.073	.075	.076	.078
6.0000	.080	.082	.084	.085	.087
6.5000	.089	.091	.093	.095	.097
7.0000	.099	.101	.103	.105	.107
7.5000	.109	.111	.113	.116	.118
8.0000	.120	.122	.125	.127	.130
8.5000	.132	.135	.138	.141	.144
9.0000	.147	.150	.153	.157	.160
9.5000	.163	.166	.170	.173	.177
10.0000	.181	.185	.189	.194	.199
10.5000	.204	.209	.215	.221	.228
11.0000	.235	.243	.251	.261	.271
11.5000	.283	.307	.354	.431	.568
12.0000	.663	.682	.699	.713	.725
12.5000	.735	.743	.751	.759	.766
13.0000	.772	.778	.784	.789	.794
13.5000	.799	.804	.808	.812	.816
14.0000	.820	.824	.827	.831	.834
14.5000	.838	.841	.844	.847	.850
15.0000	.854	.856	.859	.862	.865
15.5000	.868	.870	.873	.875	.878
16.0000	.880	.882	.885	.887	.889
16.5000	.891	.893	.895	.898	.900
17.0000	.902	.904	.906	.908	.910
17.5000	.912	.914	.915	.917	.919
18.0000	.921	.923	.925	.926	.928
18.5000	.930	.931	.933	.935	.936
19.0000	.938	.939	.941	.942	.944
19.5000	.945	.947	.948	.949	.951
20.0000	.952	.953	.955	.956	.957
20.5000	.958	.960	.961	.962	.964
21.0000	.965	.966	.967	.968	.970
21.5000	.971	.972	.973	.975	.976
22.0000	.977	.978	.979	.981	.982
22.5000	.983	.984	.985	.986	.988

CUMULATIVE RAINFALL FRACTIONS
Output Time increment = .1000 hrs
Time on left represents time for first value in each row.

Time hrs					
23.0000	.989	.990	.991	.992	.993
23.5000	.994	.996	.997	.998	.999
24.0000	1.000				

:::
TIME OF CONCENTRATION CALCULATOR
:::

Segment #1: Tc: User Defined

Segment #1 Time: .3300 hrs

========================
Total Tc: .3300 hrs
========================

Tc Equations used...

==== User Defined ==

Tc = Value entered by user

Where: Tc = Time of concentration

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_2_A.PPW

TIME OF CONCENTRATION CALCULATOR

Segment #1: Tc: User Defined

Segment #1 Time: .1500 hrs

Total Tc: .1500 hrs

Tc Equations used...

==== User Defined ====

Tc = Value entered by user

Where: Tc = Time of concentration

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_2_A.PPW

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TIME OF CONCENTRATION CALCULATOR
::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::


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Segment #1:  Tc: User Defined

                                        Segment #1 Time:     .1500 hrs
------------------------------------------------------------------------

                                              ========================
                                               Total Tc:     .1500 hrs
                                              ========================
```

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_2_A.PPW

Tc Equations used...

==== User Defined ====

Tc = Value entered by user

Where: Tc = Time of concentration

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_2_A.PPW

::
TIME OF CONCENTRATION CALCULATOR
::

Segment #1: Tc: User Defined

Segment #1 Time: .1500 hrs

=========================
Total Tc: .1500 hrs
=========================

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_2_A.PPW

Tc Equations used...

==== User Defined ====

Tc = Value entered by user

Where: Tc = Time of concentration

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_2_A.PPW

::
TIME OF CONCENTRATION CALCULATOR
::

Segment #1: Tc: User Defined

Segment #1 Time: .3300 hrs

Total Tc: .3300 hrs

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_2_A.PPW

Tc Equations used...

==== User Defined ====

Tc = Value entered by user

Where: Tc = Time of concentration

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_2_A.PPW

::

TIME OF CONCENTRATION CALCULATOR

::

Segment #1: Tc: User Defined

Segment #1 Time: .1500 hrs

Total Tc: .1500 hrs

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_2_A.PPW

Tc Equations used...

==== User Defined ==

Tc = Value entered by user

Where: Tc = Time of concentration

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_2_A.PPW

::
TIME OF CONCENTRATION CALCULATOR
::

Segment #1: Tc: User Defined

Segment #1 Time: .3300 hrs

========================
Total Tc: .3300 hrs
========================

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_2_A.PPW

Tc Equations used...

==== User Defined ====

Tc = Value entered by user

Where: Tc = Time of concentration

::
TIME OF CONCENTRATION CALCULATOR
::

Segment #1: Tc: User Defined

Segment #1 Time: .1500 hrs

=========================
Total Tc: .1500 hrs
=========================

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_2_A.PPW

Tc Equations used...

==== User Defined ====

Tc = Value entered by user

Where: Tc = Time of concentration

::

TIME OF CONCENTRATION CALCULATOR

::

Segment #1: Tc: User Defined

Segment #1 Time: .1200 hrs

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Total Tc: .1200 hrs

=========================

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_2_A.PPW

Tc Equations used...

==== User Defined ==

Tc = Value entered by user

Where: Tc = Time of concentration

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_2_A.PPW

::
TIME OF CONCENTRATION CALCULATOR
::

Segment #1: Tc: User Defined

Segment #1 Time: .2000 hrs

=========================
Total Tc: .2000 hrs
=========================

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_2_A.PPW

Tc Equations used...

==== User Defined ====

Tc = Value entered by user

Where: Tc = Time of concentration

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_2_A.PPW

TIME OF CONCENTRATION CALCULATOR

Segment #1: Tc: User Defined

Segment #1 Time: .1000 hrs

Total Tc: .1000 hrs

Tc Equations used...

==== User Defined ====

Tc = Value entered by user

Where: Tc = Time of concentration

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_2_A.PPW

TIME OF CONCENTRATION CALCULATOR

Segment #1: Tc: User Defined

Segment #1 Time: .2000 hrs

Total Tc: .2000 hrs

Tc Equations used...

==== User Defined ====

Tc = Value entered by user

Where: Tc = Time of concentration

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_2_A.PPW

TIME OF CONCENTRATION CALCULATOR

Segment #1: Tc: User Defined

Segment #1 Time: .1000 hrs

Total Tc: .1000 hrs

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_2_A.PPW

Tc Equations used...

==== User Defined ====

Tc = Value entered by user

Where: Tc = Time of concentration

TIME OF CONCENTRATION CALCULATOR

Segment #1: Tc: User Defined

Segment #1 Time: .0800 hrs

Total Tc: .0800 hrs

Calculated Tc < Min.Tc:
Use Minimum Tc...
Use Tc = .0833 hrs

Tc Equations used...

==== User Defined ==

Tc = Value entered by user

Where: Tc = Time of concentration

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_2_A.PPW

TIME OF CONCENTRATION CALCULATOR

Segment #1: Tc: User Defined

Segment #1 Time: .1000 hrs

Total Tc: .1000 hrs

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_2_A.PPW

Tc Equations used...

==== User Defined ====

Tc = Value entered by user

Where: Tc = Time of concentration

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_2_A.PPW

::
TIME OF CONCENTRATION CALCULATOR
::

Segment #1: Tc: User Defined

Segment #1 Time: .1500 hrs

========================
Total Tc: .1500 hrs
========================

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_2_A.PPW

Tc Equations used...

==== User Defined ====

Tc = Value entered by user

Where: Tc = Time of concentration

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_2_A.PPW

TIME OF CONCENTRATION CALCULATOR

Segment #1: Tc: User Defined

Segment #1 Time: .3300 hrs

Total Tc: .3300 hrs

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_2_A.PPW

Tc Equations used...

==== User Defined ====

Tc = Value entered by user

Where: Tc = Time of concentration

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_2_A.PPW

::

TIME OF CONCENTRATION CALCULATOR

::

Segment #1: Tc: User Defined

Segment #1 Time: .1000 hrs

Total Tc: .1000 hrs

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_2_A.PPW

Tc Equations used...

==== User Defined ==

Tc = Value entered by user

Where: Tc = Time of concentration

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_2_A.PPW

TIME OF CONCENTRATION CALCULATOR

Segment #1: Tc: User Defined

Segment #1 Time: .1500 hrs

Total Tc: .1500 hrs

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_2_A.PPW

Tc Equations used...

==== User Defined ====

Tc = Value entered by user

Where: Tc = Time of concentration

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_2_A.PPW

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::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
TIME OF CONCENTRATION CALCULATOR
::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::


------------------------------------------------------------------------

Segment #1:  Tc: User Defined

                                          Segment #1 Time:      .1500 hrs
------------------------------------------------------------------------

                                                 =========================
                                                  Total Tc:     .1500 hrs
                                                 =========================
```

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_2_A.PPW

Tc Equations used...

==== User Defined ====

Tc = Value entered by user

Where: Tc = Time of concentration

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_2_A.PPW

TIME OF CONCENTRATION CALCULATOR

Segment #1: Tc: User Defined

Segment #1 Time: .1500 hrs

Total Tc: .1500 hrs

Tc Equations used...

==== User Defined ====

Tc = Value entered by user

Where: Tc = Time of concentration

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_2_A.PPW

TIME OF CONCENTRATION CALCULATOR

Segment #1: Tc: User Defined

Segment #1 Time: .1000 hrs

Total Tc: .1000 hrs

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_2_A.PPW

Tc Equations used...

==== User Defined ==

Tc = Value entered by user

Where: Tc = Time of concentration

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_2_A.PPW

::

TIME OF CONCENTRATION CALCULATOR

::

Segment #1: Tc: User Defined

Segment #1 Time: .1000 hrs

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Total Tc: .1000 hrs

========================

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_2_A.PPW

Tc Equations used...

==== User Defined ====

Tc = Value entered by user

Where: Tc = Time of concentration

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_2_A.PPW

::

TIME OF CONCENTRATION CALCULATOR

::

Segment #1: Tc: User Defined

Segment #1 Time: .1000 hrs

========================

Total Tc: .1000 hrs

========================

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_2_A.PPW

Tc Equations used...

==== User Defined ==

Tc = Value entered by user

Where: Tc = Time of concentration

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_2_A.PPW

TIME OF CONCENTRATION CALCULATOR

Segment #1: Tc: User Defined

Segment #1 Time: .1000 hrs

Total Tc: .1000 hrs

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_2_A.PPW

Tc Equations used...

==== User Defined ====

Tc = Value entered by user

Where: Tc = Time of concentration

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_2_A.PPW

TIME OF CONCENTRATION CALCULATOR

Segment #1: Tc: User Defined

Segment #1 Time: .1500 hrs

Total Tc: .1500 hrs

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_2_A.PPW

Tc Equations used...

==== User Defined ====

Tc = Value entered by user

Where: Tc = Time of concentration

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_2_A.PPW

::
TIME OF CONCENTRATION CALCULATOR
::

Segment #1: Tc: User Defined

Segment #1 Time: .1500 hrs

========================
Total Tc: .1500 hrs
========================

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_2_A.PPW

Tc Equations used...

==== User Defined ====

Tc = Value entered by user

Where: Tc = Time of concentration

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_2_A.PPW

RUNOFF CURVE NUMBER DATA

Soil/Surface Description	CN	Area acres	Impervious Adjustment %C	Impervious Adjustment %UC	Adjusted CN
A14.1&14.2&B2.8	87	9.150			87.00
COMPOSITE AREA & WEIGHTED CN --->		9.150			87.00 (87)

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_2_A.PPW

RUNOFF CURVE NUMBER DATA

Soil/Surface Description	CN	Area acres	Impervious Adjustment %C	Impervious Adjustment %UC	Adjusted CN
A15.1&15.4&15.6&16.1	71	4.220			71.00
COMPOSITE AREA & WEIGHTED CN --->		4.220			71.00 (71)

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_2_A.PPW

RUNOFF CURVE NUMBER DATA

Soil/Surface Description	CN	Area acres	Impervious Adjustment %C	Impervious Adjustment %UC	Adjusted CN
A15.2	87	1.250			87.00
A16.2	71	2.320			71.00
COMPOSITE AREA & WEIGHTED CN --->		3.570			76.60 (77)

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_2_A.PPW

RUNOFF CURVE NUMBER DATA

Soil/Surface Description	CN	Area acres	Impervious Adjustment %C	Impervious Adjustment %UC	Adjusted CN
A15.5&15.7&16.3	71	3.200			71.00
COMPOSITE AREA & WEIGHTED CN --->		3.200			71.00 (71)

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_2_A.PPW

RUNOFF CURVE NUMBER DATA

Soil/Surface Description	CN	Area acres	Impervious Adjustment %C	Impervious Adjustment %UC	Adjusted CN
A7	87	3.200			87.00
COMPOSITE AREA & WEIGHTED CN --->		3.200			87.00 (87)

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_2_A.PPW

RUNOFF CURVE NUMBER DATA

::

Soil/Surface Description	CN	Area acres	Impervious Adjustment %C	Impervious Adjustment %UC	Adjusted CN
B2.2	87	2.180			87.00

COMPOSITE AREA & WEIGHTED CN ---> 2.180 87.00 (87)

::

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_2_A.PPW

RUNOFF CURVE NUMBER DATA

Soil/Surface Description	CN	Area acres	Impervious Adjustment %C	Impervious Adjustment %UC	Adjusted CN
A13.2	87	1.560			87.00
COMPOSITE AREA & WEIGHTED CN --->		1.560			87.00 (87)

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_2_A.PPW

RUNOFF CURVE NUMBER DATA

Soil/Surface Description	CN	Area acres	Impervious Adjustment %C	%UC	Adjusted CN
A7.1	71	1.830			71.00
A9.5	87	.740			87.00
COMPOSITE AREA & WEIGHTED CN --->		2.570			75.61 (76)

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_2_A.PPW

RUNOFF CURVE NUMBER DATA

Soil/Surface Description	CN	Area acres	Impervious Adjustment %C	Impervious Adjustment %UC	Adjusted CN
A7.2	71	2.240			71.00
A9.6	87	.480			87.00
COMPOSITE AREA & WEIGHTED CN --->		2.720			73.82 (74)

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_2_A.PPW

RUNOFF CURVE NUMBER DATA

Soil/Surface Description	CN	Area acres	Impervious Adjustment %C	Impervious Adjustment %UC	Adjusted CN
A7.3	71	2.130			71.00
A9.4	87	2.210			87.00
COMPOSITE AREA & WEIGHTED CN --->		4.340			79.15 (79)

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_2_A.PPW

RUNOFF CURVE NUMBER DATA

Soil/Surface Description	CN	Area acres	Impervious Adjustment %C	Impervious Adjustment %UC	Adjusted CN
A7.4	71	2.000			71.00
A9.7	87	.480			87.00
COMPOSITE AREA & WEIGHTED CN --->		2.480			74.10 (74)

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_2_A.PPW

RUNOFF CURVE NUMBER DATA

Soil/Surface Description	CN	Area acres	Impervious Adjustment %C	Impervious Adjustment %UC	Adjusted CN
A7.5	71	2.960			71.00
A9.3	87	2.540			87.00
COMPOSITE AREA & WEIGHTED CN --->		5.500			78.39 (78)

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_2_A.PPW

RUNOFF CURVE NUMBER DATA

Soil/Surface Description	CN	Area acres	Impervious Adjustment %C	Impervious Adjustment %UC	Adjusted CN
A8.1	71	1.510			71.00
COMPOSITE AREA & WEIGHTED CN --->		1.510			71.00 (71)

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_2_A.PPW

RUNOFF CURVE NUMBER DATA

Soil/Surface Description	CN	Area acres	Impervious Adjustment %C	Impervious Adjustment %UC	Adjusted CN
A8.2&13.4	71	2.640			71.00
COMPOSITE AREA & WEIGHTED CN --->		2.640			71.00 (71)

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_2_A.PPW

RUNOFF CURVE NUMBER DATA

Soil/Surface Description	CN	Area acres	Impervious Adjustment %C	Impervious Adjustment %UC	Adjusted CN
A9.1	71	2.450			71.00
13.1	87	.840			87.00
COMPOSITE AREA & WEIGHTED CN --->		3.290			75.09 (75)

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_2_A.PPW

RUNOFF CURVE NUMBER DATA

Soil/Surface Description	CN	Area acres	Impervious Adjustment %C	Impervious Adjustment %UC	Adjusted CN
A15.2	87	1.250			87.00
COMPOSITE AREA & WEIGHTED CN --->		1.250			87.00 (87)

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_2_A.PPW

RUNOFF CURVE NUMBER DATA

Soil/Surface Description	CN	Area acres	Impervious Adjustment %C	%UC	Adjusted CN
A2	71	3.620			71.00
COMPOSITE AREA & WEIGHTED CN --->		3.620			71.00 (71)

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_2_A.PPW

RUNOFF CURVE NUMBER DATA

Soil/Surface Description	CN	Area acres	Impervious Adjustment %C	Impervious Adjustment %UC	Adjusted CN
B1.1	71	1.520			71.00
COMPOSITE AREA & WEIGHTED CN --->		1.520			71.00 (71)

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_2_A.PPW

RUNOFF CURVE NUMBER DATA

Soil/Surface Description	CN	Area acres	Impervious Adjustment %C	Impervious Adjustment %UC	Adjusted CN
B2.1	87	2.200			87.00
COMPOSITE AREA & WEIGHTED CN --->		2.200			87.00 (87)

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_2_A.PPW

RUNOFF CURVE NUMBER DATA

Soil/Surface Description	CN	Area acres	Impervious Adjustment %C	Impervious Adjustment %UC	Adjusted CN
B2.3	87	2.600			87.00
COMPOSITE AREA & WEIGHTED CN --->		2.600			87.00 (87)

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_2_A.PPW

RUNOFF CURVE NUMBER DATA

Soil/Surface Description	CN	Area acres	Impervious Adjustment %C	Impervious Adjustment %UC	Adjusted CN
B2.4	87	2.940			87.00
COMPOSITE AREA & WEIGHTED CN --->		2.940			87.00 (87)

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_2_A.PPW

RUNOFF CURVE NUMBER DATA

Soil/Surface Description	CN	Area acres	Impervious Adjustment %C	Impervious Adjustment %UC	Adjusted CN
B2.5	87	3.450			87.00
COMPOSITE AREA & WEIGHTED CN --->		3.450			87.00 (87)

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_2_A.PPW

RUNOFF CURVE NUMBER DATA

Soil/Surface Description	CN	Area acres	Impervious Adjustment %C	Impervious Adjustment %UC	Adjusted CN
B7.1	71	4.960			71.00
COMPOSITE AREA & WEIGHTED CN --->		4.960			71.00 (71)

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_2_A.PPW

RUNOFF CURVE NUMBER DATA

Soil/Surface Description	CN	Area acres	Impervious Adjustment %C	Impervious Adjustment %UC	Adjusted CN
B7.2	71	3.950			71.00
COMPOSITE AREA & WEIGHTED CN --->		3.950			71.00 (71)

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_2_A.PPW

RUNOFF CURVE NUMBER DATA

Soil/Surface Description	CN	Area acres	Impervious Adjustment %C	Impervious Adjustment %UC	Adjusted CN
B7.3	71	2.130			71.00
COMPOSITE AREA & WEIGHTED CN --->		2.130			71.00 (71)

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_2_A.PPW

RUNOFF CURVE NUMBER DATA

Soil/Surface Description	CN	Area acres	Impervious Adjustment %C	Impervious Adjustment %UC	Adjusted CN
B2.6&1.2	87	5.280			87.00
COMPOSITE AREA & WEIGHTED CN --->		5.280			87.00 (87)

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP W_PHASE2_DITCHES_2_A.PPW

RUNOFF CURVE NUMBER DATA

Soil/Surface Description	CN	Area acres	Impervious Adjustment %C	Impervious Adjustment %UC	Adjusted CN
B2.7	87	3.330			87.00
COMPOSITE AREA & WEIGHTED CN --->		3.330			87.00 (87)

SUMMARY FOR HYDROGRAPH ADDITION
at Node: JUNC 10

HYG Directory: C:\Haestad\PPKW\KIF\

Upstream Link ID	Upstream Node ID	HYG file	HYG ID	HYG tag
D30B	SUBAREA B1.1		SUBAREA B1.1	25yr
D24A	SUBAREA B2.5		SUBAREA B2.5	25yr

INFLOWS TO: JUNC 10

HYG file	HYG ID	HYG tag	Volume ac-ft	Peak Time hrs	Peak Flow cfs
	SUBAREA B1.1	25yr	.317	11.9200	5.66
	SUBAREA B2.5	25yr	1.162	11.9200	20.55

TOTAL FLOW INTO: JUNC 10

HYG file	HYG ID	HYG tag	Volume ac-ft	Peak Time hrs	Peak Flow cfs
	JUNC 10	25yr	1.478	11.9200	26.22

TOTAL NODE INFLOW...
HYG file =
HYG ID = JUNC 10
HYG Tag = 25yr

Peak Discharge =	26.22 cfs
Time to Peak =	11.9200 hrs
HYG Volume =	1.478 ac-ft

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
4.5200	.00	.00	.00	.00	.01
4.7200	.01	.01	.01	.01	.01
4.9200	.01	.01	.02	.02	.02
5.1200	.02	.02	.02	.02	.03
5.3200	.03	.03	.03	.03	.03
5.5200	.03	.04	.04	.04	.04
5.7200	.04	.04	.05	.05	.05
5.9200	.05	.05	.05	.06	.06
6.1200	.06	.06	.06	.06	.07
6.3200	.07	.07	.07	.07	.07
6.5200	.08	.08	.08	.08	.08
6.7200	.08	.09	.09	.09	.09
6.9200	.09	.10	.10	.10	.10
7.1200	.10	.10	.11	.11	.11
7.3200	.11	.11	.12	.12	.12
7.5200	.12	.12	.12	.13	.13
7.7200	.13	.13	.13	.14	.14
7.9200	.14	.14	.14	.15	.15
8.1200	.15	.16	.16	.16	.17
8.3200	.17	.18	.18	.19	.19
8.5200	.20	.20	.21	.21	.22
8.7200	.22	.23	.23	.24	.24
8.9200	.25	.25	.26	.27	.27
9.1200	.27	.28	.28	.28	.29
9.3200	.29	.29	.30	.30	.30
9.5200	.31	.31	.32	.32	.33
9.7200	.34	.35	.36	.37	.38
9.9200	.39	.40	.42	.43	.44
10.1200	.45	.47	.48	.50	.52
10.3200	.53	.55	.56	.58	.60
10.5200	.61	.64	.66	.68	.71
10.7200	.73	.76	.79	.82	.85
10.9200	.88	.91	.94	.97	1.03

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
11.1200	1.07	1.14	1.20	1.26	1.34
11.3200	1.40	1.48	1.56	1.62	1.71
11.5200	1.85	2.56	3.35	4.37	6.33
11.7200	7.82	10.27	12.78	16.10	22.35
11.9200	26.22	25.21	22.88	19.26	11.59
12.1200	7.00	5.14	4.32	3.93	3.59
12.3200	3.40	3.17	2.96	2.79	2.53
12.5200	2.37	2.21	2.07	1.99	1.92
12.7200	1.88	1.82	1.77	1.73	1.67
12.9200	1.64	1.58	1.53	1.50	1.45
13.1200	1.42	1.39	1.36	1.34	1.31
13.3200	1.29	1.26	1.23	1.21	1.18
13.5200	1.16	1.13	1.11	1.09	1.07
13.7200	1.05	1.03	1.02	1.00	.98
13.9200	.96	.94	.92	.91	.89
14.1200	.88	.87	.87	.86	.85
14.3200	.85	.84	.83	.83	.82
14.5200	.82	.81	.80	.80	.79
14.7200	.78	.78	.77	.76	.76
14.9200	.75	.74	.74	.73	.72
15.1200	.72	.71	.70	.70	.69
15.3200	.69	.68	.67	.66	.66
15.5200	.65	.64	.64	.63	.62
15.7200	.62	.61	.60	.60	.59
15.9200	.59	.58	.57	.57	.56
16.1200	.56	.55	.55	.55	.55
16.3200	.54	.54	.54	.54	.53
16.5200	.53	.53	.53	.53	.52
16.7200	.52	.52	.52	.51	.51
16.9200	.51	.51	.50	.50	.50
17.1200	.50	.49	.49	.49	.49
17.3200	.49	.48	.48	.48	.48
17.5200	.47	.47	.47	.47	.46
17.7200	.46	.46	.46	.45	.45
17.9200	.45	.45	.44	.44	.44
18.1200	.44	.44	.43	.43	.43
18.3200	.43	.42	.42	.42	.42
18.5200	.41	.41	.41	.41	.40
18.7200	.40	.40	.40	.39	.39
18.9200	.39	.39	.38	.38	.38
19.1200	.38	.38	.37	.37	.37
19.3200	.37	.36	.36	.36	.36
19.5200	.35	.35	.35	.35	.34
19.7200	.34	.34	.34	.33	.33
19.9200	.33	.33	.32	.32	.32
20.1200	.32	.32	.32	.32	.32
20.3200	.32	.32	.32	.32	.32

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
20.5200	.31	.31	.31	.31	.31
20.7200	.31	.31	.31	.31	.31
20.9200	.31	.31	.31	.31	.31
21.1200	.31	.31	.31	.31	.31
21.3200	.31	.30	.30	.30	.30
21.5200	.30	.30	.30	.30	.30
21.7200	.30	.30	.30	.30	.30
21.9200	.30	.30	.30	.30	.30
22.1200	.30	.30	.29	.29	.29
22.3200	.29	.29	.29	.29	.29
22.5200	.29	.29	.29	.29	.29
22.7200	.29	.29	.29	.29	.29
22.9200	.29	.29	.29	.28	.28
23.1200	.28	.28	.28	.28	.28
23.3200	.28	.28	.28	.28	.28
23.5200	.28	.28	.28	.28	.28
23.7200	.28	.28	.28	.28	.28
23.9200	.27	.27	.27	.23	.11
24.1200	.04	.02	.01	.00	.00

SUMMARY FOR HYDROGRAPH ADDITION
at Node: JUNC 100

HYG Directory: C:\Haestad\PPKW\KIF\

Upstream Link ID	Upstream Node ID	HYG file	HYG ID	HYG tag
D36	SUBA7.5&A9.3		SUBA7.5&A9.3	25yr
D53	SUBA7.4&A9.7		SUBA7.4&A9.7	25yr
D37	SUBA7.3&9.4		SUBA7.3&9.4	25yr
D54	SUBA7.2&A9.6		SUBA7.2&A9.6	25yr
D55	SUBA7.1&A9.5		SUBA7.1&A9.5	25yr

INFLOWS TO: JUNC 100

HYG file	HYG ID	HYG tag	Volume ac-ft	Peak Time hrs	Peak Flow cfs
	SUBA7.5&A9.3	25yr	1.440	12.0000	22.49
	SUBA7.4&A9.7	25yr	.572	11.9200	10.31
	SUBA7.3&9.4	25yr	1.171	12.0000	18.27
	SUBA7.2&A9.6	25yr	.628	11.9600	11.00
	SUBA7.1&A9.5	25yr	.632	11.9600	10.59

TOTAL FLOW INTO: JUNC 100

HYG file	HYG ID	HYG tag	Volume ac-ft	Peak Time hrs	Peak Flow cfs
	JUNC 100	25yr	4.443	12.0000	71.14

TOTAL NODE INFLOW...
HYG file =
HYG ID = JUNC 100
HYG Tag = 25yr

Peak Discharge = 71.14 cfs
Time to Peak = 12.0000 hrs
HYG Volume = 4.443 ac-ft

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
7.0000	.00	.00	.00	.00	.00
7.2000	.01	.01	.01	.01	.02
7.4000	.02	.02	.03	.03	.03
7.6000	.04	.04	.04	.05	.05
7.8000	.06	.06	.06	.07	.07
8.0000	.08	.08	.09	.09	.10
8.2000	.11	.11	.12	.13	.13
8.4000	.14	.15	.16	.17	.18
8.6000	.20	.21	.22	.23	.25
8.8000	.26	.27	.29	.30	.32
9.0000	.33	.35	.36	.38	.39
9.2000	.41	.42	.43	.44	.45
9.4000	.47	.48	.49	.50	.51
9.6000	.53	.54	.56	.58	.60
9.8000	.63	.65	.68	.70	.73
10.0000	.76	.78	.81	.84	.88
10.2000	.91	.95	.99	1.03	1.07
10.4000	1.11	1.16	1.20	1.25	1.30
10.6000	1.35	1.41	1.47	1.54	1.61
10.8000	1.68	1.75	1.83	1.91	1.99
11.0000	2.08	2.17	2.28	2.40	2.53
11.2000	2.69	2.85	3.04	3.23	3.42
11.4000	3.63	3.84	4.06	4.36	5.28
11.6000	6.69	8.77	12.16	16.18	21.42
11.8000	27.94	36.11	49.08	62.26	69.44
12.0000	71.14	66.90	54.64	40.80	30.13
12.2000	23.00	18.54	15.73	13.77	12.36
12.4000	11.21	10.31	9.42	8.68	8.03
12.6000	7.47	7.04	6.71	6.46	6.25
12.8000	6.05	5.89	5.72	5.56	5.40
13.0000	5.24	5.10	4.96	4.83	4.72
13.2000	4.61	4.53	4.43	4.35	4.26
13.4000	4.17	4.09	4.00	3.92	3.84

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
13.6000	3.76	3.69	3.62	3.56	3.50
13.8000	3.43	3.37	3.31	3.25	3.19
14.0000	3.13	3.07	3.02	2.97	2.94
14.2000	2.90	2.88	2.85	2.83	2.81
14.4000	2.79	2.76	2.74	2.72	2.70
14.6000	2.68	2.66	2.64	2.62	2.60
14.8000	2.57	2.55	2.53	2.51	2.49
15.0000	2.47	2.45	2.43	2.41	2.38
15.2000	2.36	2.34	2.32	2.30	2.28
15.4000	2.25	2.23	2.21	2.19	2.17
15.6000	2.15	2.12	2.10	2.08	2.06
15.8000	2.04	2.02	1.99	1.97	1.95
16.0000	1.93	1.91	1.89	1.87	1.86
16.2000	1.85	1.84	1.83	1.82	1.81
16.4000	1.80	1.80	1.79	1.78	1.77
16.6000	1.77	1.76	1.75	1.74	1.74
16.8000	1.73	1.72	1.71	1.71	1.70
17.0000	1.69	1.68	1.67	1.67	1.66
17.2000	1.65	1.64	1.64	1.63	1.62
17.4000	1.61	1.60	1.60	1.59	1.58
17.6000	1.57	1.57	1.56	1.55	1.54
17.8000	1.53	1.53	1.52	1.51	1.50
18.0000	1.50	1.49	1.48	1.47	1.46
18.2000	1.46	1.45	1.44	1.43	1.43
18.4000	1.42	1.41	1.40	1.39	1.39
18.6000	1.38	1.37	1.36	1.35	1.35
18.8000	1.34	1.33	1.32	1.31	1.31
19.0000	1.30	1.29	1.28	1.27	1.27
19.2000	1.26	1.25	1.24	1.23	1.23
19.4000	1.22	1.21	1.20	1.19	1.19
19.6000	1.18	1.17	1.16	1.15	1.15
19.8000	1.14	1.13	1.12	1.11	1.11
20.0000	1.10	1.09	1.08	1.08	1.07
20.2000	1.07	1.07	1.07	1.06	1.06
20.4000	1.06	1.06	1.06	1.06	1.05
20.6000	1.05	1.05	1.05	1.05	1.05
20.8000	1.05	1.04	1.04	1.04	1.04
21.0000	1.04	1.04	1.03	1.03	1.03
21.2000	1.03	1.03	1.03	1.03	1.02
21.4000	1.02	1.02	1.02	1.02	1.02
21.6000	1.01	1.01	1.01	1.01	1.01
21.8000	1.01	1.01	1.00	1.00	1.00
22.0000	1.00	1.00	1.00	1.00	.99
22.2000	.99	.99	.99	.99	.99
22.4000	.98	.98	.98	.98	.98
22.6000	.98	.97	.97	.97	.97
22.8000	.97	.97	.97	.96	.96

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
23.0000	.96	.96	.96	.96	.96
23.2000	.95	.95	.95	.95	.95
23.4000	.95	.94	.94	.94	.94
23.6000	.94	.94	.93	.93	.93
23.8000	.93	.93	.93	.93	.92
24.0000	.92	.86	.66	.44	.26
24.2000	.16	.09	.05	.03	.02
24.4000	.01	.01	.00	.00	.00

SUMMARY FOR HYDROGRAPH ADDITION
at Node: JUNC 20

HYG Directory: C:\Haestad\PPKW\KIF\

Upstream Link ID	Upstream Node ID	HYG file	HYG ID	HYG tag
D32A	SUBAREA B7.3		SUBAREA B7.3	25yr
D26B	SUBAREA B2.3		SUBAREA B2.3	25yr
D26	SUBAREA B2.4		SUBAREA B2.4	25yr

INFLOWS TO: JUNC 20

HYG file	HYG ID	HYG tag	Volume ac-ft	Peak Time hrs	Peak Flow cfs
	SUBAREA B7.3	25yr	.444	11.9200	7.93
	SUBAREA B2.3	25yr	.875	11.9600	14.32
	SUBAREA B2.4	25yr	.990	11.9600	16.20

TOTAL FLOW INTO: JUNC 20

HYG file	HYG ID	HYG tag	Volume ac-ft	Peak Time hrs	Peak Flow cfs
	JUNC 20	25yr	2.309	11.9600	38.40

TOTAL NODE INFLOW...
HYG file =
HYG ID = JUNC 20
HYG Tag = 25yr

Peak Discharge =	38.40 cfs
Time to Peak =	11.9600 hrs
HYG Volume =	2.309 ac-ft

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
4.5200	.00	.00	.00	.00	.01
4.7200	.01	.01	.01	.01	.02
4.9200	.02	.02	.02	.03	.03
5.1200	.03	.03	.03	.04	.04
5.3200	.04	.04	.05	.05	.05
5.5200	.05	.06	.06	.06	.06
5.7200	.07	.07	.07	.07	.08
5.9200	.08	.08	.08	.09	.09
6.1200	.09	.09	.10	.10	.10
6.3200	.10	.11	.11	.11	.12
6.5200	.12	.12	.12	.13	.13
6.7200	.13	.14	.14	.14	.14
6.9200	.15	.15	.15	.16	.16
7.1200	.16	.16	.17	.17	.17
7.3200	.18	.18	.18	.19	.19
7.5200	.19	.19	.20	.20	.20
7.7200	.21	.21	.21	.22	.22
7.9200	.22	.23	.23	.23	.24
8.1200	.24	.25	.25	.26	.27
8.3200	.27	.28	.29	.29	.30
8.5200	.31	.32	.33	.33	.34
8.7200	.35	.36	.37	.37	.38
8.9200	.39	.40	.41	.42	.43
9.1200	.43	.44	.45	.45	.46
9.3200	.46	.47	.47	.48	.48
9.5200	.49	.49	.50	.51	.52
9.7200	.54	.55	.57	.58	.60
9.9200	.61	.63	.65	.66	.68
10.1200	.70	.73	.75	.77	.80
10.3200	.82	.85	.87	.90	.93
10.5200	.95	.98	1.02	1.05	1.09
10.7200	1.13	1.17	1.22	1.26	1.31
10.9200	1.35	1.40	1.45	1.50	1.56

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
11.1200	1.63	1.72	1.82	1.91	2.02
11.3200	2.13	2.24	2.36	2.47	2.60
11.5200	2.77	3.39	4.41	5.74	7.99
11.7200	10.40	13.49	17.14	21.63	28.98
11.9200	35.97	38.40	36.94	33.08	24.75
12.1200	16.73	11.59	8.91	7.41	6.45
12.3200	5.82	5.34	4.92	4.58	4.21
12.5200	3.91	3.64	3.40	3.23	3.09
12.7200	2.99	2.90	2.82	2.75	2.67
12.9200	2.60	2.52	2.44	2.38	2.31
13.1200	2.25	2.20	2.16	2.12	2.07
13.3200	2.03	1.99	1.95	1.91	1.87
13.5200	1.83	1.79	1.76	1.72	1.69
13.7200	1.66	1.63	1.60	1.57	1.54
13.9200	1.51	1.49	1.45	1.43	1.41
14.1200	1.39	1.37	1.36	1.34	1.33
14.3200	1.32	1.31	1.30	1.29	1.28
14.5200	1.27	1.26	1.25	1.24	1.23
14.7200	1.22	1.21	1.20	1.19	1.18
14.9200	1.17	1.16	1.15	1.14	1.13
15.1200	1.12	1.11	1.10	1.09	1.08
15.3200	1.07	1.06	1.05	1.04	1.03
15.5200	1.02	1.01	1.00	.99	.98
15.7200	.97	.96	.95	.94	.93
15.9200	.92	.91	.89	.88	.88
16.1200	.87	.86	.86	.85	.85
16.3200	.85	.84	.84	.84	.83
16.5200	.83	.83	.82	.82	.81
16.7200	.81	.81	.80	.80	.80
16.9200	.79	.79	.78	.78	.78
17.1200	.77	.77	.77	.76	.76
17.3200	.76	.75	.75	.74	.74
17.5200	.74	.73	.73	.73	.72
17.7200	.72	.72	.71	.71	.70
17.9200	.70	.70	.69	.69	.69
18.1200	.68	.68	.67	.67	.67
18.3200	.66	.66	.66	.65	.65
18.5200	.65	.64	.64	.63	.63
18.7200	.63	.62	.62	.61	.61
18.9200	.61	.60	.60	.60	.59
19.1200	.59	.59	.58	.58	.57
19.3200	.57	.57	.56	.56	.56
19.5200	.55	.55	.54	.54	.54
19.7200	.53	.53	.52	.52	.52
19.9200	.51	.51	.51	.50	.50
20.1200	.50	.50	.49	.49	.49
20.3200	.49	.49	.49	.49	.49

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
20.5200	.49	.49	.49	.49	.49
20.7200	.49	.48	.48	.48	.48
20.9200	.48	.48	.48	.48	.48
21.1200	.48	.48	.48	.48	.47
21.3200	.47	.47	.47	.47	.47
21.5200	.47	.47	.47	.47	.47
21.7200	.47	.47	.47	.46	.46
21.9200	.46	.46	.46	.46	.46
22.1200	.46	.46	.46	.46	.46
22.3200	.46	.46	.45	.45	.45
22.5200	.45	.45	.45	.45	.45
22.7200	.45	.45	.45	.45	.45
22.9200	.45	.44	.44	.44	.44
23.1200	.44	.44	.44	.44	.44
23.3200	.44	.44	.44	.43	.43
23.5200	.43	.43	.43	.43	.43
23.7200	.43	.43	.43	.43	.43
23.9200	.43	.43	.42	.39	.27
24.1200	.15	.07	.04	.02	.01
24.3200	.00	.00	.00		

SUMMARY FOR HYDROGRAPH ADDITION
at Node: JUNC 30

HYG Directory: C:\Haestad\PPKW\KIF\

Upstream Link ID	Upstream Node ID	HYG file	HYG ID	HYG tag
D50	SUBAREA B7.1		SUBAREA B7.1	25yr
D34	JUNC 90		JUNC 90	25yr
D61	SUBAREA A2		SUBAREA A2	25yr
D30	SUBB2.6&1.2		SUBB2.6&1.2	25yr
D32	JUNC 20		JUNC 20	25yr
D30A	JUNC 10		JUNC 10	25yr
D51	A15.2&A16.2		A15.2&A16.2	25yr
D20	JUNC 50		JUNC 50	25yr
D3	JUNC 40		JUNC 40	25yr

INFLOWS TO: JUNC 30

HYG file	HYG ID	HYG tag	Volume ac-ft	Peak Time hrs	Peak Flow cfs
	SUBAREA B7.1	25yr	1.034	11.9200	18.47
	JUNC 90	25yr	2.298	11.9600	38.75
	SUBAREA A2	25yr	.754	12.0800	9.54
	SUBB2.6&1.2	25yr	1.778	11.9600	29.09
	JUNC 20	25yr	2.309	11.9600	38.40
	JUNC 10	25yr	1.478	11.9200	26.22
	A15.2&A16.2	25yr	.906	11.9600	15.18
	JUNC 50	25yr	4.200	12.0400	53.56
	JUNC 40	25yr	9.661	12.0000	148.56

TOTAL FLOW INTO: JUNC 30

HYG file	HYG ID	HYG tag	Volume ac-ft	Peak Time hrs	Peak Flow cfs
	JUNC 30	25yr	24.420	11.9600	366.27

TOTAL NODE INFLOW...
HYG file =
HYG ID = JUNC 30
HYG Tag = 25yr

Peak Discharge =	366.27	cfs
Time to Peak =	11.9600	hrs
HYG Volume =	24.420	ac-ft

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
4.5200	.00	.01	.01	.02	.03
4.7200	.04	.06	.07	.08	.10
4.9200	.11	.12	.14	.15	.17
5.1200	.18	.20	.21	.23	.24
5.3200	.26	.27	.29	.31	.32
5.5200	.34	.35	.37	.39	.40
5.7200	.42	.44	.45	.47	.49
5.9200	.50	.52	.54	.56	.57
6.1200	.59	.61	.63	.64	.66
6.3200	.68	.70	.72	.73	.75
6.5200	.77	.79	.81	.83	.85
6.7200	.86	.88	.90	.92	.94
6.9200	.96	.98	1.00	1.02	1.04
7.1200	1.06	1.08	1.10	1.12	1.15
7.3200	1.17	1.19	1.21	1.24	1.26
7.5200	1.29	1.31	1.33	1.36	1.39
7.7200	1.41	1.44	1.46	1.49	1.51
7.9200	1.54	1.57	1.60	1.62	1.66
8.1200	1.69	1.73	1.78	1.83	1.88
8.3200	1.94	1.99	2.05	2.11	2.18
8.5200	2.24	2.31	2.37	2.44	2.51
8.7200	2.58	2.66	2.73	2.81	2.88
8.9200	2.96	3.04	3.12	3.20	3.27
9.1200	3.34	3.41	3.48	3.55	3.61
9.3200	3.67	3.73	3.79	3.85	3.91
9.5200	3.96	4.03	4.11	4.20	4.31
9.7200	4.43	4.56	4.70	4.84	4.99
9.9200	5.14	5.29	5.45	5.62	5.80
10.1200	5.98	6.18	6.40	6.61	6.85
10.3200	7.08	7.32	7.58	7.82	8.09
10.5200	8.35	8.65	8.96	9.28	9.66
10.7200	10.03	10.44	10.86	11.28	11.74
10.9200	12.18	12.65	13.13	13.64	14.29

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
11.1200	14.93	15.74	16.64	17.54	18.61
11.3200	19.62	20.73	21.88	23.00	24.27
11.5200	25.98	31.68	40.12	51.79	71.62
11.7200	92.78	121.85	156.20	200.17	271.56
11.9200	338.19	366.27	365.94	341.06	272.20
12.1200	206.47	160.56	130.68	109.80	93.99
12.3200	82.21	73.11	65.78	59.86	54.14
12.5200	49.57	45.55	42.07	39.41	37.25
12.7200	35.59	34.13	32.86	31.78	30.66
12.9200	29.72	28.76	27.84	27.05	26.24
13.1200	25.58	24.96	24.40	23.92	23.39
13.3200	22.94	22.46	21.99	21.56	21.07
13.5200	20.66	20.22	19.81	19.44	19.06
13.7200	18.73	18.38	18.04	17.73	17.38
13.9200	17.07	16.74	16.41	16.13	15.85
14.1200	15.62	15.42	15.24	15.10	14.96
14.3200	14.84	14.71	14.59	14.47	14.35
14.5200	14.25	14.14	14.01	13.91	13.79
14.7200	13.69	13.58	13.46	13.35	13.23
14.9200	13.14	13.02	12.90	12.79	12.67
15.1200	12.58	12.46	12.34	12.23	12.11
15.3200	12.01	11.89	11.77	11.66	11.55
15.5200	11.45	11.33	11.20	11.09	10.98
15.7200	10.88	10.76	10.63	10.52	10.40
15.9200	10.30	10.18	10.06	9.96	9.86
16.1200	9.78	9.71	9.64	9.59	9.54
16.3200	9.50	9.45	9.41	9.37	9.32
16.5200	9.29	9.25	9.20	9.16	9.12
16.7200	9.09	9.04	9.00	8.96	8.92
16.9200	8.88	8.84	8.80	8.76	8.72
17.1200	8.68	8.64	8.59	8.56	8.52
17.3200	8.48	8.44	8.39	8.35	8.31
17.5200	8.28	8.23	8.19	8.15	8.11
17.7200	8.07	8.03	7.98	7.94	7.90
17.9200	7.87	7.83	7.78	7.74	7.70
18.1200	7.66	7.62	7.57	7.53	7.49
18.3200	7.46	7.41	7.37	7.33	7.29
18.5200	7.25	7.21	7.16	7.12	7.08
18.7200	7.04	7.00	6.95	6.91	6.87
18.9200	6.84	6.79	6.75	6.71	6.66
19.1200	6.63	6.59	6.54	6.50	6.46
19.3200	6.42	6.38	6.33	6.29	6.25
19.5200	6.21	6.17	6.12	6.08	6.04
19.7200	6.00	5.96	5.91	5.87	5.83
19.9200	5.79	5.75	5.70	5.66	5.63
20.1200	5.61	5.58	5.56	5.55	5.54
20.3200	5.53	5.52	5.51	5.50	5.49

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
20.5200	5.49	5.48	5.46	5.45	5.45
20.7200	5.44	5.44	5.42	5.41	5.41
20.9200	5.40	5.40	5.38	5.37	5.37
21.1200	5.36	5.36	5.34	5.33	5.33
21.3200	5.32	5.32	5.30	5.29	5.29
21.5200	5.28	5.28	5.26	5.25	5.25
21.7200	5.24	5.24	5.22	5.21	5.21
21.9200	5.20	5.19	5.18	5.17	5.17
22.1200	5.16	5.15	5.14	5.13	5.13
22.3200	5.12	5.11	5.10	5.09	5.09
22.5200	5.08	5.07	5.06	5.05	5.05
22.7200	5.04	5.03	5.02	5.01	5.01
22.9200	5.00	4.99	4.98	4.97	4.97
23.1200	4.96	4.95	4.94	4.93	4.92
23.3200	4.92	4.91	4.90	4.89	4.88
23.5200	4.88	4.87	4.86	4.85	4.84
23.7200	4.84	4.83	4.82	4.81	4.80
23.9200	4.80	4.79	4.77	4.38	3.23
24.1200	2.15	1.42	.97	.67	.47
24.3200	.33	.23	.16	.12	.09
24.5200	.06	.04	.03	.02	.02
24.7200	.01	.01	.01	.00	.00
24.9200	.00	.00			

SUMMARY FOR HYDROGRAPH ADDITION
at Node: JUNC 40

HYG Directory: C:\Haestad\PPKW\KIF\

Upstream Link ID	Upstream Node ID	HYG file	HYG ID	HYG tag
D41	JUNC 70		JUNC 70	25yr
D4	JUNC 60		JUNC 60	25yr
D52	SUBA8.2&A13.4		SUBA8.2&A13.4	25yr
D2	JUNC 100		JUNC 100	25yr
D40	A15.1.4.6&16.1		A15.1.4.6&16.1	25yr

INFLOWS TO: JUNC 40

HYG file	HYG ID	HYG tag	Volume ac-ft	Peak Time hrs	Peak Flow cfs
	JUNC 70	25yr	1.088	11.9600	17.96
	JUNC 60	25yr	2.701	12.0000	35.92
	SUBA8.2&A13.4	25yr	.550	11.9200	10.31
	JUNC 100	25yr	4.443	12.0000	71.14
	A15.1.4.6&16.1	25yr	.880	12.0000	14.70

TOTAL FLOW INTO: JUNC 40

HYG file	HYG ID	HYG tag	Volume ac-ft	Peak Time hrs	Peak Flow cfs
	JUNC 40	25yr	9.661	12.0000	148.56

TOTAL NODE INFLOW...
HYG file =
HYG ID = JUNC 40
HYG Tag = 25yr

Peak Discharge = 148.56 cfs
Time to Peak = 12.0000 hrs
HYG Volume = 9.661 ac-ft

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
4.6000	.00	.00	.00	.00	.01
4.8000	.01	.01	.01	.01	.02
5.0000	.02	.02	.02	.03	.03
5.2000	.03	.03	.04	.04	.04
5.4000	.04	.05	.05	.05	.05
5.6000	.06	.06	.06	.06	.07
5.8000	.07	.07	.07	.08	.08
6.0000	.08	.09	.09	.09	.09
6.2000	.10	.10	.10	.11	.11
6.4000	.11	.11	.12	.12	.12
6.6000	.13	.13	.13	.14	.14
6.8000	.14	.14	.15	.15	.15
7.0000	.16	.16	.17	.17	.17
7.2000	.18	.18	.19	.19	.20
7.4000	.21	.21	.22	.23	.23
7.6000	.24	.25	.26	.26	.27
7.8000	.28	.28	.29	.30	.31
8.0000	.32	.32	.33	.34	.35
8.2000	.37	.38	.39	.41	.43
8.4000	.44	.46	.48	.50	.52
8.6000	.54	.57	.59	.61	.64
8.8000	.66	.69	.71	.74	.77
9.0000	.79	.82	.85	.87	.90
9.2000	.93	.96	.98	1.01	1.04
9.4000	1.06	1.09	1.11	1.14	1.16
9.6000	1.19	1.23	1.27	1.31	1.35
9.8000	1.40	1.45	1.51	1.56	1.62
10.0000	1.67	1.73	1.80	1.87	1.94
10.2000	2.02	2.09	2.18	2.26	2.35
10.4000	2.45	2.54	2.64	2.73	2.84
10.6000	2.96	3.08	3.22	3.35	3.51
10.8000	3.66	3.82	3.99	4.16	4.34
11.0000	4.52	4.72	4.96	5.20	5.50

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
11.2000	5.84	6.18	6.58	6.97	7.39
11.4000	7.84	8.27	8.76	9.43	11.54
11.6000	14.59	19.00	26.44	34.62	46.07
11.8000	59.75	77.64	106.53	133.91	146.59
12.0000	148.56	139.17	111.77	84.92	65.43
12.2000	52.46	43.64	37.29	32.64	29.08
12.4000	26.23	23.93	21.69	19.90	18.31
12.6000	16.95	15.91	15.08	14.44	13.88
12.8000	13.40	12.98	12.54	12.18	11.79
13.0000	11.43	11.11	10.78	10.52	10.27
13.2000	10.04	9.84	9.63	9.45	9.25
13.4000	9.06	8.89	8.69	8.52	8.34
13.6000	8.17	8.02	7.86	7.73	7.58
13.8000	7.45	7.32	7.17	7.05	6.91
14.0000	6.78	6.66	6.55	6.45	6.37
14.2000	6.30	6.24	6.18	6.14	6.09
14.4000	6.03	5.99	5.94	5.90	5.85
14.6000	5.80	5.76	5.71	5.67	5.62
14.8000	5.57	5.53	5.48	5.44	5.39
15.0000	5.34	5.30	5.25	5.21	5.16
15.2000	5.11	5.07	5.02	4.98	4.93
15.4000	4.88	4.84	4.79	4.75	4.70
15.6000	4.65	4.60	4.55	4.51	4.46
15.8000	4.41	4.37	4.32	4.28	4.23
16.0000	4.17	4.13	4.09	4.06	4.03
16.2000	4.00	3.98	3.96	3.95	3.93
16.4000	3.91	3.89	3.87	3.86	3.84
16.6000	3.82	3.81	3.79	3.78	3.76
16.8000	3.74	3.72	3.71	3.69	3.68
17.0000	3.66	3.64	3.62	3.61	3.59
17.2000	3.57	3.56	3.54	3.53	3.51
17.4000	3.49	3.47	3.46	3.44	3.43
17.6000	3.41	3.39	3.37	3.36	3.34
17.8000	3.32	3.31	3.29	3.27	3.26
18.0000	3.24	3.22	3.20	3.19	3.17
18.2000	3.15	3.14	3.12	3.10	3.09
18.4000	3.07	3.05	3.03	3.02	3.00
18.6000	2.98	2.97	2.95	2.93	2.92
18.8000	2.90	2.88	2.86	2.85	2.83
19.0000	2.81	2.79	2.78	2.76	2.74
19.2000	2.72	2.71	2.69	2.67	2.66
19.4000	2.64	2.62	2.60	2.59	2.57
19.6000	2.55	2.53	2.52	2.50	2.48
19.8000	2.46	2.45	2.43	2.41	2.40
20.0000	2.38	2.36	2.35	2.34	2.33
20.2000	2.32	2.31	2.31	2.31	2.30
20.4000	2.30	2.29	2.29	2.29	2.28

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
20.6000	2.28	2.28	2.27	2.27	2.27
20.8000	2.26	2.26	2.26	2.25	2.25
21.0000	2.25	2.24	2.24	2.24	2.23
21.2000	2.23	2.23	2.22	2.22	2.22
21.4000	2.21	2.21	2.21	2.21	2.20
21.6000	2.20	2.19	2.19	2.19	2.19
21.8000	2.18	2.18	2.17	2.17	2.17
22.0000	2.16	2.16	2.16	2.16	2.15
22.2000	2.15	2.14	2.14	2.14	2.14
22.4000	2.13	2.13	2.12	2.12	2.12
22.6000	2.11	2.11	2.11	2.11	2.10
22.8000	2.10	2.09	2.09	2.09	2.09
23.0000	2.08	2.08	2.07	2.07	2.07
23.2000	2.06	2.06	2.06	2.06	2.05
23.4000	2.05	2.04	2.04	2.04	2.03
23.6000	2.03	2.03	2.02	2.02	2.02
23.8000	2.01	2.01	2.01	2.00	2.00
24.0000	1.99	1.83	1.35	.90	.58
24.2000	.38	.25	.17	.11	.08
24.4000	.05	.04	.03	.02	.01
24.6000	.01	.01	.00	.00	.00
24.8000	.00	.00			

SUMMARY FOR HYDROGRAPH ADDITION
at Node: JUNC 50

HYG Directory: C:\Haestad\PPKW\KIF\

Upstream Link ID	Upstream Node ID	HYG file	HYG ID	HYG tag
D22	SUBB2.7		SUBB2.7	25yr
D18	A14.1&14.2&B2.8		A14.1&14.2&B2.8	25yr

INFLOWS TO: JUNC 50

HYG file	HYG ID	HYG tag	Volume ac-ft	Peak Time hrs	Peak Flow cfs
	SUBB2.7	25yr	1.121	11.9600	18.34
	A14.1&14.2&B2.8	25yr	3.079	12.0800	38.52

TOTAL FLOW INTO: JUNC 50

HYG file	HYG ID	HYG tag	Volume ac-ft	Peak Time hrs	Peak Flow cfs
	JUNC 50	25yr	4.200	12.0400	53.56

TOTAL NODE INFLOW...
HYG file =
HYG ID = JUNC 50
HYG Tag = 25yr

Peak Discharge =	53.56	cfs
Time to Peak =	12.0400	hrs
HYG Volume =	4.200	ac-ft

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
4.5200	.00	.00	.00	.00	.01
4.7200	.01	.01	.02	.02	.03
4.9200	.03	.04	.04	.05	.05
5.1200	.05	.06	.06	.07	.07
5.3200	.08	.09	.09	.10	.10
5.5200	.11	.11	.12	.12	.13
5.7200	.13	.14	.14	.15	.16
5.9200	.16	.17	.17	.18	.18
6.1200	.19	.20	.20	.21	.21
6.3200	.22	.23	.23	.24	.24
6.5200	.25	.26	.26	.27	.28
6.7200	.28	.29	.29	.30	.31
6.9200	.31	.32	.33	.33	.34
7.1200	.35	.35	.36	.37	.37
7.3200	.38	.39	.39	.40	.41
7.5200	.41	.42	.43	.43	.44
7.7200	.45	.45	.46	.47	.47
7.9200	.48	.49	.50	.50	.51
8.1200	.52	.53	.54	.55	.56
8.3200	.58	.59	.61	.62	.64
8.5200	.65	.67	.69	.71	.72
8.7200	.74	.76	.78	.79	.81
8.9200	.83	.85	.87	.89	.91
9.1200	.93	.94	.96	.97	.98
9.3200	1.00	1.01	1.02	1.03	1.03
9.5200	1.04	1.05	1.06	1.08	1.09
9.7200	1.11	1.14	1.16	1.19	1.21
9.9200	1.24	1.27	1.30	1.33	1.37
10.1200	1.40	1.44	1.48	1.52	1.56
10.3200	1.60	1.65	1.70	1.74	1.79
10.5200	1.84	1.90	1.95	2.01	2.07
10.7200	2.14	2.21	2.28	2.36	2.44
10.9200	2.52	2.61	2.69	2.78	2.88

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
11.1200	2.99	3.11	3.25	3.41	3.57
11.3200	3.75	3.93	4.12	4.32	4.53
11.5200	4.79	5.34	6.28	7.64	9.76
11.7200	12.45	15.89	20.18	25.51	32.83
11.9200	41.21	48.02	52.14	53.56	51.08
12.1200	45.92	39.97	34.15	28.74	24.03
12.3200	20.15	17.25	15.00	13.20	11.70
12.5200	10.45	9.41	8.52	7.77	7.16
12.7200	6.65	6.23	5.88	5.59	5.33
12.9200	5.11	4.91	4.73	4.57	4.42
13.1200	4.29	4.17	4.06	3.96	3.87
13.3200	3.78	3.70	3.62	3.54	3.46
13.5200	3.39	3.32	3.25	3.18	3.12
13.7200	3.06	3.00	2.94	2.89	2.83
13.9200	2.78	2.73	2.67	2.62	2.58
14.1200	2.53	2.49	2.45	2.42	2.39
14.3200	2.37	2.34	2.32	2.30	2.28
14.5200	2.26	2.24	2.22	2.20	2.19
14.7200	2.17	2.15	2.13	2.11	2.10
14.9200	2.08	2.06	2.04	2.02	2.01
15.1200	1.99	1.97	1.95	1.94	1.92
15.3200	1.90	1.88	1.86	1.85	1.83
15.5200	1.81	1.79	1.77	1.76	1.74
15.7200	1.72	1.70	1.68	1.67	1.65
15.9200	1.63	1.61	1.59	1.58	1.56
16.1200	1.54	1.53	1.52	1.51	1.50
16.3200	1.49	1.48	1.47	1.46	1.46
16.5200	1.45	1.44	1.44	1.43	1.42
16.7200	1.42	1.41	1.40	1.40	1.39
16.9200	1.38	1.38	1.37	1.36	1.36
17.1200	1.35	1.35	1.34	1.33	1.33
17.3200	1.32	1.31	1.31	1.30	1.29
17.5200	1.29	1.28	1.27	1.27	1.26
17.7200	1.26	1.25	1.24	1.24	1.23
17.9200	1.22	1.22	1.21	1.20	1.20
18.1200	1.19	1.19	1.18	1.17	1.17
18.3200	1.16	1.15	1.15	1.14	1.13
18.5200	1.13	1.12	1.11	1.11	1.10
18.7200	1.09	1.09	1.08	1.08	1.07
18.9200	1.06	1.06	1.05	1.04	1.04
19.1200	1.03	1.02	1.02	1.01	1.00
19.3200	1.00	.99	.98	.98	.97
19.5200	.97	.96	.95	.95	.94
19.7200	.93	.93	.92	.91	.91
19.9200	.90	.89	.89	.88	.88
20.1200	.87	.87	.86	.86	.85
20.3200	.85	.85	.85	.85	.84

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
20.5200	.84	.84	.84	.84	.84
20.7200	.84	.83	.83	.83	.83
20.9200	.83	.83	.83	.83	.82
21.1200	.82	.82	.82	.82	.82
21.3200	.82	.82	.81	.81	.81
21.5200	.81	.81	.81	.81	.80
21.7200	.80	.80	.80	.80	.80
21.9200	.80	.80	.79	.79	.79
22.1200	.79	.79	.79	.79	.79
22.3200	.78	.78	.78	.78	.78
22.5200	.78	.78	.78	.77	.77
22.7200	.77	.77	.77	.77	.77
22.9200	.77	.76	.76	.76	.76
23.1200	.76	.76	.76	.75	.75
23.3200	.75	.75	.75	.75	.75
23.5200	.75	.74	.74	.74	.74
23.7200	.74	.74	.74	.74	.73
23.9200	.73	.73	.73	.71	.64
24.1200	.54	.44	.35	.27	.20
24.3200	.15	.11	.08	.06	.04
24.5200	.03	.02	.02	.01	.01
24.7200	.01	.00	.00	.00	.00
24.9200	.00	.00			

SUMMARY FOR HYDROGRAPH ADDITION
at Node: JUNC 60

HYG Directory: C:\Haestad\PPKW\KIF\

Upstream Link ID	Upstream Node ID	HYG file	HYG ID	HYG tag
D6	SUBA9.1&A13.1		SUBA9.1&A13.1	25yr
D7	A9.2		A9.2	25yr
D5	SUBA13.2		SUBA13.2	25yr
D7A	SUBA8.1		SUBA8.1	25yr

INFLOWS TO: JUNC 60

HYG file	HYG ID	HYG tag	Volume ac-ft	Peak Time hrs	Peak Flow cfs
	SUBA9.1&A13.1	25yr	.784	11.9200	14.14
	A9.2	25yr	1.077	12.0800	13.47
	SUBA13.2	25yr	.525	12.0800	6.57
	SUBA8.1	25yr	.315	11.9200	5.62

TOTAL FLOW INTO: JUNC 60

HYG file	HYG ID	HYG tag	Volume ac-ft	Peak Time hrs	Peak Flow cfs
	JUNC 60	25yr	2.701	12.0000	35.92

TOTAL NODE INFLOW...
HYG file =
HYG ID = JUNC 60
HYG Tag = 25yr

Peak Discharge = 35.92 cfs
Time to Peak = 12.0000 hrs
HYG Volume = 2.701 ac-ft

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
4.6400	.00	.00	.00	.00	.01
4.8400	.01	.01	.01	.01	.01
5.0400	.02	.02	.02	.02	.02
5.2400	.02	.03	.03	.03	.03
5.4400	.03	.04	.04	.04	.04
5.6400	.04	.05	.05	.05	.05
5.8400	.06	.06	.06	.06	.06
6.0400	.07	.07	.07	.07	.08
6.2400	.08	.08	.08	.08	.09
6.4400	.09	.09	.09	.10	.10
6.6400	.10	.10	.11	.11	.11
6.8400	.11	.11	.12	.12	.12
7.0400	.12	.13	.13	.13	.13
7.2400	.14	.14	.14	.14	.15
7.4400	.15	.15	.16	.16	.16
7.6400	.16	.17	.17	.17	.17
7.8400	.18	.18	.18	.18	.19
8.0400	.19	.19	.20	.20	.20
8.2400	.21	.22	.22	.23	.24
8.4400	.24	.25	.26	.27	.27
8.6400	.28	.29	.30	.31	.32
8.8400	.33	.34	.35	.36	.37
9.0400	.38	.39	.40	.41	.41
9.2400	.42	.43	.44	.45	.45
9.4400	.46	.47	.47	.48	.49
9.6400	.50	.51	.52	.53	.54
9.8400	.56	.58	.59	.61	.63
10.0400	.64	.66	.68	.70	.73
10.2400	.75	.78	.80	.83	.86
10.4400	.88	.91	.94	.97	1.01
10.6400	1.04	1.08	1.12	1.16	1.21
10.8400	1.25	1.30	1.35	1.40	1.46
11.0400	1.51	1.58	1.64	1.73	1.82

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
11.2400	1.91	2.02	2.12	2.24	2.36
11.4400	2.49	2.62	2.81	3.38	4.10
11.6400	5.14	6.98	8.82	11.64	14.90
11.8400	19.26	26.39	32.44	34.92	35.92
12.0400	34.91	29.38	25.07	21.91	18.98
12.2400	16.29	13.83	11.84	10.28	9.04
12.4400	8.05	7.15	6.44	5.83	5.32
12.6400	4.92	4.57	4.30	4.06	3.86
12.8400	3.69	3.53	3.40	3.27	3.15
13.0400	3.06	2.96	2.88	2.81	2.74
13.2400	2.68	2.62	2.56	2.51	2.45
13.4400	2.40	2.35	2.30	2.25	2.21
13.6400	2.17	2.12	2.08	2.04	2.00
13.8400	1.97	1.93	1.90	1.86	1.82
14.0400	1.79	1.76	1.73	1.71	1.69
14.2400	1.67	1.65	1.64	1.62	1.60
14.4400	1.59	1.58	1.57	1.55	1.54
14.6400	1.53	1.51	1.50	1.49	1.48
14.8400	1.47	1.45	1.44	1.43	1.42
15.0400	1.40	1.39	1.38	1.37	1.35
15.2400	1.34	1.33	1.32	1.31	1.29
15.4400	1.28	1.27	1.26	1.24	1.23
15.6400	1.22	1.21	1.20	1.18	1.17
15.8400	1.16	1.14	1.13	1.12	1.11
16.0400	1.10	1.08	1.08	1.07	1.06
16.2400	1.05	1.05	1.04	1.03	1.03
16.4400	1.02	1.02	1.02	1.01	1.01
16.6400	1.00	1.00	.99	.99	.98
16.8400	.98	.97	.97	.97	.96
17.0400	.96	.95	.95	.94	.94
17.2400	.93	.93	.93	.92	.92
17.4400	.91	.91	.90	.90	.89
17.6400	.89	.89	.88	.88	.87
17.8400	.87	.86	.86	.85	.85
18.0400	.85	.84	.84	.83	.83
18.2400	.82	.82	.81	.81	.80
18.4400	.80	.80	.79	.79	.78
18.6400	.78	.77	.77	.76	.76
18.8400	.76	.75	.75	.74	.74
19.0400	.73	.73	.72	.72	.71
19.2400	.71	.71	.70	.70	.69
19.4400	.69	.68	.68	.67	.67
19.6400	.66	.66	.66	.65	.65
19.8400	.64	.64	.63	.63	.62
20.0400	.62	.62	.61	.61	.61
20.2400	.61	.60	.60	.60	.60
20.4400	.60	.60	.60	.60	.59

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
20.6400	.59	.59	.59	.59	.59
20.8400	.59	.59	.59	.59	.59
21.0400	.58	.58	.58	.58	.58
21.2400	.58	.58	.58	.58	.58
21.4400	.58	.58	.57	.57	.57
21.6400	.57	.57	.57	.57	.57
21.8400	.57	.57	.57	.56	.56
22.0400	.56	.56	.56	.56	.56
22.2400	.56	.56	.56	.56	.55
22.4400	.55	.55	.55	.55	.55
22.6400	.55	.55	.55	.55	.55
22.8400	.54	.54	.54	.54	.54
23.0400	.54	.54	.54	.54	.54
23.2400	.54	.54	.53	.53	.53
23.4400	.53	.53	.53	.53	.53
23.6400	.53	.53	.53	.52	.52
23.8400	.52	.52	.52	.52	.52
24.0400	.47	.36	.28	.22	.18
24.2400	.14	.10	.08	.06	.04
24.4400	.03	.02	.02	.01	.01
24.6400	.01	.00	.00	.00	.00
24.8400	.00				

SUMMARY FOR HYDROGRAPH ADDITION
at Node: JUNC 70

HYG Directory: C:\Haestad\PPKW\KIF\

Upstream Link ID	Upstream Node ID	HYG file	HYG ID	HYG tag
D41A	A15.5&.7&16.3		A15.5&.7&16.3	25yr
D16	SUBAREA A15.2		SUBAREA A15.2	25yr

INFLOWS TO: JUNC 70

HYG file	HYG ID	HYG tag	Volume ac-ft	Peak Time hrs	Peak Flow cfs
	A15.5&.7&16.3	25yr	.667	12.0000	11.15
	SUBAREA A15.2	25yr	.421	11.9600	6.89

TOTAL FLOW INTO: JUNC 70

HYG file	HYG ID	HYG tag	Volume ac-ft	Peak Time hrs	Peak Flow cfs
	JUNC 70	25yr	1.088	11.9600	17.96

TOTAL NODE INFLOW...
HYG file =
HYG ID = JUNC 70
HYG Tag = 25yr

Peak Discharge = 17.96 cfs
Time to Peak = 11.9600 hrs
HYG Volume = 1.088 ac-ft

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
4.6000	.00	.00	.00	.00	.00
4.8000	.00	.00	.00	.00	.00
5.0000	.01	.01	.01	.01	.01
5.2000	.01	.01	.01	.01	.01
5.4000	.01	.01	.01	.01	.01
5.6000	.01	.01	.01	.01	.02
5.8000	.02	.02	.02	.02	.02
6.0000	.02	.02	.02	.02	.02
6.2000	.02	.02	.02	.02	.02
6.4000	.02	.03	.03	.03	.03
6.6000	.03	.03	.03	.03	.03
6.8000	.03	.03	.03	.03	.03
7.0000	.03	.04	.04	.04	.04
7.2000	.04	.04	.04	.04	.04
7.4000	.04	.04	.04	.04	.04
7.6000	.04	.05	.05	.05	.05
7.8000	.05	.05	.05	.05	.05
8.0000	.05	.05	.05	.05	.06
8.2000	.06	.06	.06	.06	.06
8.4000	.06	.07	.07	.07	.07
8.6000	.07	.08	.08	.08	.08
8.8000	.08	.08	.09	.09	.09
9.0000	.09	.09	.10	.10	.10
9.2000	.10	.10	.11	.11	.11
9.4000	.12	.12	.12	.12	.13
9.6000	.13	.13	.14	.14	.15
9.8000	.16	.16	.17	.17	.18
10.0000	.19	.19	.20	.21	.22
10.2000	.23	.23	.24	.25	.26
10.4000	.27	.28	.30	.31	.32
10.6000	.33	.35	.36	.38	.39
10.8000	.41	.43	.45	.47	.49
11.0000	.51	.53	.56	.59	.62

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
11.2000	.66	.70	.75	.79	.84
11.4000	.89	.94	1.00	1.07	1.29
11.6000	1.69	2.23	3.12	4.17	5.48
11.8000	7.14	9.18	12.47	16.06	17.96
12.0000	17.82	16.44	13.00	9.02	6.22
12.2000	4.74	3.89	3.36	3.02	2.76
12.4000	2.54	2.36	2.18	2.03	1.89
12.6000	1.76	1.67	1.60	1.54	1.50
12.8000	1.46	1.42	1.38	1.34	1.30
13.0000	1.27	1.23	1.20	1.17	1.14
13.2000	1.12	1.10	1.07	1.05	1.03
13.4000	1.01	.99	.97	.95	.93
13.6000	.91	.90	.88	.86	.85
13.8000	.83	.82	.80	.79	.77
14.0000	.76	.75	.73	.72	.71
14.2000	.71	.70	.69	.69	.68
14.4000	.68	.67	.67	.66	.66
14.6000	.65	.65	.64	.64	.63
14.8000	.63	.62	.62	.61	.61
15.0000	.60	.60	.59	.59	.58
15.2000	.58	.57	.57	.56	.56
15.4000	.55	.54	.54	.53	.53
15.6000	.52	.52	.51	.51	.50
15.8000	.50	.49	.49	.48	.48
16.0000	.47	.46	.46	.46	.45
16.2000	.45	.45	.45	.45	.44
16.4000	.44	.44	.44	.44	.43
16.6000	.43	.43	.43	.43	.42
16.8000	.42	.42	.42	.42	.42
17.0000	.41	.41	.41	.41	.41
17.2000	.40	.40	.40	.40	.40
17.4000	.39	.39	.39	.39	.39
17.6000	.39	.38	.38	.38	.38
17.8000	.38	.37	.37	.37	.37
18.0000	.37	.36	.36	.36	.36
18.2000	.36	.35	.35	.35	.35
18.4000	.35	.34	.34	.34	.34
18.6000	.34	.34	.33	.33	.33
18.8000	.33	.33	.32	.32	.32
19.0000	.32	.32	.31	.31	.31
19.2000	.31	.31	.30	.30	.30
19.4000	.30	.30	.29	.29	.29
19.6000	.29	.29	.28	.28	.28
19.8000	.28	.28	.27	.27	.27
20.0000	.27	.27	.27	.26	.26
20.2000	.26	.26	.26	.26	.26
20.4000	.26	.26	.26	.26	.26

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
20.6000	.26	.26	.26	.26	.26
20.8000	.26	.26	.26	.26	.26
21.0000	.25	.25	.25	.25	.25
21.2000	.25	.25	.25	.25	.25
21.4000	.25	.25	.25	.25	.25
21.6000	.25	.25	.25	.25	.25
21.8000	.25	.25	.25	.25	.25
22.0000	.25	.24	.24	.24	.24
22.2000	.24	.24	.24	.24	.24
22.4000	.24	.24	.24	.24	.24
22.6000	.24	.24	.24	.24	.24
22.8000	.24	.24	.24	.24	.24
23.0000	.24	.24	.24	.23	.23
23.2000	.23	.23	.23	.23	.23
23.4000	.23	.23	.23	.23	.23
23.6000	.23	.23	.23	.23	.23
23.8000	.23	.23	.23	.23	.23
24.0000	.23	.21	.16	.09	.05
24.2000	.02	.01	.01	.00	.00
24.4000	.00				

SUMMARY FOR HYDROGRAPH ADDITION
at Node: JUNC 90

HYG Directory: C:\Haestad\PPKW\KIF\

Upstream Link ID	Upstream Node ID	HYG file	HYG ID	HYG tag
D34A	SUBAREA B7.2		SUBAREA B7.2	25yr
D28	B2.2		B2.2	25yr
D28B	SUBAREA B2.1		SUBAREA B2.1	25yr

INFLOWS TO: JUNC 90

HYG file	HYG ID	HYG tag	Volume ac-ft	Peak Time hrs	Peak Flow cfs
	SUBAREA B7.2	25yr	.823	11.9200	14.71
	B2.2	25yr	.734	11.9600	12.01
	SUBAREA B2.1	25yr	.741	11.9600	12.12

TOTAL FLOW INTO: JUNC 90

HYG file	HYG ID	HYG tag	Volume ac-ft	Peak Time hrs	Peak Flow cfs
	JUNC 90	25yr	2.298	11.9600	38.75

TOTAL NODE INFLOW...
HYG file =
HYG ID = JUNC 90
HYG Tag = 25yr

Peak Discharge = 38.75 cfs
Time to Peak = 11.9600 hrs
HYG Volume = 2.298 ac-ft

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
4.5200	.00	.00	.00	.00	.01
4.7200	.01	.01	.01	.01	.01
4.9200	.01	.02	.02	.02	.02
5.1200	.02	.03	.03	.03	.03
5.3200	.03	.03	.04	.04	.04
5.5200	.04	.04	.05	.05	.05
5.7200	.05	.05	.06	.06	.06
5.9200	.06	.06	.07	.07	.07
6.1200	.07	.07	.08	.08	.08
6.3200	.08	.09	.09	.09	.09
6.5200	.09	.10	.10	.10	.10
6.7200	.10	.11	.11	.11	.11
6.9200	.12	.12	.12	.12	.13
7.1200	.13	.13	.13	.13	.14
7.3200	.14	.14	.14	.15	.15
7.5200	.15	.15	.16	.16	.16
7.7200	.16	.17	.17	.17	.17
7.9200	.18	.18	.18	.18	.19
8.1200	.19	.19	.20	.20	.21
8.3200	.22	.22	.23	.23	.24
8.5200	.24	.25	.26	.26	.27
8.7200	.28	.28	.29	.30	.30
8.9200	.31	.32	.32	.33	.34
9.1200	.34	.35	.35	.36	.37
9.3200	.37	.38	.38	.39	.39
9.5200	.40	.40	.41	.42	.43
9.7200	.45	.46	.47	.49	.50
9.9200	.52	.53	.55	.56	.58
10.1200	.60	.62	.64	.66	.69
10.3200	.71	.73	.76	.78	.81
10.5200	.83	.86	.89	.93	.96
10.7200	1.00	1.04	1.08	1.12	1.17
10.9200	1.21	1.26	1.31	1.35	1.42

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

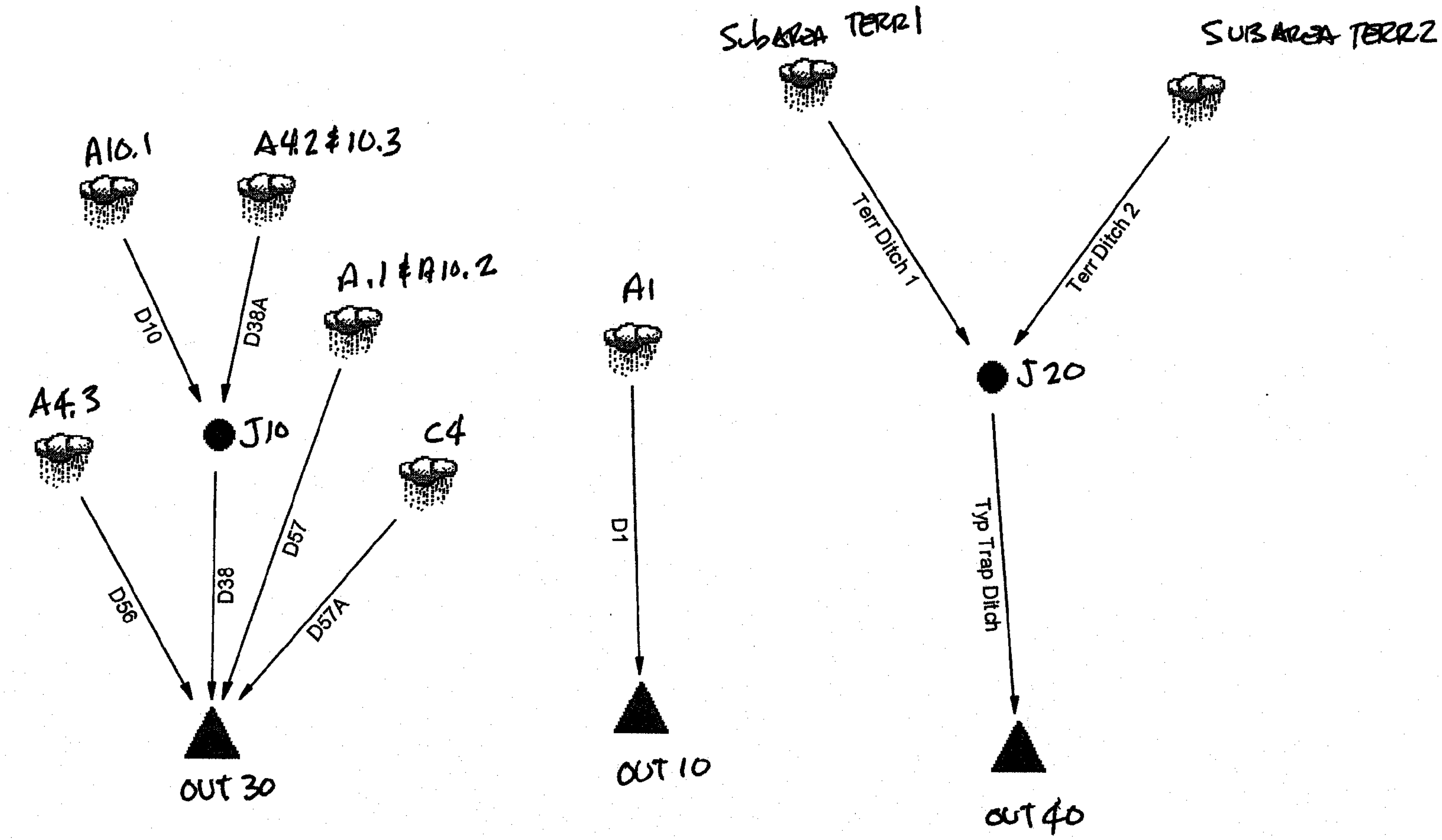
Time hrs					
11.1200	1.49	1.57	1.66	1.76	1.86
11.3200	1.96	2.07	2.19	2.30	2.42
11.5200	2.59	3.25	4.25	5.58	7.87
11.7200	10.22	13.42	17.13	21.83	29.81
11.9200	36.88	38.75	37.04	32.88	23.66
12.1200	15.72	11.01	8.61	7.29	6.41
12.3200	5.85	5.38	4.98	4.65	4.26
12.5200	3.97	3.70	3.45	3.29	3.15
12.7200	3.06	2.97	2.89	2.82	2.73
12.9200	2.66	2.59	2.51	2.44	2.37
13.1200	2.32	2.26	2.22	2.18	2.13
13.3200	2.09	2.05	2.01	1.97	1.92
13.5200	1.89	1.85	1.81	1.78	1.74
13.7200	1.71	1.68	1.65	1.62	1.59
13.9200	1.56	1.53	1.50	1.48	1.45
14.1200	1.43	1.42	1.40	1.39	1.38
14.3200	1.37	1.36	1.35	1.34	1.33
14.5200	1.32	1.31	1.30	1.29	1.28
14.7200	1.27	1.26	1.24	1.23	1.22
14.9200	1.22	1.20	1.19	1.18	1.17
15.1200	1.16	1.15	1.14	1.13	1.12
15.3200	1.11	1.10	1.09	1.08	1.07
15.5200	1.06	1.05	1.03	1.02	1.01
15.7200	1.00	.99	.98	.97	.96
15.9200	.95	.94	.93	.92	.91
16.1200	.90	.90	.89	.89	.88
16.3200	.88	.88	.87	.87	.87
16.5200	.86	.86	.85	.85	.85
16.7200	.84	.84	.84	.83	.83
16.9200	.82	.82	.82	.81	.81
17.1200	.81	.80	.80	.79	.79
17.3200	.79	.78	.78	.77	.77
17.5200	.77	.76	.76	.76	.75
17.7200	.75	.74	.74	.74	.73
17.9200	.73	.73	.72	.72	.71
18.1200	.71	.71	.70	.70	.69
18.3200	.69	.69	.68	.68	.68
18.5200	.67	.67	.66	.66	.66
18.7200	.65	.65	.64	.64	.64
18.9200	.63	.63	.62	.62	.62
19.1200	.61	.61	.61	.60	.60
19.3200	.59	.59	.59	.58	.58
19.5200	.58	.57	.57	.56	.56
19.7200	.56	.55	.55	.54	.54
19.9200	.54	.53	.53	.52	.52
20.1200	.52	.52	.52	.52	.51
20.3200	.51	.51	.51	.51	.51

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
20.5200	.51	.51	.51	.51	.51
20.7200	.51	.51	.50	.50	.50
20.9200	.50	.50	.50	.50	.50
21.1200	.50	.50	.50	.50	.50
21.3200	.50	.49	.49	.49	.49
21.5200	.49	.49	.49	.49	.49
21.7200	.49	.49	.49	.49	.48
21.9200	.48	.48	.48	.48	.48
22.1200	.48	.48	.48	.48	.48
22.3200	.48	.48	.47	.47	.47
22.5200	.47	.47	.47	.47	.47
22.7200	.47	.47	.47	.47	.47
22.9200	.47	.46	.46	.46	.46
23.1200	.46	.46	.46	.46	.46
23.3200	.46	.46	.46	.45	.45
23.5200	.45	.45	.45	.45	.45
23.7200	.45	.45	.45	.45	.45
23.9200	.45	.45	.44	.40	.26
24.1200	.13	.06	.03	.02	.01
24.3200	.00	.00			

Index of Starting Page Numbers for ID Names

ATTACHMENT 2.3 – OFFSITE DITCH FLOW MODEL



OFF SITE AREAS & TERRACE DITCHES

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NETWORK SUMMARY -- LINKS
(UN=Upstream Node; DL=DNstream End of Link; DN=DNstream Node)
(Trun.= HYG Truncation: Blank=None; L=Left; R=Rt; LR=Left & Rt)

DEFAULT Design Storm File,ID = KIF

Storm Tag Name = 25yr

Data Type, File, ID = Synthetic Storm TypeII 24hr
Storm Frequency = 25 yr
Total Rainfall Depth= 5.5000 in
Duration Multiplier = 1
Resulting Duration = 24.0000 hrs
Resulting Start Time= .0000 hrs Step= .1000 hrs End= 24.0000 hrs

ICPM CALCULATION TOLERANCES

Target Convergence= .000 cfs +/-
Max. Iterations = 35 loops
ICPM Time Step = .0400 hrs
Output Time Step = .0400 hrs
ICPM Ending Time = 35.0000 hrs

Link ID	Type		HYG Vol ac-ft	Trun.	Peak Time hrs	Peak Q cfs	End Points
D1	ADD	UN	1.667		12.0800	21.08	SUBAREA A1
		DL	1.667		12.0800	21.08	
		DN	1.667		12.0800	21.08	OUT 10
D10	ADD	UN	.535		11.9600	8.76	SUBAREA A10.1
		DL	.535		11.9600	8.76	
		DN	1.147		11.9200	19.55	JUNC 10
D38	ADD	UN	1.147		11.9200	19.55	JUNC 10
		DL	1.147		11.9200	19.55	
		DN	3.033		11.9600	51.67	OUT 30
D38A	ADD	UN	.612		11.9200	11.50	SUB A4.2&10.3
		DL	.612		11.9200	11.50	
		DN	1.147		11.9200	19.55	JUNC 10
D56	ADD	UN	.290		11.9200	5.43	SUBA4.3
		DL	.290		11.9200	5.43	
		DN	3.033		11.9600	51.67	OUT 30

NETWORK SUMMARY -- LINKS
(UN=Upstream Node; DL=DNstream End of Link; DN=DNstream Node)
(Trun.= HYG Truncation: Blank=None; L=Left; R=Rt; LR=Left & Rt)

Link ID	Type		HYG Vol ac-ft	Trun.	Peak Time hrs	Peak Q cfs	End Points
D57	ADD	UN	.792		11.9200	14.91	SUB A.1+A10.2
		DL	.792		11.9200	14.91	
		DN	3.033		11.9600	51.67	OUT 30
D57A	ADD	UN	.805		12.0000	13.45	SUBC4
		DL	.805		12.0000	13.45	
		DN	3.033		11.9600	51.67	OUT 30
TERR DITCH 1	ADD	UN	.146		11.9200	2.73	SUBAREA TERR 1
		DL	.146		11.9200	2.73	
		DN	.294		11.9200	5.51	JUNC 20
TERR DITCH 2	ADD	UN	.148		11.9200	2.77	SUBAREA TERR 2
		DL	.148		11.9200	2.77	
		DN	.294		11.9200	5.51	JUNC 20
TYP TRAP DITCH	ADD	UN	.294		11.9200	5.51	JUNC 20
		DL	.294		11.9200	5.51	
		DN	.294		11.9200	5.51	OUT 40

File.... C:\Haestad\PPKW\KIF\
Title... Project Date: 5/3/2004
Project Engineer: Daniel R. Smith
Project Title: KIF Lat Exp Interim Operation w/phase2&3 pond
Project Comments:
This model analyzes the cond of the expan during operation, while Phase 2/3 has a pond. The time of concentration is minimized due to the pond.

DESIGN STORMS SUMMARY

Design Storm File,ID = KIF

Storm Tag Name = 2yr

Data Type, File, ID = Synthetic Storm TypeII 24hr
Storm Frequency = 2 yr
Total Rainfall Depth= 3.2500 in
Duration Multiplier = 1
Resulting Duration = 24.0000 hrs
Resulting Start Time= .0000 hrs Step= .1000 hrs End= 24.0000 hrs

Storm Tag Name = 10yr

Data Type, File, ID = Synthetic Storm TypeII 24hr
Storm Frequency = 10 yr
Total Rainfall Depth= 3.6000 in
Duration Multiplier = 1
Resulting Duration = 24.0000 hrs
Resulting Start Time= .0000 hrs Step= .1000 hrs End= 24.0000 hrs

Storm Tag Name = 25yr

Data Type, File, ID = Synthetic Storm TypeII 24hr
Storm Frequency = 25 yr
Total Rainfall Depth= 5.5000 in
Duration Multiplier = 1
Resulting Duration = 24.0000 hrs
Resulting Start Time= .0000 hrs Step= .1000 hrs End= 24.0000 hrs

Storm Tag Name = 100yr

Data Type, File, ID = Synthetic Storm TypeII 24hr
Storm Frequency = 100 yr
Total Rainfall Depth= 6.5000 in
Duration Multiplier = 1
Resulting Duration = 24.0000 hrs
Resulting Start Time= .0000 hrs Step= .1000 hrs End= 24.0000 hrs

CUMULATIVE RAINFALL DEPTHS (in)
Output Time increment = .1000 hrs
Time on left represents time for first value in each row.

Time hrs					
.0000	.0000	.0056	.0111	.0168	.0224
.5000	.0282	.0340	.0399	.0458	.0518
1.0000	.0578	.0639	.0700	.0762	.0824
1.5000	.0887	.0950	.1015	.1079	.1145
2.0000	.1210	.1277	.1343	.1411	.1478
2.5000	.1547	.1616	.1686	.1756	.1827
3.0000	.1898	.1970	.2042	.2115	.2188
3.5000	.2262	.2336	.2412	.2487	.2564
4.0000	.2640	.2718	.2796	.2876	.2957
4.5000	.3039	.3122	.3206	.3291	.3378
5.0000	.3465	.3554	.3643	.3734	.3826
5.5000	.3919	.4013	.4108	.4204	.4302
6.0000	.4400	.4500	.4600	.4702	.4805
6.5000	.4909	.5014	.5120	.5227	.5336
7.0000	.5445	.5556	.5667	.5780	.5894
7.5000	.6009	.6125	.6242	.6360	.6480
8.0000	.6600	.6724	.6853	.6988	.7128
8.5000	.7274	.7425	.7582	.7744	.7912
9.0000	.8085	.8261	.8437	.8613	.8789
9.5000	.8965	.9145	.9335	.9533	.9739
10.0000	.9955	1.0182	1.0421	1.0674	1.0941
10.5000	1.1220	1.1517	1.1836	1.2177	1.2540
11.0000	1.2925	1.3347	1.3823	1.4351	1.4931
11.5000	1.5565	1.6876	1.9490	2.3693	3.1232
12.0000	3.6465	3.7508	3.8425	3.9217	3.9884
12.5000	4.0425	4.0889	4.1325	4.1732	4.2110
13.0000	4.2460	4.2788	4.3100	4.3397	4.3679
13.5000	4.3945	4.4198	4.4440	4.4671	4.4891
14.0000	4.5100	4.5302	4.5499	4.5693	4.5883
14.5000	4.6070	4.6252	4.6430	4.6605	4.6776
15.0000	4.6943	4.7106	4.7265	4.7420	4.7572
15.5000	4.7720	4.7863	4.8003	4.8139	4.8272
16.0000	4.8400	4.8526	4.8650	4.8773	4.8895
16.5000	4.9015	4.9134	4.9252	4.9368	4.9483
17.0000	4.9596	4.9708	4.9819	4.9928	5.0036
17.5000	5.0143	5.0248	5.0352	5.0454	5.0555
18.0000	5.0655	5.0753	5.0850	5.0946	5.1040
18.5000	5.1133	5.1224	5.1314	5.1403	5.1490
19.0000	5.1576	5.1661	5.1744	5.1826	5.1906
19.5000	5.1985	5.2063	5.2139	5.2214	5.2288
20.0000	5.2360	5.2432	5.2502	5.2573	5.2644
20.5000	5.2714	5.2784	5.2854	5.2923	5.2993
21.0000	5.3061	5.3130	5.3198	5.3266	5.3334
21.5000	5.3402	5.3469	5.3536	5.3602	5.3669
22.0000	5.3735	5.3801	5.3866	5.3932	5.3997
22.5000	5.4062	5.4126	5.4190	5.4254	5.4318

CUMULATIVE RAINFALL DEPTHS (in)
Output Time increment = .1000 hrs
Time on left represents time for first value in each row.

Time hrs					
23.0000	5.4381	5.4445	5.4507	5.4570	5.4632
23.5000	5.4694	5.4756	5.4817	5.4878	5.4940
24.0000	5.5000				

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP PHASE2_OFFSITE AREAS & TERRACE DITCHES_A.PPW

::
TIME OF CONCENTRATION CALCULATOR
::

Segment #1: Tc: User Defined

Segment #1 Time: .0800 hrs

=========================
Total Tc: .0800 hrs

Calculated Tc < Min.Tc:
Use Minimum Tc...
Use Tc = .0833 hrs
=========================

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP PHASE2_OFFSITE AREAS & TERRACE DITCHES_A.PPW

Tc Equations used...

==== User Defined ====

Tc = Value entered by user

Where: Tc = Time of concentration

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP PHASE2_OFFSITE AREAS & TERRACE DITCHES_A.PPW

TIME OF CONCENTRATION CALCULATOR

Segment #1: Tc: User Defined

Segment #1 Time: .0800 hrs

Total Tc: .0800 hrs

Calculated Tc < Min.Tc:
Use Minimum Tc...
Use Tc = .0833 hrs

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP PHASE2_OFFSITE AREAS & TERRACE DITCHES_A.PPW

Tc Equations used...

==== User Defined ====

Tc = Value entered by user

Where: Tc = Time of concentration

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP PHASE2_OFFSITE AREAS & TERRACE DITCHES_A.PPW

::
TIME OF CONCENTRATION CALCULATOR
::

Segment #1: Tc: User Defined

Segment #1 Time: .0800 hrs

========================
Total Tc: .0800 hrs

Calculated Tc < Min.Tc:
Use Minimum Tc...
Use Tc = .0833 hrs
========================

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP PHASE2_OFFSITE AREAS & TERRACE DITCHES_A.PPW

Tc Equations used...

==== User Defined ====

Tc = Value entered by user

Where: Tc = Time of concentration

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP PHASE2_OFFSITE AREAS & TERRACE DITCHES_A.PPW

::
TIME OF CONCENTRATION CALCULATOR
::

Segment #1: Tc: User Defined

Segment #1 Time: .3300 hrs

========================
Total Tc: .3300 hrs
========================

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP PHASE2_OFFSITE AREAS & TERRACE DITCHES_A.PPW

Tc Equations used...

==== User Defined ====

Tc = Value entered by user

Where: Tc = Time of concentration

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP PHASE2_OFFSITE AREAS & TERRACE DITCHES_A.PPW

::
TIME OF CONCENTRATION CALCULATOR
::

Segment #1: Tc: User Defined

Segment #1 Time: .1500 hrs

========================
Total Tc: .1500 hrs
========================

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP PHASE2_OFFSITE AREAS & TERRACE DITCHES_A.PPW

Tc Equations used...

==== User Defined ==

Tc = Value entered by user

Where: Tc = Time of concentration

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP PHASE2_OFFSITE AREAS & TERRACE DITCHES_A.PPW

TIME OF CONCENTRATION CALCULATOR

Segment #1: Tc: TR-55 Sheet

Mannings n	.0240	
Hydraulic Length	100.00	ft
2yr, 24hr P	3.2500	in
Slope	.330000	ft/ft
Avg.Velocity	2.28	ft/sec

Segment #1 Time: .0122 hrs

Segment #2: Tc: TR-55 Channel

Flow Area	3.5000	sq.ft
Wetted Perimeter	12.75	ft
Hydraulic Radius	.27	ft
Slope	.005000	ft/ft
Mannings n	.0350	
Hydraulic Length	300.00	ft
Avg.Velocity	1.27	ft/sec

Segment #2 Time: .0655 hrs

Total Tc: .0777 hrs

Calculated Tc < Min.Tc:
Use Minimum Tc...
Use Tc = .0833 hrs

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP PHASE2_OFFSITE AREAS & TERRACE DITCHES_A.PPW

Tc Equations used...

==== SCS TR-55 Sheet Flow ====

```
Tc = (.007 * ((n * Lf)**0.8)) / ((P**.5) * (Sf**.4))

Where:  Tc = Time of concentration, hrs
        n  = Mannings n
        Lf = Flow length, ft
        P  = 2yr, 24hr Rain depth, inches
        Sf = Slope, %
```

==== SCS Channel Flow ====

```
R  = Aq / Wp
V  = (1.49 * (R**(2/3)) * (Sf**-0.5)) / n

Tc = (Lf / V) / (3600sec/hr)

Where:  R  = Hydraulic radius
        Aq = Flow area, sq.ft.
        Wp = Wetted perimeter, ft
        V  = Velocity, ft/sec
        Sf = Slope, ft/ft
        n  = Mannings n
        Tc = Time of concentration, hrs
        Lf = Flow length, ft
```

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP PHASE2_OFFSITE AREAS & TERRACE DITCHES_A.PPW

TIME OF CONCENTRATION CALCULATOR

Segment #1: Tc: TR-55 Sheet

Mannings n	.0240	
Hydraulic Length	100.00	ft
2yr, 24hr P	3.2500	in
Slope	.330000	ft/ft
Avg.Velocity	2.28	ft/sec

Segment #1 Time: .0122 hrs

Segment #2: Tc: TR-55 Channel

Flow Area	3.5000	sq.ft
Wetted Perimeter	12.75	ft
Hydraulic Radius	.27	ft
Slope	.005000	ft/ft
Mannings n	.0350	
Hydraulic Length	300.00	ft
Avg.Velocity	1.27	ft/sec

Segment #2 Time: .0655 hrs

Total Tc: .0777 hrs

Calculated Tc < Min.Tc:
Use Minimum Tc...
Use Tc = .0833 hrs

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP PHASE2_OFFSITE AREAS & TERRACE DITCHES_A.PPW

Tc Equations used...

==== SCS TR-55 Sheet Flow ====

```
Tc = (.007 * ((n * Lf)**0.8)) / ((P**.5) * (Sf**.4))

Where:  Tc = Time of concentration, hrs
        n  = Mannings n
        Lf = Flow length, ft
        P  = 2yr, 24hr Rain depth, inches
        Sf = Slope, %
```

==== SCS Channel Flow ====

```
R  = Aq / Wp
V  = (1.49 * (R**(2/3)) * (Sf**-0.5)) / n

Tc = (Lf / V) / (3600sec/hr)

Where:  R  = Hydraulic radius
        Aq = Flow area, sq.ft.
        Wp = Wetted perimeter, ft
        V  = Velocity, ft/sec
        Sf = Slope, ft/ft
        n  = Mannings n
        Tc = Time of concentration, hrs
        Lf = Flow length, ft
```

TIME OF CONCENTRATION CALCULATOR

Segment #1: Tc: User Defined

Segment #1 Time: .1500 hrs

Total Tc: .1500 hrs

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP PHASE2_OFFSITE AREAS & TERRACE DITCHES_A.PPW

Tc Equations used...

==== User Defined ====

Tc = Value entered by user

Where: Tc = Time of concentration

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP PHASE2_OFFSITE AREAS & TERRACE DITCHES_A.PPW

RUNOFF CURVE NUMBER DATA

Soil/Surface Description	CN	Area acres	Impervious Adjustment %C	Impervious Adjustment %UC	Adjusted CN
A4.1	71	1.940			71.00
A10.2	87	1.180			87.00
COMPOSITE AREA & WEIGHTED CN --->		3.120			77.05 (77)

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP PHASE2_OFFSITE AREAS & TERRACE DITCHES_A.PPW

RUNOFF CURVE NUMBER DATA

Soil/Surface Description	CN	Area acres	Impervious Adjustment %C	Impervious Adjustment %UC	Adjusted CN
A4.2	71	2.470			71.00
10.3	87	.270			87.00
COMPOSITE AREA & WEIGHTED CN --->		2.740			72.58 (73)

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP PHASE2_OFFSITE AREAS & TERRACE DITCHES_A.PPW

RUNOFF CURVE NUMBER DATA

Soil/Surface Description	CN	Area acres	Impervious Adjustment %C	Impervious Adjustment %UC	Adjusted CN
A4.3	71	1.390			71.00
COMPOSITE AREA & WEIGHTED CN --->		1.390			71.00 (71)

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP PHASE2_OFFSITE AREAS & TERRACE DITCHES_A.PPW

RUNOFF CURVE NUMBER DATA

Soil/Surface Description	CN	Area acres	Impervious Adjustment %C	Impervious Adjustment %UC	Adjusted CN
A1	71	8.000			71.00
COMPOSITE AREA & WEIGHTED CN --->		8.000			71.00 (71)

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP PHASE2_OFFSITE AREAS & TERRACE DITCHES_A.PPW

RUNOFF CURVE NUMBER DATA

Soil/Surface Description	CN	Area acres	Impervious Adjustment %C	Impervious Adjustment %UC	Adjusted CN
A10.1	87	1.590			87.00
COMPOSITE AREA & WEIGHTED CN --->		1.590			87.00 (87)

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP PHASE2_OFFSITE AREAS & TERRACE DITCHES_A.PPW

RUNOFF CURVE NUMBER DATA

Soil/Surface Description	CN	Area acres	Impervious Adjustment %C	Impervious Adjustment %UC	Adjusted CN
3:1 Slope w/vegetation	71	.700			71.00
COMPOSITE AREA & WEIGHTED CN --->		.700			71.00 (71)

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP PHASE2_OFFSITE AREAS & TERRACE DITCHES_A.PPW

RUNOFF CURVE NUMBER DATA

Soil/Surface Description	CN	Area acres	Impervious Adjustment %C	Impervious Adjustment %UC	Adjusted CN
3:1 Slope vegetated	71	.710			71.00
COMPOSITE AREA & WEIGHTED CN --->		.710			71.00 (71)

File.... C:\Haestad\PPKW\KIF\KIF LAT EXP PHASE2_OFFSITE AREAS & TERRACE DITCHES_A.PPW

RUNOFF CURVE NUMBER DATA

Soil/Surface Description	CN	Area acres	Impervious Adjustment %C	Impervious Adjustment %UC	Adjusted CN
c4	71	3.860			71.00
COMPOSITE AREA & WEIGHTED CN --->		3.860			71.00 (71)

SUMMARY FOR HYDROGRAPH ADDITION
at Node: JUNC 20

HYG Directory: C:\Haestad\PPKW\KIF\

Upstream Link ID	Upstream Node ID	HYG file	HYG ID	HYG tag
TERR DITCH 1	SUBAREA TERR 1		SUBAREA TERR 1	25yr
TERR DITCH 2	SUBAREA TERR 2		SUBAREA TERR 2	25yr

INFLOWS TO: JUNC 20

HYG file	HYG ID	HYG tag	Volume ac-ft	Peak Time hrs	Peak Flow cfs
	SUBAREA TERR 1	25yr	.146	11.9200	2.73
	SUBAREA TERR 2	25yr	.148	11.9200	2.77

TOTAL FLOW INTO: JUNC 20

HYG file	HYG ID	HYG tag	Volume ac-ft	Peak Time hrs	Peak Flow cfs
	JUNC 20	25yr	.294	11.9200	5.51

TOTAL NODE INFLOW...
HYG file =
HYG ID   = JUNC 20
HYG Tag   = 25yr

Peak Discharge = 5.51 cfs
Time to Peak = 11.9200 hrs
HYG Volume = .294 ac-ft

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
9.1600	.00	.00	.00	.00	.00
9.3600	.01	.01	.01	.01	.01
9.5600	.01	.01	.01	.01	.01
9.7600	.01	.02	.02	.02	.02
9.9600	.02	.02	.02	.03	.03
10.1600	.03	.03	.03	.04	.04
10.3600	.04	.04	.05	.05	.05
10.5600	.05	.06	.06	.07	.07
10.7600	.07	.08	.08	.09	.09
10.9600	.10	.10	.11	.12	.12
11.1600	.14	.14	.16	.17	.18
11.3600	.19	.21	.22	.23	.26
11.5600	.40	.51	.72	1.07	1.33
11.7600	1.89	2.38	3.25	4.72	5.51
11.9600	5.17	4.80	3.85	2.05	1.29
12.1600	1.02	.91	.85	.79	.76
12.3600	.70	.66	.62	.56	.53
12.5600	.49	.47	.45	.44	.43
12.7600	.42	.41	.40	.38	.38
12.9600	.36	.35	.35	.34	.33
13.1600	.32	.32	.31	.30	.30
13.3600	.29	.29	.28	.27	.27
13.5600	.26	.26	.26	.25	.25
13.7600	.24	.24	.23	.23	.23
13.9600	.22	.22	.21	.21	.21
14.1600	.21	.20	.20	.20	.20
14.3600	.20	.20	.20	.19	.19
14.5600	.19	.19	.19	.19	.19
14.7600	.18	.18	.18	.18	.18
14.9600	.18	.18	.17	.17	.17
15.1600	.17	.17	.17	.16	.16
15.3600	.16	.16	.16	.16	.16
15.5600	.15	.15	.15	.15	.15

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
15.7600	.15	.14	.14	.14	.14
15.9600	.14	.14	.14	.13	.13
16.1600	.13	.13	.13	.13	.13
16.3600	.13	.13	.13	.13	.13
16.5600	.13	.13	.13	.13	.13
16.7600	.12	.12	.12	.12	.12
16.9600	.12	.12	.12	.12	.12
17.1600	.12	.12	.12	.12	.12
17.3600	.12	.12	.12	.12	.11
17.5600	.11	.11	.11	.11	.11
17.7600	.11	.11	.11	.11	.11
17.9600	.11	.11	.11	.11	.11
18.1600	.11	.10	.10	.10	.10
18.3600	.10	.10	.10	.10	.10
18.5600	.10	.10	.10	.10	.10
18.7600	.10	.10	.10	.10	.10
18.9600	.09	.09	.09	.09	.09
19.1600	.09	.09	.09	.09	.09
19.3600	.09	.09	.09	.09	.09
19.5600	.09	.08	.08	.08	.08
19.7600	.08	.08	.08	.08	.08
19.9600	.08	.08	.08	.08	.08
20.1600	.08	.08	.08	.08	.08
20.3600	.08	.08	.08	.08	.08
20.5600	.08	.08	.08	.08	.08
20.7600	.08	.08	.08	.08	.08
20.9600	.08	.08	.08	.08	.08
21.1600	.08	.08	.08	.08	.08
21.3600	.07	.07	.07	.07	.07
21.5600	.07	.07	.07	.07	.07
21.7600	.07	.07	.07	.07	.07
21.9600	.07	.07	.07	.07	.07
22.1600	.07	.07	.07	.07	.07
22.3600	.07	.07	.07	.07	.07
22.5600	.07	.07	.07	.07	.07
22.7600	.07	.07	.07	.07	.07
22.9600	.07	.07	.07	.07	.07
23.1600	.07	.07	.07	.07	.07
23.3600	.07	.07	.07	.07	.07
23.5600	.07	.07	.07	.07	.07
23.7600	.07	.07	.07	.07	.07
23.9600	.07	.07	.05	.02	.01
24.1600	.00				

SUMMARY FOR HYDROGRAPH ADDITION
at Node: OUT 10

HYG Directory: C:\Haestad\PPKW\KIF\

Upstream Link ID	Upstream Node ID	HYG file	HYG ID	HYG tag
D1	SUBAREA A1		SUBAREA A1	25yr

INFLOWS TO: OUT 10

HYG file	HYG ID	HYG tag	Volume ac-ft	Peak Time hrs	Peak Flow cfs
	SUBAREA A1	25yr	1.667	12.0800	21.08

TOTAL FLOW INTO: OUT 10

HYG file	HYG ID	HYG tag	Volume ac-ft	Peak Time hrs	Peak Flow cfs
	OUT 10	25yr	1.667	12.0800	21.08

TOTAL NODE INFLOW...
HYG file =
HYG ID = OUT 10
HYG Tag = 25yr

Peak Discharge =	21.08 cfs
Time to Peak =	12.0800 hrs
HYG Volume =	1.667 ac-ft

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
9.1600	.00	.00	.00	.00	.01
9.3600	.01	.01	.02	.02	.03
9.5600	.03	.04	.04	.05	.05
9.7600	.06	.06	.07	.07	.08
9.9600	.09	.09	.10	.11	.12
10.1600	.13	.13	.14	.15	.16
10.3600	.18	.19	.20	.21	.22
10.5600	.24	.25	.27	.28	.30
10.7600	.32	.34	.36	.38	.40
10.9600	.43	.45	.48	.51	.54
11.1600	.57	.61	.65	.69	.74
11.3600	.80	.85	.91	.98	1.06
11.5600	1.17	1.35	1.64	2.08	2.72
11.7600	3.62	4.83	6.47	8.66	11.51
11.9600	14.71	17.72	19.97	21.08	20.83
12.1600	19.35	17.11	14.63	12.31	10.32
12.3600	8.83	7.67	6.75	5.98	5.35
12.5600	4.82	4.36	3.98	3.65	3.37
12.7600	3.15	2.96	2.81	2.67	2.56
12.9600	2.45	2.36	2.28	2.21	2.15
13.1600	2.09	2.03	1.98	1.93	1.89
13.3600	1.85	1.81	1.77	1.74	1.70
13.5600	1.67	1.63	1.60	1.57	1.54
13.7600	1.51	1.48	1.45	1.43	1.40
13.9600	1.38	1.35	1.33	1.30	1.28
14.1600	1.26	1.24	1.22	1.21	1.19
14.3600	1.18	1.17	1.16	1.15	1.14
14.5600	1.13	1.12	1.11	1.10	1.10
14.7600	1.09	1.08	1.07	1.06	1.05
14.9600	1.04	1.04	1.03	1.02	1.01
15.1600	1.00	.99	.99	.98	.97
15.3600	.96	.95	.94	.93	.93
15.5600	.92	.91	.90	.89	.88

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .0400 hrs
Time on left represents time for first value in each row.

Time hrs					
15.7600	.87	.86	.86	.85	.84
15.9600	.83	.82	.81	.80	.79
16.1600	.79	.78	.77	.77	.76
16.3600	.76	.75	.75	.75	.74
16.5600	.74	.74	.73	.73	.73
16.7600	.72	.72	.72	.71	.71
16.9600	.71	.71	.70	.70	.70
17.1600	.69	.69	.69	.68	.68
17.3600	.68	.67	.67	.67	.67
17.5600	.66	.66	.66	.65	.65
17.7600	.65	.64	.64	.64	.63
17.9600	.63	.63	.62	.62	.62
18.1600	.61	.61	.61	.61	.60
18.3600	.60	.60	.59	.59	.59
18.5600	.58	.58	.58	.57	.57
18.7600	.57	.56	.56	.56	.55
18.9600	.55	.55	.54	.54	.54
19.1600	.53	.53	.53	.52	.52
19.3600	.52	.51	.51	.51	.50
19.5600	.50	.50	.50	.49	.49
19.7600	.49	.48	.48	.48	.47
19.9600	.47	.47	.46	.46	.46
20.1600	.45	.45	.45	.45	.45
20.3600	.44	.44	.44	.44	.44
20.5600	.44	.44	.44	.44	.44
20.7600	.44	.44	.44	.43	.43
20.9600	.43	.43	.43	.43	.43
21.1600	.43	.43	.43	.43	.43
21.3600	.43	.43	.43	.43	.42
21.5600	.42	.42	.42	.42	.42
21.7600	.42	.42	.42	.42	.42
21.9600	.42	.42	.42	.42	.42
22.1600	.42	.41	.41	.41	.41
22.3600	.41	.41	.41	.41	.41
22.5600	.41	.41	.41	.41	.41
22.7600	.41	.41	.40	.40	.40
22.9600	.40	.40	.40	.40	.40
23.1600	.40	.40	.40	.40	.40
23.3600	.40	.40	.40	.39	.39
23.5600	.39	.39	.39	.39	.39
23.7600	.39	.39	.39	.39	.39
23.9600	.39	.38	.38	.36	.33
24.1600	.29	.24	.19	.14	.11
24.3600	.08	.06	.04	.03	.02
24.5600	.02	.01	.01	.01	.00
24.7600	.00	.00	.00	.00	.00

Index of Starting Page Numbers for ID Names

APPENDIX A – DITCH HYDRAULIC DESIGN

Attachment 3

PARSONS	CLIENT NAME: TVA				JOB NO.: 55090501
	PROJECT NAME: KINGSTON-DREDGE CELL				
STANDARD CALCULATION SHEET	SUBJECT: DITCH DESIGN				CALC NO.:
	REVISION	0	1	2	3
	ORIGINATOR:	WPT			Page 1
	REVIEWER:	DW			of
	DATE:	6/9/04			

REFERENCES

1. DRAWINGS
   10W425-34E (DITCH NETWORK PLAN AND DRAINAGE AREAS)
   10W425-76 (DRAINAGE PLAN & SCHEDULE)
   10W425-71 (DITCH DETAILS)

2. ATTACHMENTS 2.2 AND 2.3 (DITCH FLOWS AND DITCH SIZING (DITCH CLASS 1 & TERRACE DITCHES)
3. "DESIGN CHARTS FOR OPEN CHANNEL FLOW" HYDRAULIC DESIGN SERIES NO. 3 - FEDERAL HIGHWAY ADMIN) SEE APPENDIX A FOR EXCERPTS
4. "DESIGN OF STABLE CHANNELS WITH FLEXIBLE LININGS" HYDRAULIC ENGR. CIRCULAR NO. 15 - FEDERAL HIGHWAY ADMIN) SEE APPENDIX B FOR EXCERPTS
5. "DESIGN OF ROCK CHUTES" - BY K.M. ROBINSON, C.E. RICE, K.C. KADAVY, AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS, 1998 SEE APPENDIX C FOR EXCERPTS.

PARSONS	CLIENT NAME: TVA				JOB NO.:
	PROJECT NAME: KINGSTON-DREDGE CELL				
STANDARD CALCULATION SHEET	SUBJECT: DITCH DESIGN				CALC NO.:
	REVISION	0	1	2	3
	ORIGINATOR:	WPT			Page 2 of
	REVIEWER:	[illegible]			
	DATE:	6/9/04			

DESIGN CRITERIA

(1) SIZE DITCHES FOR 25-YR STORM FLOWS -
(2) CONFIRM NO OVERTOPPING FOR 100-YR STORM FLOWS
(3) PROVIDE EROSION PROTECTION FOR 25-YR STORM -

PARSONS	CLIENT NAME: TVA FOSSIL ENGINEERING PROJECT NAME: KINGSTON PLANT-DREDGE CELL				JOB NO.: SS090501
STANDARD CALCULATION SHEET	SUBJECT: DITCH DESIGN-HYDRAULICS				CALC NO.:
	REVISION	0	1	2	3
	ORIGINATOR:	WPT			
	REVIEWER:	DM			
	DATE:	6/9/04			

Page 3 of

DITCH CLASS 1: n=.03
SEE ATTACHMENTS 2.2 and 2.3

TERRACE DITCHES; n=.03
SEE ATTACHMENTS 2.2 and 2.3

DITCH CLASSES 2 THRU 8 IN TABLE I

TABLE I

DESIGN CLASS	n	SLOPE	FLOW Q_{25} (CFS)	BASIS* DITCH	CHART PAGE	BOTT WIDTH	FLOW DEPTH	VELOCITY FPS)	DITCH DEPTH
2	.03	.01	39	D7	A-3	5'	1.2'	4.5	2.5
3	.03	.005	37	D60	A-4	10'	1.1	3.0	3.5
4	.03	.0055	171	D2	A-5	20	1.6'	4.2	3.5
5	.03	.0005	370	D62	A-5	40	3.3	2.0	4.0
6	.03	.33	39	D34	A-3	5	0.4	16.0	2.5
7	.042	.15175	118	D19	A-4	10'	0.8'	14.0	4.0
8	.03	.0025	71	D2	A-3	5'	1.9'	4.0	3.5'

*

THIS IS A DESIGN RECORD

EP3-2 12/96

Attachment 3

PARSONS	CLIENT NAME: TVA				JOB NO.: 55090501
	PROJECT NAME: KINGSTON - DREDGE CELL				
STANDARD CALCULATION SHEET	SUBJECT: DITCH DESIGN - EROSION PROT.				CALC NO.:
	REVISION	0	1	2	3
	ORIGINATOR:	WPTaylor			
	REVIEWER:	DBS			
	DATE:	6/9/04			

See Chart A-1 - Ditch Bott = 10'

for Q = 117.7 cfs on Ditch D19
S = .15
V = 14 fps & d = 0.8' ≤ 0.8' allow ~ OK

per Chart on sht B-2 ∴
for D_{50} = 1.5' & S = 0.15
Max depth = 0.8' for erosion control

for Q = 70 cfs - Ditch D20, S = 0.15
V = 12.5 fps & d = 0.55' < 0.8' with D_{50} = 1.5'
Use 10' Ditch

for Q = 59.5 cfs on Ditch D4
S = .175
W = 10' - See Chart on sht A-4
V = 12 fps & d = 0.48' < 0.7 with D_{50} = 1.0'
per Chart on sht B-2
for D_{50} = 1.5' & S = 0.175
max depth = 0.7 for erosion control

See Chart on sht B-2
for D_{50} = 1.00 & S = .15, d_{max} allow = 0.54

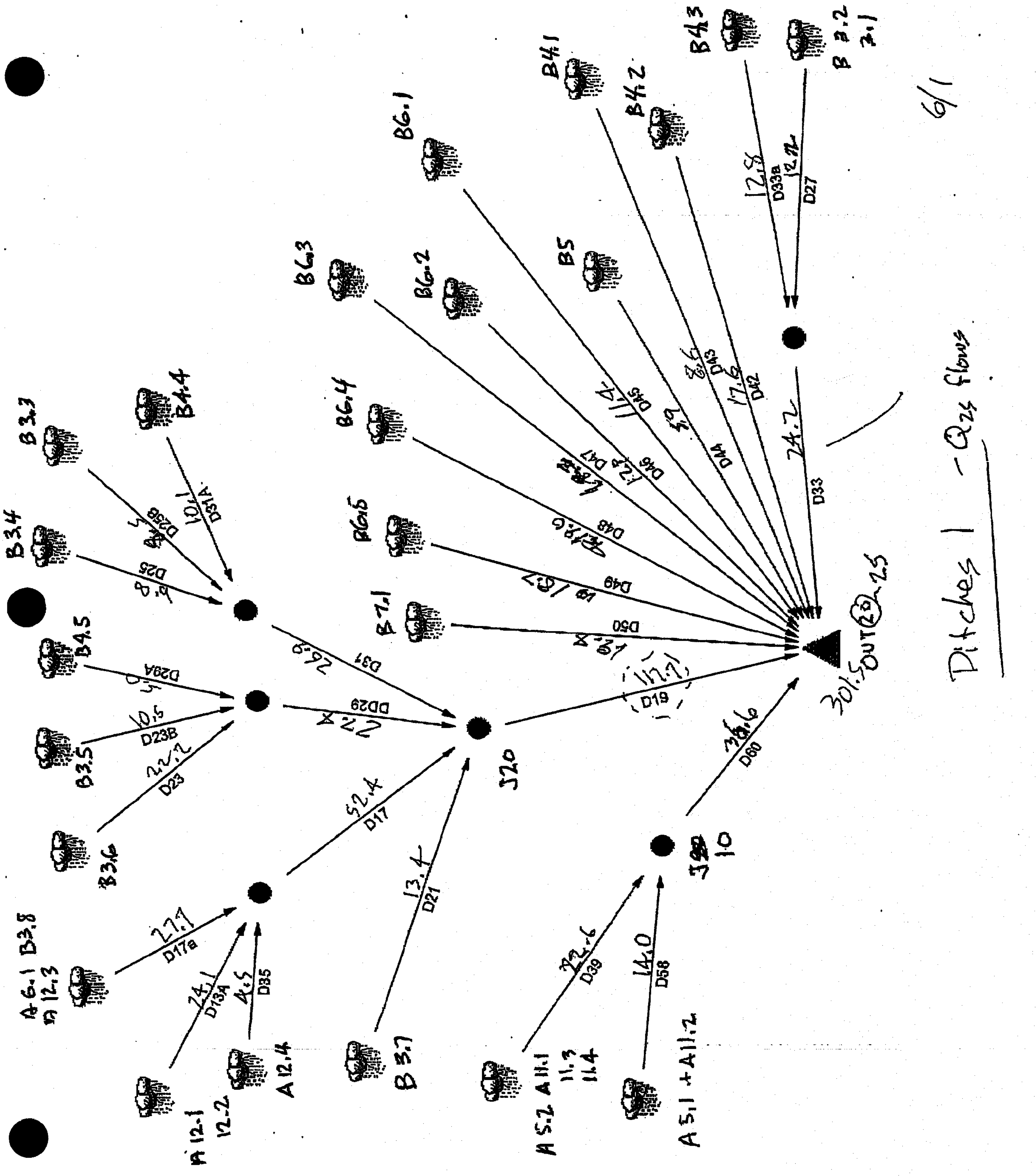
for D_{50} = 1.00 & S = .175; d_{max} allow = 0.46'

Conclusions - D_{50} = 1.00' Not sufficient -
Use D_{50} = 1.50' ~ could possibly use D_{50} = 1.25'

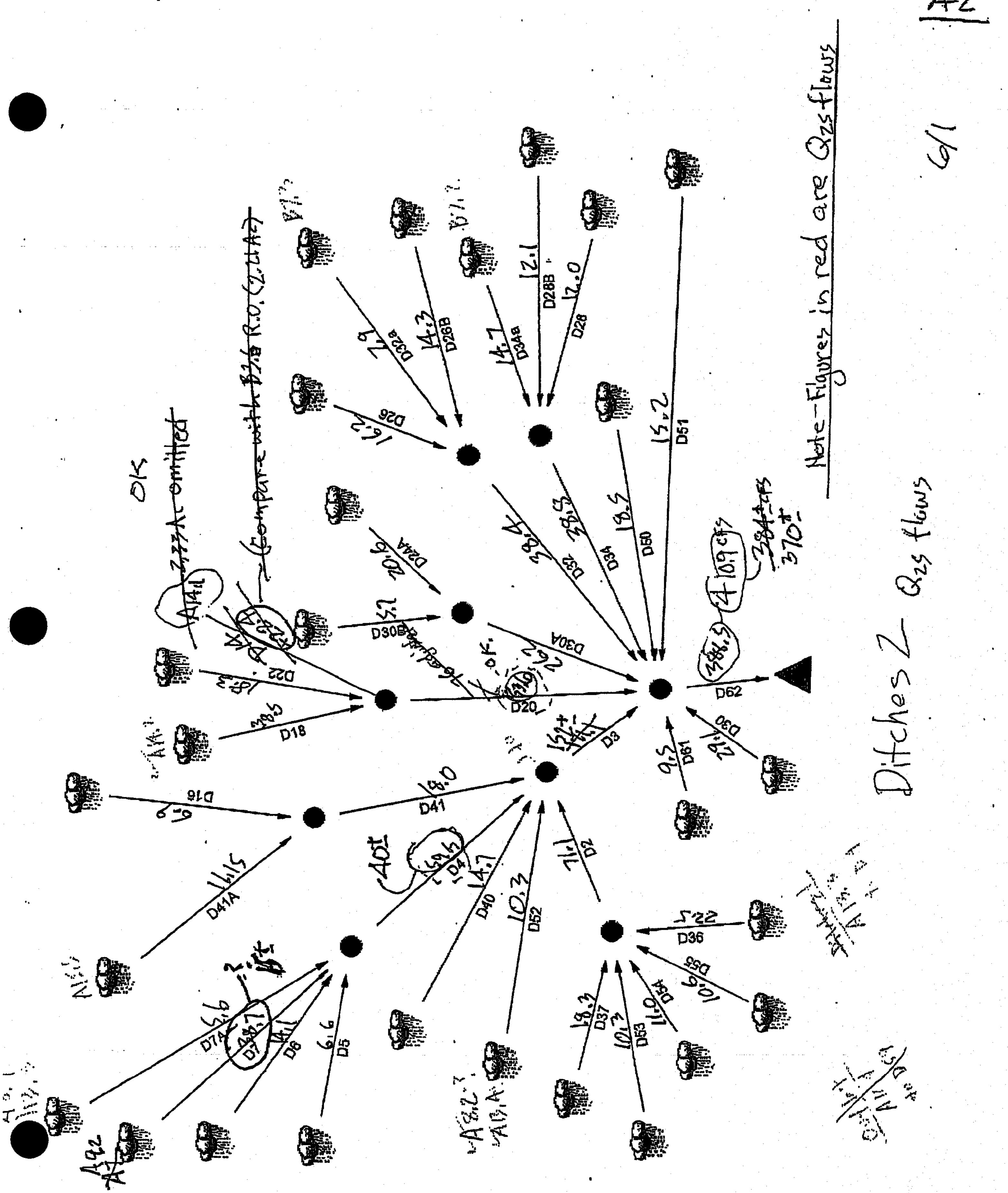
THIS IS A DESIGN RECORD

EPS-2 12/96

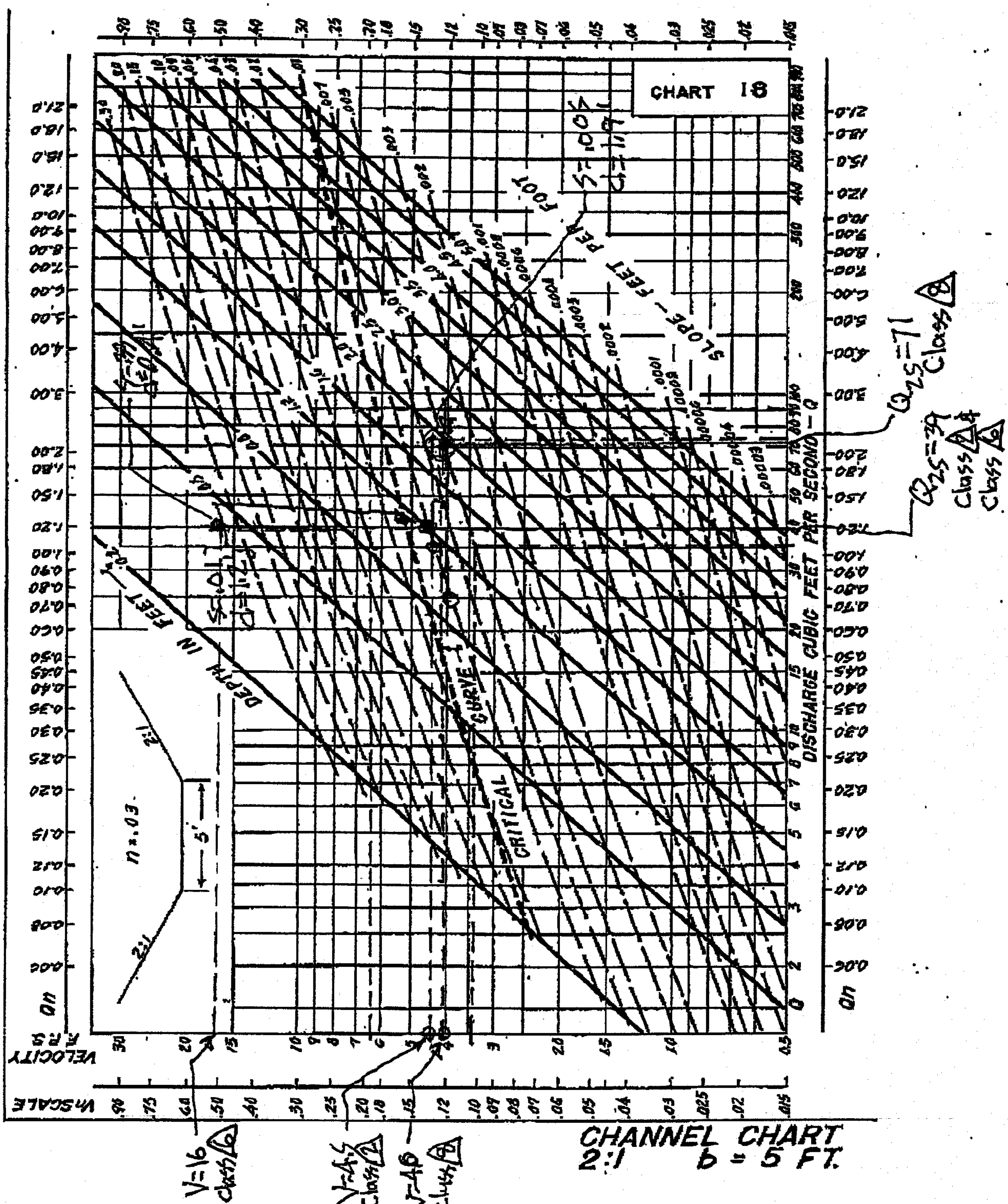
Appendix A A-1



A2


Note-Figures in red are Q25 flows
Ditches Z Q25 flows
D62
D3
D20
D30A
D30B
D22
D18
D16
D41
D41A
D4
D40
D52
D2
D36
D55
D54
D53
D37
D7A
D7
D6
D5
D26
D32a
D26B
D34a
D28B
D28
D51
D50
D34
D32
D24A
D30
D61
Compare with B1.6 R.O. (2,LLA?)
2.77 Ac omitted
OK

A-3



05/24/2004 MON 11:49 FAX 770 822 5990 PRECISION PLANNING 005/016

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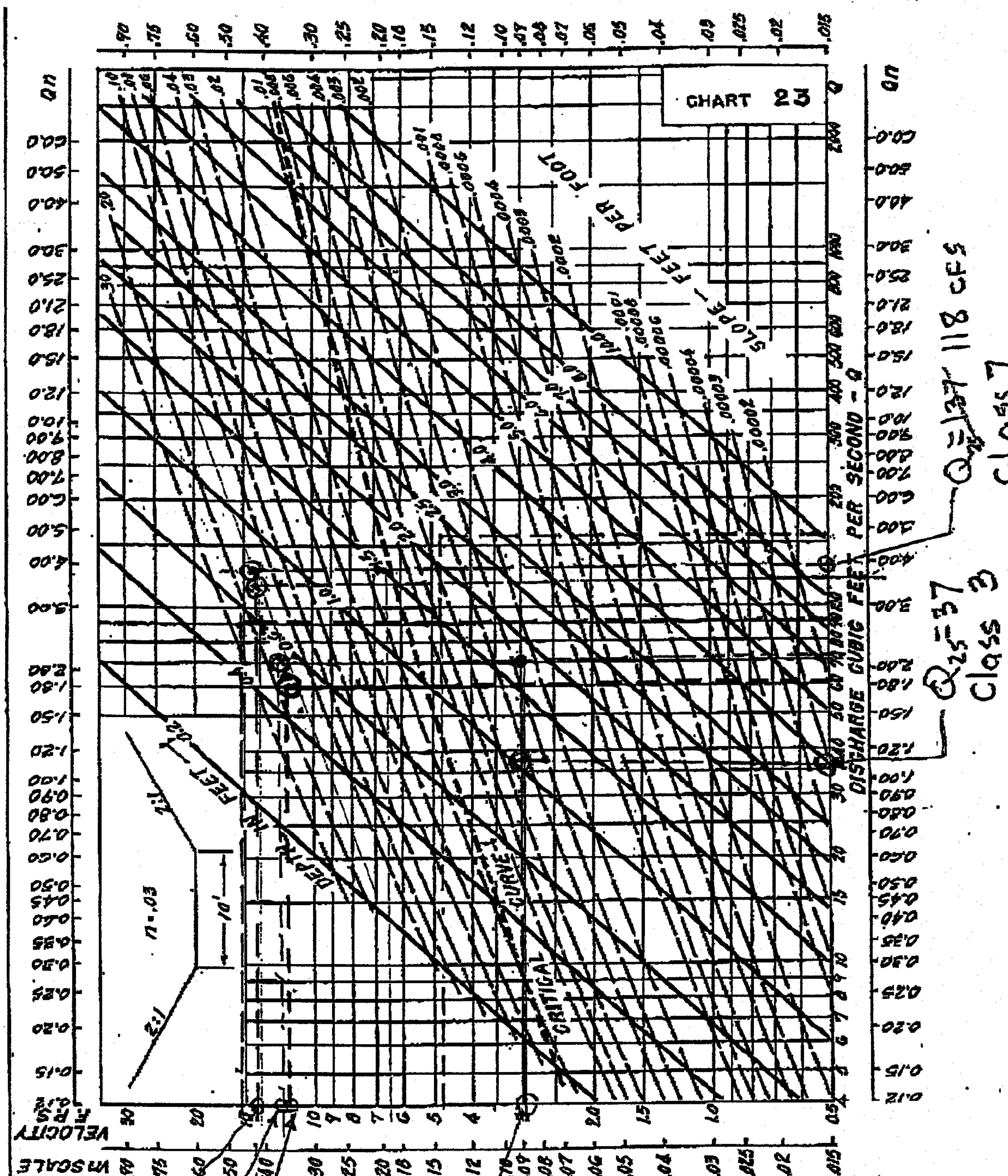
A-4



CHANNEL CHART
2:1 b = 10 FT.

$V_{D14} = 14$
$V_{D20} = 12.5$
$V_{D4} = 12.0$ $V = \frac{.42}{.042} = 10$ fps

V = 3.0 class 3

31

A-5

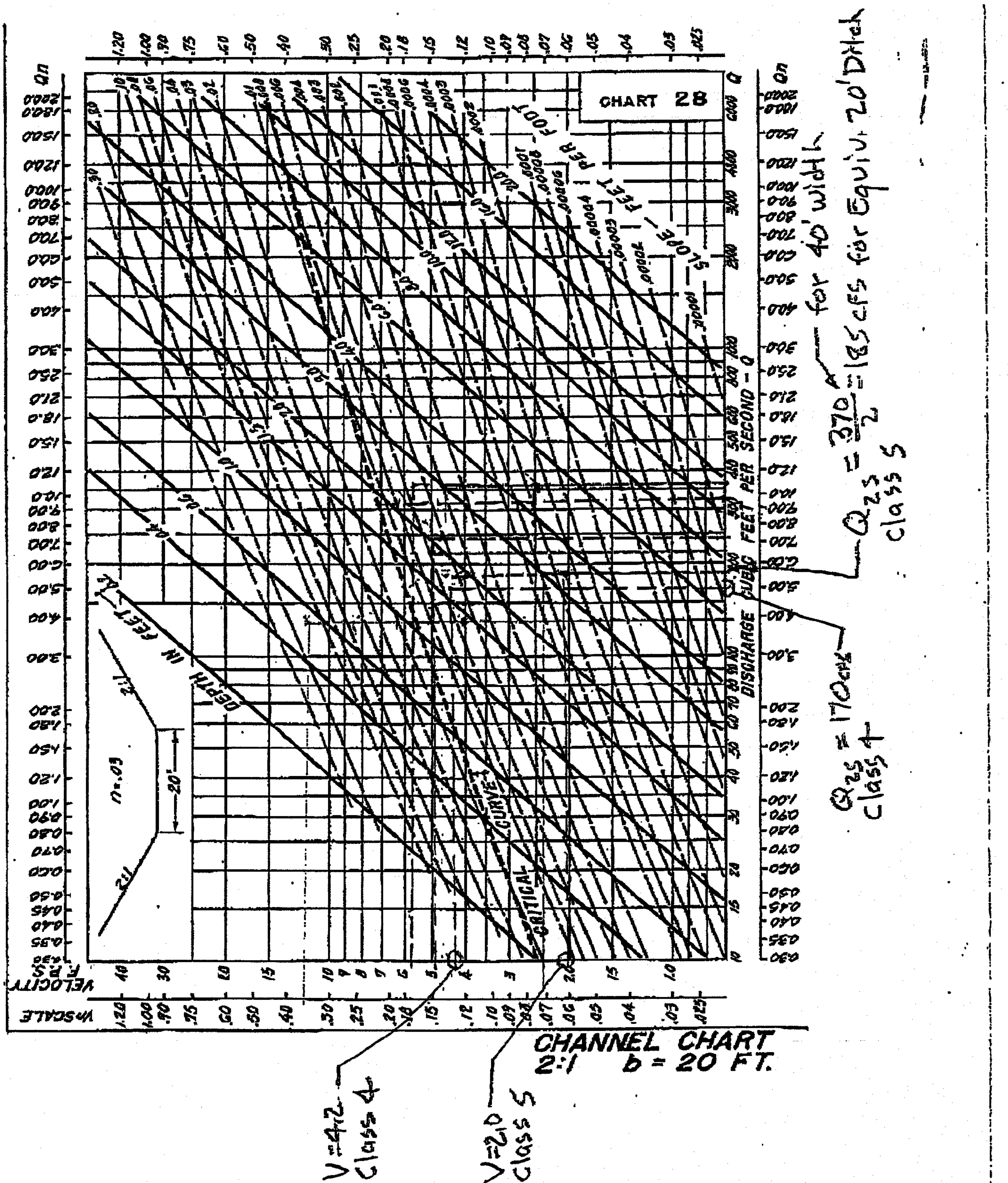


CHART 28
CHANNEL CHART
2:1 b = 20 FT.
VELOCITY F.P.S.
Vn SCALE
Qn
DISCHARGE CUBIC FEET PER SECOND - Q
DEPTH IN FEET
SLOPE - FEET PER FOOT
CRITICAL CURVE
n=.03
20'
2:1
$Q_{25} = \frac{370}{2} = 185$ cfs for Equiv. 20' Ditch
370 for 40' width
class 5
Q_{25} = 170 cfs
class 4
V=4.2
Class 4
V=2.0
Class 5

APPENDIX B – RIPRAP

Appendix B B-1.

PB86-184835

DESIGN OF STABLE CHANNELS WITH FLEXIBLE LININGS, HYDRAULIC ENGINEERING CIRCULAR (HEC) 15

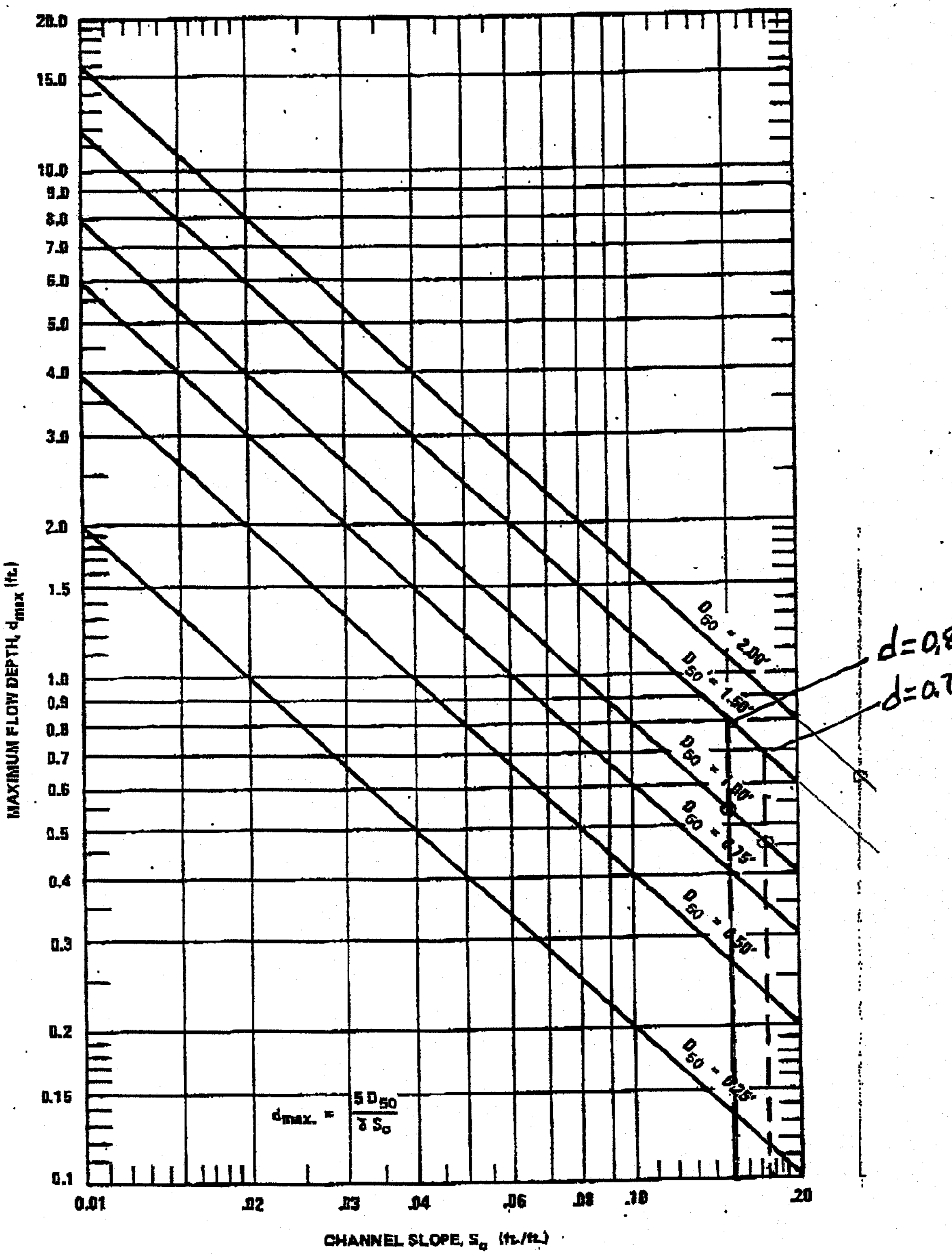
FEDERAL HIGHWAY ADMINISTRATION
WASHINGTON, D.C.

OCT 75

U.S. DEPARTMENT OF COMMERCE
National Technical Information Service
NTIS

B2

Chart 27



MAXIMUM PERMISSIBLE DEPTH OF FLOW (d_{max})
FOR CHANNELS LINED WITH ROCK RIPRAP

APPENDIX C – ROCK CHUTE DESIGN

Appendix C

C-1

DESIGN OF ROCK CHUTES

K. M. Robinson, C. E. Rice, K. C. Kadavy

ABSTRACT. *Rock chute design information is consolidated from several sources to provide a comprehensive design tool. The rock slope stability, boundary roughness, and outlet stability of rock chutes are each discussed. Tests were performed in three rectangular flumes and in two full size structures. Angular riprap with a median stone size ranging from 15 to 278 mm was examined on rock chutes with slopes ranging from 2 to 40%. The typical mode of channel failure is described. An empirical prediction equation is presented relating the highest stable discharge on a rock chute to the median stone size and the bed slope. A boundary roughness relationship is also presented that relates the Manning roughness coefficient to the median stone size and bed slope. These tests also suggest that the riprap size required for stability on the slope will remain stable in the outlet reach even with minimal tailwater. This article contains information needed to perform a rock chute design.*

Keywords. *Rock chutes, Riprap, Channel design, Hydraulics, Stability, Roughness, Grade control.*

Rock chutes or loose-riprap-lined channels are used to safely convey water to a lower elevation. These structures provide an alternative method of protecting the soil surface to maintain a stable slope and to dissipate a portion of the flow energy. Watershed management applications for this type of structure are numerous such as channel stabilization, grade control, and embankment overtopping. Depending on the availability and quality of accessible rock materials, rock chutes may offer economic advantages over more traditional structures. Flow cascading down a rock chute is visually pleasing, and these structures offer aesthetic advantages for sensitive locations. Construction of these chutes can be performed with unskilled labor and a comparatively small amount of equipment. A typical rock chute profile is shown in figure 1.

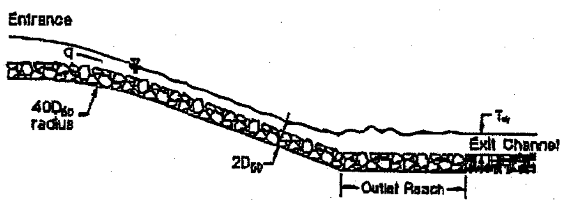


Figure 1—Typical rock chute profile.

Article was submitted for publication in September 1997; reviewed and approved for publication by the Soil & Water Div. Of ASAE in March 1998. Presented as ASAE Paper No. 97-2062.

The authors are **Kerry M. Robinson**, P.E., ***ASAE Member Engineer***, Research Hydraulic Engineer, **Charles E. Rice**, P.E., ***ASAE Member Engineer***, Research Hydraulic Engineer, and **Kem C. Kadavy**, P.E., ***ASAE Member Engineer***, Agricultural Engineer, USDA ARS, Stillwater, OK. **Corresponding author:** Kerry M. Robinson, 1301 N. Western St., Stillwater, OK 74075; tel: (405) 624-4135; fax: (405) 624-4136; e-mail: krob@ag.gov.

Rock chute structures have been the subject of several recent investigations. The objective of this article is to present pertinent information from several sources to provide the designer with a comprehensive design tool.

RELATED WORK

Rock chutes in various forms have been used for many years. Isbash (1936) examined the ability of flowing water to move rocks. The shape of a rock fill cross-section was described while stone of a known size and weight was deposited in flowing water. Isbash developed a relationship describing the minimum velocity necessary to move stones of a known size and specific gravity. Anderson et al. (1970) developed a design procedure for riprap-lined drainage channels by testing rounded stone on relatively flat slopes. Uniformly sized riprap materials remained stable at higher flow rates than non-uniform materials. The non-uniform materials enhanced the protection of the filter material below the rock layer. Wittler and Abt (1990) found that the stone gradation has a significant influence on chute performance. The uniformly sized riprap withstood higher flow rates than non-uniform material of the same D_{50}. The uniform material did fail more suddenly than the non-uniform materials once the slope became unstable.

Abt et al. (1987) and Abt and Johnson (1991) tested both angular and rounded stone and found that the rounded stone failed at a unit discharge of approximately 40% less than angular shaped stones of the same median stone size. These researchers developed design criteria for median stone sizes between 25 and 152 mm on slopes ranging between 1 and 20%.

Maynord (1988) developed a riprap sizing method for stable open channel flows on slopes of 2% or less. This design method, based on the average local velocity and flow depth, used the D_{30} as the characteristic rock size. The effects of riprap gradation, thickness, and shape were also examined. Maynord (1992) extended this design method to slopes between 2 and 20% for nonimpinging flows. Frizell

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C-2

and Ruff (1995) examined riprap with a D_{50} of 380 mm on 2:1 slopes (horizontal:vertical). These researchers investigated riprap for embankment overtopping protection.

Anderson et al. (1970) developed a relationship for the boundary roughness of rock-lined channels. The Manning roughness was described as a function of the stone size only. Abt et al. (1987) also developed a relationship that predicts the Manning roughness as a function of the bed slope and stone size.

Rock chutes testing performed at the USDA-ARS Hydraulic Engineering Unit is the primary source of information for this report. These tests focused on three specific areas: rock slope stability, roughness, and outlet stability. Robinson et al. (1995) reported an empirical rock slope stability relationship for rock sizes ranging from 15 to 145 mm on slopes of 10 to 40%. This stability relationship predicts rock size as a function of the discharge and channel slope. Robinson et al. (1997) revised this design relationship in an attempt to better represent the data base. Rock chutes were tested to failure in three different flumes as well as full-size prototype structures for slopes of 8 to 40% and median rock sizes up to 278 mm. Rice et al. (1996) examined six design procedures and compared their results for a range of discharges and bed slopes. Rice et al. (1998a) developed empirical relationships to predict the Manning roughness coefficient as a function of stone size and bed slope. These roughness relationships allow calculation of the flow depth in a rock chute. Rice et al. (1998b) conducted tests to examine the rock size necessary to maintain stability of the rock chute outlet.

Riprap Properties

The rock chutes testing described in this article was performed using predominantly angular crushed limestone with a D_{50} of 15 to 278 mm. The rock layers in all tests were $2D_{50}$ thick. The D_{50} is the particle size for which 50% of the material sample is finer. The median stone diameter and the D_{50} are considered equal. Rock used in this study displayed a coefficient of uniformity ($C_u = D_{60}/D_{10}$) of 1.25 to 1.73. The specific gravity of the stones ranged from 2.54 to 2.82. The geometric standard deviation ($\sigma_g = D_{84.1}/D_{50} = D_{50}/D_{15.9}$) ranged from 1.15 to 1.47 with all but one rock sample ranging between 1.31 and 1.47. The length to width ratio (L/B) ranged from 1.98 to 2.36. The geometric stone properties were similar for all rock sizes, and the gradations exhibited by these materials were more uniform than well graded.

Sufficient quantities of each material were sampled to accurately represent each rock size. ASTM (1996) Standard D5519 suggests that a sample size should be large enough to ensure a representative gradation and to provide test results to the desired level of accuracy. The specimen size should be large enough that the addition or loss of the largest stone in the sample will not change the results by more than a specified amount. For this study the largest element in each test material represented 0.7% to 3.1% of the sample weight.

Results and Discussion

Rock Slope Stability

Rock chute stability tests were performed in three separate flumes with widths of 0.76, 1.07, and 1.83 m (2.5, 3.5, and 6.0 ft). Two full size prototype structures were also constructed and tested to failure. These large-scale chutes were constructed with a 2.74-m (9-ft) bottom width and 2:1 side slopes. A total of 38 rock chute stability tests were performed on slopes ranging from 2 to 40% for median rock sizes of 15 to 278 mm. Rock chutes testing was initially limited to slopes between 10 and 40%. However, interest was expressed in slopes below 10%. Eleven tests were conducted on slopes ranging from 2 to 8%. Four of these tests were conducted with bed slopes ranging from 2 to 6% with 2:1 side slopes. Table 1 lists the test results for this study. The tests were performed by introducing a base flow in the rock chute, then increasing the flow incrementally. Orifice plates and air-water differential manometers were used to measure flow in the two smaller models, while Parshall flumes were used to measure flow in the larger models. Rock slope stability was observed at each flow rate, with particular attention directed to stone movement on the slope. The flow rate was increased until the rock chute was judged to be unstable.

Table 1. Test results

Run No.	Flume Width (m)	D_{50} (mm)	Specific Gravity	Geometric Std. Dev.	Coef. of Uniformity	Slope (%)	Max. Stable q ($m^3/s/m$)
1	1.07	15	2.76	1.42	1.65	10	0.00578
2	1.07	15	2.76	1.42	1.65	12.5	0.00529
3	1.07	15	2.76	1.42	1.65	16.7	0.00378
4	1.07	15	2.76	1.42	1.65	22.2	0.00314
5	1.07	33	2.70	1.42	1.65	10	0.0248
6	1.07	33	2.70	1.42	1.65	12.5	0.0235
7	1.07	33	2.70	1.42	1.65	16.7	0.0186
8	1.07	33	2.70	1.42	1.65	22.2	0.0147
9	0.76	46	—	1.15	1.25	40	0.0381
10	1.07	52	2.82	1.46	1.72	10	0.0762
11	1.07	52	2.82	1.46	1.72	12.5	0.0624
12	1.07	52	2.82	1.46	1.72	16.7	0.0578
13	1.07	52	2.82	1.46	1.72	22.2	0.0483
14	0.76	52	2.82	1.46	1.72	40	0.0349
15	1.07	89	2.54	1.41	1.58	10	0.1738
16	1.07	89	2.54	1.41	1.58	12.5	0.1514
17	1.07	89	2.54	1.41	1.58	16.7	0.1596
18	1.07	89	2.54	1.41	1.58	22.2	0.1105
19	1.83	89	2.54	1.41	1.58	12.5	0.1663
20	1.83	89	2.54	1.41	1.58	22.2	0.1003
21	1.83	89	2.54	1.41	1.58	40	0.0865
22	1.83	145	2.55	1.35	1.54	12.5	0.3307
23	1.83	145	2.55	1.35	1.54	22.2	0.2239
24	1.83	145	2.55	1.35	1.54	40	0.1951
25*	2.74	188	2.58	1.47	1.73	16.7	0.4385
26*	2.74	278	2.59	1.31	1.47	33.3	0.6726
27	1.83	188	2.58	1.47	1.73	8	0.7525
28	1.83	188	2.58	1.47	1.73	22.2	0.5416
29	1.83	188	2.58	1.47	1.73	40	0.3279
30	1.07	52	2.82	1.46	1.72	6	0.1858
31	1.07	33	2.70	1.42	1.65	6	0.0892
32	1.07	33	2.70	1.42	1.65	4	0.1830
33	1.07	15	2.76	1.42	1.65	2	0.0427
34	1.83	192	2.61	1.35	1.58	6	1.6258
35*	1.07	52	2.82	1.46	1.72	6	0.2025
36*	1.07	52	2.82	1.46	1.72	4	0.2546
37*	1.07	33	2.70	1.42	1.65	4	0.1096
38*	1.07	33	2.70	1.42	1.65	2	0.2518

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C-3

AN EXCEL PROGRAM TO DESIGN ROCK CHUTES FOR GRADE STABILIZATION

by
Eric A. Lorenz, P.E., Morris N. Lobrecht, P.E., and Kerry M. Robinson, Ph.D., P.E.

Introduction

Chutes, in general, are used to transport water from a higher elevation to a lower elevation in a non-erosive manner. Examples include flow from one waterway to another waterway, flow from a waterway to a drainage ditch, flow from a lake to a channel, etc. Chutes are composed of three parts: a level inlet apron, the chute slope, and a level outlet apron. The chute is assumed to have a uniform cross section throughout. Rock is commonly used to protect the underlying soil from erosion. Specifying the correct rock size and chute thickness are only a small portion of rock chute design. Proper design is very time consuming when several options are considered. This program will reduce design time by selecting the stable median **angular** rock size based on chute geometry and discharge. The output can be used for preparing final plans and field layout. The word angular is shown in bold in this paper and refers to rock that is 50% round and 50% cubical. The equations given in this paper are intended for use with English units. They can be used for cross sections having a trapezoidal, triangular, or rectangular shape. The equations are shown without proof and their verification is left up to the reader.

General Chute Hydraulics

Figure 1 shows a typical rock chute profile and defines various hydraulic properties of chutes in general.

d = depth of the outlet apron below the outlet channel (1-foot suggested minimum), feet
*D_{50} = median **angular** rock size (50% of the sample is finer by weight), inches*
g = acceleration due to gravity, 32.2 ft/sec^2
H_{drop} = height of drop from the weir crest elevation to the outlet channel elevation, feet
H_{ee} = minimum specific energy head corresponding to a given discharge (at critical depth), feet
H_p = static head required to force the discharge through the weir (H_{pe} is the energy head), feet
h_v = velocity head associated with the critical depth, feet
S_{ch} = chute bed slope (1/z), ft./ft.
Tw = tailwater depth in the outlet channel, feet
y_c = critical depth in the chute, feet
y_n = normal depth in the inlet channel, feet
z = horizontal component of the chute slope (z:1)
z_1 = normal depth in the chute slope, feet
z_2 = hydraulic jump height, feet

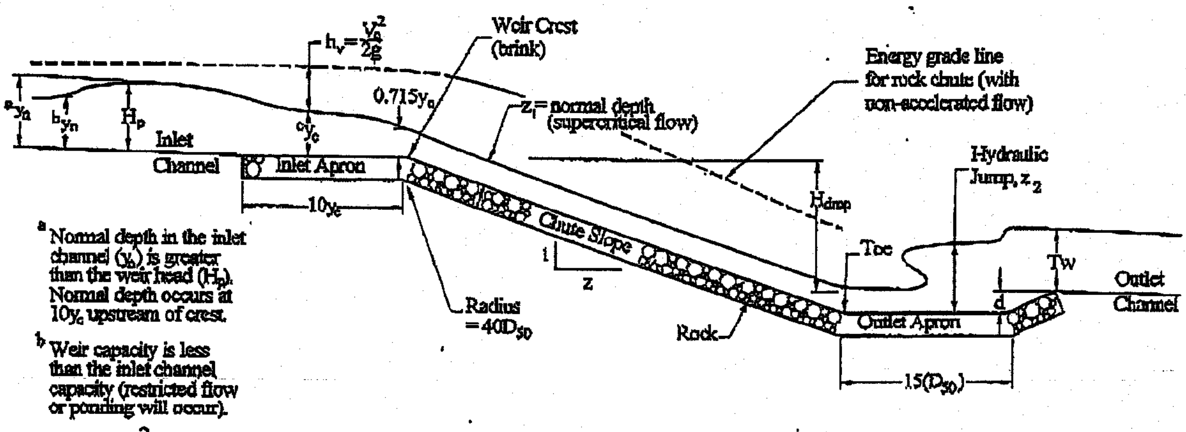

Figure 1 – Typical Rock Chute Profile

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The most important property defining the chute is the weir head (H_p). The H_p determines the amount of flow that will go through the weir entrance (at the crest or brink) and down the chute. The shape of the weir entrance and the velocity of the approach channel affect the weir head. A method to control H_p will be discussed later in this paper. As the water approaches the inlet apron the flow accelerates. Several references define different locations upstream of the weir crest at which accelerated flow begins. The most conservative distance of $10y_c$ was used to set the inlet apron length. Critical depth occurs between $2y_c$ and $4y_c$ upstream of the weir crest. Depth at the weir crest is $0.715y_c$ (brink depth). Whenever the chute slope is steeper than critical slope, normal depth in the chute slope (z_1) is below critical depth resulting in supercritical flow. For rock chutes, the flow will reach normal depth, generally in the middle 1/3 of the slope, and continue down the slope without accelerating (roughness offsets the acceleration due to gravity). As flow reaches the outlet apron (near the toe) it will transition from supercritical flow to subcritical flow in the form of a hydraulic jump. The hydraulic jump height (z_2) varies with the chute slope (thus the velocity) and the chute cross section. The hydraulic jump height will normally be less than the weir head (H_p) for flat chute slopes. As the chute slope increases, z_2 will exceed H_p. Figure 2 illustrates a typical cross section of a rock chute.

m_{ch} = horizontal component of the chute side slope
Bw_{ch} = bottom width of the chute, feet

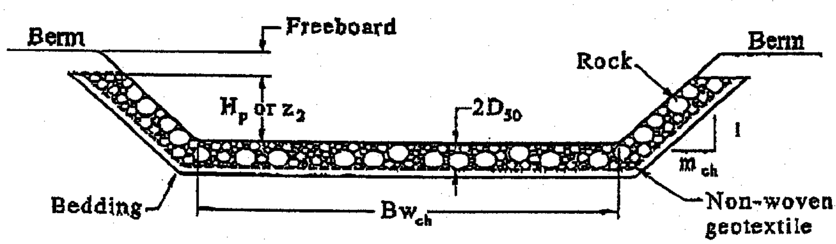


Figure 2 – Typical Rock Chute Cross Section

The height of protection along the side slope shall be the greater of H_p or z_2. The tailwater may be greater than the height of riprap along the side slope in the outlet apron. If good vegetation has been established above the riprap this is adequate to prevent erosion. Problems may occur during long duration discharges from flat watersheds or those below a watershed detention dam. Longer peak flows can be expected to have a greater potential for scouring on the side slopes. Consider placing riprap (or other types of protection) above H_p or z_2 and up to the tailwater depth (or higher) for this case. The hydraulic jump length is given as $15D_{50}$ from the research performed on rock chutes[1]. A rock thickness of $2D_{50}$[1] is recommended in addition to a non-woven geotextile over sand bedding. The geotextile acts as a filter and prevents material under the chute from being pulled up through the rocks. A non-woven geotextile is used because there is less chance of soil particle migration through this material as compared with a woven geotextile. The bedding should prevent migration of fine soil particles that may plug the non-woven geotextile. Also, the bedding provides better contact between the rock and the underlying soil and provides a cushion when the rock is placed. The cushion helps prevent damage to the non-woven geotextile.

Design Approach

The approach for designing rock chutes presented in this paper is given in sequential order (Equations 1 through 16). An example design is presented later to familiarize the reader with the design procedure and

C-5

Rock Chute Design Data

(Version 4.0 - 07/10/00, Based on Design of Rock Chutes by Robinson, Rice, Kadavy, ASAE, 1998)

Project: *Spillway protection* **County:** *Woodbury*
Designer: *Jim Villa* **Checked by:**
Date: *9/27/00* **Date:**

Input Channel Geometry

→ Inlet Channel	→ Chute	→ Outlet Channel
Bw = 20.0 ft.	Bw = 20.0 ft.	Bw = 40.0 ft.
Side slopes = 4.0 (m:1)	Factor of safety = 1.20 (F_s)	Side slopes = 4.0 (m:1)
n-value = 0.035	Side slopes = 4.0 (m:1) → 2.0:1 max.	n-value = 0.045
Bed slope = 0.0060 ft./ft.	Bed slope (5:1) = 0.200 ft./ft. → 2.5:1 max.	Bed slope = 0.0050 ft./ft.
Freeboard = 0.5 ft.	Outlet apron depth, d = 1.0 ft.	Base flow = 0.0 cfs

Design Storm Data (Table 2, NHCP, NRCS Grade Stabilization Structure No. 410)

Drainage area = 450.0 acres   Rainfall = ○ 0 - 3 in. ◉ 3 - 5 in. ○ 5+ in.

Apron elev. — Inlet = 105.0 ft. — Outlet = 99.0 ft. — (H_{drop} = 5 ft.)

Chute capacity = Q5-year
Total capacity = Q10-year
[*Minimum capacity (based on a 5-year, 24-hour storm with a 3 - 5 inch rainfall)*

Q_{high} = 330.0 cfs   High flow storm through chute → Tw (ft.) = *Program*

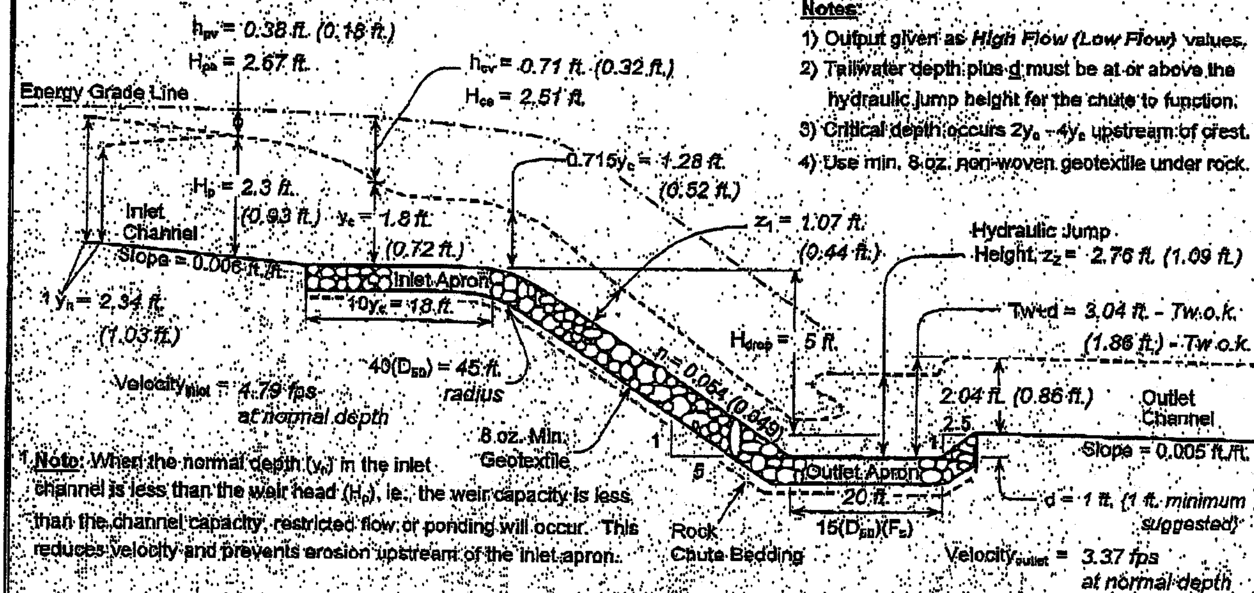
Q_{low} = 75.0 cfs   Low flow storm through chute → Tw (ft.) = *Program*

***Note**: The total required capacity is routed through the chute (principal spillway) or in combination with an auxiliary spillway.*

Input tailwater (Tw):

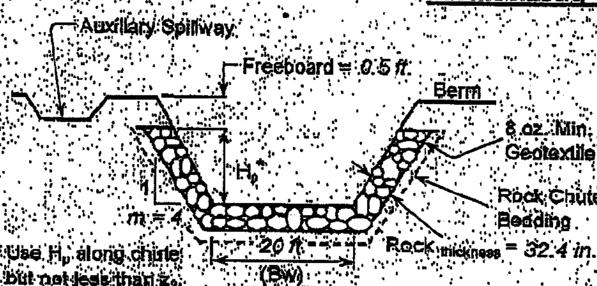
Profile and Cross Section (Output)

Notes:
1) Output given as *High Flow (Low Flow)* values.
2) Tailwater depth plus d must be at or above the hydraulic jump height for the chute to function.
3) Critical depth occurs $2y_c - 4y_c$ upstream of crest.
4) Use min. 8 oz. non-woven geotextile under rock.



¹**Note:** When the normal depth (y_n) in the inlet channel is less than the weir head (H_p), ie., the weir capacity is less than the channel capacity, restricted flow or ponding will occur. This reduces velocity and prevents erosion upstream of the inlet apron.

Profile Along Centerline of Chute



*Use H_p along chute but not less than z_2.

Typical Cross Section

q_t =	13.65 cfs/ft.	Equivalent unit discharge
F_s =	1.20	Factor of safety (multiplier)
z_1 =	1.07 ft.	Normal depth in chute
n-value =	0.054	Manning's roughness coefficient
$D_{50}(F_s)$ =	16.2 in. (309 lbs. 50% round / 50% angular)	
$2(D_{50})(F_s)$ =	32.4 in.	Rock chute thickness
Tw + d =	3.04 ft.	Tailwater above outlet apron
z_2 =	2.76 ft.	Hydraulic jump height
*** The outlet	will	function adequately

High Flow Storm Information

ATTACHMENT 3 – DRAINAGE AREA MAPS

SUB-AREAS

NO.	AREAS (SF)	AC
A4.1	84,375	1.9
A4.2	107,555	2.5
A4.3	60,542	1.4
A5.1	85,038	2.0
A5.2	138,142	3.2
A6.1	23,684	0.5
A6.2	74,177	1.7
A7.1	79,766	1.8
A7.2	97,418	2.2
A7.3	92,792	2.1
A7.4	86,910	2.0
A7.5	129,126	3.0
A8.1	65,893	1.5
A8.2	82,706	1.9
A9.1	106,643	2.4
A9.2	140,016	3.2
A9.3	110,806	2.5
A9.4	96,090	2.2
A9.5	32,058	0.7
A9.6	21,012	0.5
A9.7	20,920	0.5
A10.1	69,131	1.6
A10.2	51,399	1.2
A10.3	11,970	0.3
A10.4	6,219	0.1
A11.1	75,735	1.7
A11.2	52,523	1.2
A11.3	11,533	0.3
A11.4	2,484	0.1
A12.1	91,907	2.1
A12.2	157,784	3.6
A12.3	69,554	1.6
A12.4	46,032	1.1
A13.1	36,502	0.8
A13.2	67,883	1.6
A13.3	66,299	1.5
A13.4	32,385	0.7
A14.1	101,632	2.3
A14.2	123,896	2.8
A15.1	63,342	1.5
A15.2	54,514	1.3
A15.3	40,303	0.9
A15.4	9,999	0.2
A15.5	9,742	0.2
A15.6	3,175	0.1
A15.7	4,981	0.1
A16.1	107,714	2.5
A16.2	101,051	2.3
A16.3	125,133	2.9
B1.1	66,070	1.5
B1.2	94,477	2.2
B2.1	95,717	2.2
B2.2	94,923	2.2
B2.3	113,134	2.6
B2.4	128,156	2.9
B2.5	150,280	3.4
B2.6	135,587	3.1
B2.7	144,918	3.3
B2.8	173,418	4.0
B3.1	53,066	1.2
B3.2	43,319	1.0
B3.3	67,394	1.5
B3.4	70,138	1.6
B3.5	83,287	1.9
B3.6	96,378	2.2
B3.7	108,630	2.5
B3.8	112,166	2.6
B4.1	95,512	2.2
B4.2	196,259	4.5
B4.3	142,619	3.3
B4.4	112,301	2.6
B4.5	55,989	1.3
B5	65,343	1.5
B6.1	127,724	2.9
B6.2	143,141	3.3
B6.3	202,805	4.7
B6.4	212,213	4.9
B6.5	208,162	4.8
B7.1	216,193	5.0
B7.2	172,119	4.0
B7.3	163,600	3.8

AREAS

NO.	AREAS (SF)	AC
A1	347,930	8.0
A2	157,754	3.6
A3	550,828	12.6
A4	240,898	5.5
A5	220,865	5.1
A6	98,259	2.3
A7	454,416	10.4
A8	133,907	3.1
A9	543,559	12.5
A10	138,675	3.2
A11	144,237	3.3
A12	369,448	8.5
A13	217,076	5.0
A14	226,510	5.2
A15	178,705	4.1
A16	331,937	7.6
B1	159,054	3.7
B2	1,027,381	23.6
B3	630,447	14.5
B4	604,832	13.9
B5	59,822	1.4
B6	887,345	20.4
B7	553,854	12.7
C1	966,057	22.2
C2	469,700	10.8
C3	146,519	3.4
C4	169,142	3.9
D1	1,227,994	28.2

LEGEND

AREA BOUNDARY
SUB AREA BOUNDARY
DITCHES
TERRACE DITCHES
B6 AREA DESIGNATION
B6.1 SUB-AREA DESIGNATION
D32 DITCH DESIGNATION

R 0 REVISED FOR DREDGE CELL EXPANSION PH2

REV. NO.	DATE	DSGN	DRWN	CHKD	SUPV	RVWD	APPD	ISSD	PROJECT ID	AS CONST	REV ID

DISCIPLINE INTERFACE

SCALE: 1"=200' EXCEPT AS NOTED

YARD

DREDGE CELL
LATERAL EXPANSION STAGE 6
DRAINAGE AREAS

DESIGNED BY:	DRAWN BY:	CHECKED BY:	SUPERVISED BY:	REVIEWED BY:	APPROVED BY:	ISSUED BY:

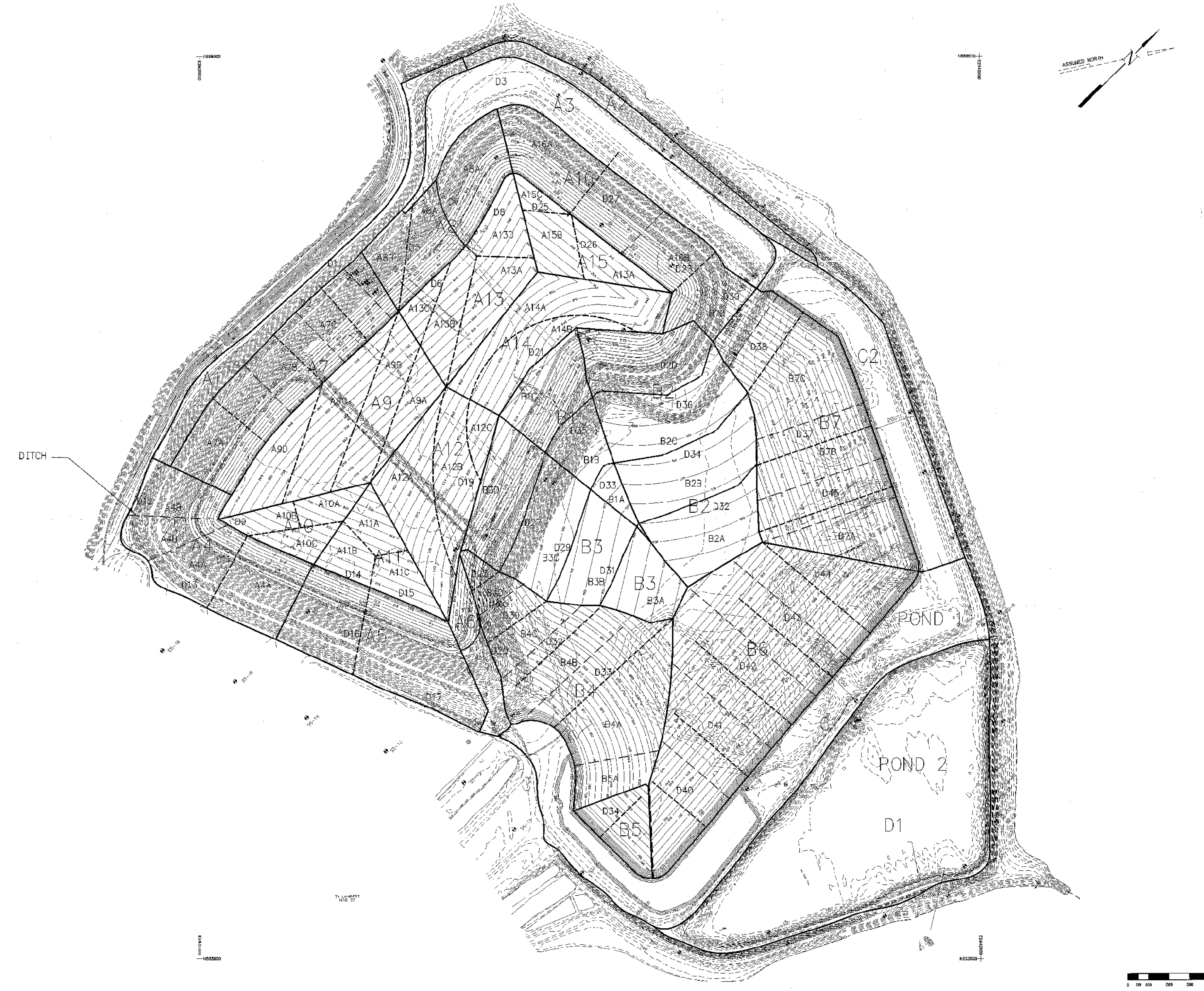
KINGSTON FOSSIL PLANT
TENNESSEE VALLEY AUTHORITY
FOSSIL AND HYDRO ENGINEERING

AUTOCAD R14 | DATE | 36 | C | 10W425-34E | R 0

PLOT FACTOR:200
W_TVA

C.A.D. DRAWING
DO NOT ALTER MANUALLY

PARSONS 0
TASK COMPLETED BY: REV NO.



MAJOR AREAS (SF)		AC
A1	226,602	5.21
A2	161,220	3.71
A3	464,532	10.66
A4	412,970	9.50
A5	402,252	9.23
A6	90,388	2.07
A7	423,951	9.75
A8	297,557	6.83
A9	475,534	10.92
A10	127,333	2.92
A11	166,168	3.81
A12	349,867	8.03
A13	301,344	6.92
A14	303,988	7.00
A15	158,297	3.63
A16	441,313	10.13
B1	254,835	5.85
B2	766,010	17.56
B3	558,846	12.83
B4	664,000	15.24
B5	93,126	2.13
B6	1,004,646	23.06
B7	746,594	17.04
C1	702,594	16.16
C2	390,814	9.00
D1	1,228,142	28.19

MINOR AREAS (SF)		AC
A4A	251,531	5.79
A4B	160,267	3.69
A6A	32,391	.75
A6B	64,225	1.48
A7A	178,925	4.12
A7B	121,271	2.79
A7C	105,217	2.42
A8A	229,940	5.29
A8B	59,261	1.36
A9A	66,777	1.54
A9B	132,768	3.05
A9C	167,973	3.86
A9D	85,609	1.97
A10A	43,633	1.00
A10B	39,029	.90
A10C	44,230	1.02
A11A	54,545	1.25
A11B	51,146	1.18
A11C	61,619	1.42
A12A	189,025	4.35
A12B	126,377	2.91
A12C	33,234	.76
A13A	110,079	2.53
A13B	83,494	1.92
A13C	35,421	.81
A13D	77,578	1.78
A14A	112,796	2.59
A14B	207,650	4.78
A15A	59,999	1.38
A15B	70,062	1.61
A15C	21,898	.50
A16A	235,823	5.42
A16B	91,152	2.10
B1A	28,474	.65
B1B	63,864	1.47
B1C	138,513	3.19
B2A	183,388	4.22
B2B	211,157	4.86
B2C	207,293	4.77
B2D	173,921	4.00
B3A	111,178	2.56
B3B	132,129	3.04
B3C	163,370	3.76
B3D	154,470	3.55
B4A	309,105	7.11
B4B	146,467	[illegible]
B4C	107,608	2.47
B4D	44,035	1.01
B5A	155,388	3.57
B6A	131,830	3.03
B6B	219,570	5.05
B6C	226,003	5.20
B6D	185,685	4.27
B6E	249,126	5.73
B7A	267,697	6.16
B7B	168,214	3.87
B7C	251,571	5.79
B7D	147,932	3.40

R 0 REVISED FOR DREDGE CELL EXPANSION PH2

REV. NO.	DATE	DSGN	DRWN	CHKD	SUPV	RVWD	APPD	ISSD	PROJECT ID	AS CONST	REV CD
R 0											D

DISCIPLINE INTERFACE

SCALE: 1"=200' EXCEPT AS NOTED

YARD

DREDGE CELL
LATERAL EXPANSION STAGE 6
DRAINAGE AREAS

DESIGNED BY:	DRAWN BY:	CHECKED BY:	SUPERVISED BY	REVIEWED BY:	APPROVED BY:	ISSUED BY:

KINGSTON FOSSIL PLANT
TENNESSEE VALLEY AUTHORITY
FOSSIL AND HYDRO ENGINEERING

AUTOCAD R14 | DATE | 36 | C | 10W425-34F | R 0

PLOT FACTOR:200
W_TVA

C.A.D. DRAWING
DO NOT ALTER MANUALLY

PARSONS | C
TASK COMPLETED BY: | REV NO.

APPENDIX E

Hydrogeologic Evaluation of Ash Pond Area

PLEASE SEE VOLUME 2
OPERATIONS MANUAL DREDGE CELL LATERAL EXPANSION

APPENDIX F

Workplan – Groundwater Monitoring

Appendix F

Samples will be collected according to procedures detailed in TVA's Quality Assurance Procedure *Groundwater Sample Collection Techniques* (attached to this appendix). An abbreviated summary of these procedures include the following:

1. The elevation of groundwater will be measured prior to sampling.
2. The volume of the water in the well will be calculated, in liters, from measurements of depth to water surface and total depth of the well. If there is insufficient water in a well for pumping, bailers may be used for purging and sampling.
3. The pump will be carefully lowered to approximately 0.5 meters below the water surface before pumping begins. The pump will be lowered with the drop in water surface. This ensures that no stagnant water remains in the well after pumping. Ideally, at least two well volumes of water should be purged before sampling. For wells with slow recharge, the pump rate will need to be reduced to minimize the drawdown of the level in the well, if possible. If insufficient water for sampling exists after purging, the wells can be allowed to recover, but sampling should take place as soon after purging as possible.
4. While pumping, temperature, pH, DO, ORP, and conductivity will be continuously monitored using a calibrated Hydrolab® flow through cell system to avoid air contact. These data will be recorded on form TVA 30066A approximately every five minutes. When the Hydrolab® readings have stabilized and at least two well volumes have been pumped or bailed, unfiltered samples will be collected for the parameters listed in Table 1.
5. Special care will be taken with wells that produce turbid samples. For wells producing turbid water at the time of sampling, water will be allowed to settle in the well before collecting samples, or extra containers filled, kept on ice, and allowed to settle up to two hours. When the particulates have settled, all bottles required will be carefully filled.
6. Samples will be shipped on ice by TVA mail and/or public carrier to TVA's Environmental Chemistry laboratory. Samples not meeting holding times will be rejected and new samples collected.

Copy No. ______

TENNESSEE VALLEY AUTHORITY

ENGINEERING SERVICES

QUALITY ASSURANCE PROCEDURE

UNCONTROLLED COPY
FOR INFORMATION ONLY

No. ES-41.6

Title: GROUNDWATER SAMPLE COLLECTION TECHNIQUES

Revision:	0
Effective Date:	4/29/94
Prepared by:	L. F. Graser 4-26-94
Technical Reviewer Engineering Services	A. J. Danzig 5-4-94
Technical Reviewer Engineering Services	J. L. Miller
Technical Reviewer Engineering Services	D. J. Bruggink 5-6-94
Concurred by: QA, Engineering Services	S. A. Pannell 4-29-94
Approved by: Manager, R. K. Alexander	R. K. Alexander 5/16/94
Concurred by: Manager, Hydraulic Engineering	P. A. March 5/27/94
Concurred by: Manager, Chatt Engineering	J. W. Shapp 5/6/94
Concurred by: Clean Water Initiative	N. E. Carriker
Concurred by: Environmental Chemistry	G. Quintero

TVA 30025 (RD-PRO 8-91)

TVA-00015471

e: GROUNDWATER SAMPLE COLLECTION TECHNIQUES		No. ES-41.6 Page 1 of 1	REVISION LOG

Rev. No.	Date Approved	Revision Description	Reason for Revision
0	4/29/94	Procedure ES-41.6 replaces DS-41.6. Title and organizational changes made.	To reflect reorganization

TVA 30037 (S&F OPS 5-88)

1.0 OBJECTIVE

To prescribe specific, detailed instructions for Engineering Services (ES) personnel involved in the collection of water samples in accordance with standard practices generally accepted by the U.S. Environmental Protection Agency (EPA), U.S. Geological Survey (USGS), and TVA.

2.0 SCOPE

The techniques described herein are limited to those to be used by ES personnel for routine studies. They do not apply to special studies that may require special apparatus and/or handling or specially trained personnel. For example, the collection of groundwater samples at Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) sites (i.e., "Superfund" sites), certain Resource Conservation and Recovery Act (RCRA) sites, and those activities which fall under the scope of the Superfund Amendments and Reauthorization Act (SARA) of 1986 are not within the scope of this procedure. This procedure applies to collection of routine groundwater samples in connection with TVA's regional water management program activities and assessment of groundwater quality in the vicinity of TVA power facilities.

3.0 REFERENCES

3.1 National Handbook of Recommended Methods for Water Data Acquisition, Chapter 2, "Groundwater" (January 1980), U.S. Geological Survey, Reston, VA, 1977.

3.2 Handbook--Groundwater, Environmental Protection Agency, EPA/625/6-87/016, Cincinnati, OH, 1987.

3.3 A Guide to Groundwater Sampling-Technical Bulletin No. 362, National Council of the Paper Industry for Air and Stream Improvement, Inc., New York, NY, 1982.

3.4 Practical Guide for Groundwater Sampling, Environmental Protection Agency, EPA/600/2-85/104, Ada, Oklahoma, 1985.

3.5 Macrodispersion Experiment Management Policies and Requirements (EPRI RP 2485-05), TVA Engineering Laboratory Report No. WR28-2-520-136, Chapters 4.2.6, "Field Tracer Sampling," and 4.2.7, "Field Monitoring and Sampling," 1987.

3.6 Fletcher G. Driscoll, Groundwater and Wells, Johnson Division, St. Paul, Minnesota, Second Ed., 1982.

3.7 40 CFR 136, "Guidelines Establishing Test Procedures for the Analysis of Pollution," Table II - Required Containers, Preservation Techniques, and Holding Times.

3.8 Methods for Chemical Analysis of Water and Wastes, Environmental Protection Agency, EPA-600/4-79-020, Cincinnati, OH, 1979.

3.9 Standard Methods for the Examination of Water and Wastewater, 18th Ed., American Public Health Association, Washington, D.C., 1992.

3.10 Handbook for Sampling and Sample Preservation of Water and Wastewater, Environmental Protection Agency, EPA-600/4-82-029, Cincinnati, OH, 1982.

3.11 Sampling Guidelines for Groundwater Quality, Electric Power Research Institute, EA-4952, Research Project 2485-1, Palo Alto, CA, 1987.

3.12 Groundwater Manual for the Electric Utility Industry, Electric Power Research Institute, CS-3901, Research Project 2301-1 (volumes 1, 2, and 3), Palo Alto, CA, 1985.

.12.1 Volume 1: Geological Formations and Groundwater Aquifers.

.12.2 Volume 2: Groundwater Related Problems.

3.12.3 Volume 3: Groundwater Investigations and Mitigation Techniques.

3.13 Resource Conservation and Recovery Act (RCRA) Groundwater Monitoring Technical Enforcement Guidance Document, Environmental Protection Agency, PB87-107751, OSWER-9950.1, Washington, D.C., 1986.

3.14 ES-41.1, "Collection and Handling of Samples."

3.15 ES-41.2, "Water Sample Collection Techniques."

3.16 ES-41.4, "Trace Organics Sample Collection Techniques."

3.17 ES-42.1, 42.3, 42.4, 42.7, 42.8, and 42.11, "Water Quality Field Analyses."

3.18 ES-43.1, 43.2, 43.3, 43.7, and 43.8, "Standardization of Field Instruments."

3.19 ES-5.20, "STORET - Water Quality Data Management."

.20 Lysimeter Evaluation Study, American Petroleum Institute, Publication No. 4433, 1986.

.21 Handbook of Groundwater Development, Roscoe Moss Company, Los Angeles, California, Published by John Wiley and Sons, 1990.

4.0 ABBREVIATIONS AND DEFINITIONS

4.1 Definitions

4.1.1 Definitions of job titles and general responsibilities of managerial and supervisory personnel in ES are given in section 5.0.

4.2 Abbreviations

4.2.1 BOD--Biochemical Oxygen Demand

4.2.2 DO--Dissolved oxygen

4.2.3 CHATT ENGG--Chattanooga Engineering Services

4.2.4 Dw--Depth of well in meters

4.2.5 Dws--Distance to water surface from top of well R.P. in meters

4.2.6 EDM--Environmental Data Management (CHATT ENGG)

4.2.7 ES--Engineering Services

4.2.8 ENVIR CHEM--Environmental Chemistry, Water Management Services

4.2.9 EPA--United States Environmental Protection Agency

4.2.10 MLS--Multilevel sampling well

4.2.11 NPDES--National Pollutant Discharge Elimination System

4.2.12 ORP-Oxidation-reduction potential (REDOX)

4.2.13 pH--Measure of hydrogen ion concentration

4.2.14 QAC--Quality Assurance Coordinator

4.2.15 R.P.--Reference Point

4.2.16 USGS--United States Geological Survey

4.2.17 Vw--Volume of water in well measured in liters

5.0 RESPONSIBILITIES

5.1 Functional Area Manager--The manager responsible for various functions such as field engineering projects in a geographical area (i.e., eastern, central, or western geographical locations). The manager directly supervises project engineers and team members in his geographical area.

5.2 Project Engineer--The person responsible for a particular area of expertise, subfunction, or specific projects within the geographical area. The project engineer assists and reports directly to the functional area manager, advises and acts as a resource to teams within his area of expertise and provides technical help to other teams as needed.

5.3 Technical Lead Engineer--The person responsible for a particular project(s) or tasks. These responsibilities include coordination with client organizaion(s), workplan preparation, budget estimates, scheduling of field studies to meet project deadlines, technical adequacy of the work performed and report preparation. All of these lead engineer responsibilities are assumed by team members for their own support of the team.

5.4 Quality Assurance Coordinator--The QAC is the functional area manager or his designate and is responsible for Engineering Services procedures that are assigned to that functional area. The QAC assigns a technical writer or reviewer for each procedure. The QAC assures that procedures are correct and up-to-date by requiring technical writers and reviewers to certify in writing on a yearly basis that assigned procedures have received a thorough review. The QAC works closely with the organization Quality Assurance Manager.

5.5 Survey Leader--The survey leader is the individual responsible for a particular piece of work. This individual is responsible for seeing that field work is performed in a technically adequate, timely, and safe manner. The survey leader is responsible for the equipment and supplies; technical supervision of personnel while in the field; collection, handling, and shipping of samples. The survey leader, more than any other person, is responsible for being familiar with the procedures. The survey leader reports directly to the lead engineer for which the work is being done.

5.6 Engineering Services personnel--Personnel assigned to a particular work activity or team. Responsible for conducting tasks in a technically adequate manner and for following QA procedures. Any certification must be current for collection or handling samples (i.e., radiological, hazardous waste, water quality, etc.).

5.7 The Environmental Chemistry Lab, Water Management Services (ECHEM), performs chemical, and physical analyses.

5.8 CHATT ENGG EDM is responsible for coding, keypunching, processing, reviewing, validating, retrieving, and reporting field and laboratory data related to ambient groundwater quality.

6.0 PROCEDURES/REQUIREMENTS

6.1 Workplans

6.1.1 A written workplan is usually prepared in advance of the sampling activities. This written workplan must be coordinated with the client organization and other service organizations. The workplan must receive concurrence by all affected organizations and will address, at a minimum, the purpose of the monitoring activities, the choice of water characteristics to be measured, the method or methods to be employed in collection of the samples, the locations and frequency of sampling, project deadlines, schedules, parameters to be analyzed by the laboratory, budget requirements, and collection of auxiliary data.

6.1.2 If special sample collection requirements, handling techniques, or analyses are required (other than the standard procedures contained in this manual), they will be spelled out in detail in the workplan or in supplemental procedures. All items which will affect the quality of the data to be collected must be addressed in the written workplan and/or referenced to the appropriate ES procedures. The written workplan must be approved by the lead engineer prior to any fieldwork. Also, any workplan revisions must be approved by the lead engineer prior to any field activities associated with a particular workplan revision.

6.2 General Requirements and Instructions for Groundwater Sampling

6.2.1 "Collection and Handling of Samples" (reference 3.14) will be followed as appropriate. In addition, particular attention must be given to the following requirements.

6.2.2 The survey leader will review the workplan in detail and consult with his or her lead engineer prior to the first survey to ensure that no misunderstanding exists about how, when, where, and what samples are to be collected.

6.2.3 Before starting a new work activity at a TVA facility (i.e., nuclear, steam, hydro, etc.), the survey leader will contact the facility manager or his/her designee (usually the Results Section supervisor at a steam plant) and inform them of the work to be performed and on what schedule it will be done. To ensure recognition of any situations which may require special safety awareness, the survey leader will communicate with the plant manager or his/her designee and discuss safety procedures which need to be observed, unusual conditions to be aware of, and names of ES personnel working at the TVA facility.

6.2.4 The survey leader will select and assemble the needed equipment (pumps, meters, Hydrolabs, filtration apparatus, tapes/plunkers, compressor, generators, titration equipment, pH/conductance/ORP standards, buckets, etc), sample containers, workplan, maps, well driller logs, and forms and field worksheets. The survey leader will ensure that all equipment and supplies are appropriately cleaned, in good working order and within their laboratory calibration interval as specified in ES-43.1, attachment 1 (reference 3.18). It is recommended that an equipment checklist be prepared on the initial field survey and that it be referred to and updated on each subsequent survey.

2.5 The survey leader may obtain a summary of the last four sets of field data for use to validate and compare information at the time it is being collected. A computer printout can be obtained from CHATT ENGG-EDM to facilitate this data validation process.

6.2.6 Generally, the survey leader should monitor the wells in a particular order as determined by their typical pH values. For instance, all wells below a pH of 7.0 should be sampled, then all wells above a pH of 7.0 should be sampled. The monitoring equipment should be restandardized between the two ranges of wells using the appropriate pH buffers.

6.2.7 Also, water levels of the wells and reference points should be measured prior to any sampling and recorded. These measurements should be made in as short of a time interval (hrs.) as possible. These "snapshot measurements" should be converted to water level elevations (meters above MSL). Both values should be recorded in a table and presented with well/R.P. description, time of measurement, and depth to well bottom (in meters) along with any pertinent remarks.

6.3 Groundwater Sample Collection Techniques

6.3.1 Quality Control of Sampling Operations

3.1.1 Every effort will be made to collect a representative and uncontaminated sample. After each sample is collected, it will be visually examined for any foreign material that is not representative. If any foreign material is observed, or suspected, the sample will be discarded and new sample recollected in a fresh sample container. Do not immerse anything--even a thermometer--in the sample. Always pour the sample directly into the specified containers one at a time. Transferral to another container will greatly increase the opportunity for contamination and cross contamination.

6.3.1.2 Many sample containers contain chemical preservatives. These preservatives may be a source of contamination to other samples, may be ineffective if diluted, or may be harmful if allowed to contact skin or eyes. Use care when handling sample containers with chemical preservatives. Fill sample containers individually, one at a time, to prevent cross contamination of preservatives: uncap the container, fill it directly from the sampler, and recap the sample container immediately. Do not place flexible sample tubing inside the containers unless specifically instructed to do so. Do not lay caps on surfaces that might contaminate them. Do not overfill containers. If any of these potential sources of contamination occur, discard the affected portion of the sample, and collect another portion in a fresh container.

6.3.1.3 Sample collection methods for groundwater may include the use of a submersible centrifugal pump, pneumatic bladder pump, single or 10-channel peristaltic pump, check valve bailer, lysimeter, or perhaps a gas lift pump. The method used to collect a groundwater sample must be compatible with the water quality characteristics of interest. All of these methods, in one or more ways, alter the quality of the sample while it is being collected. In most instances, the submersible centrifugal (low flow, variable speed) pump, the pneumatic bladder pump, or check valve bailer, when used properly, will collect the most representative (least altered) sample for a variety of constituents (particularly volatile organics and reduced/dissolved species). The use of gas lift devices for collection of groundwater quality samples is not recommended. Chapter 6 of reference 3.2 provides additional details.

6.3.1.4 When collecting groundwater samples, the sample should be obtained as close to the discharge of the source or wellhead as possible to reduce the potential for contamination, precipitation of solute, and loss of dissolved gasses. Treated (chlorinated or filtered) or stored groundwater samples, such as from some private or domestic wells are of limited value. Care must be taken to limit sample contact with air and agitation that would interfere with the field determination of pH, ORP, dissolved gasses, acidity, and alkalinity, or the laboratory determination of volatile organics and reduced species.

6.3.1.5 On occasion it may be desirable to determine concentrations of dissolved inorganic constituents (i.e., dissolved minerals or dissolved metals) in groundwater. In such cases, by definition, the sample is filtered through a 0.45 mm average pore diameter cellulose ester membrane filter (Millipore Cat. No. HAWP04700 or equivalent) during (pressure filtration) or immediately after (vacuum filtration) sample collection. Techniques used to filter groundwater samples should be discussed in detail in the project's workplan. In most cases, the preferred method for filtration of groundwater is an "in-line" pressure filtration technique which eliminates sample contact with the atmosphere and utilizes the sampling pump's pressure for filtration. <u>The field worksheets and request for laboratory analysis forms must clearly indicate when samples are filtered in the field</u>. Also, all bottles must be properly marked for which constituent the sample was performed (e.g., DM, dissolved metals and etc.). Samples for field analysis (temperature, DO, pH, conductance, ORP, alkalinity, etc.) and certain laboratory analyses (ferrous and manganous ions, sulfide, organics, turbidity, suspended solids, etc.) are never filtered. Additional details in regard to sample filtration procedures are given in section 6.2.2 of reference 3.15.

Condition the filter prior to sampling with 200 to 300 mL of deionized, distilled water (Super Q). This hydrates the filter to lessen the chance of channelization through the filter during sampling. Collect a filter blank with Super Q water after conditioning at the frquency specified in section 6.3.1.7. If filtration difficulties are anticipated because of high solids concentrations, try to develop the well to reduce the level of solids. If too much mud is still present, measure the Hydrolab parameters and pump up as much sample as possible. Let it stand in a sealed, clean container, and decant enough sample for filtering.

6.3.1.6 Samples collected for extremely low levels (i.e., less than one part per billion) of trace organics and/or trace elements may easily be contaminated by contact with foreign materials. Motor oil, gasoline, soft plastics, etc., may be potential sources of contamination for trace organic/pesticide sampling, while soil and dust, which is ubiquitous at fossil plants, may be potential sources of contamination for many trace elements. Reference 3.16 and section 6.3.3.5 below discuss routine precautions which are taken to minimize potential sources of contamination. The permanent installation of a groundwater sampling device in each monitoring well has many advantages. It will eliminate the possibility of the introduction of foreign material during the lowering of sampling equipment into the well and the potential for cross contamination between wells caused by the possible carryover of contaminants on the sampling equipment from one well to another. In those cases where special attention must be paid to extremely low levels of organics or trace elements, permanent installation of sampling equipment/pumps in each groundwater monitoring well is recommended.

6.3.1.7 Unless otherwise specified in the project's workplan, duplicate groundwater samples will be collected at every 20th well (i.e., five percent site specific of the samples collected). Further details in regard to collection of duplicate samples are given in section 6.15.3 of reference 3.14. Also, filter blanks shall be taken when dissolved samples are collected.

6.3.2 Standardization of Field Equipment and Field Measurements

6.3.2.1 ES procedures for standardization of field instruments (reference 3.18) must be followed, as appropriate, with particular attention given to the following instruments which are commonly used by ES in the collection of groundwater quality samples.

6.3.2.1.1

Field Instruments (reference 3.18)	ES Procedure
Hydrolabs	ES-43.2
YSI Conductance Meters	ES-43.3
Orion pH Instruments	ES-43.7
Thermometers	ES-43.8

6.3.2.1.2 Field instruments will be standardized as specified in the above referenced procedures. At a minimum, instruments will be standardized before and after field measurements are made and whenever the accuracy of the instrument is questioned. Form TVA 30035, "Instrument Standardization, Field Standardization of Instruments," will be completed to document all field standardizations of instruments.

6.3.2.2 ES procedures for water quality field analyses (reference 3.17) must be followed, as appropriate, with particular attention given to the following analyses which are commonly used by ES in the collection of groundwater quality samples.

6.3.2.2.1

Water Quality Field Analyses (reference 3.17)	ES Procedure
Alkalinity and Acidity (Ref. Attachment 6 for summary worksheet)	ES-42.1
Total and fecal coliform bacteria	ES-42.2
Conductance	ES-42.3
Dissolved Oxygen (DO)	ES-42.4
Oxidation-Reduction Potential (ORP)	ES-42.7
pH	ES-42.8
Temperature	ES-42.11

6.3.3 Collection of Well Samples Using a Submersible Pump

6.3.3.1 To obtain a representative sample of groundwater, it must be understood that the composition of the water within the well casing and in close proximity to the well is probably not representative of the overall groundwater quality at the sampling site. This is due to the possible presence of drilling contaminants near the well, introduction of foreign material from the surface, casing corrosion, and/or because environmental conditions such as the oxidation-reduction potential (ORP or REDOX) may differ drastically near the well from the conditions in the surrounding water-bearing materials. Consequently, each well must be flushed (purged) of standing (i.e., stagnant) water until it contains fresh water from the surrounding aquifer. The recommended length of time required to pump a well and the rate at which a well can be pumped before sampling are dependent on many factors including the physical characteristics of the well, the hydrogeological nature of the aquifer (i.e., hydraulic conductivity), the type of sampling equipment being used, and the water quality parameters of interest.

6.3.3.2 Prior to any sampling or pumping of a well, measure and record the distance to the water surface (Dws) with an acoustic or electric plunker. Also measure and record the depth of the well (Dw) on each survey. Do not rely on past well depth data, since the well may be silting in. Depth measurements (measured to the nearest 0.01 meter i.e. nearest cm.) are usually referenced to the top of the inner well casing and not the outer protective casing. All data, measurements, observations, and computations are to be recorded on form TVA 30066A, "Groundwater Quality Data Field Worksheet (Chemical Data)," attachment 1. In addition, if the well to be sampled is a new well or has never been sampled, form TVA 30066B, "Groundwater Quality Data Field Worksheet (Physical Data)," attachment 2, which documents information about type of well, owner of well, location of well, well drillers log/information, etc., must also be completed.

6.3.3.3 Calculate the volume of water in the well as shown below:

Well Casing ID (mm)	Liters Per Meter
51	2.027
76	4.560
102	8.107
127	12.668
153	18.228

Vw (in liters) = (Dw - Dws) x liters/meter

where:

Vw = Volume of well, liters;
Dw = Depth of well, meters; and
Dws = Depth to water surface, in meters

6.3.3.4 If a submersible pump is not already permanently installed, such as might be the case at "dedicated" pump wells, private or domestic wells, the preferred method of purging and sampling a well is to use a low flow (variable speed controlled) centrifugal pump, a pneumatic bladder pump, or a peristaltic pump (shallow wells). However, in situations where large volumes of water must be purged from a well, resulting in long pumping times (i.e., greater than one hour), a centrifugal pump with a higher pumping capacity (4 to 16 liters per minute) may be used for purging only instead of the lower capacity bladder pump (1-3 liters per minute). All such cases should be specifically addressed in each project's workplan. Domestic wells with a submersible pump already permanently installed can be sampled from a convenient tap or faucet after letting the water run for several minutes.

6.3.3.5 Prior to lowering the pump into the well, (when advantageous) a large tarpaulin or heavy sheet of plastic should be spread on the ground to cover the necessary portion of the work area. This "good housekeeping" practice will help minimize the potential for contamination caused by contact of the soil with the pump and/or pump tubing. Immediately prior to placing the pump into the well, rinse the outside of the pump and the first meter of pump tubing with deionized water. Successive lengths of pump/sample tubing shall be rinsed/wiped with deionized (DI) water before insertion into the well casing.

6.3.3.6 Carefully lower the pump intake to approximately 0.6 to 1.3 meters below the water surface (dependent upon the length of the pump head). The pump should not be lowered below the top of the well screen or to the bottom of the well unless specific instructions to do so are given in the workplan. Studies have shown that lowering the pump to the bottom of a well (below the well screen) may result in a poor flushing of the column of water above the pump if the transmissivity of the aquifer is high. In such cases the pump would be primarily removing inflowing water from the lower portion of the well casing and not effectively removing the water in the upper water column. Pumping from near the surface (and lowering the pump with the drop in the water surface) ensures that inflowing water moves up through the water column and that no stagnant water will remain in the well after purging. The past performance of a well should be used to indicate the appropriate steps for lowering the pump. If the well's recharge rate is slow, the pumping rate will need to be reduced to minimize the drawdown of the water level in the well, or in extreme cases the well maybe completely evacuated ("pumped dry") and allowed to recharge overnight before sampling. At no time should the water level be drawn below the top of the well screen, unless dictated by a very slow recharge rate, requiring "next day" sampling.

6.3.3.7 While purging the well, continuously monitor the time, pumping rate, and distance to water surface. The pumping rate should be adjusted (when possible or reasonable) to minimize the drawdown of the water surface in the well. Using a Hydrolab flow-through cell system to avoid groundwater-air contact, also monitor the groundwater's temperature, pH, DO, conductance, and ORP. Record all the stabilization test data on form TVA 30066A, "Groundwater Data Field Worksheet," attachment 1, approximately every five minutes or less if purge time is expected to be of a short duration. At each well, while recording and monitoring the field stabilization test data (i.e., pumping rate, water surface, temperature, pH, DO, conductivity, and ORP), the survey leader will compare the data being collected with previously collected field data. A computer printout of the last four sets of field results, obtained from the CHATT ENGG, will facilitate this comparison and ensure, on the spot, that valid and comparable data are being obtained.

6.3.3.8 Unless otherwise stated in the workplan, when at least two well volumes of water have been purged from the well and the Hydrolab readings (temperature, pH, DO, conductivity, and ORP) have stabilized, (i.e., do not change by more than 5 percent or have essentially ceased any obviously upward or downward trend between readings), samples may be collected. If the water quality readings have not stabilized after removal of two well volumes, remove a third well volume (if conditions permit), then begin sampling. When filling the various sample bottles/containers, care must be taken to minimize sample aeration, and to gently fill each bottle. This will often necessitate the lowering of the pumping rate to less than one liter per minute to avoid the turbulence caused by the high velocity of the water as it is discharged from the pump tubing. Be sure to record the pumping rate, temperature, pH, DO, conductivity, ORP, etc., at the time of sample collection and record the distance to the water surface immediately upon completion of sampling.

6.3.3.9 If the well's recharge is slow, the pumping rate will need to be reduced to minimize the drawdown of the water surface level in the well. If a well becomes dry during the purging, it must be allowed to recover before sampling to avoid taking a nonrepresentative sample. It may be necessary to allow 24 hours or longer for recovery. If circumstances are encountered which are not addressed in this procedure or in the project's workplan, notify the lead engineer immediately for instructions.

6.3.3.10 After purging and sampling, sample water should be removed from the pump and tubing before sampling another well. A centrifugal pump should have the check valve removed so that water will drain back into the well when the pump is turned off. Before reuse of any pump/sample tubing at any successive well, place the pump head in a container of deionized water (Super Q) and pump through two line volumes of Super Q water to flush the pump and lines thoroughly. NOTE: The "DI" flush water must be removed with two line volumes of sample water. The outside of lines should be wiped with a clean rag or paper towel soaked with DI water. This process shall be repeated at each well that is sampled.

6.3.4 Collection of Samples Using a Bailer

6.3.4.1 Prior to sampling a well with a bailer, measure and record the distance to the water surface and the depth of the well as given in section 6.3.3.2.

6.3.4.2 Calculate the volume of water in the well as shown in 6.3.3.3.

6.3.4.3 Prior to sampling a well with a bailer, thoroughly flush the sampler with deionized water. (As an alternate method, a pre-cleaned disposable Teflon bailer may be used.) Carefully lower the sampler to the water surface. Do not drop the sampler or let it free fall to the water surface, as this will cause aeration of the sample. Gently lower the sampler into the water. Retrieve the bailer. Repeat this process until two well volumes of water have been removed or as specified in the project's workplan.

6.3.4.4 Collect the samples by carefully lowering the sampler to the well screen or the perforated section of the well casing or to the depth specified in the workplan. Care should be taken to avoid striking the bottom of the well with the sampler.

6.3.4.5 Fill the specified bottles/containers directly from the sampler. Slow and careful transfer is important to minimize sample aeration. When filtered samples are requested, use a bailer fitted with an in-line filter. Measure and record temperature, pH, DO, conductivity, ORP, and the distance to the water surface immediately after collection of the sample.

6.3.5 Collection of Samples From Multilevel Sampling (MLS) Wells

6.3.5.1 A typical MLS well, see attachment 3, will consist of several (often 20 to 30) small diameter, flexible sampling tubes. Each tube will have a filter, usually a nylon mesh, on the intake end of the tube with the intake ends of these tubes spaced at known distances below the ground surface. These flexible sampling tubes are housed and extend to the surface inside a PVC pipe as shown in attachment 3.

6.3.5.2 Groundwater samples will be collected from MLS wells using peristaltic 10-channel pumps (i.e., two 10-channel pumps for 20 flexible sampling tubes, three 10-channel pumps for 30 flexible sampling tubes, etc.). In all sample collections from MLS wells, the 10-channel peristaltic pumps will be used in parallel to purge all tubes and collect all samples simultaneously. Every effort will be made to collect representative and uncontaminated samples. An important consideration in obtaining a valid, representative sample is first the removal of the standing water which has been trapped in the multilevel flexible sample tubing since the last sample collection. However, to avoid stressing the aquifer and perhaps altering its natural movement, this purging of the trapped water in the tubing will be minimized. One of the reasons for using the small diameter flexible tubing is that it minimizes the amount of water which is purged. For example, one meter of 5 mm ID tubing contains approximately 19.6 mL of water. Therefore, the purging of two tubing volumes would result in the purging of approximately one liter of water from each sample tube (assuming 25 meter lengths of 5 mm ID tubing) prior to collection of the samples. Specific purging instructions for individual MLS wells will be detailed in each project's workplan.

6.3.5.3 To collect samples at MLS wells, connect the MLS flexible sampling tubes to the 10-channel peristaltic pump tubes by mating like numbered (colored) tubes number 1 through 30 (assuming there are 30 flexible sample tubes and that three 10-channel pumps are used).

6.3.5.4 Place waste containers beneath each sampling tube, turn on the 10-channel peristaltic pumps, and simultaneously purge all the sample tubes of stagnant water by pumping approximately two volumes of water from each sample tube. (One meter of 5 mm ID tubing contains approximately 19.6 mL of water.) Discard the purge water as appropriate or as outlined in the customer's request documentation. Record on the field worksheets any tubes which do not produce water or produce only small quantities of water.

6.3.5.5 After purging the MLS sample tubes, place sample bottles/containers marked with sample identification numbers and in proper numerical order under each correspondingly numbered sample tube. Fill the bottles/containers to the required volume and repeat this step until all types of sample bottles (i.e., metals, minerals, nutrients, sulfide, etc.) have been collected.

6.3.5.6 During the collection of the MLS groundwater samples, it is important to keep track of the fluid volume in each bottle/container, because each sampling tube will not discharge at the same rate. As a bottle or container reaches the proper volume of sample, the sample collector will clamp off the appropriate peristaltic pump tube while allowing the remaining bottles/containers to continue to fill. Finally, after the last bottle or container has filled and the pump tube has been clamped off, the 10-channel peristaltic pumps can be shut off.

6.3.5.7 Immediately after collection of MLS well samples, make field measurements for those water quality characteristics specified in the project's workplan (e.g., temperature, pH, DO, conductivity, ORP, alkalinity, etc.).

6.3.6 <u>Collection of Samples Using a Peristaltic Pump</u>

.6.1 A peristaltic pump can be used to collect a sample from a shallow well (water surface less than 7.6 meters below ground surface), spring or seep.

6.3.6.2 Prior to sampling a shallow well, measure and record the distance to the water surface and the depth of the well as given section 6.3.3.2.

6.3.6.3 Calculate the volume of water in the well as shown in 6.3.3.3.

6.3.6.4 Lower the tygon or teflon tubing connected to the peristaltic pump into the water. Remove at least two volumes of water before collection of samples from a shallow well. No purging of water is necessary if collecting a sample from a spring or seep, since the water is naturally flowing.

6.3.6.4 Fill the specified containers, process the samples, and make the water quality field measurements as specified in the project's workplan. Measure (or estimate) and record the spring or seep discharge rate (or the pumping rate if sampling a shallow well) on form TVA 30066A, "Groundwater Quality Data Field Worksheet," attachment 1.

6.3.7 <u>Collection of Samples Using a Lysimeter</u> (Pressure-Vacuum Soil Water Sampler)

6.3.7.1 General Instructions--Lysimeter (pressure/vacuum soil water samplers) can generally be installed and used at any depth up to approximately 15 meters. The access tubes (i.e., pressure/vacuum tube and sample discharge tube) from the lysimeter can extend above the ground surface directly above the lysimeter, or if conditions require, the access tubes can be laid in a trench, terminating above the ground surface at some distance from the lysimeter. The ends of the access tubes should be installed so that they will be protected from damage by mechanical equipment, livestock, etc. The tube ends should be covered or plugged to prevent debris from entering the tubes and later contaminating the samples. The ground surface directly above the lysimeter should not be covered in any manner that would interfere with the normal percolation of soil moisture down to the depth of the lysimeter. Attachment 4 shows a typical lysimeter installation.

6.3.7.2 Access Tubes--The "pressure/vacuum" access tube and the "sample discharge" access tube are usually small diameter polyethylene tubes (e.g., 5 mm I.D.) that extend from the porous ceramic collection device to the ground surface. Typically the tubes are inserted through a cap or plug at the open end of the porous collection cup as shown in attachment 4. One end of the "sample discharge" tube extends nearly to the bottom of the porous ceramic collection cup with the other (discharge) end extending to the ground surface. The discharge end of this tube must be marked and identified as the tube from which the samples are collected. The "pressure/vacuum" access tube is installed slightly differently. One end of the "pressure/vacuum" tube is inserted only about an 2.5 cm past the cap or plug with the other end also extending to the ground surface. The fit of the tubing through the cap or plug and the fit of the cap or plug at the open end of the porous collection cup must be tight and well seated so as to be able to maintain a pressure-vacuum seal.

6.3.7.3 Installing a Soil Water Sampler--Installation of a lysimeter can be performed in several ways. Methods for installation of a lysimeter must be specified in the project's workplan. Typically a 102 mm hole is cored using a T-handle bucket auger. The augered soil should be sifted through a 6.0 mm mesh screen to remove any larger rocks and pebbles. This sifted soil will provide a reasonably uniform backfill for filling in around the inplaced lysimeter. The following discussion details some of the more common methods for installation of a lysimeter. The primary concern in all the methods is that the porous ceramic cup of the lysimeter be in tight, intimate contact with the soil so that soil moisture can move readily from the soil through the pores of the ceramic cup where it can then be withdrawn through the sample discharge tube.

6.3.7.3.1 Native Soil Backfill Method--After the hole has been cored to the desired depth, insert the lysimeter and backfill the hole with native screened (sifted) soil, tamping continuously with a small-diameter rod to ensure good soil contact with the porous ceramic cup and to prevent surface water from channeling down the cored hole.

6.3.7.3.2 Soil Slurry Method--After the hole has been cored, mix a substantial quantity of the sifted soil from the bottom of the hole with water to make a slurry which has a consistency of cement mortar. This slurry is then poured into the bottom of the cored hole. Immediately after the slurry has been poured, push the lysimeter into the hole so that approximately the bottom third of the lysimeter is completely embedded in the soil slurry. Backfill the remaining voids around the lysimeter with sifted soil, tamping lightly with a small-diameter rod to ensure good soil contact with the lysimeter. Backfill the remainder of the hole, tamping firmly, to prevent surface water from running down the cored hole. The first set(s) of soil water samples collected after installing a lysimeter by this soil slurry method may need to be discarded to avoid differences in water chemistry between the water used to prepare the slurry and the natural soil water.

6.3.7.3.3 Sand and Soil Method--Core hole to the desired depth. Pour into the hole, to a depth of about 51 mm, crushed 200 mesh pure silica sand of almost talcum powder consistency (commercially available under trade names of Super-Sil and Silica Flour). Insert the lysimeter and pour in additional sand until at least the bottom third of the lysimeter is covered. Backfill the remainder of the hole with sifted native soil, tamping to ensure good soil contact with the lysimeter and to prevent surface water from channeling down between the lysimeter and the soil.

6.3.7.3.4 Bentonite-Sand-Soil Method--Core hole to the desired depth. Pour into the hole, to a depth of about 51 mm, a small quantity of wet bentonite clay. This will isolate the lysimeter from soil below. Next, pour in a small quantity of 200 mesh silica-sand and insert the lysimeter. Pour in additional sand until at least the bottom third of the lysimeter is covered. Backfill with sifted native soil to a level about 51 mm above the lysimeter, tamping lightly. Again add about two inches of wet bentonite clay as a plug to further isolate the lysimeter and guard against possible channeling of water down the hole. Finally, backfill the remainder of the hole slowly with sifted native soil, tamping continuously. Allow sufficient time for the wet bentonite clay to harden before using the lysimeter to collect soil water samples.

6.3.7.4 Collecting a Soil Water Sample--After the lysimeter has been installed, a pinch clamp is securely tightened on the sample discharge tube, and a vacuum is applied to the pressure/vacuum tube. A vacuum of approximately 60 centibars (46 cm of mercury) is applied. A pinch clamp is then securely tightened on the pressure/vacuum tube. The lysimeter is then left undisturbed for a predetermined period of time, determined by experience and trial and error or as set forth by work plan instructions.

6.3.7.4.1 The vacuum within the lysimeter causes the soil moisture to move from the soil through and into the porous ceramic cup. The rate at which the soil water will collect in the lysimeter depends on the capillary conductivity of the soil and the amount of vacuum that has been created within the lysimeter. In most soils of good conductivity, substantial soil water samples can be collected within a few hours. Under more difficult conditions it may require several days to collect an adequate volume of sample.

6.3.7.4.2 In general, vacuums of 50-85 centibars (38 cm - 64 cm of mercury) are normally applied to the lysimeter. However, in very sandy soils it has been shown that high vacuums may result in a slow rate of sample collection. In coarse, sandy soils, the high vacuums may deplete the soil moisture in the immediate vicinity of the porous ceramic cup and, hence, reduce the capillary conductivity, which results in lower sample collection rates. In loam and gravelly clay loam, collection rates of 300-500 mL/day at 50 centibars (38 cm of mercury) are common. On waste water disposal sites, collection rates of up to 1500 mL/day have been observed.

6.3.7.4.3 To recover the soil water from the lysimeter, attach the pressure/vacuum access tube to the pressure port on a pump. Place the sample discharge tube into the sample bottle or container being careful to avoid and minimize sample contamination from the surrounding soil excavation. Open both pinch clamps (one on the pressure/vacuum tube and one on the sample discharge tube) and gently apply pressure to develop enough pressure within the lysimeter to force the collected soil water out of the lysimeter and into the sample bottle or container.

6.3.7.4.4 Subsequent samples are collected by again creating a vacuum within the lysimeter and repeating the above steps, sections 6.3.7.4 through 6.3.7.4.3

7.0 <u>HANDLING OF SAMPLES</u>

7.1 <u>Sample Identification</u>--All sample bottles and sample containers shall be labeled with a permanent sample identification number. This sample identification number or tag number must be unique for each sample collected and must be cross referenced on all field sheets (forms TVA 30066A and 30066B), and Analysis Request and Custody Record forms (TVA 30488). Prior to packaging and shipping of samples, all containers and bottles shall be inspected for tag numbers and cross checked against all field sheets, and Analysis Request and Custody Record forms. Additional explanation of sample identification requirements are given in section 6.11, reference 3.14 .

7.2 <u>Packing and Shipping of Samples</u>--Sample containers should be closely protected against contamination while transporting them to the survey site, during sampling, field handling and analysis processes, and while transporting them back to the laboratory. Detailed instructions for packing and shipping the various kinds of samples are given in reference 3.7. These requirements are summarized in attachment 1 of reference 3.15. As soon as possible, samples shall be packed on ice. To avoid breakage, care must be taken when packing bottles and containers in shipping chests. Copies of the Analysis Request and Custody Record forms must be sent to the laboratory with the samples. Check to make sure all paperwork has been accurately completed and sealed in a plastic bag to prevent water damage. All shipping containers shall be clearly addressed and shall be sealed and closed with strapping tape.

7.3 <u>Holding Times</u>--The time which elapses between sample collection and sample analysis is critical for many constituents (e.g., BOD, ortho-phosphorus, turbidity, nitrite, etc.). So that the laboratory can complete the analyses within the appropriate holding times, samples must be shipped or transported so as to arrive within the time limits given in attachment 1, reference 3.15. (ES 41.2) Any time samples are to be collected with holding times less than 48 hours, the laboratory must be notified in advance. All collections of samples should be coordinated with the laboratory.

7.4 <u>Chain-of-Custody</u>--The sample collector is responsible for the care and custody of the samples until they are properly dispatched to the receiving laboratory. The sample collector will ensure that each sample is under his/her control at all times. When samples are dispatched to the laboratory for analyses, the sample collector will retain a copy of the completed Analysis Request and Custody Record form(s), the originals of which accompany the samples. All samples shipped to the laboratory will be listed on the custody record form and cross referenced with their unique sample tag (identification) number. The custody record form should reveal the name and telephone number of the sample collector/shipper and the date of shipment. Shipping record receipts for shipments (UPS, Greyhound bus, etc.) will be retained by the sample collector/shipper as part of the permanent chain-of-custody documentation. Upon receipt, the laboratory will inspect for the shipping container for broken seals and will inspect the samples for breakage, missing samples, tampering, etc. The laboratory will verify all samples by cross referencing tag numbers between the custody record and the sample bottles received to ensure that all samples which were shipped have been received complete and intact. The laboratory will immediately notify the sample collector/ES/shipper of any discrepancies. For non-routine sampling or if shipping after Wednesday of a given week, the shipper should verify the arrival of the samples at the laboratory.

7.5 Field Data Worksheets--Copies of all field data worksheets will be sent to the CHATT ENGG-EDM in Chattanooga. Section 8.3 gives additional details.

8.0 RECORDKEEPING

8.1 Project Notebooks

8.1.1 A project field notebook and/or file shall be maintained by the ES survey leader to record pertinent information and observations. The project field notebook accompanies the survey leader to the field. The survey leader shall record and/or file all physical measurements and field analyses performed in the project notebook/file. In addition, auxiliary data often prove very useful in the interpretation of the results. Thus, water surface elevations of nearby ash ponds, basins, lakes, streams, etc., gas bubbles in the sample line, rapid development of turbidity or color in the sample, equipment problems, clogged sampling ports at MLS wells, weather conditions, deviations from workplans or this procedure, or any number of other observations could prove very helpful and should be recorded. Project field notebooks, should there be a change in personnel, should include all information necessary to properly conduct the field survey. At a minimum this would include: the original project workplan with all approved revisions; sample identification (tag) numbers and descriptions of the well locations; copies of past survey field worksheets and groundwater level observations; computer printouts of prior field data; a survey equipment checklist; and all field instrument calibration records. Also included in the field notebook might be maps, sample collection and handling instructions, bus schedules, names and telephone numbers of project personnel, and any miscellaneous notes to aid in conducting the survey.

8.1.2 A project office notebook and/or file are maintained by the lead engineer. The project office notebooks remain in the office at all times and are available for reference by ES, client, and other project organizations. In addition to containing the original approved project workplan and all approved revisions, it should contain information relating to the project such as memoranda, budget estimates, progress reports, data reports, correspondence with client organizations, etc.

8.2 Survey Reports--Following completion of each groundwater field survey, the ES survey leader will prepare a draft report to the client organization which will be finalized by the lead engineer. The report shall contain:

a. A cover letter addressed to the client from the lead engineer which describes the field activities and notes any unusual conditions (weather, equipment problems, breach of well security, etc.);
b. The Ground Water Quality Data Field Worksheets;
c. Special worksheets (e.g., Acidity and Alkalinity);
d. Instrument Standardization Forms;
e. Groundwater Level Measurements Form; and
f. Analysis Request and Custody Record Form.
g. Other Forms (i.e. bacterial organism worksheet)

Note: The survey leader is responsible for proper routing of the five (color coded) field sheets).

8.3 Disposition of Forms

8.3.1 Forms TVA 30066A and B, Groundwater Quality Data Field Worksheets, attachments 1 and 2, are used any time physical and/or chemical groundwater measurements are made. The original (white copy) is sent to and is filed by CHATT ENGG-EDM. Copies are retained by ES field office per attachment 7 (distribution) and may be sent to the client organization(s) at their request.

8.3.2 Form TVA 11552 (or similar project specific form/table), Groundwater Level Measurements (Field), attachment 5, is used as required, when groundwater elevations are observed or recorded at ash ponds, coal pile runoff ponds, metal cleaning waste ponds, rivers, lakes, groundwater wells, etc. The original (white copy) is sent to and is filed by CHATT ENGG (EDM). Copies are retained by ES field office per attachment 7 (distribution) and may be sent to the client organization(s) at their request.

3.3 Form TVA 30488, Tennessee Valley Authority, Water Management Services, Environmental Chemistry Analysis and Custody Record, is used to ship samples to the ECHEM Laboratory and identify the desired analyses. It is to be used anytime samples are shipped or delivered to the ECHEM Laboratory to ensure that the proper number and types of samples as specified in the approved project workplan, are in fact received by the

ECHEM Laboratory. The original (white copy) is sent with the samples to the laboratory. Copies are retained by ES field office per attachment 7 (distribution) and one copy (pink) is sent to CHATT ENGG-EDM. Reference 3.15 contains an example of form TVA 30488.

8.3.4 Form TVA 11064, Sample Custody Record, is only used when samples are shipped or delivered to an external TVA laboratory to aid ES in its internal record keeping functions, or as an aid for shipping/record keeping, for sample custody to an external TVA laboratory. Reference section 3.15 of ES-41.2, contains an example of form TVA 11064.

8.3.5 Form TVA 991, Request for Analysis, is only used for samples requiring external TVA laboratory analyses. It specifies which analyses are to be performed or which workplan is to be followed for sample analyses. The original is sent with the samples to the external TVA laboratory, additional copies will be retained by ES. Reference 3.15 contains an example of form TVA 991.

8.3.6 Form TVA 30533, Acidity and Alkalinity Field Worksheet is to be used by ES, the original is sent to CHATT ENGG-EDM and copies distributed per attachment 7 (distribution).

8.3.7 Retention periods and file locations for these forms are given in attachment 7.

CE 0127V

LIST OF ATTACHMENTS

1. Groundwater Quality Data Field Worksheet (Chemical Data), form TVA 30066A.
2. Groundwater Quality Data Field Worksheet (Physical Data), form TVA 30066B.
3. Schematic Drawing of a Multilevel Sampling (MLS) well.
4. Typical Lysimeter Installation.
5. Groundwater Level Measurements (Field), form TVA 11552.
6. Acidity and Alkalinity Field Worksheet, TVA Form 30533.
7. Records (Use, Distribution, and Retention).

ATTACHMENT 1

GROUNDWATER QUALITY DATA FIELD WORKSHEET (CHEMICAL DATA), FORM TVA 30066A

GROUNDWATER DATA FIELD WORKSHEET

SHEET OF

PRELIMINARY DATA

PROJECT/SITE

PURGE DATE ▶ YEAR / MONTH / DAY

WELL NO.	DEPTH TO WATER (m) 4195	BOTTOM OF WELL (m) 4194	SURVEY LEADER	FIELD CREW
WELL DIAM (mm) 4186	DEPTH OF SCREEN OR OPEN BORE HOLE (CIRCLE) (m) 4191	TO (m) 4190		

[BOTTOM OF WELL - DEPTH TO WATER] x VOL. FACTOR =	WELL VOLUME	TARGET PURGE VOL.	ACTUAL PURGE VOL.
[( )m - ( )m] x ( ) l/m =	4187 (l)	(l)	4188 (l)

SAMPLE TAG NO. (Circle) UNFLT FLT BOTH

FILTER TYPE/SIZE

PURGE PUMP (Circle) BLADDER CENTRIFUGAL PERISTALTIC BAILER OTHER (list) ____

SAMPLE PUMP (Circle) BLADDER CENTRIFUGAL PERISTALTIC BAILER OTHER (list) ____

NOTES AND WQ OBSERVATIONS	ET CT TIME (mil)	PUMP RATE (l/min)	DEPTH TO WATER (m)	PUMP DEPTH (m)	TEMP (°C)	pH (units)	DO (mg/l)	COND (µs/cm)	(+/-) ORP (mV)	
BEGIN PURGE ⟶										

REMARKS:

Reviewed by:
Survey Ldr: Date
FE Proj. Eng: Date

SAMPLE READINGS ⟶										
SAMPLE DATE YR / MO / DAY		4193		4192	10	400	300	84	90	
PUMP DURATION mn ("mi" ≤ 2 DAYS)	(mil) TIME	(l/min) SAMPLE RATE	(m) WATER SURFACE	(m) SAMPLE DEPTH	(°C) TEMP	pH	(mg/l) DO	(µs/cm) CONDUC-TIVITY	(mV) ORP (+/-)	

ADDITIONAL SAMPLE DATA
TURBIDITY 1350 (circle): CLEAR 1 SLIGHTLY TURBID 2 TURBID 3 HIGHLY TURBID 4
COLOR: ODOR:

PHENOL ALK. mg/l	415	MINERAL ACIDITY mg/l	436
TOTAL ALK. mg/l	431	CO_2 ACIDITY mg/l	437

BOTTLES REQUIRED (circle)

BOD	TIC	FERROUS	MINERAL	PHENOL	OTHERS (list): ____
COD	SOC	METALS	DIS MINERAL	FILT TIC	____ ____
TOC	O&G	DIS METALS	NUTRIENT	TSS/TDS	____ ____

WELL DIAM mm		VOL. FACTOR l/m
51	(2 in)	2.027
76	(3 in)	4.560
102	(4 in)	8.107
127	(5 in)	12.668
153	(6 in)	18.228

DISTRIBUTION: (1) Original - Data Mgt (2) Pink - Lab With Samples (3) Blue - Unit Leader (Office Notebook) (4) Green - Survey Leader (Field Notebook) (5) Yellow - F.E. Project Engineer

TVA 30066A (RD BUS 1-93)

ATTACHMENT 2
GROUNDWATER QUALITY DATA FIELD WORKSHEET (PHYSICAL DATA), FORM TVA 30066B

Ground Water Quality Data Field Worksheet
(Physical Data)

Project ____________________

Well Name/Number ____________ Spring Name/Number ____________

Owner's Name ____________________

Address ____________________

Phone Number ____________________

Well/Spring Information

Lat ____________ Long ____________ State ____________

Location ____________________

Well Depth (ft.) ____________________

Depth of Well Screen (ft.) ____________________

Approximate Water Surface Depth (ft.) ____________________

Description of Reference Point Used to Make Depth Measurement ____________________

____

Elevation of Reference Point (MSL-ft.) ____________________

Water Use ____________________

Volume of Water Use (GPD) ____________________

Type Casing ____________________

Casing Dimensions ID ________ (in) OD ________ (in) Length ________ (ft)

Does well have permanently installed pump? ________ If so, type of pump ________,

capacity (gpm) ____________, discharge flow rate (gpm) ____________

Well Drillers Log Data

(Attach sketch and/or provide written detailed description)

Remarks: ____________________

____

____

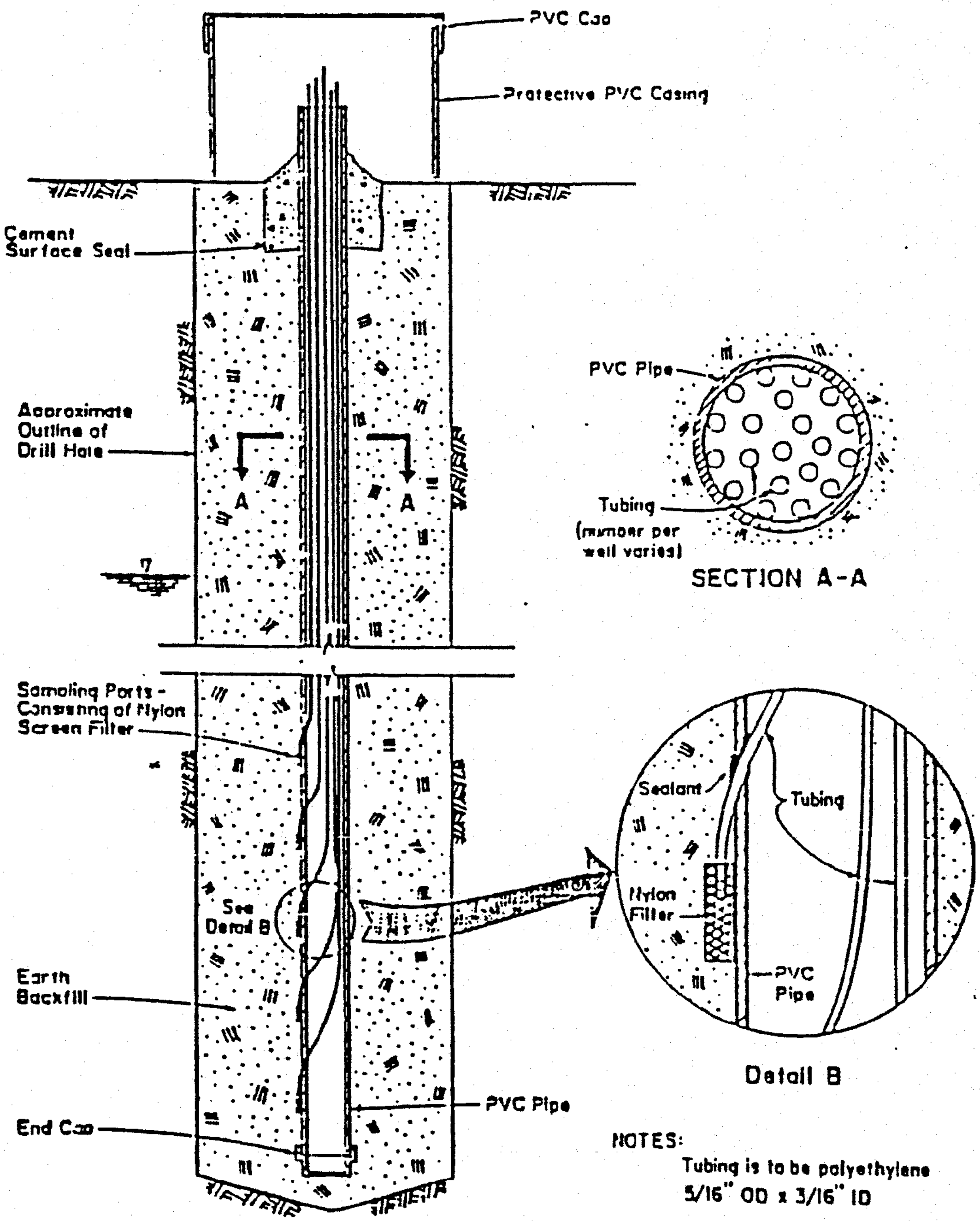
____

____

TVA 30066B (NROPS-1-88)

Reviewed by ____________ Date ____________

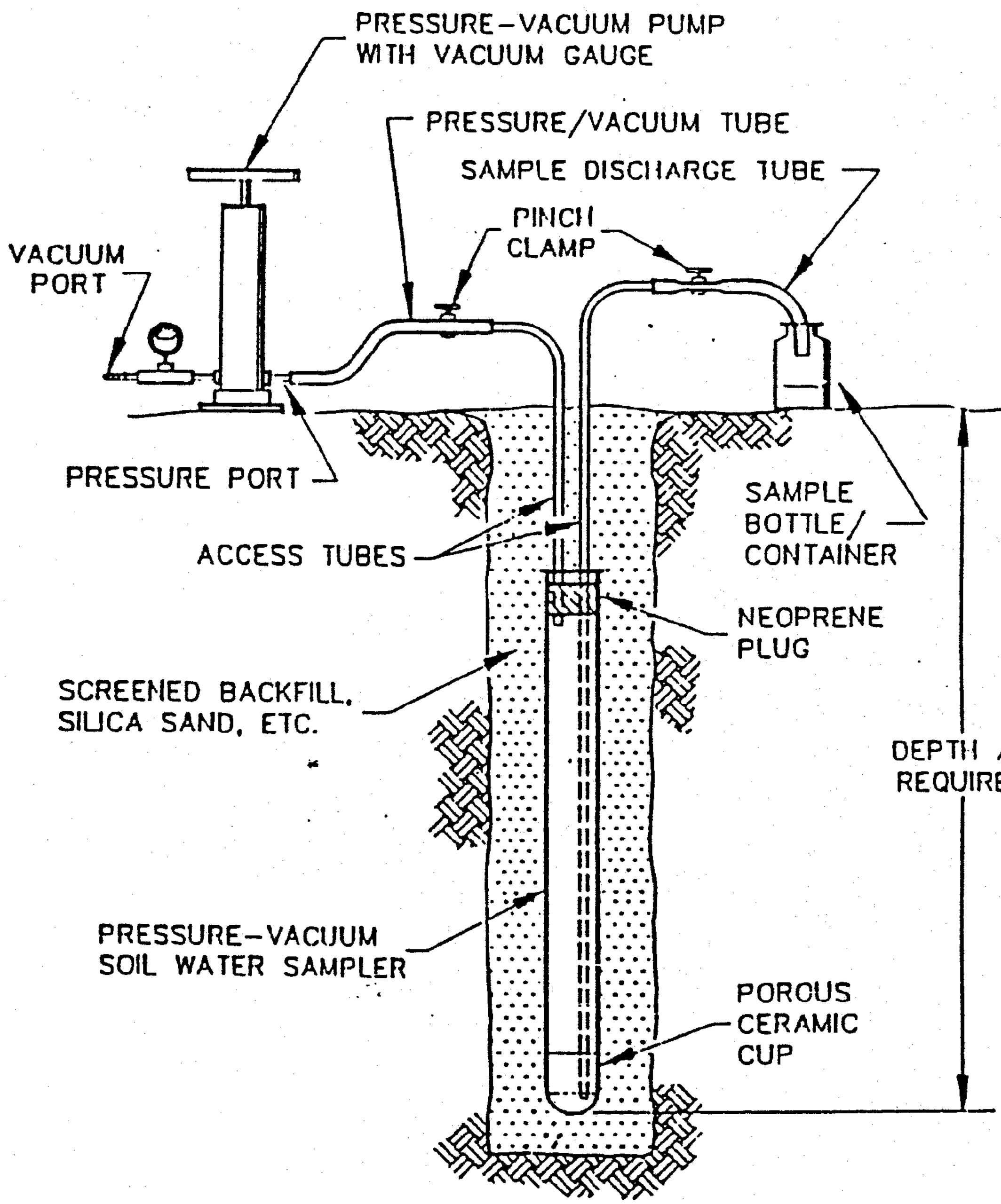
ATTACHMENT 3
SCHEMATIC DRAWING OF A MULTILEVEL SAMPLING (MLS) WELL



(NOT TO SCALE)

Engineering Lab-Nov 1987

ATTACHMENT 4
TYPICAL LYSIMETER INSTALLATION (PRESSURE-VACUUM SOIL WATER SAMPLER)



TYPICAL LYSIMETER INSTALLATION
(PRESSURE-VACUUM SOIL WATER SAMPLER)

ATTACHMENT 5

TENNESSEE VALLEY AUTHORITY
ENGINEERING SERVICES
GROUND-WATER LEVEL MEASUREMENTS (FIELD)

Date___________
Location_______________
Measured by_____________

Well/ RP No. (P84068)*	Description	Reference Point (RP)	Time (ET)	Well RP Elevation(m)	Depth to Water Surface(m) (4195)*	Water Level Elevation (m) (4189)*	Depth to Well Bottom (m) (4194)*	Remarks

* STORET codes

TVA 11552 (5/94)

ATTACHMENT 6
ACIDITY AND ALKALINITY FIELD WORKSHEET, FORM TVA 30533

PRELIMINARY DATA

ACIDITY AND ALKALINITY FIELD WORKSHEET

PROJECT/SITE	COLLECTION DATE	NORMALITY
SURVEY LEADER		ACID
FIELD CREW		BASE

SAMPLE TAG NO.	INITIAL pH	SAMPLE VOL TI-TRATED (ml)	FAC-TOR	ALKALINITY TITRATION(S) ml ACID TO pH 8.3	PHENOL ALK (mg/L) (Ca CO_3)	TOTAL ml ACID TO pH 4.5	TOTAL ALK. (mg/L) (Ca CO_3)	ACIDITY TITRATION(S) ml BASE TO pH 3.7	MINERAL ACIDITY (mg/L) (Ca CO_3)	TOTAL ml BASE TO pH 8.3	CO_2 ACIDITY (mg/L) (Ca CO_3)

ALKALINITY OR ACIDITY (mg/L $CaCO_3$) = $\frac{A \times N \times 50{,}000}{V}$

A = ml TITRANT
N = TITRANT NORMALITY
V = SAMPLE VOLUME

NORMALITY	SAMPLE VOL TITRATED	FACTOR
0.02N	100 ml	10
0.02N	50 ml	20

REVIEWED BY:

_______________ Survey Leader   _______________ Date

_______________ FE Proj. Eng.   _______________ Date

TVA 30533 (RD-BUS 4-92)

DISTRIBUTION: (1) Original - Data Management (2) Pink - Lab with samples (3) Blue - Unit Leader (Office Notebook) (4) Green - survey Leader (Field Notebook) (5) Yellow - F.E. Project Engineer (AJDMDS)

ATTACHMENT 7
RECORDS (USE, DISTRIBUTION, AND RETENTION)

Record	Use	Distribution[d]	Retention	Time[a,b,c]
TVA 30066A	GW Data Chemical, Field Worksheet	1-Original to CHATT ENGG-EDM	Files	20 yrs
		2-Copy (pink) ECHEM	as needed	as needed
		3-Copy (blue) ES Field Office	Office notebook	2-3 yrs
		4-Copy (green) ES Field Office	Field notebook	2-3 yrs
		5-Copy (yellow) ES Field Office	Lead Engineer	2-3 yrs
TVA 11552	Groundwater Elevations (wells, water bodies, etc.)	1-Original to CHATT ENGG-EDM	Files	20 yrs
		2-Copy (pink) extra	Lead Engineer	
		3-Copy (blue) ES Field Office	Office notebook	2-3 yrs
		4-Copy (green) ES Field Office	Field notebook	2-3 yrs
		5-Copy (yellow) ES Field Office	Lead Engineer	2-3 yrs
TVA 30488	Request for Analysis and Custody Record	1-Original to ECHEM	ES sample analysis (marked up copy immediately to ES if discrepancies occur)	as needed
		2-Copy (pink) to CHATT ENGG -EDM	Files	20 yrs
		3-Copy (blue) ES Field Office	Office notebook	2-3 yrs
		4-Copy (green) ES Field Office	Field notebook	2-3 yrs
		5-Copy (yellow) ES Field Office	Lead Engineer	2-3 yrs
TVA 11064	Sample Custody Record	1-Original to Lab (outside TVA)	Return to ES w/ sample analysis (Field notebook)	2-3 yrs
		2-Copy (pink) extra	Lead Engineer	
		3-Copy (blue) ES Field Office	Office notebook	2-3 yrs
		4-Copy (green) ES Field Office	Field notebook	2-3 yrs
		5-Copy (yellow) ES Field Office	Lead Engineer	2-3 yrs
TVA 991	Request for Analysis	1-Original to Lab (outside TVA)	Return to ES w/ sample analysis (Field notebook)	2-3 yrs
		2-Copy (pink) extra	Lead Engineer	
		3-Copy (blue) ES Field Office	Office notebook	2-3 yrs
		4-Copy (green) ES Field Office	Field notebook	2-3 yrs
		5-Copy (yellow) ES Field Office	Lead Engineer	2-3 yrs
TVA 30533	Acidity and Alkalinity Field Worksheet	1-Original to CHATT ENGG-EDM	Files	20 years
		2-Copy (pink) extra (client)	Lead Engineer	-
		3-Copy (blue) ES Field Office	Office notebook	2-3 yrs
		4-Copy (green) ES Field Office	Field notebook	2-3 yrs
		5-Copy (yellow) ES Field Office	Lead Engineer	2-3 yrs
Various	Laboratory Results	1-Original to CHATT ENGG by Lab	Files STORET	2 yrs
		2-Copy to ES Field Office	Office notebook	2-3 yrs
		3-Copy to client as required by ES after review	as needed	as needed

a. Retention time for STORET-related data and field sheets is 20 years
b. Retention time for STORET-related laboratory results report forms is 2 years beyond project completion.
c. ES retention time is 2 years MINIMUM after total completion of project and 3 years MINIMUM for on-going projects.
d. Color coded copies may not be available for all forms.

APPENDIX G

Stability and Seismic Impact Analysis

PARSONS

CALCULATION COVER SHEET

CLIENT	TVA		
PROJECT	Kingston Fossil Plant – Dredge Cell Expansion		
SUBJECT	Slope Stability Evaluation and Recommendations		
JOB NUMBER	55090501	WBS NUMBER	-
CALCULATION NO.:	DC-55090501-001	PAGE 1 OF 32	

DESCRIPTION/PURPOSE

Review available subsurface data including that obtained recently, develop subsurface profiles for critical locations, determine design soil parameters, and evaluate factor of safety against failure of slopes of both the ash pile (existing cell area) and the gypsum-ash stack (existing ash-pond area).

METHOD OF ANALYSIS

Pseudostatic method (cylindrical surface of failure and sliding-block analysis) using computer program PC STABL5M

CODES AND STANDARDS

1. Tennessee Division of Solid Waste Management, Technical Guidance Document – Earthquake Evaluation Guidance Policy (Guidance Document)

INFORMATION SOURCES

See REFERENCES list on Page 29.

ASSUMPTIONS

Read Pages 3 through 23.

CONCLUSIONS OR RESULTS

See Pages 27 and 28.

REV	DATE	DESCRIPTION	PAGES REVISED	PAGES ADDED	PAGES DELETED	BY/DATE	REV/DATE	LDE/DATE
3								
2								
1								
0		ORIGINAL ISSUE	NA	NA	NA	Y.S.Shah 05-26-04	W.Anundsn 05-26- 04	D.R.Smith 05-26-04

TABLE OF CONTENTS

1. INTRODUCTION

Reference 1 drawings show the existing or present topography of the ash site and the proposed Phase 1, 2 and 3 construction plans. The site is divided into three primary areas:

A. Cell Area, consisting of cells 1, 2 and 3, where ash has been deposited to-date to Elev. ~**810'**.

B. Ash Pond Area, where ash has been deposited to-date to Elev. **760'** or lower, and

C. Stilling Basin, wherein water from the above two areas is drained and where the surface of pond water now is at Elev. **756'±**.

Currently, a new cell area is being created between Cell Area and Ash Pond Area, located inside Ash Pond Area, where a Stage 1 dike to Elev. 780' is being constructed. This area is called Phase 1, where ash will be temporarily deposited and later raised to be even with Cell Area elevation (810').

(NOTE: For convenience herein, Cell Area is referred to as the area located on the north side of the ash site, and Stilling Pond on the south side. Thus, the ash site is bounded by Dike B on the north, Dike C on the east, and North Dike and Road Dike on the west. Dike B and North Dike form the north and west boundaries, respectively, of Cell Area; Road Dike forms the west boundary of both Ash Pond Area and Stilling Basin; and Divider Dike separates Ash Pond Area and Stilling Basin.)

The original topography of the ash site may be assumed as shown in the Reference 2 drawing. This drawing shows that the original ground surface (GS) in the eastern half of Cell Area was approximately at Elev. 730', and dipped gently to Elev. 724' at its west edge. In Ash Pond Area, the GS dipped gently westward from Elev. 735' at its east edge to 724' or lower at its west edge. The GS varied from Elev. 745' to 730' in Stilling Basin Area.

Thus, the original GS at the ash site was roughly at Elev. 730' ± a few feet and that ash has been stacked up by at least **80 feet** (= 810' – 730') in Cell Area and approximately **30 feet** (= 760' – 730') in Ash Pond Area over the original GS. If the Stilling Basin bottom consisted of the original GS (i.e., the bottom was left uneven), the water and sediment depth there is maximum **26 feet** (= 756' – 730'). For this analysis, however, it is assumed that the bottom was excavated to Elev. **729'** and that the basin is silted up so far to Elev. **746'**; i.e., a loose silt/flyash deposit of 17 feet exists at the bottom of the pond.

The proposed plan is to stack ash to Elevation as high as **868 feet** in Cell Area (i.e., raise the area further by 58**feet**) and stack gypsum and fly ash both to Elevation approximately **970 feet** in Ash Pond Area (i.e., raise the area there further by **210 feet**) as shown on the drawings (Ref.1). Both ash and gypsum will be placed wet primarily (sluiced in from the plant) until the year 2019 and gypsum will be placed dry thereafter. For this analysis, it is assumed conservatively that the Ash Pond stack consists of wet placed gypsum and fly ash up to Elevation approximately 930 feet (maximum expected) with dry-placed gypsum above it.

Prior to performing the latest subsurface exploration, it was believed that (as no subsurface data was then available for the interior Ash Pond area of Phase 1) the foundation condition beneath the intermediate cell dikes might be incapable of supporting the proposed intermediate cell construction at the south edge of Cell Area. However, based both on the exploratory data and satisfactory performance of the dike built so far to Elevation 780' it is evident that the foundation condition at the dikes is capable of supporting the proposed construction. Therefore, a separate evaluation of stability for the intermediate cell dikes is not performed as it is considered that the stability evaluation for Section 1-1 as done herein is adequate to demonstrate stability of these dikes also.

The static stability evaluation is performed also for the existing ash stack where a groundwater blowout occurred in the Fall of 2003 at Elevation 770' at the Swan Pond side slope of Dike B, outside Cell 3. This is done to support the conclusion that the failure was due not to the slope stability but to the piping or the excessive seepage gradient. The excessive seepage gradient may have resulted from the raised phreatic surface inside the ash stack as a result of inadequate drainage of both the storm water and water drained from the wet stacking operations.

Except the stability evaluation for the blowout location (for which only the static condition is considered), stability evaluation for three critical sections across the proposed two stacks includes evaluation for the design seismic condition in accordance with the Guidance Document; i.e., assuming a peak or maximum ground acceleration of 0.22g.

2. SITE HISTORY & PERTINENT DATA

Based on the data from References 2 through 6, the developmental history for the ash site and other information pertinent to this analysis are summarized as follows.

1. Referring to Drawing 10N400 (Ref. 2), it is evident that

- *The initial North Dike (top at Elev. 746'), along with East Dike (top at Elev. 750'), was planned in August 1951. Both dikes were to be built of earth materials.*
- *The initial Dike C (top at Elev. 748'±) was planned in January 1958. It was to be built of borrowed earth materials.*

- *The initial Dike B (top at Elev. 748') and future raising of all these dikes were planned in August 1967. Use of bottom ash (BA) was planned for raising the dikes and construction of the initial Dike B.*

Thus, the ash site (then called, "'New Ash Disposal Area") was created after January 1958 when Dike C was built. Further, it should be noted that the dike slopes below Elev. 735' were to be constructed under the submerged condition (i.e., the Watts Bar Lake water level then was at Elev. 735' and the site was perhaps a part of Swan Pond Embayment or was mostly a swamp). That also implies that the lake water level might have been drawn down to Elevation 735' ± during construction of these dikes and that the ash site might have remained water-logged prior to ash disposal there.

2. *The TVA document dated June 26, 1974 (Ref. 4) indicates that*

   - *The dikes were not yet raised, and Dike B was not yet built. Although Dike B was planned to be built "in the wet on previously deposited ash .... by end-dumping to minimum depth and compacting with tracked equipment", a hand-written note dated November 10, 1975 on the document states that "as ash is of poor quality, Dike B will be built all earth". Thus, it is indicated that Dike B foundation consisted of loose, wet ash and that the ash would not be suitable for the initial Dike B construction (although, borings B-1 and B-2 drilled through Dike B show that it was built of ash)!!*
   - *Southern portion of the initial Dike C was built using ash.*

3. *TVA's soil investigation report dated November 3, 1975 (borings SS-1 through SS-11 on the initial Dike C and initial Road Dike; borings SS-12 through SS-24 into ash adjacent to these two dikes and initial North Dike; Ref. 5) shows that*

   - *Dike B was not yet built. However, ash was deposited to Elev. varying between 749' and 755'± within the area enclosed by Dike C, Road Dike and North Dike. See sketch titled, Plan of Foundation Investigation (Ref.5).*
   - *The top of initial Dike C and initial Road Dike was at Elev. 752'± 1' and the top two feet consisted of crushed shale and limestone. Also, it was not clear from the borings that the southern portion of Dike C at SS-6, SS-7 and SS-8 locations was built all of ash. It appeared that ash, if used, was mixed with clayey earth fill.*
   - *Approximately 11 feet below the top 2 feet of crushed stone fill (i.e., to Elev. ~739') of initial Dike C and initial Road Dike consisted of compacted ash and soil (SPT N greater than 10). Below that depth, both the fill soil and alluvial soil were soft or loose (SPT N of 4 or less). The fill soil was fine-grained, consisting of CL, CH and SM containing chert fragments. The GWL into the dikes varied between Elev. 735' and 750', dipping southward.*
   - *The top 5 to 8 feet of ash in the ash pile adjacent to the dikes or nearby areas was medium compact to compact, but was loose (SPT N less than 4) below that depth. The GWL into the ash was approximately 6 feet higher than into the dikes.*

4. *Drawings 10N420 and 421 (Ref. 3), both dated May 1976, indicate that*

- *All the initial dikes noted above were built and raised to Elev. 765' (with the top of the initial dikes left as bench) before May 1976, although Dike C and Road Dike were raised using "Rolled Earth Fill", and not BA as originally planned. That was perhaps because enough BA, called "heavy ash", wasn't available! (See Sect's A-A and B-B on 10N421)*

- *The Divider Dike, to be built of BA, was planned in May 1976. The BA would be placed by end-dumping below water level (then perhaps at Elev. 746'± as indicated in Sect. AA – AA on 10N421), and to be placed in compacted lifts above up to Elev. 765'.*

- *The lake water level then varied between Elev.'s 735' and 741' (Sect. A-A on 10N421).*

5. *Logs of hand-auger borings AH-1 through AH-17 and exploratory borings SS-35 through SS-38 (Ref. 6), drilled by TVA during May and December 1984 along the initial Dike C and initial Road Dike, show that:*

   -

   - *The southern part of the initial Dike C along Stilling Basin between AH-1 and AH-3 was apparently constructed of coarse BA. The BA was found in all four SS borings (located between AH-1 and AH-3) from Elev. ~748' down to approximately Elev. 739' ± 1'. Soft clayey soil (SPT N = 2 to 8) was encountered below BA for several feet. Silty clay fill was encountered above BA to the top of the dike (i.e., to Elev. 753' ± 1'), except for some coarse material at the surface. The top 5 feet of BA in the dike was found to be compact, and loose to medium compact below.*

   - *The remaining northern portion of the initial Dike C and the entire initial Road Dike were apparently built of highly plastic clayey (CH) earth fill, perhaps mixed occasionally with ash.*

6. *Borings SB-1 through SB-10, drilled by Singleton during July-August 1994 on the perimeter dikes along Cell Area (Ref. 7), show that*

   - *Dike C at Cell Area (Cell No. 2) was raised to Elev. 773', and North Dike (Cell 3) had been raised to Elev. 797.5'. (Note that Cell Area then, as now, was divided into Cell 1 on the west side, Cell 2 on the east side, and Cell 3 in between those two.) Other dikes forming Cells 1 and 3, including Dike B, then had been raised to Elev. ~795'. (See Location Plan in Ref. 7.) Apparently, the dikes were raised above Elev. ~765' using compacted ash.*

   - *The surface of ash in Cell 1 was at Elev. ~785', at Elev. ~ 770' in Cell 3, and at Elev. ~769' or lower in Cell 2. Apparently, Cells 1 and 2 were active then. (See Location Plan in Ref. 7.)*

7. *A blowout at the exterior (Swan Pond Road side) slope of Dike B outside Cell 3 at Elev. 770' occurred in the Fall of 2003. (A stability evaluation for this slope is included herein, as stated earlier, in support of a conclusion that the blowout occurred as a result of excessive seepage pressure of water from the ash pile and not the sliding failure of the slope.)*

8. *The existing or recent ground-surface condition at the ash site is shown on the drawings in Reference 1. The dikes surrounding Cell 1 now are at Elev. ~810' and the remaining dikes*

surrounding Cells 2 and 3 are at Elev. ~805'. The ash level in all three cells are at Elev. 805' or lower. None of these cells is active at present.

NOTE: Reviewing all the subsurface data, especially the 2004 Normalized CPT Plots (Ref. 9), it is apparent that several feet of ash overlying the natural clay layer (top approximately at Elev. 730') has remained apparently loose despite years of being under the existing ash overburden. Also, the loose ash generally is described as silt; i.e., it is primarily fly ash. The CPT logs also show that the dynamic pore-water pressure generated in this ash during sounding was high and the nature of dissipation of the pore-water pressure resembled that for clay. This means that the ash has not been consolidating or that it may undergo significant strength loss when disturbed or shaken.. Interestingly, John Boschuk of JLT laboratories also observed that the fly ash "liquefies under even slight vibrations"; i.e., if pore-water pressure induced by shaking is not allowed to dissipate, the ash looses its strength. This may also explain why the SPT blowcount in this ash is very low – almost zero. Thus, the need for a provision for a quicker relief of this pressure and for a speedier gain in strength of this ash at critical locations for an effective improvement of the stability of the proposed stacks during a seismic event is perhaps indicated. Furthermore, it is also interesting to note that the subterranean water from the adjacent Pine Ridge area, located northwest of the ash site, drains into the lake as shown in Fig. 2-5 of the hydrogeology report (Ref.8). Thus, any downward seepage of water from the wet-sluiced ash deposited in the cell area recharges the GWL and raises it just upstream of Cell Area. This is important to note when planning an interceptor drain enveloping the cell and pond areas, especially to control the exit gradient of water seepage from the ash stack at safer levels and thereby to help mitigate future recurrence of the blowout that occurred in the Fall of 2003.)

3. SUBSURFACE EXPLORATIONS

Locations of all exploratory borings drilled at the ash site prior to 2004 are shown on the Reference 10 drawing.

No deep borings were drilled in the interior cell and ash pond areas during the past investigations. Therefore, an additional subsurface exploration was undertaken in March 2004 that consisted of the following:

- Twelve borings (B-1 through B-12),
- Eleven cone-penetrometer (CPT) soundings (CPT-1, 1A, 4, 6, 8, 9, 10, 11, 12A, DN and DS) with pore-water pressure measurement located adjacent to selected boring locations,
- Field permeability testing (at the blowout location), and
- Laboratory testing of disturbed and undisturbed ash and soil samples collected from the borings.

The exploration was performed to obtain the subsurface conditions of ash and natural subsoil in the interior areas and also to verify those obtained from the past explorations. The data obtained from the 2004 exploration is given in Reference 9 and is used primarily to determine the design conditions for this analysis, although the data from the past explorations is also considered both as complimentary and supplementary data.

Also, undisturbed Shelby-tube samples of both sedimented Gypsum-fly ash mixture and cast Gypsum were obtained from the active Cumberland Fossil Plant disposal facility by Mactec and tested in their laboratory for its shear strength (Ref. 11). The values of the strength obtained from this testing were compared with the extensive data available from the existing TVA and EPRI sources (References 12, 13 and 14) and the design values were chosen based on a review of the entire data base.

4. CRITICAL SECTIONS FOR STABILITY EVALUATION

An examination of the proposed stacking plan (Phases 1, 2 and 3 or the final phase) and the subsurface data shows that the critical locations for the slope stability evaluation are in Ash Pond Area adjacent to the proposed Drainage Pond and existing Stilling Basin. Noting that the proposed stack toe will be located 100 feet and 200 feet from the two ponds, respectively, the following three critical sections, one for each of the three phases of construction are chosen for the stability evaluation. Also, a section at the blowout location is analyzed as noted before. The critical sections chosen for the stability evaluation are:

a. Section 1-1: North-South section, through Cell Area and Drainage Pond (End of Phase 1)

b. Section 2-2: East-West section, through Gypsum-Flyash Stack and Drainage Pond (End of Phase 2)

c. Section 3-3: North-South section, through final Gypsum-Flyash and Stilling Basin (End of Phase 3 or Final Phase)

d. Section 4-4: Section through existing Cell Area at the "blowout" location

The first three sections are illustrated on the drawings (Ref.1).

The computer program PCSTABL5M is used for the stability evaluation, assuming a cylindrical surface of failure. Further, a sliding block analysis for the most critical Section 3-3 (Final Phase condition) is also performed using the same computer program.

The simplified versions of all sections are illustrated in the computer printouts of the respective stability evaluation.

5. FOUNDATION STRATIFICATION FOR ANALYTICAL MODELS

An extensive review of data from all past and recent borings and CPT soundings was performed for determination of the generalized existing subsurface stratification to be used for the stability evaluation. Generally, data from the past borings matched the subsurface conditions revealed from the investigation performed in 2004. However, unlike the past investigations, the 2004 investigation included CPT soundings. The continuous record of data obtained from these soundings was found to be more definitive of changes in the stratification and, hence, was the determining factor in choosing the design profile.

The most critical area for the stability is clearly the existing ash pond area due to location of Stilling Basin and the proposed drainage pond ("Drainage Pond") adjacent to the proposed stack and also due to the anticipated maximum loading condition (i.e., maximum proposed stack height) in that area. Therefore, the stratification used for the stability evaluation at Sections 2-2 and 3-3 corresponds to Ash Pond Area. The same stratification also is used for apparently less critical Section 1-1: Further, it is proposed that

1. The existing Ash Pond Area be graded (where the existing GS is at or lower than Elev. 760'),
2. The graded surface (Elev. ~758') be stabilized and compacted using a heavy roller or compaction equipment and then
3. A well-compacted fly ash pad, gently sloping towards Stilling Basin, be constructed.

This construction will raise the bottom of the proposed stack from the graded existing surface (Elev. ~758') to Elev. 760' at Stilling Basin and to Elev. 770' at the south edge of the existing Cell Area. Bottom ash and/or Tensar geogrid may be required to stabilize the area to be occupied by the fly ash base during construction to support construction equipment. A 3-foot thick filter blanket of coarse bottom ash (two feet) and bottom ash-fly ash mixture (1 foot) will be placed over the compacted fly-ash pad in the stack area. (See Ref.1 drawings)

Thus, the subsurface profile below the stack is generalized as follows for the stability evaluation:

Stratum No.	Elevation Range	General description
1	763'+ to 760'+	Bottom Ash, lightly compacted
2	760'+ to 758'	Compacted Fly Ash
3	758' to 739'	Loose Fly Ash - Bottom Ash Mixture (FA+BA)
4	739' to 729'	Loose Fly Ash (FA)
5	729' to 714'	Natural Clay, soft to stiff (CL)
6	714' to 703'	Clayey Silty Sand, Residuum (SC-SM)
7	Below703'	Bedrock (Soft Shale)

6. ANALYTICAL MODELS FOR PROPOSED STACKS

A. GYPSUM-ASH STACK:

The foundation stratification for this model is given in the preceding section.

After constructing the filter blanket over the fly-ash pad, the perimeter dike to Elev. 780' will be constructed of compacted BA/fly ash mixture. Gypsum slurry will be deposited into the area enclosed by the perimeter dike. The gypsum sedimented from this initial gypsum deposit will be scooped from areas adjacent to the perimeter dike to build the initial cast gypsum dikes above Elev. 780', using the rim-ditch operation as shown on the Reference-1 drawings. The subsequent construction of the stack also is shown on these drawings.

As sedimented gypsum is to be deposited first to Elev. 780', the bottom of the stack up to Elev. 780' consists of sedimented gypsum for the analytical model for this stack. It is assumed as stated earlier that the stack will be raised to Elev. 930' with wet-stacking operation; and, with dry-stacking operation above it.

The outer slope of the stack will consist of cast-gypsum dikes, raised in 10-feet vertical heights, with a 15-foot wide bench at every 30-foot height interval. Also, drains will be installed as shown in the Ref. 1 drawings at the bottom of each perimeter dike. Simplifying this condition, a cast-gypsum zone of 150 feet horizontal width is assumed conservatively for the stability evaluation as shown in the computer printout of the model. The phreatic surface inside the stack for the stability evaluation is assumed conservatively to be as high as the top of the wet-stacking operation (Elev. 930') and bounded by the inner boundary of the assumed cast-gypsum zone along the stack slope. Thus, all simplifying assumptions for this analytical model are conservative.

B. <u>ASH-ONLY STACK</u>

TVA also wanted PE&C to perform the stability evaluation of this stack assuming that only ash would be deposited in the stack, instead of ash and gypsum. For that, the stack is assumed to be raised over the BA filter blanket by the wet operation, using compacted BA perimeter dikes. The outer slopes, drains, dike height, etc. and the foundation condition are assumed similar to the gypsum-ash stack. However, for this stack, the width of the outer compacted BA-zone is conservatively assumed to be only 120-feet horizontally, instead of the 150-foot width of cast-gypsum zone used for the gypsum-ash stack. Note that this width is greater for the gypsum-ash stack due to the rim-ditch operation.

For the ash-only stack, the evaluation is performed to examine the maximum height attainable using only the wet operation. An evaluation is also performed additionally for this stack where the wet operation is used first, followed by the dry operation.

The phreatic surface for all-wet operation stack is conservatively assumed at a depth of 10 feet below the final top based on recent observations of GWL in Cell Area condition, although the proposed new ash stack will have more efficient drainage than the existing cells in Cell Area. The phreatic surface for the wet-and-dry stack is assumed conservatively at the top of the termination of the wet operation, although it is likely to be lower than that with the planned provision for the drainage.

C. <u>EXISTING CELLS</u>: (For Blowout Location Stability Evaluation)

The analytical model for the interior of the existing cells and the foundation stratification at the blowout location are based primarily on the borings and soundings within Cell Area; specifically, B-1 through B-5 and CPT-1, 4 and 6. The simplified model of existing cells and foundation for this location is as follows:

Stratum No.	Elevation Range	General description
1	810'+ to 794'+	Medium dense to dense FA + BA
2	794' to 773'	Loose FA
3	773' to 763'	Medium dense to dense FA + BA
4	763' to 745'	Loose FA
5	745' to 737'	Loose FA + BA

6	737' to 730'	Loose FA
7	730' to 718'	Natural Clay, soft to stiff (CL)
8	718' to 703'	Clayey Silty Sand, Residuum (SC-SM)
9	Below703'	Bedrock (Soft Shale)

The top of the phreatic surface for this model is assumed at Elev. ~ 785'; i.e., approximately 2 feet above that observed in the monitoring well MW-3 temporarily installed near boring B-3 during the April 2004 investigation. The profile and the phreatic surface along the slope are based on the data from borings B-1, 2, 3 and monitoring wells MW-1, 2, 3 and are shown on the computer printout sketch for the blowout-location stability evaluation. *(Note that the stack height used for this evaluation corresponds to the recent condition under which the blowout occurred and not the future raised-stack condition. The latter is apparently not more critical for stability than the other conditions analyzed herein, especially those for the Ash-Only options.)*

Other details of the interior of all stacks used for the evaluation are illustrated in the computer printout sketches for each stack.

7. DESIGN MATERIAL/SOIL PROPERTIES

The design properties of various materials constituting the proposed stacks and existing ash deposits (namely, FA, FA+BA, Gypsum, and Gypsum+FA) and foundation subsoils have been determined based on the data referenced herein and as interpreted below.

Note that the test data referenced was obtained over the years from 1974 till the current year for the existing ash and foundation soils and that for the gypsum was obtained under variable conditions and locations; specifically, undisturbed and remolded conditions, and had variable aging effect. This is important to note in the case of a material like fly ash, bottom ash or gypsum that is known to harden or attain increased strength with aging in place and, when remolded, exhibits a significantly reduced strength. It should be noted further that these materials do not behave exactly like naturally occurring soils.

As far as the existing subsurface soils/materials are concerned, it should be noted that these will undergo further consolidation under a gradually raised stack over a period of more than 20 years; i.e. the loading would not be imposed suddenly and in a manner like that by a structural mat foundation but by a relatively much more flexible stack of materials of relatively huge-size and that will exhibit internal arching. In view of these factors, the strength properties selected based on past or recent data and laboratory conditions are conservative. Therefore, the reduction of shear-strength of these materials during a seismic event, although done for the natural clay (CL) soil, is unwarranted.

A. FA:

The FA is encountered as wet-placed ash in the past at the site and also will be deposited primarily by the wet operation (i.e., similarly as was done in the past) for the Ash Only Option stack. In the dry operation (a probability after termination of wet operation in the Ash Only Option), both FA and BA are likely to be mixed in a variable proportion. However, it is assumed conservatively that the dry-placed ash will consist primarily of FA and, accordingly, the design properties are determined herein.

1. Dry-Placed FA:

Per Ref.15, (noting that compacted ash gains strength as it ages in place),

For the three U.S. ashes tested @ 100% modified Proctor max. dry density (Tables 3 and 4),

Ave. Max. Dry Density, Y_{dmax} = 92.0 pcf.....(0.85 x 92.0 pcf = 78.2 pcf)

Ave. Opt. Moisture Content, w_{opt} = 24.8%, say 25%

Ave. 28-day strength (saturated):

Cohesion, c = 12 psi

Friction, $\Phi = 40.3^0$

For the four British ashes tested @ 100% std. Proctor max. dry density (Table 5),

Ave. 28-day strength (undrained):

Cohesion, c = 24 psi

Friction, $\Phi = 40.4^0$

Assume: (a) Cohesion, c = 12 psi, and $\Phi = 40^0$, at 100% density; (b) The ash actually will have an average density of 85% the maximum density (i.e., Y_d = 78.2 pcf and Y_t = say 1.25 x 78.2 pcf ~ 98 pcf).

Then, the strength @ 85% density is as follows:

Strength @ 85% density = 0.60 (Strength @ 100% density)... (P. 369, Ref. 15)

$$c = 0.6 \times 12 \text{ psi} = 7.2 \text{ psi} = 1{,}037 \text{ psf}$$

$$\Phi = \tan^{-1}(0.6 \tan 40^0) \quad = 27^0$$

For the Bull Run Facility ash-pile stability analysis, TVA used $Y_t = Y_{sat} = 106$ pcf, c = 200 psf and $\Phi = 30^0$.

Based on these data, the following properties are assumed conservatively for the stability evaluation,

c = 200 psf ; $\Phi = 30^0$; Y_t, Y_{sat} = 100, 108.4 pcf, resp. .... Dry-placed Ash Only stack

c = 100 psf ; $\Phi = 38^0$; $Y_t = Y_{sat}$ = 113.4 pcf......Well-Compacted Ash below BA Filter*

* Low cohesion value is assumed due to probable addition of bentonite to reduce its permeability, although friction angle of 38^0 (smaller than 40^0 test value) is reasonable for the well-compacted placement of this ash based on the test data presented below for the wet-placed ash.

2. Wet-Placed FA:

Per Ref. 9, for loose FA,

Ave. G_s = (2.58 + 2.42 + 2.35 + 2.52) / 4 = 2.47

Ave. w = (39 + 40 + 34 + 37.2 + 37.6 + 32 + 39 + 41 + 48) % / 9 = 38.6 %

Ave.Y_d = (76.3 + 80.3) pcf / 2 = 78.3 pcf (Y_t = 78.3 pcf x 1.386 = 108.5 pcf)

c = 0; $\Phi = 32^0$..... Effective; sample remolded @ Y_d = 78.4 pcf and saturated

Based on CPT data, for this ash, shear strength, s_u = 0.17 tsf = 340 psf. If a Mohr's envelope is drawn for the corresponding unconfined compression strength and Φ is assumed to be **28^0**, the corresponding cohesion intercept, **c = 200 psf.**

Per Ref. 7, Table 1,

Ave. $G_s = (2.32 + 2.30 + 2.25 + 2.28 + 2.31 + 2.22 + 2.29 + 2.27) / 8 = \underline{2.28}$

Ave. $w = (34.5 + 25.8 + 42 + 34.5 + 33.2 + 35.2 + 29.7 + 31.2)\ \% / 8 = \underline{33.3}\ \%$

Ave.$Y_d = (77.9 + 84.9 + 74.4 + 74.9 + 79.1 + 81.6 + 79.9 + 85.2 + 75.7)/8 = \underline{79.9}$ pcf

$Y_t = 79.9$ pcf x $1.333 = 106.5$ pcf ($Y_{sat} = 108.2$ pcf... $w_{sat} = 35.04\%$)

$c = 0$; $\Phi = 37.5^0$ ..... Effective, $Y_d = 85.2$ pcf

$c = 2600$ psf; $\Phi = 22.3^0$ ....Undisturbed; @ field moisture content; $Y_d = 85.2$ pcf

TVA used the following values for their analysis,

$c = 540$ psf ; $\Phi = 28.3^0$ ..... Effective; saturated sample; $Y_t = 99.9$ pcf

$c = 2{,}080$ psf; $\Phi = 23.7^0$ .... Total; unsaturated sample; $Y_t = 99.9$ pcf

Based on all of the above data, the following values are selected conservatively for FA for various locations/depths (*note that the ash in-place in the stack well above general GWL should attain greater strength with age as discussed in Ref.15*):

	Cohesion, c, psf	**Friction, Φ**
Loose FA, existing, just above CL layer	**0**	**28^0**
Loose FA, existing, near existing GS	**200**	**28^0**
Wet-Placed FA, lowest level (Ash Only stack)...	**500**	**28^0**
Wet-Placed FA, middle level (Ash Only stack)...	**200**	**28^0**

For all wet-placed FA, it's assumed conservatively that **$Y_t = Y_{sat} = 108.4$ pcf.**

B. <u>FA + BA</u>:

The grain-size analysis of the samples per data in Ref. 9 for FA+BA mixture is ML to SM-ML.

Per Ref. 9,

Ave. G_s = (2.40 + 2.35 + 2.49 + 2.29 + 2.28) / 5 = 2.36

For LOOSE condition,

Ave. w = (39 + 43 + 32.2 + 30 + 45 + 32 + 48 + 38.1 + 36.5) % / 9 = 38.2 % .. Below GWL

Ave.Y_d = (81.8 + 74.0 + 78.4) pcf / 3 = 78.0 pcf.... (Y_t = 78.0 pcf x 1.382 = 107.8 pcf)

c = 0; $\Phi = 32^0$ ..... Effective; sample was remolded @ Y_d = 78.4 pcf and was saturated

For MEDIUM DENSE condition,

Ave. w = (31 + 29 + 34 + 28) % / 4 = 30.5 % .... Below GWL

Ave.Y_d = (87.4 + 89.4) pcf / 2 = 88.4 pcf.... (Y_t = 88.4 pcf x 1.305 = 115.4 pcf)

c = 0; $\Phi = 37^0$ ..... Effective; sample remolded @ Y_d = 89.4 pcf and saturated

Per Ref. 7, Table 1,

Ave. G_s = (2.21 + 2.22 + 2.29 + 2.37) / 4 = 2.27

Ave. w = (22.3 + 26.3 + 30.3) % / 3 = 26.3 %

Ave. Y_d = (87.1 + 82.8 + 90.7) / 3=86.9 pcf ... (Y_t = 86.9 pcf x 1.263 = 109.8 pcf...S_r < 1.0)

c = 980 psf; $\Phi = 29.1^0$ ..... Effective; Y_d = 90.7 pcf

c = 0; $\Phi = 37.4^0$ .... Undisturbed; sample @ field moisture content; Y_d = 90.7 pcf

For the Ash Only stack, the perimeter dikes will consist of dry-placed and compacted mixture of BA and FA. As this zone will be exposed to air and above the phreatic surface due to the planned drainage system under each dike, a cohesion value of 100 psf and a friction angle of 38^0 along with saturated unit weight of 120.4 pcf are conservatively assumed.

Thus, and if Y_d = 78 pcf, 88 pcf and w = 39%, 30% for the LOOSE and MEDIUM DENSE conditions are assumed, respectively, the following design properties are selected for the stability evaluation:

	Y_t=Y_{sat}, pcf	Cohesion, c, psf	Friction, Φ
Loose FA+BA	**108.4**	**0**	**31^0**
Medium Dense FA+BA..	**114.4**	**0**	**37^0**
Compacted FA+BA in dike..	**120.4**	**100**	**38^0**

C. Natural CL:

Per Ref. 7, Table 1,

Ave. G_s = (2.53 + 2.63 + 2.72 + 2.66) / 4 = 2.64

Ave. w = (28.8 + 22.8) % / 2 = 25.8 %

Ave. Y_d = (94.2 + 97.8) / 2 = 96.0 pcf ..... (Y_t = 96.0 pcf x 1.258 = 120.8 pcf...S_r < 1.0)

c = 800 psf; Φ = 22.6^0 ..... Effective; saturated sample; Y_d = 94.2 pcf

Per Ref. 5,

Ave. w = (25.4 + 25.1) % / 2 = 25.3 % ...... Foundation CL; US-7; saturated moisture content

Ave. Y_d = (99.9 + 99.6) / 2 = 99.8 pcf .... Foundation CL; US-7

Y_{sat} = 99.8 pcf x 1.253 = 125.0 pcf

NOTE: Triaxial-shear test results in this data appear unreliable and are not considered.

Per Ref.9,

G_s = 2.68

W = 21.9%

Y_d = (102.2 + 102.4) / 2 = 102.3 pcf ...... w_{sat} = 23.6%

Y_{sat} = 102.3 pcf x !.236 = 126.4 pcf

The CPT data for this stratum gives the following interpreted strength values:

CPT   Ave. s_u in tsf

1A	0.68	
4	0.82	
6	0.53	
DN	0.375	
DS	0.84	
8	0.87	
9	0.47	
12	1.00	Average s_u = 0.70 tsf = 1,400 psf

If the Mohr's envelope is drawn for this strength and if $\Phi = 23^0$ is assumed for this soil, a cohesion intercept of 1,000 psf is obtained. This is close to Ref. 7 data of 800 psf. However, for the static-condition stability evaluation herein, the following values are conservatively used for this soil:

$$Y_t = Y_{sat} = 126.4 \text{ pcf}$$

$$c = 400 \text{ psf}$$

$$\Phi = 23^0$$

For the seismic condition, the strength is reduced to 80% of the maximum strength per the Guidance Document as follows:

$$Y_t = Y_{sat} = 126.4 \text{ pcf}$$

$$c = 0.8(1{,}000 \text{ psf}) = 800 \text{ psf}$$

$$\Phi = \tan^{-1}(0.8 \times \tan 23^0) = 19^0$$

It should be noted that the design seismic event is a low probability occurrence. Also, both the clayey CL subsoil and the overlying existing loose ash are likely to gain strength due to further consolidation under a significantly greater surcharge load in the future compared to the present condition under which the strength was measured insitu anddue to a planned provision of enhancement of drainage of the loose ash. Thus, the strength values assumed above for these two materials are conservative.

D. Clayey Silty Sand (SC-SM)

This naturally existing soil is primarily the residuum soil originating from the parent bedrock. Therefore, although it apparently includes pockets of soft or loose soil, the shear strength of the overall stratum is likely to be significantly high enough not to be a concern for the stability. As it was difficult to obtain really undisturbed and representative samples of this soil for the strength testing during the investigations due to variability and sand content under below GWL condition, the design properties as explained below are based on the available unit weight- moisture content, triaxial shear testing of remolded samples and conservative average value of the CPT tip-resistance data.

Per Ref. 7, Table 1,

Ave. $G_s = (2.66 + 2.66 + 2.64 + 2.67) / 4 = \underline{2.66}$

Ave. w = (19.9 + 20.6 + 18.6 + 17.2 + 22.0) % / 5 = 19.9 %, say, 20.0 % = w_{sat}

Ave.Y_d = (106.8 + 105.6 + 112.9 + 112.6 + 103.5) /5 = 108.3 pcf

$Y_t = Y_{sat}$ = 108.3 pcf x 1.20 = $\underline{130.0}$ pcf

c = $\underline{1,200}$ psf; $\Phi = \underline{29.6}^0$ ..... Effective; saturated sample; Y_d = 112.9 pcf

Per Ref. 5,

Ave. w = (22.7 + 17.1) % / 2 = 19.9 % ...... (w_{sat} = 21.4%) ....US-1 and US-7 samples

Ave. Y_d = (102.8 + 110.7) / 2 = 107.3 pcf .... US-1 and US-7 samples

Y_{sat} = 107.3 pcf x 1.214 = $\underline{130.3}$ pcf

c = $\underline{620 \text{ psf}}$; $\Phi = \underline{31}^0$ ..... Effective; saturated sample; Y_d = 102.8 pcf

Per Ref.9,

$G_s = 2.67$

w = (21.9 + 20.0) / 2 = 21.0 %

Y_d = 108.3 pcf ...... w_{sat} = 20.2%

Y_{sat} = 108.3 pcf x 1.202 = $\underline{130.2}$ pcf

The CPT data for this stratum gives an interpreted unconfined compressive strength of approx. 2.0 tsf. Assuming $\Phi = \underline{30}^0$, a cohesion intercept of approximately 1,200 psf is obtained for this strength if a Mohr's envelope is drawn. Thus, for this soil, the following conservative values are used conservatively for the analysis:

$$Y_t = Y_{sat} = 130.4 \text{ pcf}$$

$$c = \text{use } 0.5\ (1{,}200 \text{ psf}) = 600 \text{ psf}$$

$$\Phi = 30^0.$$

As the strength of this soil is already reduced, considering it to be the residuum soil, there is no need to reduce its strength further for the seismic condition.

E. Soft Shale:

No strength testing was required for the bedrock as the slip circles are not likely to penetrate it. However, the values are required for the computer-program input. The following values for the rock are used for both static and seismic conditions:

$$Y_t = Y_{sat} = 150 \text{ pcf}$$

$$c = 3{,}000 \text{ psf}$$

$$\Phi = 42^0$$

F. Gypsum Sludge:

It is assumed that the sludge will be piped in the form of water-based slurry (wet-placement) and discharged at the stack using the rim-ditch concept until the stack reaches Elev. 930' above which it will be placed using the dry-placement method. The sludge will consist primarily of calcium sulphate or gypsum. Thus, design properties for cast gypsum, sedimented (wet-placed) gypsum and dry-placed gypsum are determined herein.

It is important to note that the gypsum stacks reportedly are observed to sustain steep slopes, indicative of its relatively high shear strength, especially the cohesive bondage when exposed to air. Ref. 13 states (P. 10-137), "Gypsum stacks over 100 feet high with average side slopes as steep as 1.5 horizontal to 1.0 vertical are not uncommon". Mactec also observed (Ref. 11) that after the sedimented gypsum is allowed to dry "Near vertical cuts of 20 feet or more show little if any signs of slope failure or even raveling after being exposed for several months." On the other hand, there is an indication (Ref. 13, page. 10-137) that there is "no measurable change in the shear strength or permeability of gypsum within the stack" where gypsum is not exposed to air and "indicated no cementation" (although it perhaps does crystallize in the interior portions of stacks also as long as free water is available).

The properties of the sludge at disposal sites have been studied extensively elsewhere besides TVA sites (Ref.13). Reviewing this information, it can be seen that various factors govern the properties of gypsum in a stack. That is also likely to be the case at the Kingston site just like other existing disposal sites. Therefore, the design properties selected for this analysis are primarily derived from the EPRI data (Ref. 13), using TVA-site data (Ref. 11) as supplementary data, and also are based on the observations described in the preceding paragraph.

Per data presented in Ref. 11 for sedimented gypsum,

Y_{sat} = (104.3 + 103.8 + 100.6 + 102.0) pcf / 4 = 102.7 pcf ...(Samples 2 & 4, S_r = 1.0)

c = 0

$\Phi = (40.4^0 + 39^0) / 2 = 39.7^0$, say 40^0

Per data presented in Figures 10-62 and 10-63 of Ref. 13,

c = 0

$\Phi = 40^0$ to 42^0 @ Y_d = 78 to 82 pcf or Y_{sat} = 107.1 to 109.4 pcf.......*Sedimented Gypsum*

$\Phi = 41^0$ to 47^0 @ Y_d = 87 to 103 pcf or Y_{sat} = 112.2 to 121.4 pcf .... *Cast Gypsum*

(Assumed G_s = 2.34)

Per Ref. 14 (gypsum + FA mixture),

c = 0

$\Phi = 41^0 \pm 2^0$ @ Y_d = 91.5 pcf or Y_{sat} = 117.4 pcf ...... *Sedimented*

$\Phi = 43^0$ @ Y_d = 96.2 pcf or Y_{sat} = 120.2 pcf .... *Cast*

For dry-placed gypsum, using Table 3-11 of Ref. 13,

c ~ (0 + 5) psi / 2 = 2.5 psi =360 psf.

$\Phi = (31^0 + 39^0)/2 = 35^0$

Arbitrarily, assume Y_t = 102 pcf and Y_{sat} = 107 pcf due to some compaction effort.

The following design properties for the sludge are used for the analysis:

	Y_t, pcf	Y_{sat}, pcf	Cohesion, c, psf	Friction, Φ
Sedimented Gypsum ...	116.4	116.4	0	40^0
Cast Gypsum ...	120.4	120.4	100	43^0
Dry-Placed Gypsum ...	102	105	350	35^0

8. SLOPE STABILITY EVALUATION

The slope stability evaluation is performed using the computer program PC STABL5M. The program is based on the pseudo-static method of analysis where a mass or a part of the slope of varying size is assumed to fail along a cylindrical or predetermined surface (for sliding block analysis). The resistance to sliding is provided by friction and adhesion along the surface of sliding. The program automatically searches for the most critical cylindrical surface of sliding that gives the least factor of safety against such a failure and uses the same method for both static and seismic conditions.

For the seismic condition, a horizontal destabilizing force is added to the total sliding force, that is equal to the weight of the sliding mass times a seismic coefficient, k_s. Based on extensive studies performed in the past, as discussed in Reference 16, the coefficient is found to be significantly smaller than the peak or maximum ground acceleration a_{max}/g, where a_{max} is the peak or maximum horizontal ground acceleration and g is the acceleration due to the gravity. This is simply due to the fact that the sliding mass is subjected to the peak acceleration at any one point in the mass at a time only for a fraction of a second and does not occur simultaneously at all points during an earthquake. Thus, for a simplified analysis such as the pseudo-static analysis, the coefficient corresponds to an average effective acceleration across the mass. Due to the complexity factors and difficulty involved in the determination of this effective acceleration in a mass during an earthquake, accurate value of the coefficient for such an analysis perhaps will never be determined and, therefore, an empirical value has been recommended based on observations and studies for failures in the past. A coefficient value of equal to 0.5 is found to be adequate and is recommended in Reference 16 and other publications referenced in it for the pseudo-static analyses of slopes.

According to Guidance Document, the peak ground acceleration is the "maximum horizontal acceleration in lithified earth material", corresponding to a "90 percent or greater probability that the acceleration will not be exceeded in 250 years." The document also states, "lithified earth materials means all rock, including all naturally occurring and naturally formed aggregates of masses of minerals or small particles of older rock that formed by crystallization of magma or by induration of loose sediments.... This term does not include man-made materials, such as fill, concrete, and asphalt or UNCONSOLIDATED earth materials, soil, or regolith lying at or near the earth's surface".

The peak acceleration in the bedrock at the site in accordance with Guidance Document is approximately 0.22g. Since the natural soil overburden over the bedrock at the site is very shallow (hardly 730 feet – 703 feet = 27 feet) and generally stiff, with the ash or ash-gypsum stack being medium stiff to stiff, the maximum ground acceleration for this evaluation is assumed to be the same as that in the rock (i.e., 0.22*g*) in accordance with Figure 4.2 of Reference 16. This means that the average effective acceleration in a sliding mass of the stack during the design earthquake is likely to be 0.11*g*; i.e. equal to one-half of the peak ground acceleration (a_{max}).

In accordance with the recommended procedure (Ref. 16, Page 84), the computer program is utilized herein to obtain the acceleration, called the *yield acceleration* k_y, at which the factor of safety equals approximately 1.00 against the failure. The procedure further recommends that if the yield acceleration so obtained is equal to or greater than 0.5 a_{max} *(i.e.,* 0.11*g* in this case*)*, the slope is likely to be stable during the design earthquake and no further verification by computing the deformation based on the Seed-Makdisi procedure is required. The deformation in such a case is found to be almost always less than one foot which is generally acceptable and, hence, not necessary to be computed. Thus, as the yield acceleration is equal to or greater than 0.11*g* in all cases (See Table 1) and as conservative soil/material parameters were used for the evaluation, the deformation analysis is not required and is not included herein.

9. RESULTS OF SLOPE STABILITY EVALUATION

The results of the stability evaluation for the three critical sections listed before, representing the three phases of the proposed construction, and for the section at the blowout location are summarized in Table 1. The table gives the factor of safety against the slope failure corresponding to the static condition and the yield acceleration values corresponding to the design seismic event. The table also includes the results of the sliding block analysis performed for the most critical condition; i.e., Phase 3 or Final condition at Section 3-3. The details of both input and output for each computer run are given in the printouts in Attachment A.

TABLE 1

SLOPE STABILITY FACTOR OF SAFETY & YIELD ACCELERATION

Run No.	Section (Phase)	Stack Type	Condition	F.S.	Yield Accel
1	1-1 (Phase 1 End)	Ash Cells	Static	2.00	-
2	1-1 (Phase 1 End)	Ash Cells	Seismic	-	0.18*g*
3	2-2 (Phase 2 End)	Gypsum+Ash	Static	1.90	-
4	2-2 (Phase 2 End)	Gypsum+Ash	Seismic	-	0.20*g*
5	3-3 (Final)	Gypsum+Ash	Static	1.73	-
6	3-3 (Final)	Gypsum+Ash	Seismic	-	0.16*g*
7	3-3 (Final)	Ash Only (Wet)	Static	1.51*	-
8	3-3 (Final)	As Only (Wet)	Seismic	-	0.11*g*
9	3-3 (Final)	Ash Only (Wet&Dry)	Static	1.52**	-
10	3-3 (Final)	As Only (Wet&Dry)	Seismic	-	0.11*g*
11	3-3 (Final)	Gypsum+Ash	Static(Slid.Block)	1.77	-
12	3-3 (Final)	Gypsum+Ash	Seismic(Slid.Block)	-	0.16*g*
13	1-1 (Current)	Ash Cell 3 (Blowout)	Static	1.48***	

* Maximum Stack Elev. 930'

** Maximum Stack Elev. 965'

*** Top of Cell assumed at Elev. 810'; GWL assumed at least 5 feet above the level on May 14, 2004.

It should be noted that the actual factor of safety will be significantly greater than the tabulated values due to the three-dimensional effect since the values calculated above were based not only on conservative soil or material parameters but also an assumption that a stack consists of a two-dimensional or an infinitely long embankment whereas the actual stack would have finite length and would be closer to a square-shaped body than that resembling a long embankment. Also, the stacks are bounded by the perimeter dikes composed of much stronger materials than that in the interior areas. Therefore, the resistance to a slide was derived primarily from the weaker interior slope, yielding lower values of the factor of safety than in the actual case.

10. VENEER STABILITY EVALUATION

The veneer stability is evaluated along the sloped surface of the final stack using the *landfilldesign.com* calculators (Attachment B). In accordance with the recommendation in the Guidance Document, a seismic coefficient of 0.11*g* is used. As the final cover is required to consist of a cohesive clayey soil, perhaps mixed with gypsum, two soil-cover cohesion values are used: 250 psf (12.0 kN/m^2) and 100 psf (4.8 kN/m^2) along with the friction angle of 26^0. The latter value of cohesion may be considered to correspond conservatively to a softened condition after rain. As the slope will have 15 feet wide benches at 30-feet vertical height intervals, a slope length of 90 feet (= 3 x 30' or 27.43 m) is used for the evaluation. Also, it is assumed for this analysis that the surficial slope material underlying the cover consists of either the cast gypsum or BA for which the surface friction will be approximately equal to two-thirds of 38^0 (lower of the friction angle values corresponding to the two materials); i.e., equal to 25^0. The results are summarized in Table 2 below.

TABLE 2

VENEER STABILITY FACTOR OF SAFETY

Condition	Seismic Coefficient	Cover Soil Cohesion, psf	F.S.
Static	-	250	1.761
Static	-	100	1.588

Seismic	0.11*g*	250	1.283
Seismic	0.11*g*	100	1.154

Thus, the soil cover is likely to be stable during both the static and design seismic conditions.

11. SITE LIQUEFACTION POTENTIAL

The ash site where the proposed facility will be located has been a permitted facility that has been used so far to deposit wet-sluiced ash. Therefore, several tens of feet of sedimented or settled ash (approximately 30 feet in the Ash Pond area and 75 feet in the Cells area) cover the natural soil strata at the site. Furthermore, the top natural soil stratum consists of generally stiff cohesive clay soil that is underlain by a stratum of cohesive residuum soil stronger than the clay soil. Bedrock exists below these two soil strata. Thus, the two natural soil strata are not likely to liquefy except at isolated loose cohesionless sand pockets that may exist in these two strata. Liquefaction of such pockets, if any, is likely to be inconsequential for this facility.

However, a 7 feet to 10 feet thick stratum of loose ash appears to exist immediately above the natural clay stratum; i.e., at a depth of approximately 20 feet in Ash Pond Area and more than 60 feet in Cell Area below the present GS in those areas. This stratum of loose ash may undergo an an initial liquefaction in Ash Pond Area due to insufficient existing overburden load on it if a design seismic event occurs at the site before it is buried under a sufficient overburden of ash; i.e., roughly 10 feet to 30 feet of additional ash or ash and gypsum, depending on the depth to GWL at the time of such an occurrence. The probability of such an occurrence is extremely low.

Theoretically, once this stratum is buried under a sufficient overburden load, it is not likely to liquefy but it is likely to undergo significant settlement subsequent to the occurrence of a design seismic event. A rough estimate shows that the total settlement resulting from such an occurrence is not likely to be greater than one foot and, hence, of no serious consequence. Based on Figure 8 in the Guidance Document, which is based on a 1985 study by Ishihara, it is not likely that the surface manifestation of liquefaction will occur as long as this 3-meter thick stratum is at least 3 meters (10 feet) or more below GS.

The subsurface exploration data also shows, as is expected due to the nature of wet-ash disposal and due to the very large area of the disposal site, that pockets (and not continuous strata or layers) of liquefiable ash may exist occasionally at depths shallower than the liquefiable ash stratum discussed above. However, liquefaction of such pockets for a facility such as this should not be of any serious consequence.

There are no theories that can accurately predict degrees of liquefaction as it depends on the distance of the epicenter of the earthquake, energy released, and the nature of dissipation or dispersal of this energy that depends on the nature and extent or continuity of soil overburden above bedrock strata in its path. The methods that predict liquefaction and its effects are empirical and have often proved to be insufficient. Therefore, it is recommended that measures be taken to improve drainage and consequently rate of consolidation of this loose ash stratum at least at a critical location. For this, it is suggested that columns of coarse ash, similarly to gravel columns, be inserted into this stratum and connected to the proposed BA filter system located at the bottom of the proposed gypsum-ash stack. The appropriate location of these columns would be at or near the inner toe of the starter perimeter dike along the Stilling-Basin side of the stack. This provision will facilitate dissipation of generated higher pore-water pressure in this stratum, if any, and allow it to consolidate faster. This will also improve stability of the critical toe area.

12. CONCLUSION AND RECOMMENDATIONS

1. The proposed raised Cell Area ash stack and gypsum-ash stack (wet-placed to Elevation 930' and dry-placed above it) are likely to be stable during any stage of construction and after completion of construction including during the occurrence of the design seismic event. Although a stability evaluation is not performed for a Phase 2 condition that may require the stack raised at the end of Phase 2 to Elevation 870' instead of 840', it can be deduced based on the factor of safety values obtained for the Phase 3 that the factor of safety for that condition will be satisfactory for both static and seismic conditions.

2. If instead of gypsum and ash only ash is used, it is estimated that the stack can be raised maximum to Elevation 930' if the ash is deposited using only wet operation, and to Elevation 965' if wet operation is terminated at Elevation 870' and dry stacking used above that.

3. If a clayey soil cover or veneer is used to cap the final stack, it is likely to remain stable even during the design seismic event if the cohesion and friction values of the cover soil are greater than 100 psf and 26^0, respectively.

4. The existing Ash Pond Area should be graded flat and the graded surface should be compacted using heavy compaction equipment prior to placement of the

compacted fly-ash base. The GWL should be lowered by several feet to help stabilize the graded surface. Note that bottom ash and/or Tensar geogrid or similar geonet reinforcement may be required to support construction equipment in soft areas.

5. Adequate drainage must be provided to control the phreatic water surface inside the stack.

6. It is also recommended that measures be taken to enhance drainage and consolidation of the existing approximately 7 to 10 feet thick loose ash stratum immediately overlying the natural clayey soil stratum, especially below the starter perimeter dike for the gypsum-ash stack and adjacent to the Stilling Basin. Use of coarse bottom ash columns, like gravel columns, installed by drilling to the bottom of this stratum and tying the columns to the bottom filter blanket should be adequate for improving the strength against probable instability during the design seismic event.

END

.REFERENCES

1. Drawing Nos. 10W425-22, 23, 34A, 34B, 34C (showing proposed Phase 1, 2 and 3 plans and selected critical sections 1-1, 2-2, and 3-3).

2. TVA Drawing No. 10N400 – R6, dated 7-5-56 (showing original surface topography).

3. TVA Drawings No. 10N420 and 10N421, dated 5-6-77 and 10-13-77, resp., (showing sections of Dike C, Road Dike and Divider Dike).

4. TVA document titled, "Ash Disposal Area Dike Raising – Soils Exploration and Testing" by Gene Farmer and W.W. Engle, dated June 26, 1974.

5. TVA's "Soil Investigation" report by G.L. Buchanan and Gene Farmer, dated November 3, 1975.

6. U.S. Government reports titled, *KINGSTON STEAM PLANT - DIKE C, - SOILS INVESTIGATION – EN DES SOIL SCHEDULE 82.3*, dated June 22, 1984 and January 10, 1985.

7. Singleton Laboratories' report titled, *KINGSTON FOSSIL PLANT – DREDGE CELLS CLOSURE SOILS INVESTIGATION*, dated September 29, 1994.

8. TVA report titled, *Hydro geologic Evaluation of Ash Pond Area*, dated June 1995.

9. Mactec report titled, *REPORT OF GEOTECHNICAL EXPLORATION, ASH DISPOSAL AREA,* dated May 4, 2004.

10. Drawing No. SK PR0637 C80 (showing locations of borings drilled prior to 2004).

11. Mactec report titled, *Laboratory Testing Results – Samples from Gypsum Pond at Cumberland Fossil Plant*, dated May 13, 2004.

12. Law Engineering's FINAL REPORT - *Fly Ash, Bottom Ash and Scrubber Gypsum Study* - to TVA dated November 7, 1995, along with transmittal letter dated November 10, 1995.

13. EPRI Manual TR104731 titled, *FGD by-Product Disposal Manual, Fourth Edition*, August 1995.

14. Report by Ardaman & Associates, Inc., titled, "Interim Report on Evaluation of Gypsum-Flyash Wet-Stacking Disposal facility, Widows Creek Steam Plant", dated April 22, 1991.

15. D. H. Gray and Y.-K. Lin, *Engineering Properties of Compacted Ash,* ASCE Journal of The Soil Mechanics & Foundation Division, April 1972.

16. Seminar proceeding titled, Seismic Analysis and Design Considerations for Municipal Solid Waste Landfills, March 2-3, 1994, sponsored by New York Association for Solid Waste Management, NY Dept. of Environmental Conservation and U.S. EPA.

17. The University of British Columbia, Canada, soil Mechanics Series Nos. 157 & 158, *Interpretation of Piezocone Test Data for Geotechnical Design, by R.G. Campanella et al*, September 1995.

ATTACHMENT 1

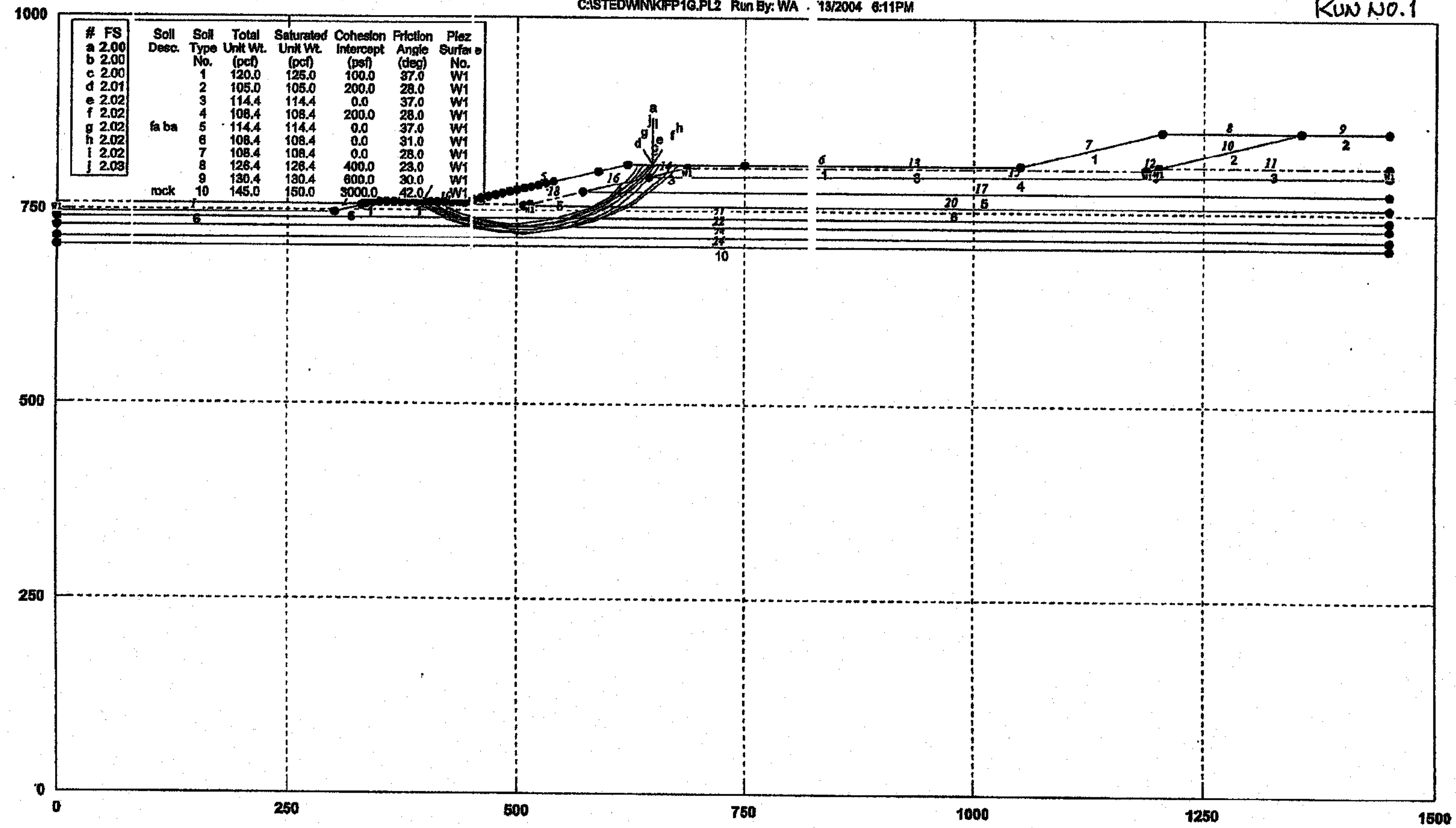
SLOPE STABILITY COMPUTER PRINTOUTS

(13 Pages)

KIF Phase 1 (Sectio ı 1-1)

C:\STEDWIN\KIFP1G.PL2 Run By: WA · 13/2004 6:11PM

Run No. 1



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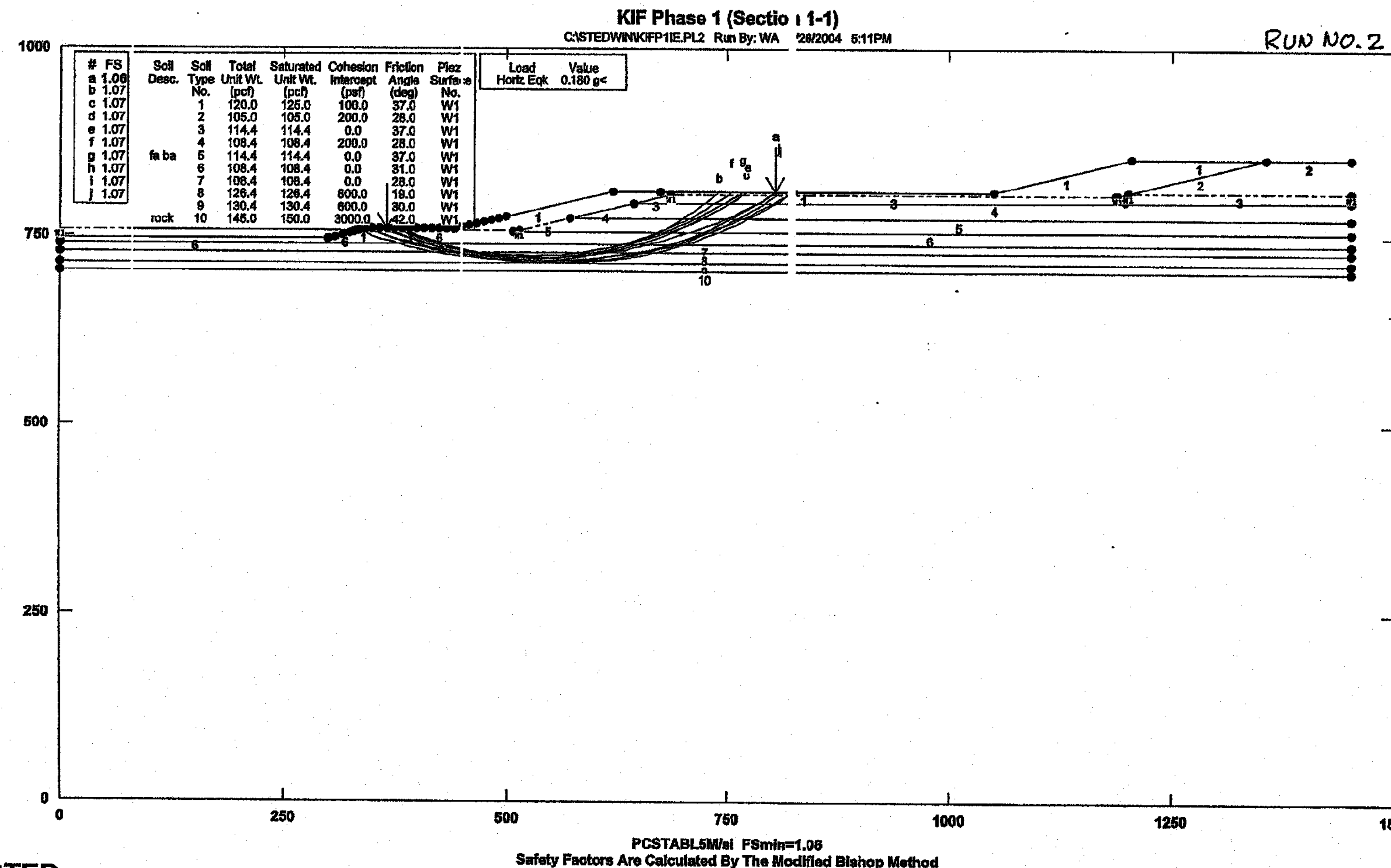
Safety Factors Are Calculated By The Modified Bishop Method

STED

RUN NO. 2



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f	1.07
g	1.07
h	1.07
i	1.07
j	1.07

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez Surface No.
	1	120.0	125.0	100.0	37.0	W1
	2	105.0	105.0	200.0	28.0	W1
	3	114.4	114.4	0.0	37.0	W1
	4	108.4	108.4	200.0	28.0	W1
fa ba	5	114.4	114.4	0.0	37.0	W1
	6	108.4	108.4	0.0	31.0	W1
	7	108.4	108.4	0.0	28.0	W1
	8	126.4	126.4	800.0	19.0	W1
	9	130.4	130.4	600.0	30.0	W1
rock	10	145.0	150.0	3000.0	42.0	W1

Load	Value
Horiz Eqk	0.180 g<

STED

KIF Phase 2 (Section 2-2) Gypsum Ash WetPlacement Intermediate Stage (el 840')

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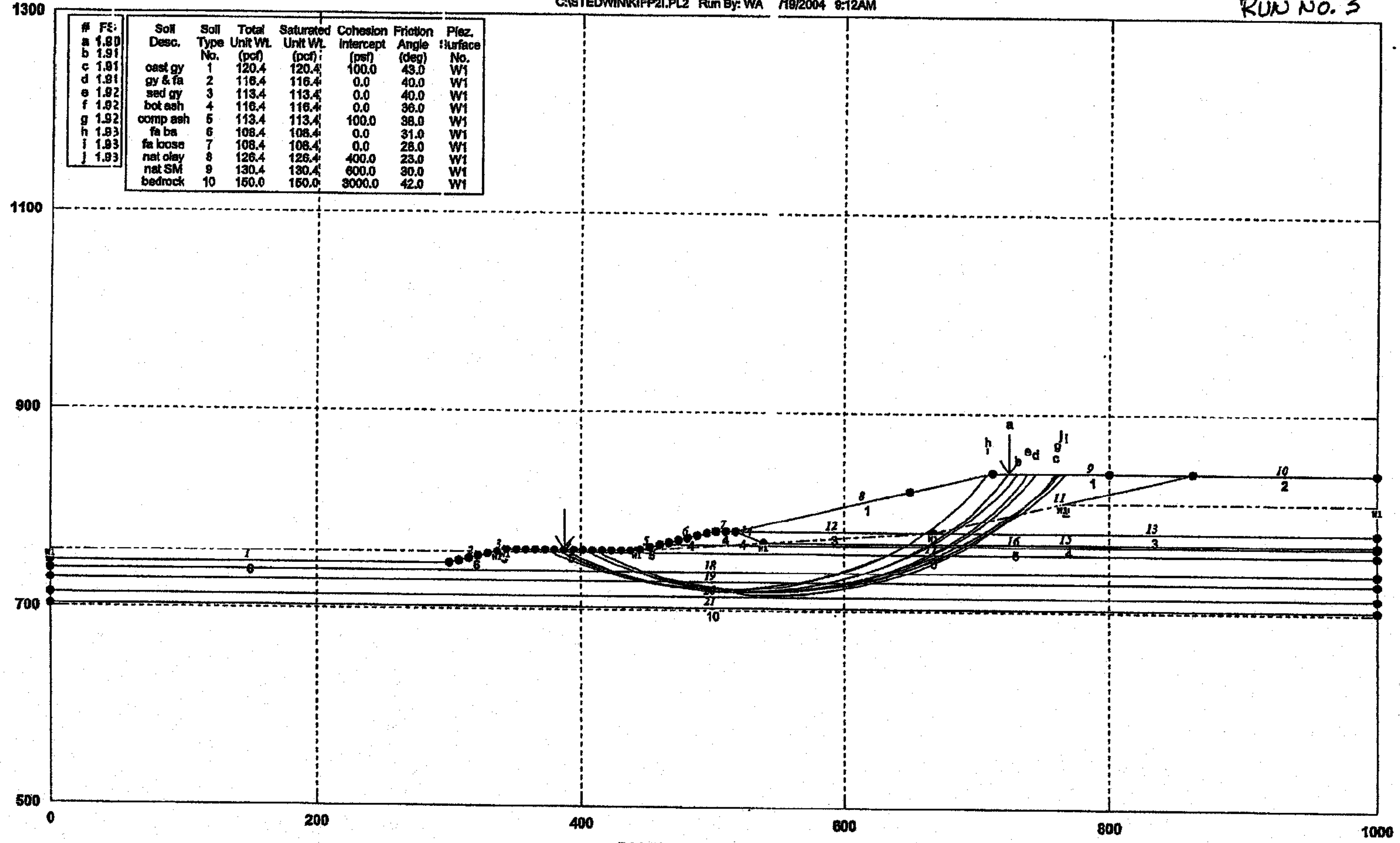

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d	1.91
e	1.92
f	1.92
g	1.92
h	1.93
i	1.93
j	1.93

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
cast gy	1	120.4	120.4	100.0	43.0	W1
gy & fa	2	116.4	116.4	0.0	40.0	W1
sed gy	3	113.4	113.4	0.0	40.0	W1
bot ash	4	116.4	116.4	0.0	36.0	W1
comp ash	5	113.4	113.4	100.0	38.0	W1
fa ba	6	108.4	108.4	0.0	31.0	W1
fa loose	7	108.4	108.4	0.0	28.0	W1
nat clay	8	126.4	126.4	400.0	23.0	W1
nat SM	9	130.4	130.4	600.0	30.0	W1
bedrock	10	150.0	150.0	3000.0	42.0	W1

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Safety Factors Are Calculated By The Modified Bishop Method

STED

KIF Phase 2 (Section 2-2) Gypsum Ash WetPlacement Intermediate Stage (el 840')

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RUN NO. 4

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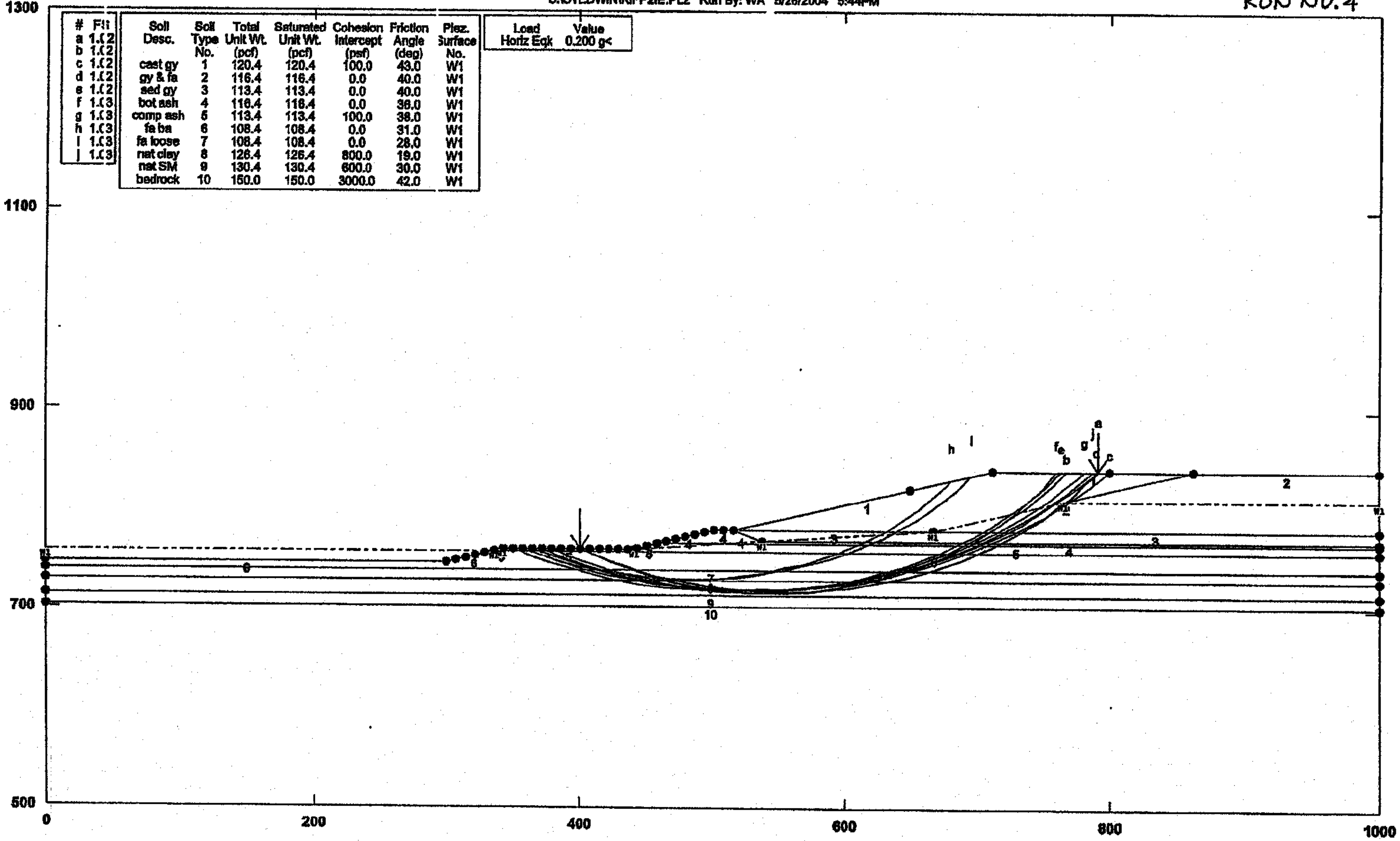
b	1.02
c	1.02
d	1.02
e	1.02
f	1.03
g	1.03
h	1.03
i	1.03
j	1.03

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
cast gy	1	120.4	120.4	100.0	43.0	W1
gy & fa	2	116.4	116.4	0.0	40.0	W1
sed gy	3	113.4	113.4	0.0	40.0	W1
bot ash	4	116.4	116.4	0.0	36.0	W1
comp ash	5	113.4	113.4	100.0	38.0	W1
fa ba	6	108.4	108.4	0.0	31.0	W1
fa loose	7	108.4	108.4	0.0	28.0	W1
nat clay	8	126.4	126.4	800.0	19.0	W1
nat SM	9	130.4	130.4	600.0	30.0	W1
bedrock	10	150.0	150.0	3000.0	42.0	W1

Load	Value
Horiz Eqk	0.200 g<



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STED

KIF Phase 3 (Section 3-3) Final Stack Gypsum and Wet Ash Placement to 930

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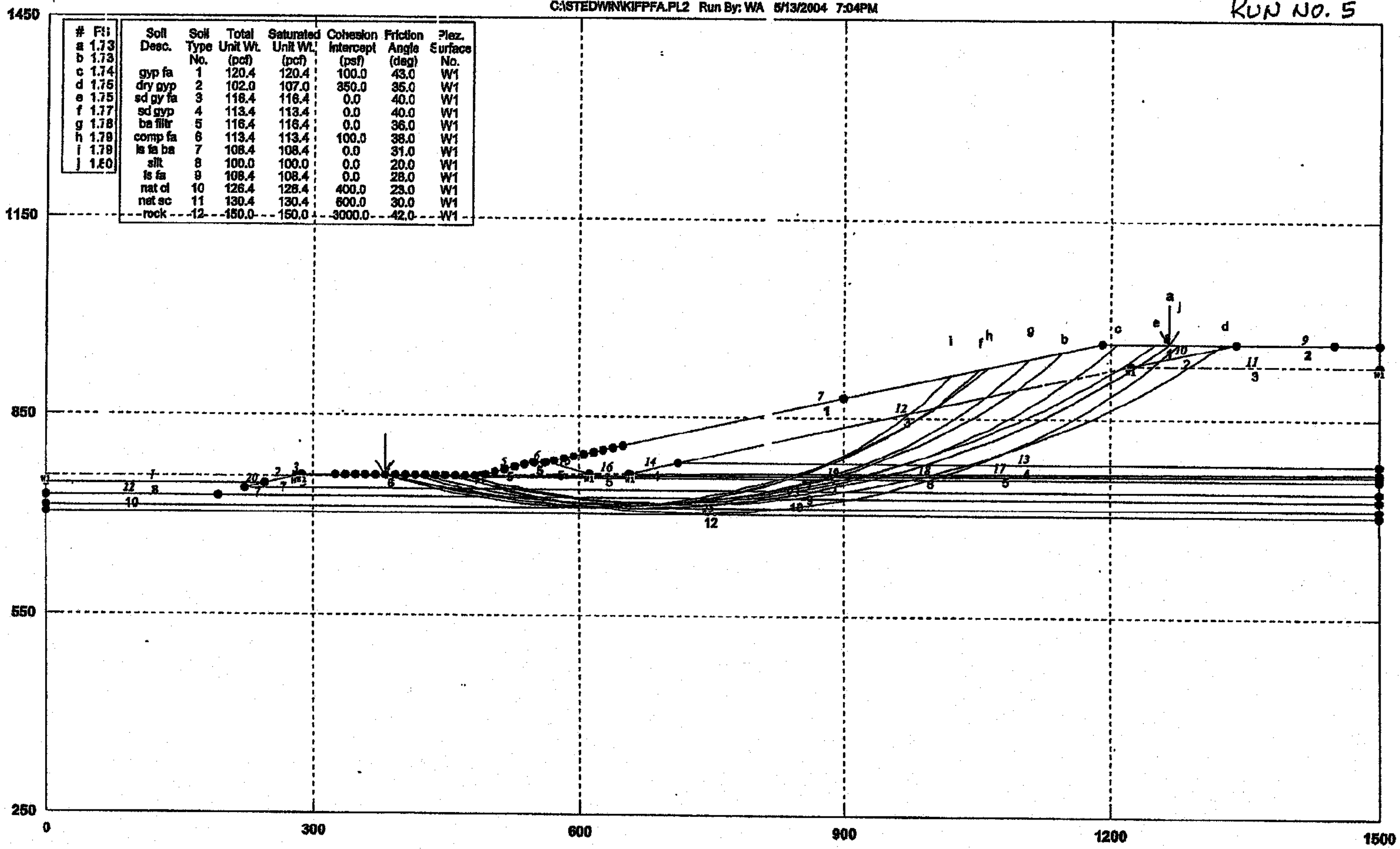

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g	1.78
h	1.79
i	1.79
j	1.80

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
gyp fa	1	120.4	120.4	100.0	43.0	W1
dry gyp	2	102.0	107.0	350.0	35.0	W1
sd gy fa	3	116.4	116.4	0.0	40.0	W1
sd gyp	4	113.4	113.4	0.0	40.0	W1
ba filtr	5	116.4	116.4	0.0	36.0	W1
comp fa	6	113.4	113.4	100.0	38.0	W1
ls fa ba	7	108.4	108.4	0.0	31.0	W1
silt	8	100.0	100.0	0.0	20.0	W1
ls fa	9	108.4	108.4	0.0	28.0	W1
nat cl	10	126.4	126.4	400.0	23.0	W1
nat sc	11	130.4	130.4	600.0	30.0	W1
rock	12	150.0	150.0	3000.0	42.0	W1

PCSTABL5M/si FSmin=1.73
Safety Factors Are Calculated By The Modified Bishop Method

STED

KIF Phase 3 (Section 3-3) Final Stack Gypsum and Wet Ash Placement to 930

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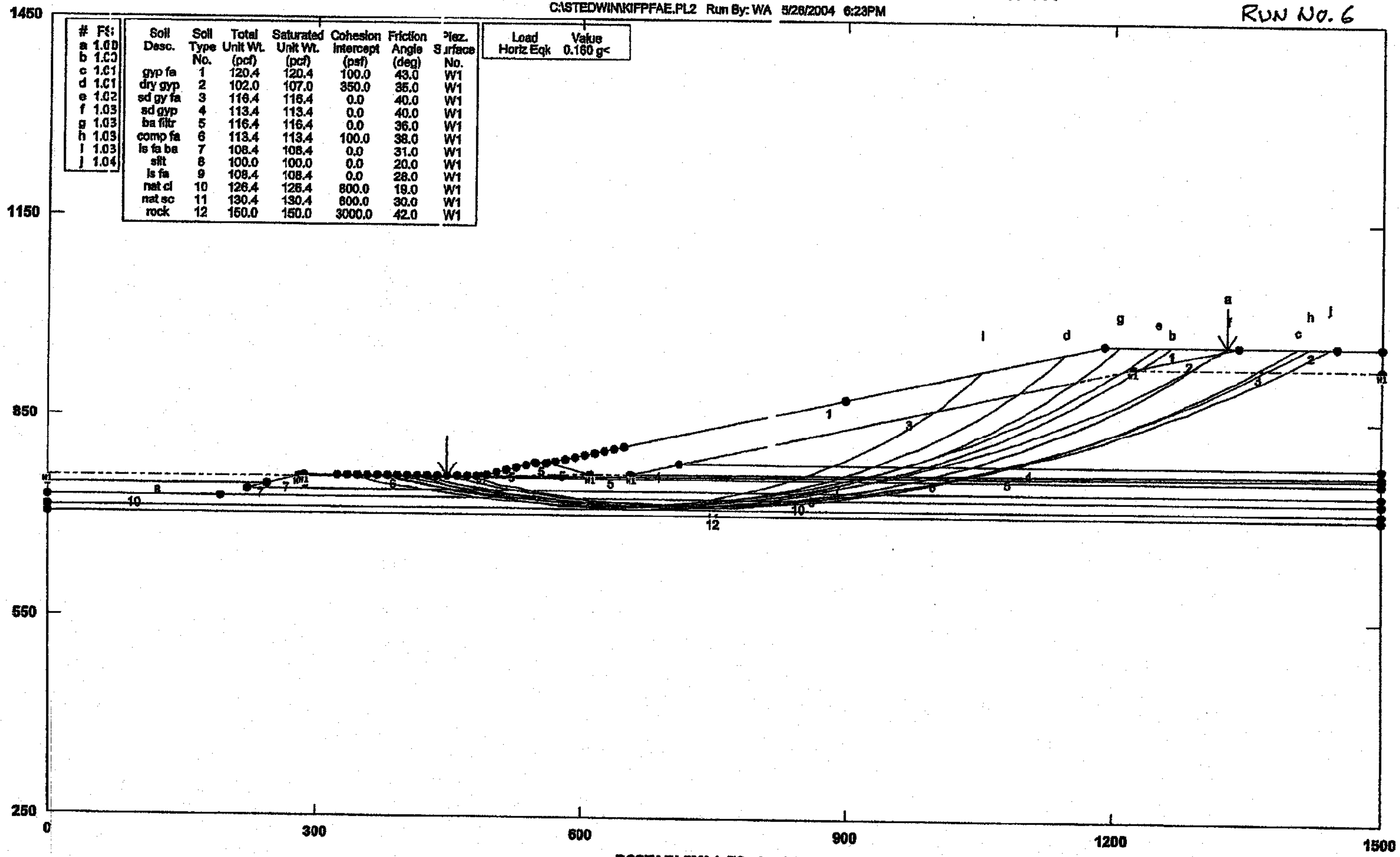

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Safety Factors Are Calculated By The Modified Bishop Method

STED

KIF All Wet Option T p at 930

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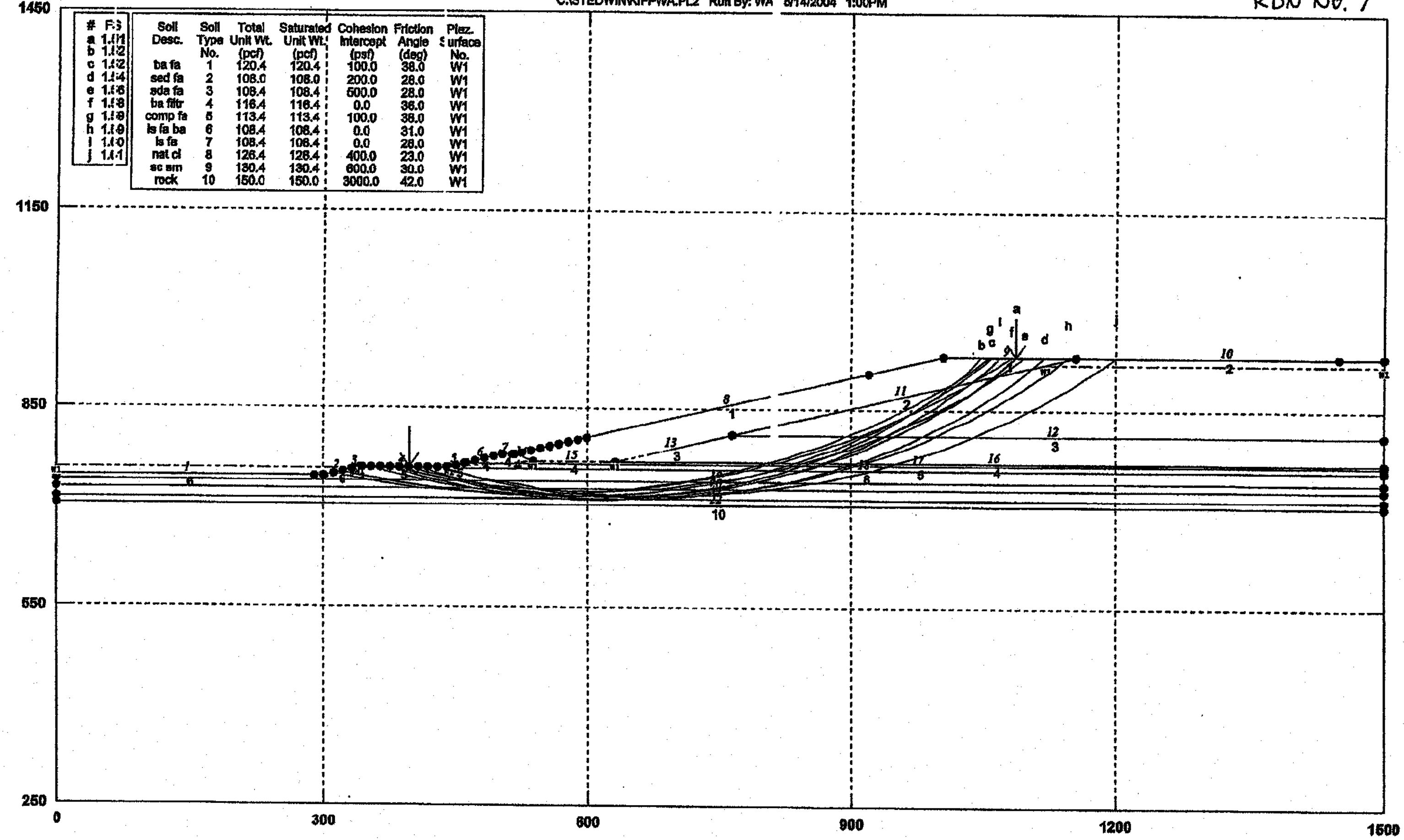
RUN NO. 7



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f	1.[illegible]8
g	1.[illegible]9
h	1.[illegible]9
i	1.[illegible]0
j	1.[illegible]1

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
ba fa	1	120.4	120.4	100.0	38.0	W1
sed fa	2	108.0	108.0	200.0	28.0	W1
sda fa	3	108.4	108.4	500.0	28.0	W1
ba filtr	4	116.4	116.4	0.0	36.0	W1
comp fa	5	113.4	113.4	100.0	38.0	W1
ls fa ba	6	108.4	108.4	0.0	31.0	W1
ls fa	7	108.4	108.4	0.0	28.0	W1
nat cl	8	126.4	126.4	400.0	23.0	W1
sc sm	9	130.4	130.4	600.0	30.0	W1
rock	10	150.0	150.0	3000.0	42.0	W1

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Safety Factors Are Calculated By The Modified Bishop Method

STED

RUN NO. 8

KIF All Wet Option T(p at 930

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b	1.03
c	1.04
d	1.04
e	1.04
f	1.05
g	1.06
h	1.07
i	1.07
j	1.09

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
ba fa	1	120.4	120.4	100.0	38.0	W1
sed fa	2	108.0	108.0	200.0	28.0	W1
sda fa	3	108.4	108.4	500.0	28.0	W1
ba filtr	4	116.4	116.4	0.0	36.0	W1
comp fa	5	113.4	113.4	100.0	38.0	W1
ls fa ba	6	108.4	108.4	0.0	31.0	W1
ls fa	7	108.4	108.4	0.0	28.0	W1
nat cl	8	126.4	126.4	800.0	19.0	W1
sc sm	9	130.4	130.4	600.0	30.0	W1
rock	10	150.0	150.0	3000.0	42.0	W1

Load	Value
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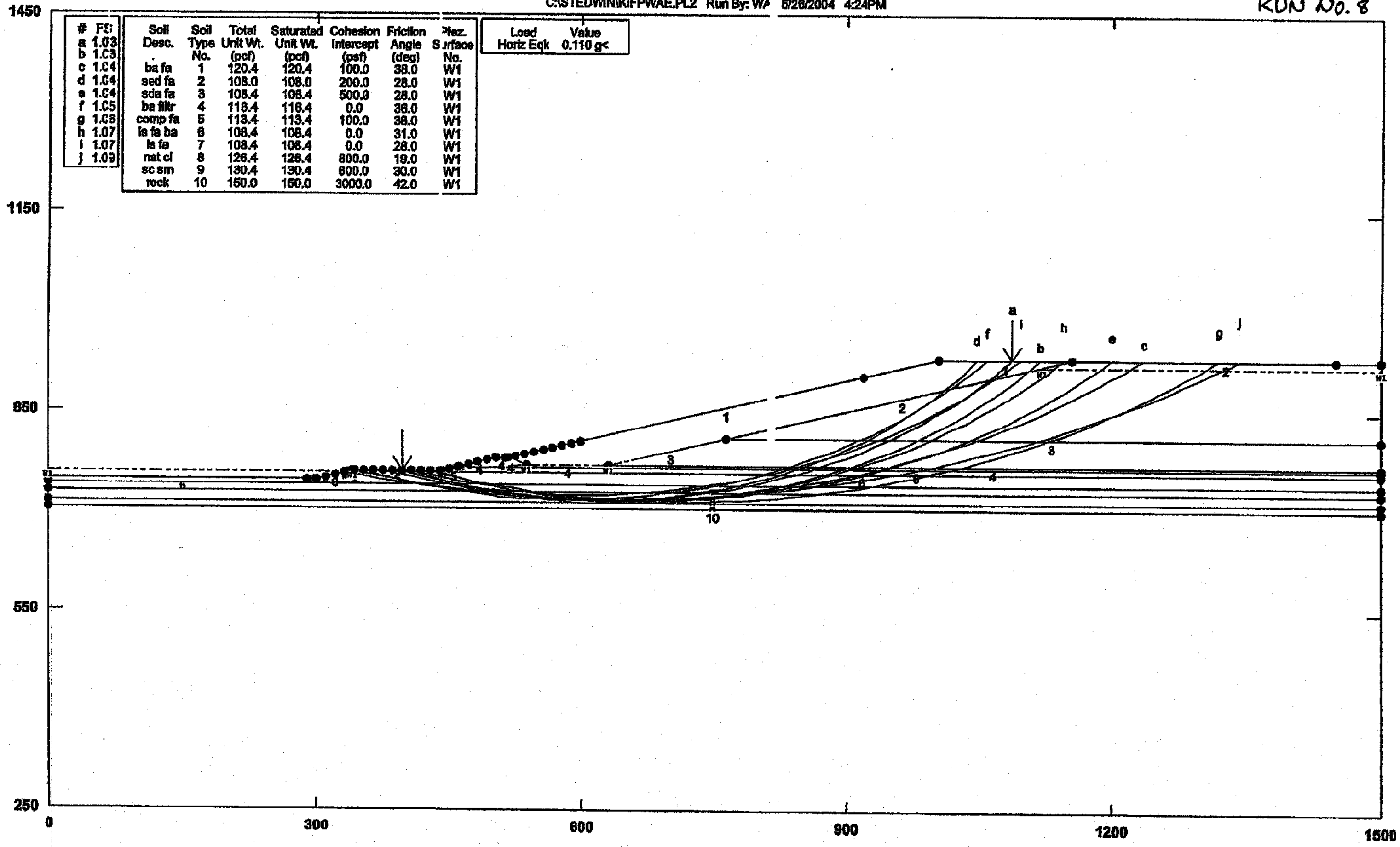

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Safety Factors Are Calculated By The Modified Bishop Method

STED

KIF Wet + Dry Option

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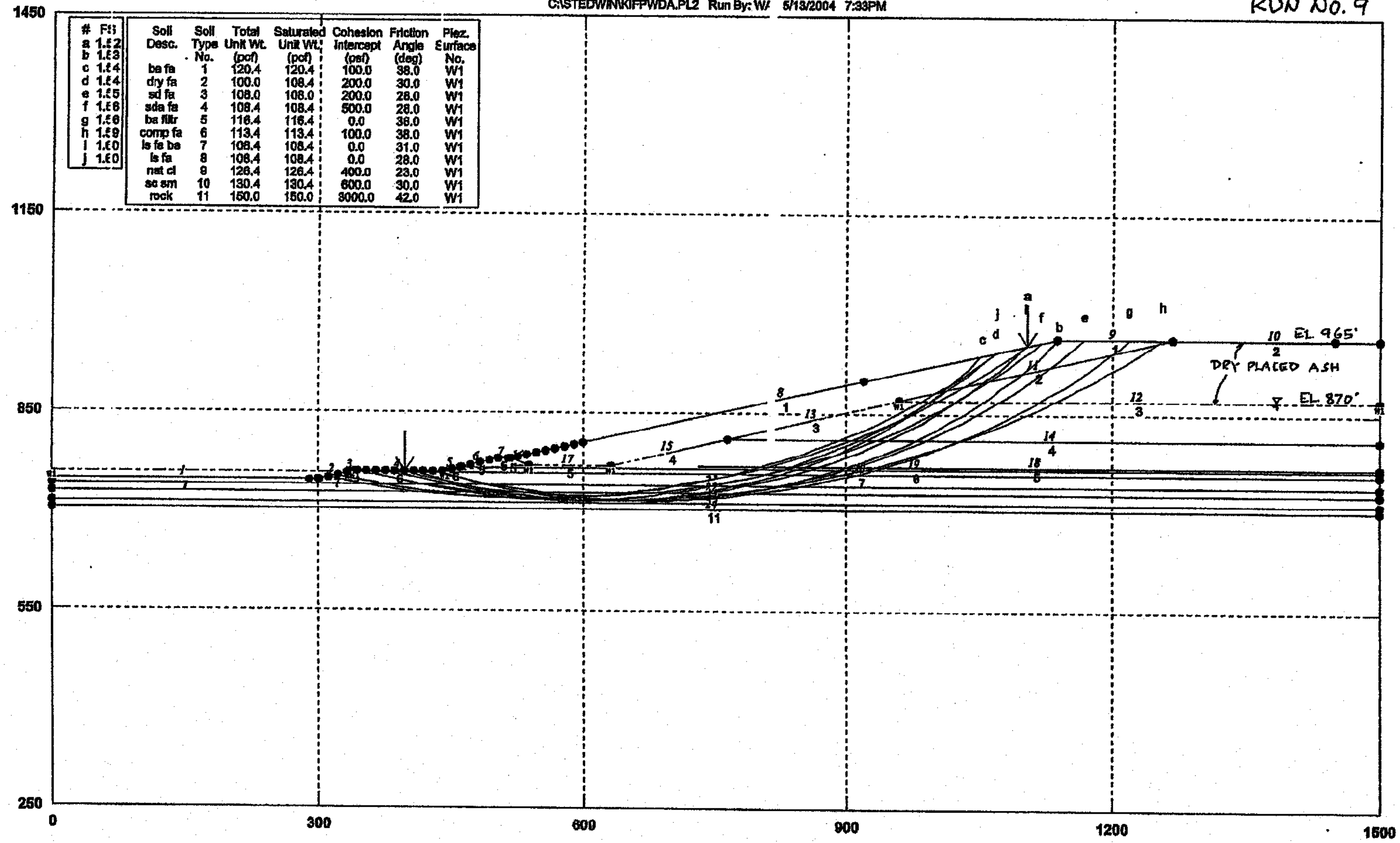
RUN NO. 9



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d	1.54
e	1.55
f	1.56
g	1.56
h	1.59
i	1.60
j	1.60

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
ba fa	1	120.4	120.4	100.0	38.0	W1
dry fa	2	100.0	108.4	200.0	30.0	W1
sd fa	3	108.0	108.0	200.0	28.0	W1
sda fa	4	108.4	108.4	500.0	28.0	W1
ba filtr	5	116.4	116.4	0.0	38.0	W1
comp fa	6	113.4	113.4	100.0	38.0	W1
ls fa ba	7	108.4	108.4	0.0	31.0	W1
ls fa	8	108.4	108.4	0.0	28.0	W1
nat cl	9	126.4	126.4	400.0	23.0	W1
sc sm	10	130.4	130.4	600.0	30.0	W1
rock	11	150.0	150.0	3000.0	42.0	W1

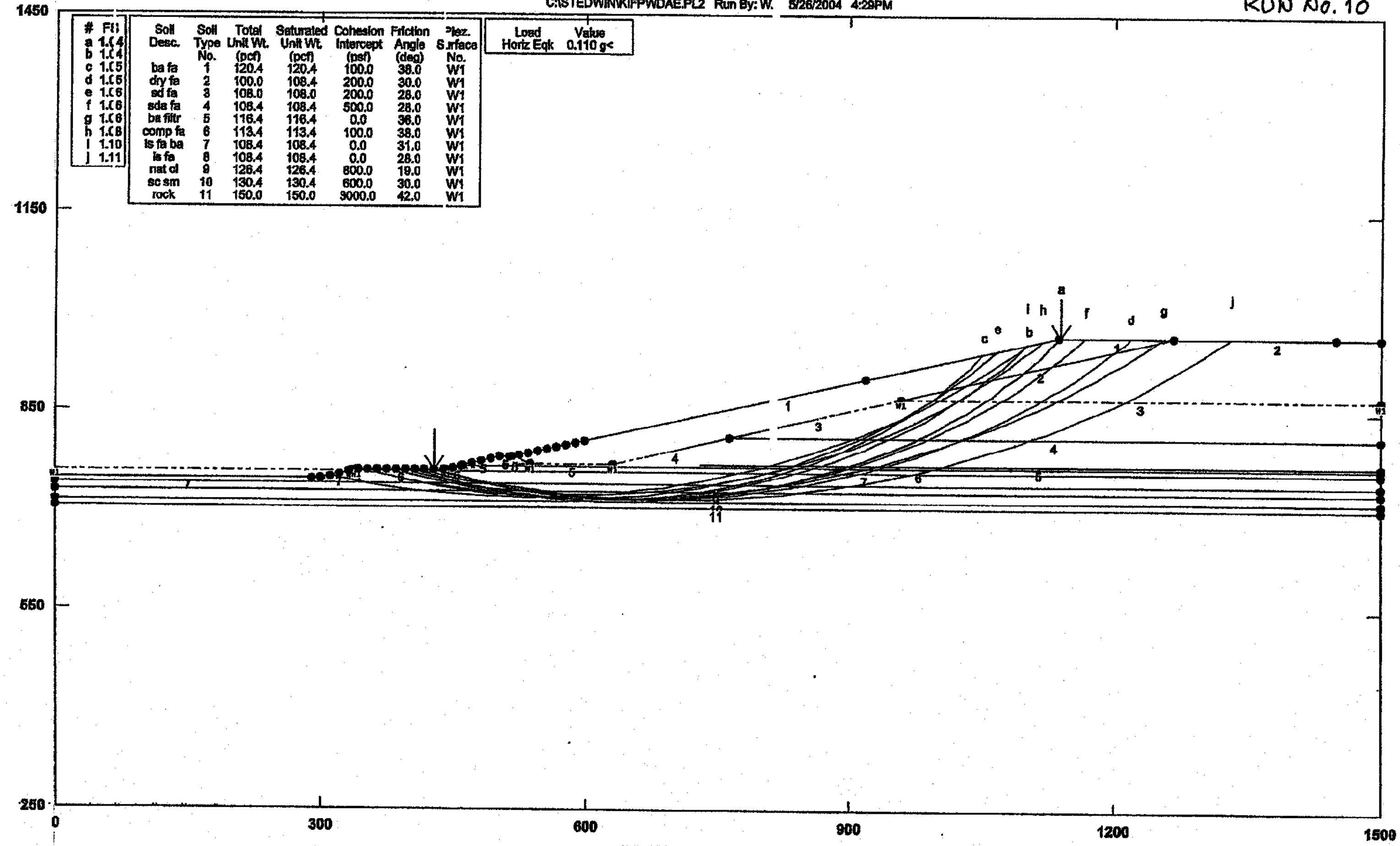
PCSTABL5M/si FSmin=1.52
Safety Factors Are Calculated By The Modified Bishop Method

STED

KIF Wet + Dry Option

C:\STEDWIN\KIFPWDAE.PL2 Run By: W. 5/26/2004 4:29PM

RUN No. 10



#	FS
a	1.(4
b	1.(4
c	1.(5
d	1.(5
e	1.(6
f	1.(6
g	1.(6
h	1.(8
i	1.10
j	1.11

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
ba fa	1	120.4	120.4	100.0	38.0	W1
dry fa	2	100.0	108.4	200.0	30.0	W1
sd fa	3	108.0	108.0	200.0	28.0	W1
sda fa	4	108.4	108.4	500.0	28.0	W1
ba filtr	5	116.4	116.4	0.0	36.0	W1
comp fa	6	113.4	113.4	100.0	38.0	W1
ls fa ba	7	108.4	108.4	0.0	31.0	W1
ls fa	8	108.4	108.4	0.0	28.0	W1
nat cl	9	126.4	126.4	800.0	19.0	W1
sc sm	10	130.4	130.4	600.0	30.0	W1
rock	11	150.0	150.0	9000.0	42.0	W1

Load	Value
Horiz Eqk	0.110 g<

PCSTABL5M/si FSmin=1.04

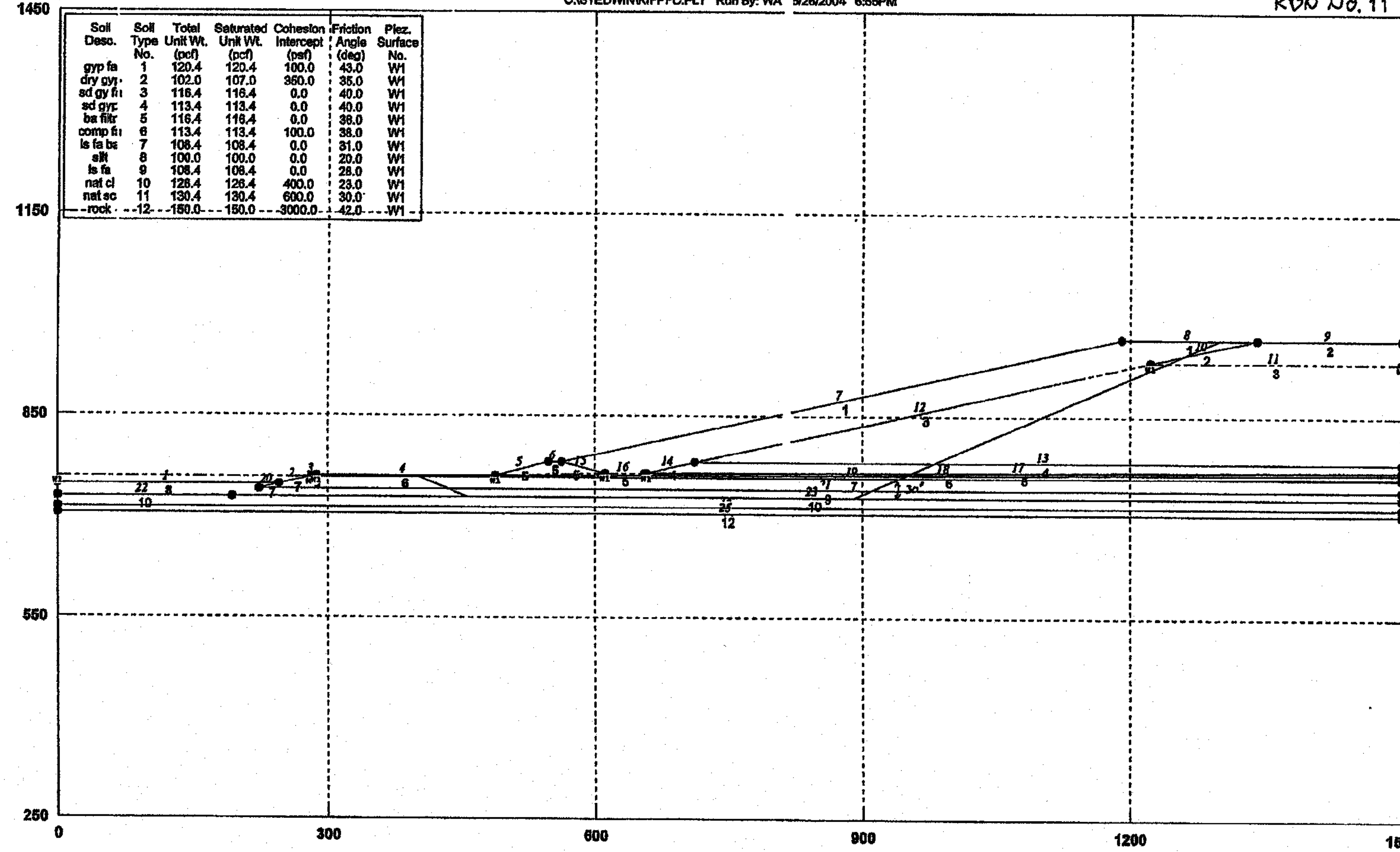
Safety Factors Are Calculated By The Modified Bishop Method

STED

KIF Phase 3 (Section 3-3) Final Stack Gypsum and Wet Ash Placement to 930

C:\STEDWIN\KIFPFC.PLT Run By: WA 5/26/2004 6:56PM

Run No. 11



Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
gyp fa	1	120.4	120.4	100.0	43.0	W1
dry gyp	2	102.0	107.0	350.0	35.0	W1
sd gy fi	3	116.4	116.4	0.0	40.0	W1
sd gyp	4	113.4	113.4	0.0	40.0	W1
ba filtr	5	116.4	116.4	0.0	38.0	W1
comp fi	6	113.4	113.4	100.0	38.0	W1
ls fa ba	7	108.4	108.4	0.0	31.0	W1
silt	8	100.0	100.0	0.0	20.0	W1
ls fa	9	108.4	108.4	0.0	28.0	W1
nat cl	10	126.4	126.4	400.0	23.0	W1
nat sc	11	130.4	130.4	600.0	30.0	W1
rock	12	150.0	150.0	3000.0	42.0	W1

PCSTABL5M/si FSmin=1.77

Factor Of Safety Is Calculated By The Modified Bishop Method

STED

KIF Phase 3 (Section 3-3) Final Stack Gypsum and Wet Ash Placement to 930

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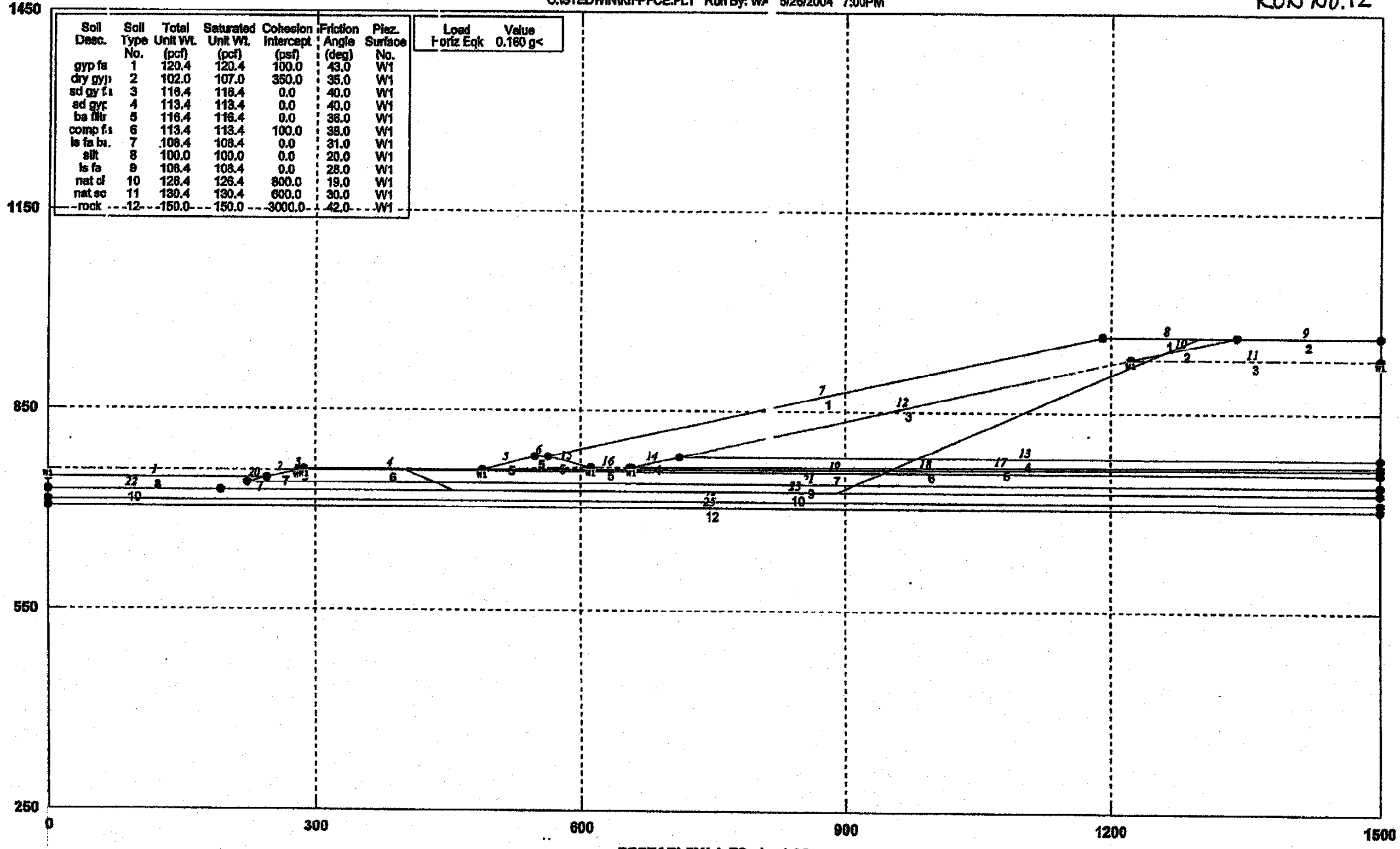
RUN NO.12



Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
gyp fa	1	120.4	120.4	100.0	43.0	W1
dry gyp	2	102.0	107.0	350.0	35.0	W1
sd gy fa	3	116.4	118.4	0.0	40.0	W1
sd gyp	4	113.4	113.4	0.0	40.0	W1
ba filt	5	116.4	116.4	0.0	36.0	W1
comp fa	6	113.4	113.4	100.0	38.0	W1
ls fa ba	7	108.4	108.4	0.0	31.0	W1
silt	8	100.0	100.0	0.0	20.0	W1
ls fa	9	108.4	108.4	0.0	28.0	W1
nat cl	10	128.4	126.4	800.0	19.0	W1
nat sc	11	130.4	130.4	600.0	30.0	W1
rock	12	150.0	150.0	3000.0	42.0	W1

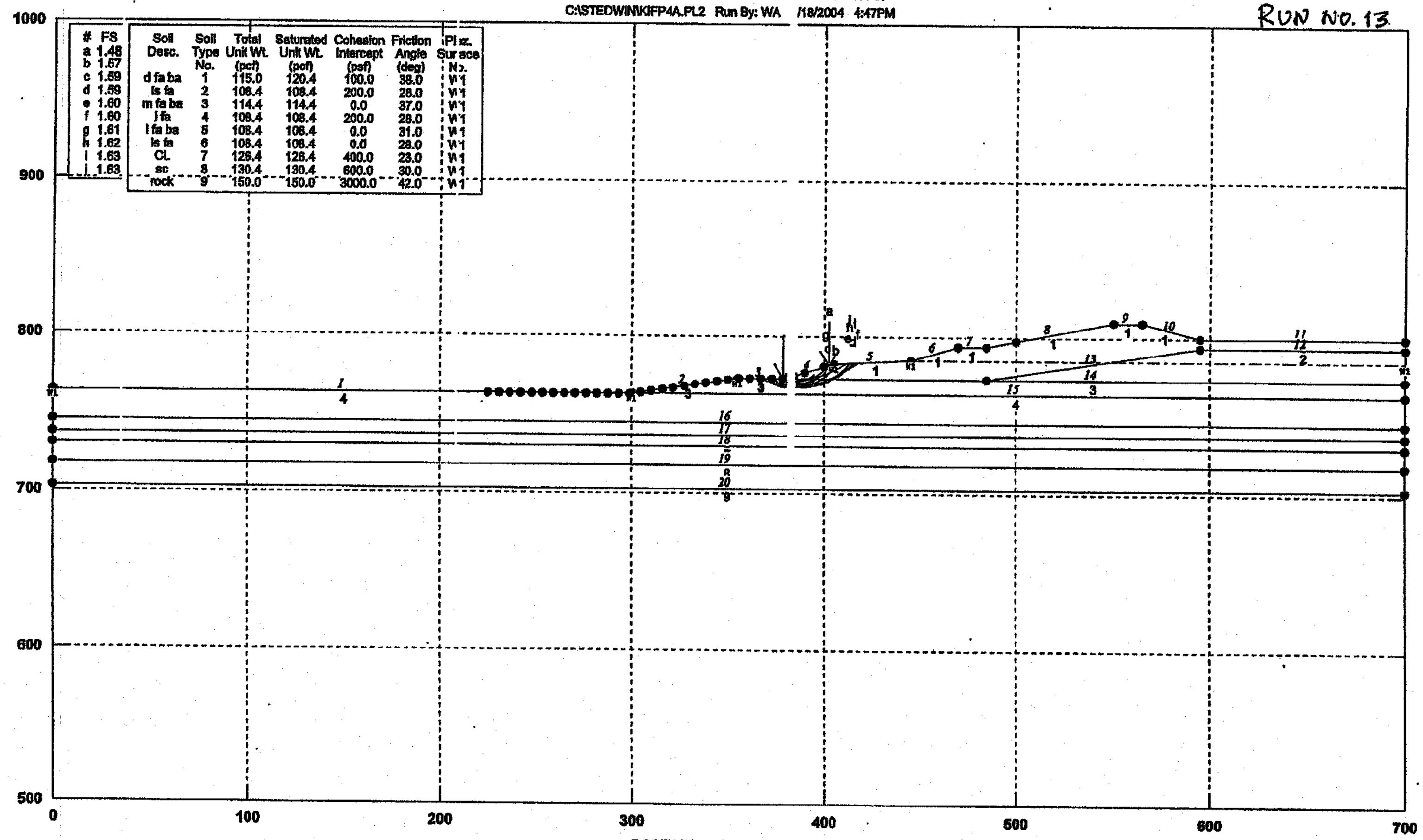
PCSTABL5M/si FSmin=1.02
Factor Of Safety Is Calculated By The Modified Bishop Method

STED

KIF Section 4 - 4 Blowou[illegible] Location

C:\STEDWIN\KIFP4A.PL2 Run By: WA /18/2004 4:47PM

RUN NO. 13



#	FS
a	1.48
b	1.57
c	1.59
d	1.59
e	1.60
f	1.60
g	1.61
h	1.62
i	1.63
j	1.63

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
d fa ba	1	115.0	120.4	100.0	38.0	W1
ls fa	2	108.4	108.4	200.0	28.0	W1
m fa ba	3	114.4	114.4	0.0	37.0	W1
l fa	4	108.4	108.4	200.0	28.0	W1
l fa ba	5	108.4	108.4	0.0	31.0	W1
ls fa	6	108.4	108.4	0.0	28.0	W1
CL	7	126.4	126.4	400.0	23.0	W1
sc	8	130.4	130.4	600.0	30.0	W1
rock	9	150.0	150.0	3000.0	42.0	W1

PCSTABL5M/si FSmin=1.48
Safety Factors Are Calculated By The Modified Bishop Method

STED

ATTACHMENT 2

VENEER STABILITY PRINTOUTS

(Six Pages)

Connection: Close

go to problem statement input values solution material selection contact help references

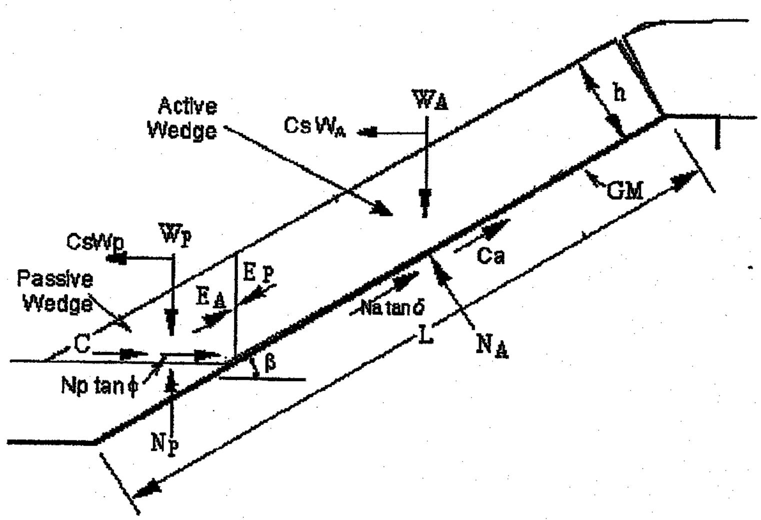
landfilldesign.com

Slope Stability:Seismic Force - Design Calculator

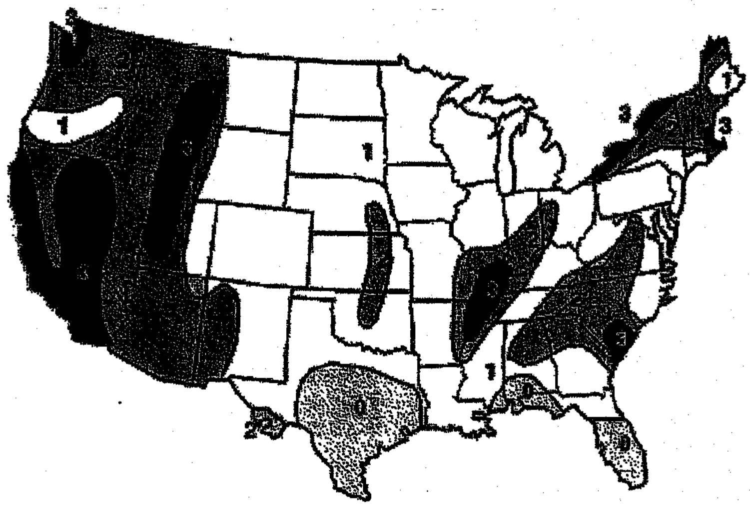
Problem Statement

This slope stability calculator utilizes a pseudo-static analysis to determine the factor of safety (FS) of a geosynthetic lined slope. This calculator assumes that no seepage forces are present. The unit gradient calculator can be used to calculate the required transmissivity of the drainage geocomposite to assure adequate drainage.

Subtitle "D" of the U.S. EPA regulations requires a seismic analysis if the site has experienced a 0.1 g horizontal acceleration, or more, in the past 250 years. For the continental USA, this does not only include the western states, but major sections of the midwest and northeast as well. The map below shows the seismic coefficients for various zones in the USA.



TVA-00015548



Legend

Zone 0: No damage

Zone 1: Minor damage; corresponds to intensities V and VI on the modified Mercalli intensity scale

Zone 2: Moderate damage; corresponds to intensity VII on the modified Mercalli intensity scale

Zone 3: Major damage; corresponds to intensity VIII and higher on the modified Mercalli intensity scale

Seismic coefficients corresponding to each zone

Zone	Remark	Modified Mercalli Scale	Average Seismic Coefficient (Cs)
0	No damage	-	0
1	Minor damage	V and VI	0.03 to 0.07
2	Moderate damage	VII	0.13
3	Major damage	VIII and higher	0.27

Input Values

Design Inputs

Slope characteristics

Thickness of cover soil (h)	0.6	m
Slope angle (ß)	18.43	degrees
Lenght of slope measured along geomembrane (L)	27.43	m

Soil characteristics

Unit weight of the cover soil (g)	18.85	kN/m^3
Friction angle of the cover soil (F)	26	degrees
Cohesion of the cover soil (c)	12.0	kN/m^2
Interface friction(d)		degrees

	25	
Interface adhesion (Ca)	0	kN/m^2
Seismic characteristic		
Seismic coefficient (Cs)	0.11	g

Seismic Stability Calculation

Solution

Factor of Safety with seismic activity (FS) 1.283

Factor of Safety no seismic activity (FS) 1.761

Material Selection

Follow the GFR link to view our extensive database of geosynthetic materials reprinted with permission of IFAI

GFR

Additional Assistance

If you would like to have Advanced Geotech Systems provide material specifications that meet your performance criteria, please fill in the following fields and click the submit button. All information is kept strictly confidential.

Name *

Company

Email Address *

Phone

Project Reference

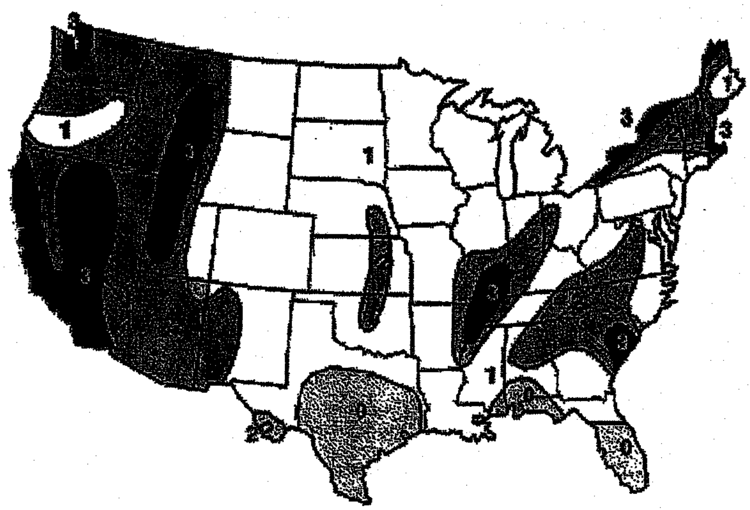
Comments

*required fields

Submit Design Results

Sponsored by

The following companies can service any of your geomembrane protection material selection needs.



Legend

Zone 0: No damage

Zone 1: Minor damage; corresponds to intensities V and VI on the modified Mercalli intensity scale

Zone 2: Moderate damage; corresponds to intensity VII on the modified Mercalli intensity scale

Zone 3: Major damage; corresponds to intensity VIII and higher on the modified Mercalli intensity scale

Seismic coefficients corresponding to each zone

Zone	Remark	Modified Mercalli Scale	Average Seismic Coefficient (Cs)
0	No damage	-	0
1	Minor damage	V and VI	0.03 to 0.07
2	Moderate damage	VII	0.13
3	Major damage	VIII and higher	0.27

Input Values

Design Inputs

Slope characteristics

Thickness of cover soil (h) 0.6 m

Slope angle (ß) 18.43 degrees

Lenght of slope measured along geomembrane (L) 27.43 m

Soil characteristics

Unit weight of the cover soil (g) 18.85 kN/m^3

Friction angle of the cover soil (F) 26 degrees

Cohesion of the cover soil (c) 4.8 kN/m^2

Interface friction(d) degrees

	25	
Interface adhesion (Ca)	0	kN/m^2
Seismic characteristic		
Seismic coefficient (Cs)	0.11	g

Seismic Stability Calculation

Solution

Factor of Safety with seismic activity (FS) 1.154

Factor of Safety no seismic activity (FS) 1.588

Material Selection

Follow the GFR link to view our extensive database of geosynthetic materials reprinted with permission of IFAI

GFR

Additional Assistance

If you would like to have Advanced Geotech Systems provide material specifications that meet your performance criteria, please fill in the following fields and click the submit button. All information is kept strictly confidential.

Name *

Company

Email Address *

Phone

Project Reference

Comments

*required fields

Submit Design Results

Sponsored by

References

R. M. Koerner, and T-Y. Soong, 1998. "Analysis and Design of Veneer Cover Soils". Proceedings of 6th International Conference on Geosynthetics, Vol. 1, pp. 1-23, Atlanta, Georgia, USA.

APPENDIX H

Closure/Post Closure Plan

APPENDIX H

Closure/Post Closure Plan

CLOSURE/POST CLOSURE PLAN
DREDGE CELL LATERAL EXPANSION
TENNESSEE VALLEY AUTHORITY
KINGSTON FOSSIL PLANT

Prepared By:
Tennessee Valley Authority
1101 Market Street
Chattanooga, TN 37401-2801

Revision 0
June 7, 2004

Revision 1
March 24, 2006

Revision 2
May 5, 2006

TABLE OF CONTENTS

1 INTRODUCTION

1.1 Site Location

The TVA KIF is located near the confluence of the Clinch and Emory Rivers (Watts Bar Lake) at Clinch River mile 2 (Emory River mile 2) in Roane Co. Tennessee, approximately 1 mi northwest of the City of Kingston. Access to the site is by state Highway 70 and Swan Pond Road. Refer to drawing 10W425-21, which depicts the plant layout and location of the existing dredge cells, and proposed dredge cell expansion.

1.2 Site Description

The site selected for the disposal facility is the existing fly ash pond, and is an expansion of the existing dredge cells, as shown on drawing 10W425-21. The ash pond is entirely within the KIF Reservation. Existing benchmarks are located as shown on the drawings.

The area surrounding the KIF is primarily agricultural, industrial, and rural in nature (refer to Drawing 10W425-21). The fossil plant powerhouse is just south of the proposed location for this disposal facility.

The methods of placement of gypsum and coal ash in this facility are discussed in the operations manual. Ash conveyance to the pond is by sluicing from the plant, and ash is dredged from the pond to the dredge cells. Dikes are progressively raised as cells are filled with waste material.

1.3 Expected Year of Closure

1.3.1 Existing Ash Dredge Cells

On a yearly basis, approximately 398,000 cubic yards of ash are produced at the KIF. Based upon the existing topographic contours, it is estimated that approximately 10 years of additional disposal capacity. When factored with the three-year expected capacity of the Phase 1 Lateral Expansion, the expected year of closure is 2017. The Operation Plan contains additional details.

1.3.2 Lateral Expansion of Dredge Cells

The Phase 1 expansion is expected to have a three-year life. However, closure of this portion of the facility will not occur until the remaining Phase 2 and Phase 3 portions of the facility reach the end of their useful life. The estimated date of closure for the Phase 2 and Phase 3 portions of the facility is 2047.

1.4 Facility Contact

The name, address, and telephone number of the TVA personnel that may be contacted during the Closure/Post-Closure care period are listed as follows:

Owner: Tennessee Valley Authority (TVA)
Contact: Plant Manager
Tennessee Valley Authority
Kingston Fossil Plant
714 Swan Pond Road
Harriman, Tennessee 37748
(865) 717-2501

As of the date of this revision, the plant manager is Mr. Michael T. Beckham.

2 FACILITY CLOSURE

2.1 Complete Closure Steps for Existing Dredge Cells

The TDEC/DSWM will be notified in writing of the intent to close this facility at least 60 days prior to the date final closure is expected to begin. Upon achieving the appropriate final grades for the ash fill (see drawing 10W425-76), the final cover, which includes compacted soil and vegetative layers, will be placed as shown on drawing 10W425-74. The final cover may also consist of the following components (see drawing 10W425-75) placed on top of the final ash grade: 1) a low density polyethylene liner, 40 mil thick; 2) a geocomposite drainage layer (consisting of an extruded polyethylene net heat bonded on both sides to a non-woven, needle punched geotextile); 3) a one ft thick layer of soil placed above the geocomposite drainage layer; and 4) a one-half ft thick vegetative soil layer. The final cover may consist of a combination of these two methods, depending on material availability or other factors.

This will be accomplished in the shortest time practical, but not exceeding 90 days after completion of final grading of the ash fill. Closure activities (including grading, drainage, and establishment of vegetative cover) will be complete in the shortest time practical, but not exceeding 180 days after completion of final grading of the ash fill.

Closure will be in accordance with this plan and as shown on the permit drawings as approved by the TDEC/DSWM. Drainage structures such as run-on and runoff ditches, culverts, sediment basin, etc., will remain functional beyond final closure in order to minimize erosion and sediment migration into surface waters. After closure is complete, agreement will be obtained from the TDEC/DSWM for elimination of the sediment basin.

2.2 Complete Closure Steps for Dredge Cell Expansion

Complete closure Steps for the Dredge Cell Expansion will be as described for the existing dredge cells.

2.3 Partial Closure of Existing Dredge Cells

A basis premise for partial closure of the existing dredge cells is that this facility, if closed before the projected closure date (see Section 1.3), will result in final grades that are less the proposed final grades shown on the drawings submitted as part of this permit application. If such a partial closure is submitted, TVA will be required to submit revisions to the Closure/Post Closure Plan and closure drawings.

2.4 Partial Closure of Dredge Cell Expansion

TVA does not intend to undergo partial closure. However, in the event that partial closure may become likely, TVA will contact TDEC, DSWM in advance, and coordinate a timetable for partial closure acceptable to TDEC, DSWM.

2.5 Notice in Deed to Property

TVA is required to ensure that within 90 days of completion of final closure of the facility and prior to sale or lease of the property on which the facility is located, there is recorded, in accordance with state law, a notation on the deed to the property or some other instrument, which is normally examined during a title search that will in perpetuity notify any person conducting a title search that the land has been used as a disposal facility.

2.6 Closure Certification

Closure of this facility shall be in accordance with this Closure/Post Closure Plan. A closure certification report prepared by an independent registered professional engineer, licensed in the State of Tennessee, shall be submitted to the Division of Solid Waste Management for review and approval.

3 POST-CLOSURE CARE

The post-closure period will be 30 years. During the post-closure care period the owner must, at a minimum, perform the following activities on the closed portions of the facility:

A. Maintain the approved final contours and drainage systems of the site such that precipitation run-on is minimized, erosion of the cover/cap is minimized, precipitation on the fill is controlled and directed off the stack, and ponding is eliminated.

B. Ensure that a healthy vegetative cover is established and maintained on the site.

C. Maintain the drainage facilities, Stilling Pond, and other erosion/sediment controls (if present) in a functional state until the vegetative cover is established sufficiently to render such maintenance unnecessary. Removal or cessation of maintenance must be approved by the TDEC/DSWM.

D. Maintain and monitor the ground water monitoring system. The approved monitoring system and sampling and analysis program shall be continued during the post-closure period, unless the Closure/Post-Closure Plan is modified to establish a different system or program. Groundwater monitoring will be conducted in accordance with the requirements contained in the operations manual for this facility. Monitoring data must be reported in writing to the DSWM within 30 days after completion of analysis.

E. Post Closure verification. Post-closure of this facility shall be in accordance with this Closure/Post Closure Plan. A post-closure certification report prepared by an independent registered professional engineer, licensed in the State of Tennessee, shall be submitted to the Division of Solid Waste Management for review and approval. There are currently no plans for future use of this site.

4 COST ESTIMATE/FINANCIAL ASSURANCE

TVA is an agency and instrumentality of the United States created by the TVA Act of 1933, 16 U.S.C. 831-831dd (1988). TVA is not required to provide financial assurance in accordance with DSWM solid waste regulations rule 1200-1-7-.03 (1)(b)(3). However, closure quantities and closure/post closure cost estimates are included in Attachments 1 and 2 respectively.

ATTACHMENT 1
CLOSURE QUANTITIES

Table A1 - Compacted Clay Final Cover

ITEM	DESCRIPTION	QUANTITY	UNITS
1.00	1 ft Compacted Clay Soil, 95% Std Proctor, Placed in 6" Lift	163,623	cu.yd.
2.00	1 ft Vegetation Layer, 90% Std Proctor, Placed in 6" Lift	163,623	cu.yd.
3.00	Seeding	101	acres
4.00	Erosion Control Matting	490,869	sq.yd.

Table A2 - Geocomposite Final Cover

ITEM	DESCRIPTION	QUANTITY	UNITS
1.00	Geomembrane	490,869	sq.yd.
2.00	Geocomposite Drainage Layer	490,869	sq.yd.
3.00	1 ft Compacted Soil, 95% Std Proctor, Placed in 6" Lift	163,623	cu.yd.
4.00	6" Vegetation Layer, 90% Std Proctor	81,812	cu.yd.
5.00	Seeding	101	acres
6.00	Erosion Control Matting	490,869	sq.yd.

ATTACHMENT 2
CLOSURE/POST CLOSURE COST ESTIMATES

Cost Estimate
Work Sheet A
Closure Activities - Compacted Clay

Notes:

1) This worksheet is to be submitted as part of the C/PC Plan.
2) Provide a cost for all activities that apply.
3) Additional cost information may be attached as needed.

I. Establishing Final Cover

A. Top Soil	
1. Quantity Needed (cu.yd.)	163,623
2. Excavation Unit Cost ($/cu.yd.)	$3.95
3. Excavation Cost (1. * 2.)	$645,950.18
4. Placement/Spreading Unit Cost ($/cu.yd.)	$9.21
5. Placement Cost (1. * 4.)	$1,507,217.08
TOTAL Top Soil (3. + 5.)	$2,153,167.26
B. Landfill Cap	
1. On-Site Clay	
a. Quantity Needed (cu.yd.)	
b. Excavation Unit Cost ($/cu.yd.)	
c. Excavation Cost (a. * b.)	$0.00
d. Placement/Spreading Unit Cost ($/cu.yd.)	
e. Placement Cost (a. * d.)	$0.00
f. Compaction Unit Cost ($/cu.yd.)	
g. Compaction Cost (a. * f.)	$0.00
TOTAL On-site Clay (c. + e. + g.)	$0.00
2. Off-Site Clay	
a. Quantity Needed (cu.yd.)	163,623
b. Purchase Unit Cost ($/cu.yd.)	$1.32
c. Purchase Cost (a. * b.)	$215,316.72
d. Delivery Unit Cost ($/cu.yd.)	$5.26
e. Delivery Cost (a. * d.)	$861,266.90
f. Placement/Spreading Unit Cost ($/cu.yd.)	$2.63
g. Placement Cost (a. * f.)	$430,633.46
h. Compaction Unit Cost ($/cu.yd.)	$1.32
i. Compaction Cost (a. * h.)	$215,316.72
TOTAL Off-Site Clay (c. + e. + g. + i.)	$1,722,533.80

3.	Quality Control/Testing of Clay	
	a.	
	b.	
	c.	
	TOTAL Clay Testing (LS)	$26,318.64
	TOTAL Landfill Cap	$1,748,852.44

C.	Synthetic Membrane	
1.	Quantity Needed (sq.yd.)	
2.	Purchase Unit Cost ($/sq.yd.)	
3.	Purchase Cost (1. * 2.)	$0.00
4.	Installation Unit Cost ($/sq.yd.)	
5.	Installation Cost (1. * 4.)	$0.00
	TOTAL Synthetic Membrane (3. + 5.)	$0.00

D.	Geotextile Filter Fabric	
1.	Quantity Needed (sq.yd.)	
2.	Purchase Unit Cost ($/sq.yd.)	
3.	Purchase Cost (1. * 2.)	$0.00
4.	Installation Unit Cost ($/sq.yd.)	
5.	Installation Cost (1. * 4.)	$0.00
	TOTAL Geotextile Filter Fabric (3. + 5.)	$0.00

TOTAL for Establishing Final Cover (A. + B. + C. + D.) — $3,902,019.70

II. Establishing Vegetative Cover

A.	Labor ($/acre)	$460.58
B.	Seeding ($/acre)	$460.58
C.	Fertilizing ($/acre)	$328.97
D.	Erosion Control Matting ($/acre)	$65.80
E.	Number of Acres	101

TOTAL for Establishing Vegetative Cover (A. + B. + C. + D.) * E. — $133,461.81

III. Establishing/Completing a System to Minimize & Control Erosion/Sedimentation

A.	Sedimentation Pond	
1.	Excavation/Construction ($)	
2.	Materials (e.g. pipe. Riprap) ($)	

TOTAL for Sedimentation Pond (1. + 2.)	$0.00

B. Diversion Ditch	
1. Construction ($)	
2. Materials ($)	
TOTAL for Diversion Ditch (1. + 2.)	$0.00

C. Temporary Structures	
1. Construction ($)	
2. Materials ($)	
TOTAL for Temporary Structures (1. + 2.)	$0.00

TOTAL for establishing or completing a system to minimize & control erosion & sedimentation (A. + B. + C.)	$0.00

IV. Establishing or Completing Leachate Collection Removal, & Treatment System

A. Installation	
1. Number of Feet	
2. Piping System Unit Cost ($/ft)	
3. Piping System Cost (1. * 2.)	$0.00
4. Storage Tanks ($)	
5. Pumps ($)	
TOTAL for Establishing or Completing Leachate System (3. + 4. + 5.)	$0.00

V. Establishing or Completing a System to Collect or Vent Gases

A. Installation	
1. Materials (e.g. piping)	
2. Equipment (e.g. pumps)	
3. Labor (e.g. drilling)	
TOTAL for Establishing or Completing a System to Collect or Vent Gases (1. + 2. + 3.)	$0.00

VI. Establishing or Completing Groundwater/Surface Water Monitoring System

A. Installation	
1. Number of Wells	
2. Drilling Unit Cost ($/Well)	

3. Drilling Cost (1. * 2.)	$0.00
4. Materials Unit Cost ($/Well)	
5. Materials (1. * 4.)	$0.00
6. Equipment (e.g. pumps)	
7. Labor	
TOTAL for Establishing or Completing Groundwater Monitoring System (3. + 5. + 6. + 7.)	$0.00
TOTAL CLOSURE COSTS (SUM OF TOTALS FOR SECTIONS I. THOUGH VI.)	$4,035,481.50

Cost Estimate
Work Sheet A
Closure Activities - Geocomposite

Notes:
1) This worksheet is to be submitted as part of the C/PC Plan.
2) Provide a cost for all activities that apply.
3) Additional cost information may be attached as needed.

I. Establishing Final Cover

A.	Top Soil		
	1.	Quantity Needed (cu.yd.)	81,812
	2.	Excavation Unit Cost ($/cu.yd.)	$3.95
	3.	Excavation Cost (1. * 2.)	$322,975.09
	4.	Placement/Spreading Unit Cost ($/cu.yd.)	$9.21
	5.	Placement Cost (1. * 4.)	$753,608.54
		TOTAL Top Soil (3. + 5.)	$1,076,583.63
B.	Landfill Cap		
	1.	On-Site Clay	
	a.	Quantity Needed (cu.yd.)	
	b.	Excavation Unit Cost ($/cu.yd.)	
	c.	Excavation Cost (a. * b.)	$0.00
	d.	Placement/Spreading Unit Cost ($/cu.yd.)	
	e.	Placement Cost (a. * d.)	$0.00
	f.	Compaction Unit Cost ($/cu.yd.)	
	g.	Compaction Cost (a. * f.)	$0.00
		TOTAL On-site Clay (c. + e. + g.)	$0.00
	2.	Off-Site Clay	
	a.	Quantity Needed (cu.yd.)	163,623.02
	b.	Purchase Unit Cost ($/cu.yd.)	$1.32
	c.	Purchase Cost (a. * b.)	$215,316.72
	d.	Delivery Unit Cost ($/cu.yd.)	$5.26
	e.	Delivery Cost (a. * d.)	$861,266.90
	f.	Placement/Spreading Unit Cost ($/cu.yd.)	$2.63
	g.	Placement Cost (a. * f.)	$430,633.46
	h.	Compaction Unit Cost ($/cu.yd.)	$1.32
	i.	Compaction Cost (a. * h.)	$215,316.72
		TOTAL Off-Site Clay (c. + e. + g. + i.)	$1,722,533.80

3. Quality Control/Testing of Clay	
a.	
b.	
c.	
TOTAL Clay Testing (LS)	$26,318.64
TOTAL Landfill Cap	$1,748,852.44

C. Synthetic Membrane	
1. Quantity Needed (sq.yd.)	490,869
2. Purchase Unit Cost ($/sq.yd.)	$4.50
3. Purchase Cost (1. * 2.)	$2,208,910.71
4. Installation Unit Cost ($/sq.yd.)	$0.10
5. Installation Cost (1. * 4.)	$49,086.90
TOTAL Synthetic Membrane (3. + 5.)	$2,257,997.62

D. Geotextile Filter Fabric	
1. Quantity Needed (sq.yd.)	490,869
2. Purchase Unit Cost ($/sq.yd.)	$4.50
3. Purchase Cost (1. * 2.)	$2,208,910.71
4. Installation Unit Cost ($/sq.yd.)	$0.10
5. Installation Cost (1. * 4.)	$49,086.90
TOTAL Geotextile Filter Fabric (3. + 5.)	$2,257,997.62

TOTAL for Establishing Final Cover (A. + B. + C. + D.) $7,341,431.30

II. Establishing Vegetative Cover

A. Labor ($/acre)	$460.58
B. Seeding ($/acre)	$460.58
C. Fertilizing ($/acre)	$328.97
D. Erosion Control Matting ($/acre)	$65.80
E. Number of Acres	101

TOTAL for Establishing Vegetative Cover (A. + B. + C. + D.) * E. $133,461.81

III. Establishing/Completing a System to Minimize & Control Erosion/Sedimentation

A. Sedimentation Pond

1. Excavation/Construction ($) ______
2. Materials (e.g. pipe. Riprap) ($) ______

TOTAL	for Sedimentation Pond (1. + 2.)	$0.00

B. Diversion Ditch

1.	Construction ($)	
2.	Materials ($)	
TOTAL	for Diversion Ditch (1. + 2.)	$0.00

C. Temporary Structures

1.	Construction ($)	
2.	Materials ($)	
TOTAL	for Temporary Structures (1. + 2.)	$0.00

TOTAL	for establishing or completing a system to minimize & control erosion & sedimentation (A. + B. + C.)	$0.00

IV. Establishing or Completing Leachate Collection Removal, & Treatment System

A. Installation

1.	Number of Feet	
2.	Piping System Unit Cost ($/ft)	
3.	Piping System Cost (1. * 2.)	$0.00
4.	Storage Tanks ($)	
5.	Pumps ($)	

TOTAL	for Establishing or Completing Leachate System (3. + 4. + 5.)	$0.00

V. Establishing or Completing a System to Collect or Vent Gases

A. Installation

1.	Materials (e.g. piping)	
2.	Equipment (e.g. pumps)	
3.	Labor (e.g. drilling)	

TOTAL	for Establishing or Completing a System to Collect or Vent Gases (1. + 2. + 3.)	$0.00

VI. Establishing or Completing Groundwater/Surface Water Monitoring System

A. Installation

1.	Number of Wells	
2.	Drilling Unit Cost ($/Well)	

3.	Drilling Cost (1. * 2.)	$0.00
4.	Materials Unit Cost ($/Well)	
5.	Materials (1. * 4.)	$0.00
6.	Equipment (e.g. pumps)	
7.	Labor	
TOTAL	for Establishing or Completing Groundwater Monitoring System (3. + 5. + 6. + 7.)	$0.00

TOTAL CLOSURE COSTS (SUM OF TOTALS FOR SECTIONS I. THOUGH VI.)	$7,474,893.11

Cost Estimate
Work Sheet B
Post Closure Activities

Notes:

1) This worksheet is to be submitted as part of the C/PC Plan.
2) This facility will be maintained and monitored for 30 years after final closure of Class I and II landfills and 2 years after final closure of Class III and IV landfills.
3) Fill in blanks for all activities which apply.
4) All costs are to be calculated on an ANNUAL BASIS

I. Survey Inspections to Confirm Final Grade and Drainage are Maintained

A. Transportation	
B. Labor	
TOTAL for Surveying Inspections (A. + B.)	$15,791.18

II. Maintain Healthy Vegetation

A. Transportation	
B. Labor	$3,947.80
C. Seeding	$3,947.80
D. Fertilizing	$2,763.46
E. Mulching	$657.97
F. Rodent Control	
G. Mowing	$15,791.18
TOTAL for Maintaining Healthy Vegetation (A. + B. + C. + D. + E. + F. + G.)	$27,108.21

III. Maintain Drainage Facilities, Sediment Ponds, & Erosion/Sediment Control Measures

A. Transportation	
B. Labor	$7,895.59
C. Cleaning out of Systems	$0.00
D. Repair of Gullies or Rills	
1. Soil Acquisition	
a. Quantity	1,000.00
b. Purchase Unit Cost ($/cu.yd.)	$1.32
c. Purchase Cost (a. * b.)	$1,315.93
d. Delivery Unit Cost ($/cu.yd.)	$5.26

e. Delivery Cost (a. * d.)	$5,263.73
2. Placement/Spreading/Compaction	$5,000.00
3. Revegetation	$3,000.00
TOTAL D.	$14,579.66
TOTAL for Maintaining Drainage (A. + B. + C. + D.)	$22,475.25

IV. Maintain and Monitor Leachate Collection, Removal, & Treatment System

A. Treatment of Leachate	
1. On-Site	
a. Quantity (cu.yd.)	
b. Treatment Unit Cost ($/cu.yd.)	
c. Treatment Costs (a. * b.)	$0.00
d. Sewer Discharge Unit Cost	
e. Discharge Costs (a. * d.)	$0.00
TOTAL 1. On-Site (c. + e.)	$0.00
2. Off-Site	
a. Quantity (cu.yd.)	
b. Hauling Unit Cost ($/cu.yd.)	
c. Hauling Costs (a. * b.)	$0.00
d. Treatment Unit Cost ($/cu.yd.)	
e. Treatment Costs (a. * d.)	$0.00
TOTAL 2. Off-Site (c. + e.)	$0.00
TOTAL for Treatment of Leachate (A.) (1. or 2. TOTAL)	$0.00
B. Maintenance of Leachate Collection System	
1. Transportation	
2. Labor	
3. Repairs/Materials	
a. Pumps	
b. Cleaning out System	
c. Leak Detection	
d. Other	
TOTAL 3. (a. + b. + c. + d.)	$0.00
TOTAL B. (1. + 2. + 3.)	$0.00
TOTAL for Monitoring and Maintaining Leachate System (A. + B.)	$0.00

V. Maintain and Monitor Gas Collection or Venting System

A.	Transportation	
B.	Labor	
C.	Repairs/Materials	
	1. Cleaning	
	2. Caps	
	3. Other	
	TOTAL C. (1. + 2. + 3.)	$0.00
TOTAL	for Maintaining & Monitoring Gas Control Systems (A. + B. + C.)	$0.00

VI. Maintain and Monitor Groundwater and/or Surface Water Monitoring System

A.	Installation	
	1. Number of Wells/Springs	5.00
	2. Number of Samples/Well	2.00
	3. Unit Costs of Analysis	$1,315.93
	4. Cost of Sampling + Analysis (1. * 2. * 3.)	$13,159.32
	5. Labor Cost/Well	
	6. Labor Costs (1. * 5.)	
	TOTAL A. (4. + 6.)	$13,159.32
B.	Inspection & Maintenance of System	
	1. Transportation	
	2. Labor	5,263.73
	3. Repairs/Materials	
	a. Caps	$526.37
	b. Tubing	$526.37
	c. Pumps	$526.37
	d. Well Replacement	$526.37
	e. Other	$526.37
	TOTAL 3. (a. + b. + c. + d. + e.)	$2,631.86
	TOTAL B. (1. + 2. + 3.)	$7,895.59
TOTAL	for Maintaining & Monitoring Groundwater Systems (A. + B.)	$21,054.91

TOTAL CLOSURE COSTS, ANNUAL BASIS (SUM OF TOTALS FOR SECTIONS I. THOUGH VI.)	**$86,429.55**
INFLATION RATE UTILIZED	**5.00%**
30 YR BASIS (Annual Cost * Inflation Rate Over 30 Years)	**$6,029,394**

SUMMARY OF ANNUAL COST, 30 YEAR BASIS

Annual Cost	Year	Inflation Rate	Annual Cost with Inflation
$86,429.55	1	5.0%	$90,751
	2	5.0%	$95,289
	3	5.0%	$100,053
	4	5.0%	$105,056
	5	5.0%	$110,308
	6	5.0%	$115,824
	7	5.0%	$121,615
	8	5.0%	$127,696
	9	5.0%	$134,081
	10	5.0%	$140,785
	11	5.0%	$147,824
	12	5.0%	$155,215
	13	5.0%	$162,976
	14	5.0%	$171,125
	15	5.0%	$179,681
	16	5.0%	$188,665
	17	5.0%	$198,098
	18	5.0%	$208,003
	19	5.0%	$218,403
	20	5.0%	$229,323
	21	5.0%	$240,789
	22	5.0%	$252,829
	23	5.0%	$265,470
	24	5.0%	$278,744
	25	5.0%	$292,681
	26	5.0%	$307,315
	27	5.0%	$322,681
	28	5.0%	$338,815
	29	5.0%	$355,756
	30	5.0%	$373,544
	TOTAL, 30 YR BASIS		$6,029,394

APPENDIX I

Quality Assurance/Quality Control (QA/QC) Plan

CONSTRUCTION QUALITY ASSURANCE/ QUALITY CONTROL PLAN DREDGE CELL LATERAL EXPANSION TENNESSEE VALLEY AUTHORITY KINGSTON FOSSIL PLANT

Prepared By:
Tennessee Valley Authority
1101 Market Street
Chattanooga, TN 37401-2801

Revision 0
June 7, 2004

CONSTRUCTION QUALITY ASSURANCE/ QUALITY CONTROL PLAN DREDGE CELL LATERAL EXPANSION TENNESSEE VALLEY AUTHORITY KINGSTON FOSSIL PLANT

Prepared By:
Tennessee Valley Authority
1101 Market Street
Chattanooga, TN 37401-2801

DRAFT
Revision 0
June 1, 2004

TABLE OF CONTENTS

ATTACHMENTS

1 INTRODUCTION

This Plan describes construction quality assurance/quality control (QA/QC) procedures for the successful construction and performance of the TVA Kingston Fossil Plant (KIF) Dredge Cell Expansion. This QA/QC Plan has been prepared in accordance with the criteria established by the State of Tennessee Department of Environment and Conservation (TDEC), Division of Solid Waste Management (DSWM) Regulations. The elements of construction the expansion and final cover requiring field monitoring and documentation under this plan include; continuation of existing dredge cell construction, Phase 1 Dredge Cell construction, starter dike for Phase 2 and 3 construction, construction of wet gypsum stack outer dikes, final cover, and vegetative layer. In addition, field monitoring and documentation and inspection of associated construction activities will also be required.

The purpose of this Plan is to outline procedures for verifying that proper materials, construction techniques, and installation procedures are used by the Constructor, and that the design intent is met. In addition, this Plan is intended to define problems that may occur during construction and to provide a mechanism to resolving these problems.

The program described by this Plan is independent of the quality control (QC) program conducted by the Constructor. This QA/QC Plan is intended to provide verification that the Constructor has met its obligation in the supply and installation of the specified materials. This Plan does not replace the contract documents (design drawings and documents) regarding the selection and installation of materials.

The construction and operation of this facility involves initial facility construction, as well as on-going operations. TVA conducts dike inspections at all fossil plants yearly, and this will continue for this facility. Because this facility will be raised during the operational phase, certification activities should be an on-going process during operation, but limited to those periods where dikes are being raised. This can be viewed as an extension of the yearly dike inspections. It is anticipated that during dike raising activities, surveillance by technicians to sample and test material and observe construction techniques would ensure that dikes are properly constructed. Less frequent site visits by the Certification Engineer would also provide assurance that construction activities are in conformance with the drawings. As stack construction proceeds, the Certification Engineer can adjust the frequency and type of testing and inspection/surveillance as needed.

2 DEFINITIONS

This section provides definitions for terms used in this QA/QC Plan.

Design Engineer — the individual(s) or firm(s) responsible for preparation of design documents and significant design changes during construction as determined by the Certification Engineer. The design engineer shall be a registered Professional Engineer in the state of Tennessee. TVA Fossil Engineering Services (FES) is the responsible engineering organization for design and certification of this facility.

Conformance Testing — refers to those activities that can take place prior to material installation.

Constructor — the individual or firm responsible for disposal facility-related construction and operational activities. This definition applied to any party performing work defined in the construction documents. TVA may use their own construction organization, Heavy Equipment Division (HED), for initial construction activities, and plant operations personnel (TVA Yard Operations) may perform dike raising activities described herein. TVA may also subcontract construction at it's discretion.

Construction Manager — the official representative of the Owner responsible for overseeing construction of the project. If TVA uses HED for initial construction, and TVA Yard Operations for operation, the Construction Manager and Constructor are one in the same.

Construction Testing — includes those activities than occur during and following material installation, including dike raising activities during facility operation.

Earthwork — an activity involving the use of soil or rock materials. It also includes activities involving the use of coal combustion byproducts in the construction of waste disposal facilities.

Certification Engineer — individual appointed by the Owner who is responsible for performing tasks outlined in this QA/QC Plan. The Certification Engineer will be selected by TVA FES and shall be a registered Professional Engineer in the state of Tennessee.

Project Design Drawings and Documents — all project-related drawings and documents, including design modifications and record drawings.

Project Documents — includes Constructor submittals, construction drawings, record drawings, specifications, shop drawings, field inspection reports, and project schedule. The drawings issued with the solid waste permit will principally used; however, TVA FES may develop additional drawings in more detail if needed to convey the original design intent. These drawings will not be submitted to TDEC DWSM. However, any changes that modify the facility operation or otherwise alter the permitted airspace will be discussed with TDEC in accordance with the Tennessee Solid Waste Regulations.

Quality Assurance/QA — provides verification that QC functions have been performed in substantial compliance with the project design drawings and documents.

CQA Consultant — individual appointed by the Constructor who is responsible for accomplishing work in accordance with the project design drawings and documents.

Quality Control/QC — functions done by the Constructor and material supplier to verify that work performed conforms to project design drawings and documents.

Record Drawings — drawings recording the locations, elevations, and details of the facility after construction in completed.

Surveyor — the individual responsible for preparation of as-constructed surveys of the completed subgrade, clay liner, starter dike, final surface of ash fill, final cover, and completed vegetation layer. The surveyor shall be a registered Surveyor in the state of Tennessee.

Testing Laboratory — a laboratory capable of conducting the tests required by this QA/QC Plan.

3 CERTIFICATION ENGINEER

The Certification Engineer (or personnel under his direct supervision) will closely monitor construction of the various soil components of the compacted base, the dike construction, and cap for the ash/gypsum fill. The Certification Engineer will be a Professional Engineer licensed to practice in the state of Tennessee, who is knowledgeable in the field of soil mechanics, and will have a good working knowledge of the equipment and procedures generally used in the construction of landfills.

The Certification Engineer has the following duties:
- provide written, certified documentation attesting to conformance to the design requirements and the QA/QC Plan with respect to conditions of subgrade, construction related to dike raising, construction of starter dikes, construction of outer wet cast gypsum dikes, final cover, and vegetative cover;
- be present at appropriate intervals during construction of the soil components, perform appropriate tests, and obtain samples for laboratory analyses;
- observe material delivery and unloading;
- use the results of tests and laboratory analyses to document conformance to performance requirements;
- furnish to the Owner and the Constructor the results of all observations and test as the work progresses. Coordinate with Constructor when modifications to the plans are necessary to ensure compliance with the design;
- educate other QA/QC personnel on the QA/QC requirements and procedures;
- schedule and coordinate the QA/QC inspection and testing activities;
- Reject defective work and verify that corrective measures have been implemented.

The Certification Engineer may utilize qualified field technicians to perform testing described and to provide additional observational oversight during construction.

4 MEETINGS

4.1 Design Review Meeting (Optional)

Following completion of the design and after review and approval by the TDEC-DSWM, a design review meeting will be held. The purpose of this meeting, which the Owner, Construction Manager, and the Certification Engineer shall attend, is to accomplish the following activities:

- identify key personnel;
- provide all parties with relevant documents;
- review the project design drawings and documents, and QA/QC Plan;
- confirm responsibilities of each party;
- review reporting and documenting procedures;
- define lines of communication;
- establish work area procedures;
- review sampling and testing procedures.

The meeting will be documented by the Certification Engineer or person designated by the Construction Manager. Copies of the minutes and relevant documents will be provided to all parties.

4.2 Preconstruction Meeting

A pre-construction meeting will be held at the site prior to the start of construction. The Owner, Construction Manager, Certification Engineer, Constructor, and others designated by the Owner will attend this meeting. In certain cases, many, if not most of these functions may be performed directly by TVA. The purpose of the meeting is to accomplish the following activities:

- review the construction drawings and documents, QA/QC Plan, work area procedures, construction procedures, and other related issues;
- define the responsibilities of each party;
- define lines of communication and authority;
- review the project schedule;
- review best management practices for erosion and sediment control during construction;
- review testing procedures and procedures for correcting and documenting; construction deficiencies, repairs, and retesting;
- review testing and record drawing documentation procedures;
- conduct a site inspection to discuss work areas, work plans, stockpiling, equipment and material laydown areas, access roads, and related items.

This meeting will be documented by the Construction Manager or authorized representative, and copies of the documentation will be distributed to all parties.

4.3 Progress Meetings

A progress meeting will be held daily just prior to commencement or just following the completion of work. This meeting will be attended by the Certification Engineer, and the Constructor's on-site superintendent and CQA Consultant. The following activities will be discussed during this meeting:

- review the previous days activities and accomplishments;
- review work locations and scheduled work;
- discuss problems;
- review test data.

This meeting will be documented by the Certification Engineer, and copies of the documentation will be distributed to the Owner, Construction Manager, and Constructor.

4.4 Deficiency Meetings

As required, meetings will be held to discuss problems or deficiencies. At a minimum, these meetings will be attended by the Certification Engineer and the Constructor's on-site superintendent and CQA Consultant. If the problem requires a design modification, the Design Engineer, Constructor, and Construction Manager should also be present. The meeting will be documented by the Certification Engineer on a daily meeting form.

5 INSTALLATION OF UNDERDRAINAGE SYSTEM FOR EXISTING DREDGE CELL SLOPES

The under drainage system for the existing dredge cells shall be installed as required in the Operations Plan. Materials specifications are shown on drawing 10W425-73, and other requirements are shown on the stage 3 drawings 10W425-42 through 45. A technician shall verify that materials meet the requirements and that installation is in accordance with the drawings. The Certification Engineer shall conduct site visits at least weekly during construction, and review daily reports.

6 CONSTRUCTION AND INSPECTION TESTING FOR FLY ASH & BOTTOM ASH DIKE RAISING

6.1 Materials Specification

Materials used to construct dikes for raising dredge cells for the existing Dredge Cell and Phase 1 expansion, and Phase 2/3 expansion (if Phases 2 and 3 are utilized for fly ash disposal instead of combined gypsum/fly ash disposal) shall be fly and bottom ash obtained from KIF. At TVA's option, bottom ash may be imported from Bull Run Fossil Plant if needed for construction. The Constructor shall make a reasonable effort to blend bottom ash to create as uniform a mixture as is practicable. Other materials used for dike raising are as specified on the drawings.

6.1 Pre-construction Testing

No testing is required prior to construction. Conduct testing as specified in the following section.

6.2 Placement

<u>6.2.1 Subgrade Preparation and Dike Construction</u>

Prior to dike raising, scarify all surfaces to prior to receiving fill. Ensure that grade stakes are set prior to proceeding with fill placement.

Place fill in alternating six-inch thick fly ash and bottom as layers. After placement of an initial one-foot layer, use a roto-tiller to blend the two layers together. The Certification Engineer shall inspect the initial placement of material to ensure that the tilling depth is correct. Exercise care with the tiller to ensure that woven geotextile is not damaged where placed. Mix an appropriate amount of water with ash during this process as directed by the Certification Engineer. Attachment 4 contains a suggested compaction procedure. In general, the material will likely have a narrow moisture window of compaction. This window range is also directly related to the compactive effort; i.e., the heavier the roller and the more compactive effort applied the narrower this window becomes. Compact the one-foot thick lift in place after tilling is completed using smooth drum rollers. If scrapers (pans) can yield the desired compaction, the smooth drum roller will not be required. Conduct proctor density testing to ascertain that compaction meets the compaction criteria discussed below. Continue this process as the dikes are raised. The Constructor shall utilize care in subsequent lift construction so that the roto-tiller depth is sufficient, yet not too deep so as to disturb previously placed material.

6.2.2 Testing

Testing should be performed more frequently at the beginning of dike construction, and can be decreased as directed by the Certification Engineer when consistent test results are obtained as the Constructor becomes accustomed to placing and mixing the fill material. Attachment 3 contains a suggested procedure for determining a compaction window for bottom and fly ash.

Initially, the Technician should be at the site continuously for at least the first week. Testing should include grain size analysis, standard proctor testing, and insitu density testing. Grain size testing should be initially be performed on the first lift every 800 feet. The Certification Engineer will review the data for uniformity. Compaction testing shall also be performed at the same frequency for the initial lift. Proctor tests shall be performed on at least two samples and these compared with previous testing results for uniformity by the Certification Engineer. If satisfactory tests are obtained with the first lift, subsequent lifts can be placed and testing can be decreased to four grain size tests and four standard proctor tests per lift. If satisfactory test results are obtained, grain size testing can be further reduced as directed by the Certification Engineer. Compaction shall be meet 95 percent standard proctor density of the material; however this requirement can be adjusted by the Certification Engineer depending on the results obtained.

7 COMPACTED FLY ASH BASE AND DRAINAGE/FILTER LAYER BENEATH PHASES 2 AND 3

7.1 Materials Specification for Fly Ash Base

Materials used to construct dikes for constructing the Phase 2 and 3 Dredge Cell Expansion shall be fly ash obtained from KIF. It is desired that the use of fly ash be maximized to construct this base to conserve available bottom ash for dike raising. However, bottom ash may be used as initial fill as needed to provide a suitable working surface for equipment. At TVA's option, bottom ash may be imported from Bull Run Fossil Plant if needed for construction. Other fill such as crushed stone may also be used if approved by the Certification Engineer. Tensar grid can also be used to stabilize the base if needed to allow equipment to initially place material, if approved by the Certification Engineer.

7.2 Material Specification for Construction of Hydraulic Isolation of Phase 2/3 from Phase 1/Existing Dredge Cells

For material specification for LLDPE geomembrane, see Section 10.4.

7.3 Pre-construction Testing

No testing is required prior to construction. Conduct testing as specified in the following section.

7.4 Placement of Compacted Fly Ash Base/Hydraulic Isolation

7.4.1 Preparation

Prior to construction, ensure that the fly ash base for Phase 2 is properly staked to locate the toe of the fill so that adequate distance is maintained from the outer ash area dikes, and the adjacent area constructed to allow continued dredging operations for wet ash stacking. New weir installation and abandonment of existing weirs should be accomplished prior to construction of the fly ash base in accordance with the drawings.

7.4.2 Hydraulic Isolation

Place the drainage layers beneath and above the LLDPE geomembrane. Place bottom ash as described in Section 7.6, except that the bottom ash drainage layer placed above the LLDPE geomembrane shall be placed in horizontal lifts to avoid placing stress on the geomembrane during installation. It is anticipated that the isolation between the existing dredge cell/Phase 1 and Phase 2/3 will be done in segments (between benches) rather than all at once. It is important that the geomembrane be properly secured to avoid damage by wind, and covered to avoid UV exposure. The geomembrane shall be tied into the fly ash base as shown on the drawings.

7.4.3 Fly Ash Base Construction

Prior to placing ash, temporary dikes can be constructed to isolate this area from the area. Standing water can be pumped out of the diked area continuously as fill is placed to provide a firm surface for equipment access. Construct access roads into the area area using fly ash and/or bottom ash and Tensar grid as necessary to provide a working surface for equipment. Material may be end-dumped from trucks and progressively pushed out into the areas using dozers. Initially, dozers can be D5 dozers with low ground pressure tracks to allow initial placement of material out into the area. Once a firm base is established, fill can be placed in six-inch thick lifts and compacted as described in Attachment 3. Continue to place fill until the grades are achieved.

7.5 Testing/Inspection

7.5.1 Fly Ash Base

After a firm based is established, insitu density testing should be performed for subsequent material placement to verify that the material is being compacted to at least 95 percent standard proctor density. This density requirement can be adjusted at the discrection of the Certification Engineer, depending upon results obtained with respect to the workability of the material as determined in the compaction window procedure in Attachment 4. Density testing should be performed random locations at an interval of five tests per acre (or approximately 50,000 ft^2 area). Attachment 3 contains a suggested procedure for determining a compaction window.

7.5.2 Hydraulic Isolation

Installation of bottom ash drainage layers above and below shall be in accordance with the same procedures outline in Section 7.7 below. Inspection and testing of the LLDPE geomembrane shall follow the requirements referenced in Section 10.4.

7.6 Placement of Bottom Ash Drainage Layer

Placement of the bottom ash layer can proceed once grades for top of the fly ash base layer have been verified. Place the bottom ash layer in six-inch lifts and compact as described in Attachment 4.

7.7 Testing/Inspection

Density testing of the two-foot thick bottom ash layer is not required. No other testing is required. A technician shall be present to observe construction practices are in accordance with these requirements and the drawings, and to document that the thickness is in accordance with the drawings.

7.8 Placement of Filter Layer

The filter layer shall consist of a 50:50 mixture (by volume) of fly and bottom ash. After grades for the bottom ash drainage layer have been verified, place an additional six-inch thick lift of bottom ash. Place an additional six-inch layer of fly ash and mix using a rototiller as described in Section 6.2.1. The depth of the tiller shall be set such that the underlying fly ash layer shall remain undisturbed as practicable. The layer shall be compacted in accordance with requirements outlined in Attachment 3 under the supervision of the Certification Engineer. Work shall be accomplished in sections such that gradation testing can be performed to verify adequate mixing prior to installation over large areas. Laboratory hydraulic conductivity testing shall also be performed initially to ensure performance meets design parameters. Upon successful placement of the filter layer in an initial area, the additional layer shall be installed.

The bottom ash drainage and filter layers are highly erodable, and storm events can cause severe erosion depending upon the intensity of the rainfall. The construction of these layers can be performed in smaller segments, rather than in one large area as depicted on the drawings, in order to lessen the likelihood of erosion. Intermediate dikes can be constructed on the upslope side to divert stormwater around construction of the drainage and filter layers. Erosion of the fly ash base is more easily repaired than repair of the filter layers, although excessive erosion should be prevented.

7.9 Testing

Initially, perform gradation testing of four tests per acre (approximately 50,000 ft^2). Additionally, perform a laboratory hydraulic conductivity test for this area. If results are satisfactory to the Certification Engineer, continue testing at this rate for the next 50,000 ft^2. If testing yields satisfactory results, reduce gradation testing to four tests per acre (approximately one test per 10,000 ft^2). No additional hydraulic conductivity testing is required, unless otherwise directed by the Certifying Engineer.

8 STARTER DIKE CONSTRUCTION AND INSPECTION TESTING FOR DREDGE CELL EXPANSION

8.1 Materials Specification

Materials used to construct dikes for constructing the Phase 2 and 3 Dredge Cell Expansion shall be bottom ash obtained from KIF. At TVA's option, bottom ash may be imported from Bull Run Fossil Plant if needed for construction.

8.2 Pre-construction Testing

No preconstruction testing is required.

8.3 Placement

Ensure that the bottom ash dikes are being placed at the proper location in accordance with the drawings. Note that the bottom ash dikes will be placed to approximately elevation 775 for initial storage of gypsum. The dikes will eventually be covered with a layer of wet cast gypsum, and allowance must be made for the gypsum and eventual final cover placement.

Place bottom ash in accordance with requirements contained earlier in Section 6.2.1.

8.4 Testing

Perform testing as described in Section 6.2.2.

9 WET CAST GYPSUM DIKE CONSTRUCTION

9.1 Placement

Initially, gypsum will be sluiced from the scrubber facility to the Phase 2 area. It is important at this phase that the slope protection be properly constructed to ensure that the bottom ash filter layer does not erode initial filling of the diked area. After gypsum fills the area, a long-reach trackhoe will be utilized by the constructor/operator to wet-cast gypsum on the starter dike and create the rim ditch and inner berm. This method of rim ditch construction utilized the upstream method of dike construction. The rim ditch will be constructed to the lines and grades shown on the drawings.

The facility is designed such that there are at least two active gypsum areas for gypsum disposal. Once the rim ditch and inner dike are constructed, gypsum will continue to be sluiced and the outer dikes will be raised. Gypsum (or ash) can be used to subdivide the Phase 2 area as depicted on the drawings. This arrangement allows gypsum areas to be located along the outer dikes. It is important that gypsum be deposited in these areas without mixing with ash or other substances, so that only wet cast gypsum be utilized for outer dike construction.

Once rim ditch construction has been completed, and an area has been filled, the second area will begin to fill. During the inactive phase of the first area, dike raising can begin. Gypsum is excavated from the rim ditch using long-reach trackhoes and placed along the dike perimeter. Leveling, spreading, shaping, and compaction will be accomplished using a small dozer. Dikes will generally be raised in five-foot height increments, with individual lift thicknesses being approximately one to two feet thick. The individual lift thicknesses should be such that material can be placed, spread, shaped, and compacted to obtain a uniform consistency and be constructed to the lines and grades on the drawings. Perimeter drains shall be installed as shown on the drawings. It is important that elevations be checked during construction and adjustments made to avoid damage to the drains. The drawings contain instructions and procedures to prevent this from occurring. Rim ditch grades are initially proposed at a slope of 0.25 percent (2.5 vertical feet per 1000 foot horizontal ditch length); however slopes can be adjusted to between 0.2 percent and 1 percent depending on the judgement of the Certification Engineer in concert with the facility operator.

After the dikes are successfully raised in the first area, the process is repeated for the second area, while filling is continued in the first area. Fly ash will also be sluiced into areas as designated on the drawings. It is important that the height of material in adjacent fly ash and gypsum areas be kept to within about 15 feet height difference, but no more than 20 feet, unless otherwise directed by the Certification Engineer. At a 0.25 percent rim ditch grade, the elevation difference at the entrance and outlet of the ditch is approximately 7-10 feet.

9.2 Inspection and Testing

Inspection and testing for wet cast dike construction will include the following activities:

- Inspection of initial dike construction is required to verify that material has the desired consistency, and is being placed, shaped, and compacted to the proper shape. It is anticipated that surveillance and inspection activities will be more frequent in the beginning, and will be reduced as successful operation is being demonstrated. The frequency of inspection will be determined by the Certification Engineer in concert with TVA FES.
- After initial dike construction is complete, and the area filled with gypsum, dike raising can begin for the second lift. The Technician shall take random samples at four locations along the rim ditch along the outer dike (not the interior dike or rim ditch) at approximate evenly spaced locations. Samples will be tested for grain size to determine variation in material. This information shall be reviewed by the Certification Engineer. Additionally, strength testing of material at the beginning and end points of the rim ditch along the outer dike (not the interior dike/rim ditch) may be performed to determine any variation in strength parameters. Operation of the rim ditch may be adjusted at the discretion of the Certification Engineer. This process can be repeated if determined necessary by the Certification Engineer in concert with TVA FES, but it is expected that as stack progression continues, the need for such testing will diminish over time if satisfactory results are obtained. This process may need to be repeated when Phase 3 construction begins, or if more frequent testing is deemed necessary by the Certification Engineer in concert with TVA FES.
- It is anticipated that quarterly inspections be performed by the Certification Engineer during dike raising activities as a minimum, and the frequency increased if necessary. The Technician should be present to inspect construction of the drains to ensure that the requirements on the drawings are being met. The frequency of these visits shall be determined by the Certification Engineer in concert with TVA FES.
- As stack construction progresses, TVA will perform surveys to determine the remaining life of the facility. These surveys will be reviewed by the Certification Engineer to ensure that grading is being adequately maintained on the side slopes.

10 FINAL COVER

10.1 Description

A compacted clay layer final cover is one option for final cover construction. It consists of: 12 inches of compacted soil with initial 12 inches being compacted low permeable select soil. KIF has soils on the reservation that would meet the criteria for these soils. The uppermost 6 inches of compacted soil shall be random soil, and will be for installation of a 6-inch vegetative layer.

An alternate final cover consisting of a LLDPE geomembrane, geosynthetic drainage layer, and 18 inches of soil (6 inches for vegetation) as shown on Drawing 10W425-75 will be installed if determined by TVA FES. See Section 10.4 for material and installation QA/QC requirements.

10.2 Material Specifications for Compacted Clay Final Cover

10.2.1 Compacted Select Soil

The first 12 inches of soil on top of the ash is the compacted select soil layer. The soil material utilized shall be CL or CH determined by ASTM D-2487. Clay soils shall possess a plasticity index (PI) greater than 10 in accordance with ASTM D 4318, and amount of fines (defined as dry-weight percentage passing the No. 200 sieve) is greater than or equal to 30% in accordance with ASTM D 1140. Clay soil materials shall be free of rock fragments larger than 2 inches in any dimension, topsoil, roots, and any other deleterious materials.

10.2.2 Compacted Random Soil

The material utilized for construction of the random soil layer shall be CL, CH, ML, or MH as determined by ASTM D-2487, and have a plasticity index (PI) less than 30 in accordance with ASTM D 4318. Material shall be free of rock fragments larger than two inches in any dimension, topsoil, roots, and any other deleterious materials.

10.2.3 Vegetative Layer

The soil to be utilized for establishing the vegetative cover shall be capable of sustaining a healthy stand of vegetation, and shall consist soil reasonably free from subsoil, noxious weeds, stones larger than two inches in diameter, or other deleterious matter that would prevent the formation of a suitable seed bed.

10.3 Pre-construction Testing

All soil to be used for construction of the clay soil liner will be inspected by the Certification Engineer to ensure that proper soils are being used. The Quality Assurance tests specified below in Table 1 will be performed on clay source material at the specified frequencies, and whenever a change in material occurs.

TABLE 1

QUALITY ASSURANCE TESTS FOR SOIL MATERIALS USED IN CLAY LINER CONSTRUCTION

Parameter	Test Method	Minimum Testing Frequency
Percent Fines	ASTM D 1140 (Note 1)	1 per 1,000 cubic yards (Note 2)
Percent Gravel	ASTM D 422 (Note 3)	1 per 1,000 cubic yards (Note 2)
Liquid and Plastic Limits	ASTM D 4318	1 per 1,000 cubic yards
Water Content	ASTM D 4643 (Note 4)	1 per 200 cubic yards
Water Content	ASTM D 2216 (Note 5)	1 per 1,000 cubic yards
Moisture/Density	ASTM D 698/ASTM D 1557	1 per 5,000 cubic yards or 1 per soil change
Permeability (Remolded)	ASTM D 5084 (Note 6)	1 per soil type

Notes:

1. Percent fines is defined as percent passing the Number 200 sieve.

2. In addition, at least one test should be performed each day that soil is excavated and transported to the site, and additional tests should be performed on any suspect or change in material observed by QA personnel.

3. Percent gravel is defined as percent retained on the Number 4 sieve.

4. This is a microwave oven drying method. Other methods may be used, if more appropriate.

5. Microwave oven drying, and other speedy methods, may involve systematic errors. Conventional oven drying (ASTM D 2216) is recommended on every fifth sample taken for rapid measurement. The intent is to document any systematic error in rapid water content measurement.

6. ASTM D 5084 is a laboratory procedure for determining hydraulic conductivity of soil materials.

The moisture/density/hydraulic conductivity relationship to control actual field placement of the clay liner and cover will be established as follows:

a. Samples of the source material will be taken for laboratory testing.
b. The soils will be prepared and compacted using Standard Proctor (ASTM D 698) and Modified Proctor (ASTM D 1557) procedures at varying moisture contents to develop compaction curves (dry unit weight vs. molding water content).
c. The compacted specimens are then subjected to permeability tests (ASTM D 5084), using care to ensure that standard permeation procedures are followed, and 2 psi is used for the maximum confining stress. The measured hydraulic conductivity is then plotted as a function of the molding water content.
d. The dry unit weight/water content points are then replotted to represent compacted specimens that have hydraulic conductivity greater than and less than 1×10^{-6} cm/sec. An "acceptable zone" is then

constructed to encompass the data points representing test results meeting or exceeding the hydraulic conductivity criteria.

e. The acceptable zone shall be limited to soil having a moisture content range at optimum to +3% of optimum moisture content (either standard or modified proctor compaction).
f. Moisture contents up to 5% above optimum may be allowed if direct shear testing of soils within this range indicate acceptable shear strength, based on shear strength values used in the analysis (see Appendix F of the Operations Manual).

Further explanation and testing procedures to establish the above relationship are presented in the report, *Water Content-Density Criteria for Compacted Soil Liners* [1].

Soils not meeting the above testing criteria are unsuitable and will not be used in clay soil liner construction.

10.4 Placement of Compacted Clay Final Cover

10.4.1 Compacted Select Soil

Prior to placement of compacted select soil, ensure that the ash fill and/or gypsum has been final graded. For the initial lift, the select soil shall be placed and spread over the ash or gypsum and compacted. For subsequent lifts, the previous lift shall be scarified to a depth of one to two inches to ensure adequate bond between the previous lift and the lift being installed. For all lifts, the soil shall be tilled as necessary to promote blending, adjust moisture content, and attain a nominal clod size of two inches or less. During tilling, the soil shall be visually checked to ensure that it does not contain rock fragments or gravel larger than two inches nominal size. Rock fragments or gravel larger than two inches nominal size shall be removed and placed in areas as directed by the Construction Manager.

The select soil shall be compacted using a suitable non-vibratory, footed compactor. The foot length of the compactor shall be a minimum four inches.

Fill material shall be placed in uniformly thick lifts not exceeding 6-inches in compacted thickness. Compaction requirements for select soil layer shall be governed by the moisture-density-permeability relationship of soils. Acceptance of a lift requires that results meet the moisture-density requirements as defined by construction of the "acceptable zone" as defined in Item 10.3. Perform testing in accordance with Section 10.5 prior to placement of subsequent layers of final cover. All test results must be satisfactory and accepted by the Certification Engineer prior to beginning the next layer.

10.4.2 Compacted Random Soil

Ensure that the select soil layer has been placed and is ready to receive the random soil layer. The random soil material shall be placed in uniformly thick lifts not exceeding 6-inches in compacted thickness. Compaction shall be a minimum of 90% of the maximum dry density at +/- 3% of the optimum moisture content in accordance with ASTM D 698.

In-place moisture and density testing in accordance with ASTM D 3017 and D 2922 respectively, shall be conducted after each lift is placed at a frequency of 5 tests per acre per lift. The location of the density tests shall be selected randomly by the Certification Engineer.

10.4.3 Vegetative Layer

Verify that random soil layer grades and elevations are correct before placing the vegetative layer. Place and spread the initial lift of vegetative layer in a manner that prevents damage to the underlying soil cap. Subsequent lifts shall be placed in a manner that prevents over-compaction such that vegetative growth is hindered. The top surface of the vegetative layer shall be roughened or scarified to an approximate depth of 2 inches to promote acceptance of seed and fertilizer.

Do not place vegetative layer until seeding and fertilization can be accomplished promptly after placement.

10.5 Field Testing

The Certification Engineer will visually inspect clay soil being placed during construction accordance with Item 10.3.

Field Testing of the clay soil liner will be performed to assure that construction meets requirements outlined in Table 2.

TABLE 2

TESTING FOR LOW PERMEABLE CLAY LAYER IN FINAL COVER

Parameter	Test Method	Minimum Testing Frequency
Water Content (Note 1)	ASTM D 3017 Nuclear Density of ASTM D 4643 microwave	5/acre/lift (Note 2)
Water Content (Note 3)	ASTM D 2216	1/acre/lift (Note 3)
Density (Note 4)	ASTM D 2922	5/acre/lift (Note 2)
Density (Note 5)	ASTM D 1556	1 acre lift (Note 5)
Permeability (Note 6)	ASTM D 5084	1/3 acres/lift or 1/ soil change
Construction Oversite	Visual Observation	Continuous

Notes:

1) ASTM D 3017 is a nuclear method and D 4643 is microwave oven drying.
2) In addition, at least one test should be performed each day soil is compacted and additional tests should be performed in areas for which the Certification Engineer has reason to suspect inadequate compaction.
3) Every fifth sample tested with ASTM D 3017 or D 4643 should also be tested by direct oven drying (ASTM D 2216) to aid in identifying any significant, systematic calibration errors with D 3017 or D 4643.
4) ASTM D 2922 is a nuclear method.
5) The sand cone (ASTM D 1556) is required in the event that the liner is to be constructed with soils having more than 20% retained on the number four sieve.

6) ASTM D 5084 is a laboratory permeability test that is to be performed on Shelby tube samples taken from the constructed liner. However, this test is not acceptable for soils with more than 20% retained on the number 4 sieve.

All voids left by test equipment shall be filled with bentonite, and hand tamped by the Subcontractor.

Additional tests may be performed as directed by the Certification Engineer based on the following conditions:

a. The clay soil or fill material appears to be at an improper moisture content or the moisture content is not uniform.
b. Fill materials appear to differ substantially from those specified or previously tested.
c. The degree of compaction is questionable or does not appear uniform.

10.6 Non-Conforming Test Results

Density and moisture content test locations that fail to meet or exceed construction criteria will require reworking. The boundaries of the area to be reworked will be defined by the closest test locations, which meet density and moisture content specifications. The non-conforming area will be reworked, dried or wetted as necessary, and retested. A non-conformance report will be prepared for areas, which do not meet construction specifications after reworking and retesting.

Laboratory permeability test results which demonstrate a permeability above 1×10^{-6} cm/sec will be immediately brought to the attention of the Certification Engineer. Non-conforming permeability test results may result in a review of previous test results, retesting, and/or a reevaluation of compaction criteria. After review and/or retesting areas which do not meet the specified permeability will require reworking.

All non-conformance reports will be brought to the attention of the Construction Manager by the Certification Engineer and will be documented in the Quality Assurance files.

10.7 Geocomposite Final Cover

10.7.1 Material and Installation Requirements

Attachments 2 and 3, Specifications KIF-0-TS-02778 and KIF-0-TS-02622 contain requirements for QA/QC for installing the geocomposite final cover.

11 CONSTRUCTION TOLERANCES

The minimum thickness of the compacted soil layer in the final cover shall be 18 inches. The top of the vegetative layer shall be such that the final grade provides a minimum 6 inches thickness for the vegetative layer. Other construction tolerances are as noted on the drawings.

12 SURVEYING

Surveying will be performed under this section to document as-built conditions, and will be the responsibility of the Constructor. The as-built survey will be performed by a Land Surveyor registered in the state of Tennessee. Intermediate surveying for construction layout, slope staking, etc., may be performed by the Constructor's personnel.

The completed subgrade surface will be surveyed, before placement of any clay liner, to verify that grades and elevations are in accordance with the approved plans. At a minimum, survey points shall be established on a 100 ft. x 100 ft. grid, and at all slope changes along the subgrade. Survey grid points shall be located such that the same grid can be reused for subsequent as-built surveys as the completion of the ash fill progresses. In addition, cross sections shall also be surveyed at locations shown on the construction drawings.

The completed compacted fly ash surface will be surveyed, before placement of the overlying drainage layer, to verify that grades and elevations are in accordance with the approved plans. At a minimum, survey points shall coincide with the 100 ft x 100 ft grid established for the as-built survey of the subgrade, and at all slope changes. Cross sections shall also be surveyed at locations shown on the construction drawings.

Survey points for the starter dike shall be along the top, crest of slope, mid-point of slope, and bottom of each slope, sufficient to document the as-built condition of the starter dike. The completed ash fill surface shall be surveyed prior to placement of the compacted soil final cover, to verify and document grades, elevations, and thickness of the ash fill. At a minimum, survey points shall be located on the same 100 ft. x 100 ft. grid used for the as-built survey of the subgrade, and at all slope changes along the ash fill. Cross sections shall also be surveyed at locations shown on the construction drawings.

After completion of the compacted soil final cover, the completed cap surface shall be surveyed prior to placement of the vegetative layer, to verify and document grades, elevations, and. At a minimum, survey points shall be located on the same 100 ft. x 100 ft. grid used for the as-built survey of the ash fill, and at all slope changes. Cross sections shall also be surveyed at locations shown on the construction drawings.

The vegetative layer shall be surveyed after completion to verify and document grades, elevations, and thickness. At a minimum, survey points shall be located on the same 100 ft. x 100 ft. grid used for the as-built survey of the final cover, and at all slope changes along the ash fill. Cross sections shall also be surveyed at locations shown on the construction drawings.

The Certification Engineer may request additional survey information as required for certification.

13 REPORTING

13.1 Deficiencies

When deficiencies are discovered, the Certification Engineer shall immediately determine the nature and extent of the problem, notify the Constructor, and complete required documentation. In all cases, the Certification Engineer will notify the Constructor within one-half hour of discovering the deficiency. If the deficiency will cause construction delays of more than four hours or will necessitate substantial rework, the Certification Engineer shall also notify the Construction Manager.

The Constructor shall correct the deficiency to the satisfaction of the Certification Engineer. If the Constructor is unable to correct the problem, the Certification Engineer will prepare a nonconformance report and will develop and present suggested solutions to the Construction Manager for approval. If the solution requires a design revision, the Owner shall also be contacted.

The corrected deficiency shall be retested before additional work is performed. All retests, and the steps taken to correct the problem, will be documented by the Certification Engineer.

13.2 Documentation

This QA/QC Plan depends on through monitoring and documentation of all construction activities. Therefore, the Certification Engineer shall document that all Quality Assurance requirements have been addressed and satisfied. Documentation shall consist of daily record keeping, construction problem resolutions, photographic records, design revisions, weekly progress reports, and a certification and summary report.

13.2.1 Daily Record Keeping

At a minimum, daily records shall consist of field notes, summaries of the daily meetings with the Constructor, observations and data sheets, and construction problems and resolution reports. This information shall be submitted to the Construction Manager for review and approval.

A Daily Meeting Report will be prepared each day, summarizing discussions held with the Constructor. This report will include the following items:

a. date, project name, and location;
b. names of parties involved in discussions;
c. data on weather conditions;
d. listing and location of construction activities underway during the time frame of the Daily Summary Report;
e. equipment present on-site;
f. descriptions of areas and/or activities being inspected and/or tested, and related documentation;
g. description of off-site materials received;
h. scheduled activities;
i. items discussed;
j. signature of the Certification Engineer.

13.2.2 Observation and Test Sheets

Observation and test data sheets shall include the following information:

a. date, project name, and location;
b. weather data;
c. reduced-scale site plan showing work areas, including sample and test locations;
d. description of ongoing construction;
e. summary of test results identified as passing, failing, or in the event of a failed test, retest;
f. calibration of test equipment;
g. summary of decisions regarding acceptance of the work and/or corrective actions taken;
h. signature of the Certification Engineer.

<u>13.2.3</u> <u>Construction Problem Reports</u>

This report identifies and documents construction problems and resolutions. It is intended to document problems involving significant rework and is not intended to document items easily corrected unless the problems are recurring. At a minimum, this report shall include the following items:

a. detailed description of the problem;
b. location and cause of the problem;
c. how the problem was identified;
d. resolution of the problem;
e. personnel involved,
f. signature of the Certification Officer and Construction Manager.

<u>13.2.4</u> <u>Survey Control</u>

The following procedures will be followed with respect to the as-built survey of the ash and gypsum fill components.

- The subgrade, ash dikes, starter dikes, wet cast gypsum dikes, completed ash and gypsum fill, compacted select soil and random soil layers, and vegetative layer will be surveyed to verify that grades and elevations are in accordance with the approved plans as described in Section 10.0. A comparison of the pre- and post-component construction surveys will be conducted to verify construction thickness.

- The Surveyor shall promptly submit results of each survey to the Construction Manager. Survey results shall include: copy of any field notes, electronic and hard copy of the survey point file, and electronic and hard copy of survey drawing.

- The Certification Engineer will certify that the components meet the requirements in the plans and will submit approval to the Construction Manager.

<u>13.2.5</u> <u>Design Changes</u>

Design changes may be required during construction. In such cases, the Certification Engineer shall notify the Construction Manager, who will then notify the Owner. Design changes shall only be made with written agreement of the Construction Manager and Owner.

<u>13.2.6</u> <u>Weekly Progress Reports</u>

The Certification Engineer shall prepare weekly progress reports summarizing construction and quality control activities. At a minimum this report, submitted to the Construction Manager, shall contain the following information:

a. date, project name, and location;
b. summary of work activities;
c. summary of deficiencies and/or defects and resolutions;
d. signature of Certification Engineer.

13.2.7 Certification Reports

The Certification Engineer will be required to submit the following certification reports. The first certification report will cover construction of ash dikes for the existing dredge cell and dike raising of Phase 1 ash dredge cells, the initial phase of construction for Phase 2, 3, construction of each stage of wet cast gypsum (or ash) dikes, and will be required prior to disposal of ash and/or gypsum. A certification report will also be required for final closure.

The final certification report will be required after the ash fill has been completed. This report will cover the capping phase of construction and will be required during closure of the facility. This report will address final ash-fill slopes, final cover, and vegetative layer.

At the completion of each phase of construction, the Certification Engineer shall submit a certification report to the Construction Manager. This report shall certify that the work has been performed in substantial compliance with the approved plans. At a minimum, this report shall contain the following information:

a. summary of all construction activities;
b. testing laboratory test results;
c. observation and test data sheets;
d. sampling and testing location plan;
e. description of significant construction problems and their resolution;
f. list of changes from the approved plans and the justification for these changes;
g. record drawings;
h. certification statement signed and sealed by the Certification Engineer.

14 REFERENCES

1. Daniel, D. E., and Benson, C. H., *Water Content-Density Criteria for Compacted Soil Liners*, Journal of Geotechnical Engineering, Vol. 116, December 1990.

Attachment 1 - Specification KIF-0-TS-02778

ATTACHMENT 1 TO KINGSTON FOSSIL PLANT DREDGE CELL LATERAL EXPANSION QA/QC PLAN

SPECIFICATION KIF-0-TS-02778

REVISION 0

FOR
LLDPE GEOMEMBRANE
CONSTRUCTION QUALITY ASSURANCE

SECTION JOHN-0-TS-02778

LLDPE GEOMEMBRANE CONSTRUCTION QUALITY ASSURANCE

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PART 1 – GENERAL - GEOMEMBRANE MANUFACTURE, FABRICATION, AND DELIVERY

1.0 GEOMEMBRANE MANUFACTURING

1.1 Raw Material - LLDPE Geomembrane

The raw materials for polyethylene (LLDPE) geomembrane manufacture shall be first-quality resins containing no more than 2% clean recycled polymer by weight and a maximum of 1% by weight of additives, extenders and fillers (not including carbon black), and meeting the minimum construction specifications.

1.2 General

Compliance testing shall be carried out by the Manufacturer to demonstrate that the product meets specifications. At the Owner's discretion and cost, the Geosynthetics CQA Laboratory for purposes of conformance may carry out additional testing. If the results of the Manufacturer's and the Geosynthetics CQA Laboratory's testing differ, the testing will be repeated by the Geosynthetics CQA Laboratory, and the Manufacturer will be allowed to monitor this testing. The results of this latter series of tests will prevail, provided that the applicable test methods have been followed.

Prior to the installation of any geomembrane material, the Manufacturer shall provide the Construction Manager and the CQA Consultant with the following information, as applicable for liner type:

a. The origin (Resin Supplier's name and production plant), identification (brand name, number) and production date of the resin.

b. A copy of the quality control certificates issued by the Resin Supplier.

c. Reports on the tests conducted by the Manufacturer to verify the quality of the resin used to manufacture the geomembrane rolls assigned to the project. At a minimum, these tests should include density, melt flow index, and oxidative induction time.

d. A statement confirming that if polymer is recycled during the manufacturing process, it is done with appropriate cleanliness and does not exceed 2% by weight for the manufacture of LLDPE.

The CQA Consultant will review these documents and report any discrepancies with the above requirements to the Construction Manager.

1.3 Geomembrane Manufacturing

Prior to the installation, the Geomembrane Manufacturer shall provide the Construction Manager and the CQA Consultant with the following:

a. A properties sheet including, at a minimum, all specified properties, measured using test methods indicated in the Specifications, or equivalent.

b. A list of quantities and descriptions of materials other than the base polymer which comprise the geomembrane.

c. The sampling procedure and results of testing.

d. A certification that property values given in the properties sheet are minimum values and are guaranteed by the Geomembrane Manufacturer.

The CQA Consultant will verify that:

a. The property values certified by the Geomembrane Manufacturer meet all of the requirements of Table 1.

b. The measures of properties by the Geomembrane Manufacturer are properly documented and that the test methods used are acceptable.

1.4 Rolls

Prior to shipment, the Geomembrane Manufacturer shall provide the Construction Manager and the CQA Consultant with a quality control certificate for each roll of geomembrane provided. A responsible party employed by the Geomembrane Manufacturer, such as the production manager, shall sign the quality control certificate. The quality control certificate shall include at least the following information:

a. Roll numbers and identification.

b. Sampling procedures and results of quality control tests. As a minimum, results shall be in accordance with Table 2

The CQA Consultant will:

a. Verify that the quality control certificates have been provided at the specified frequency for all rolls, and that each certificate identifies the rolls related to it.

b. Review the quality control certificates and verify that the certified roll properties meet the specifications.

1.5 Conformance Testing

1.5.1 Tests: Upon delivery of the rolls of geomembrane, the CQA Consultant will ensure that samples are removed at the specified frequency and forwarded to the Geosynthetics CQA Laboratory for testing to ensure conformance to both the design specifications and the list of guaranteed properties.

As a minimum, the CQA laboratory will perform the tests listed in Table 3.

1.5.2 Sampling Procedures: Samples will be taken across the entire width of the roll and will not include the first three feet. Unless otherwise specified, samples will be 3 ft. long by the roll width. The CQA Consultant will mark the machine direction on the samples with an arrow.

1.5.3 Test Results: The CQA Consultant will examine all results from laboratory conformance testing and will report any non-conformance to the Construction Manager. The minimum standards are given in Table 1.

1.5.4 Procedures for Conformance Test Failure: The following procedure will apply whenever a sample fails a conformance test that is conducted by the Geosynthetics CQA Laboratory.

Two (2) additional samples shall be taken from the roll of geomembrane that has failed the conformance test. The Geosynthetics CQA Laboratory shall perform two (2) identical retests of the failing test.

a. If both of the two (2) retests on the roll pass, the roll shall be deemed acceptable.

b. If either of the two (2) retests on the roll fail, the Installer shall replace the roll of geomembrane that is in non-conformance with the specifications with a roll that meets the specifications. In addition, the Installer shall remove conformance samples (for testing by the Geosynthetics CQA Laboratory) from the closest numerical roll on both sides of the failed roll. These two samples must both conform to the Specifications. If either one of these samples fail, every roll of geomembrane on site from the same lot and every roll delivered subsequently from the same lot must be tested by the Geosynthetics CQA Laboratory for conformance to the Specifications.

The retesting and additional conformance testing to address a test failure shall be at the expense of the Installer.

The CQA Consultant will document actions taken in conjunction with conformance test failures.

1.6 Delivery

Transportation and Handling: Transportation of the geomembrane is the responsibility of the Geomembrane Manufacturer, Installer, or other party as agreed upon. All handling on site is the responsibility of the Installer.

When the geomembrane arrives on-site, the CQA Consultant will verify that the installer supervisor has carefully checked the material for damage during shipment and will also make spot checks himself. Packing slips shall be checked to ensure delivery of the correct materials, and to verify type, thickness, and quality of material. All accessory materials such as solvents, adhesives, tapes, etc., shall be checked for damage and compatibility with material and project specifications. Shelf life shall be noted and not exceeded. A "Material Receiving Log" shall be completed for each delivery truck. All comments shall be recorded on that form.

The CQA Consultant will verify that:

a. Handling equipment used on the site is adequate and does not pose any risk of damage to the geomembrane. Typical equipment used to unload and handle liner rolls are forklifts, front-end loaders with forks, and cranes. The unloading equipment shall be of sufficient size and readily accessible to delivery vehicles (trucking and on-site transport and placement equipment).

b. The Installer's personnel shall handle the geomembranes with care. LLDPE is delivered in rolls weighing up to 5,000 pounds each and should be handled with appropriate equipment to avoid damage.

Upon delivery to the site, the Installer and the CQA Consultant will conduct a surface observation of all material for defects and for damage. This examination will be conducted without unrolling unless defects or damages are found or suspected. The CQA Consultant will indicate any problems to the Construction Manager and identify on the "Material Receiving Log":

a. Any rolls, or portions thereof, that should be rejected and removed from the site because they have severe flaws.

b. Any material that has minor repairable flaws.

c. All accessories will be inspected visually. The containers and labels shall show brand name, type of material, date of manufacture, proper method of application, and expiration date for shelf-life determination. All containers shall be properly sealed.

1.7 Storage

The Installer shall be responsible for the storage of the geomembrane on site. The Construction Manager will provide storage space in a location (or several locations) such that on-site transportation and handling are minimized. All areas will be of adequate size for ease of handling and located near the placement area to minimize handling and travel. The storage area shall be level and smooth, free of rocks, holes or debris. If in a building, the area should be of a size suitable for material handling, accessibility and maneuverability. Storage space should protect the geomembrane from theft, vandalism, passage of vehicles, etc. Storage of geomembrane rolls at the site shall not exceed five (5) rolls high, as crushing of the core or flattening of the rolls may occur. Open areas should be fenced for security.

The CQA Consultant will document that storage of the geomembrane ensures adequate protection against dirt, shock, and other sources of damage. All liner materials shall be protected from the weather, either in enclosed areas, or as a minimum, pallets and crates shall be covered with tarpaulins or plastic to keep moisture, water, and sunlight from contact with the material. All accessory materials such as adhesives, cements, solvents, mastics, caulks and tape shall be stored inside a temperature-controlled shelter.

1.8 Reference Specifications

See Specification 02777 for geomembrane installation.

2.0 GEOMEMBRANE INSTALLATION

2.1 Subgrade and Subbase Layer Construction

2.1.1 Surface Preparation: The General Contractor shall be responsible for preparing the subgrade and the subbase layer according to the Specifications.

The CQA Consultant will document that:

a. A qualified Land Surveyor has verified all lines and grades.

b. The requirements for soil testing and inspection are satisfied.

The Installer shall certify in writing that the surface on which the geomembrane is to be installed is acceptable. The "Subgrade Surface Acceptance" form shall be completed, signed by the Installer and given to the Construction Manager prior to commencement of geomembrane installation in the area under consideration. The Construction Manager will give the CQA Consultant a copy of this form.

After the subbase has been accepted by the Installer, it shall be the Installer's responsibility to indicate to the Construction Manager any change in the subbase condition that may require repair work. If the CQA Consultant concurs with the Installer, then the Construction Manager will ensure that the subbase is repaired.

2.1.2 Anchorage System: Anchor trenches shall be excavated by the Contractor to the lines and widths shown on the design drawings, prior to geomembrane placement. The Geosynthetics CQA Consultant will verify that anchor trenches have been constructed according to design drawings.

Slightly rounded corners shall be provided in trenches where the geomembrane adjoins the trench so as to avoid sharp bends in the geomembrane. No loose soil shall underlie the geomembrane in the trenches.

2.2 Geomembrane Placement

2.2.1 Personnel: Liner installation shall be performed with a combination of large equipment and placement crews. Personnel shall have training and shall be supervised by a qualified Superintendent. Minimum training shall include the following items:

a. Brief instructions on purpose of lining installation.

b. Brief instructions on placement procedures.

c. Knowledge of safety procedures to be observed during geomembrane placement including, at a minimum:

   1. Dismounting techniques from a geomembrane panel lifted several feet in the air.

   2. Safe method of removing metal bands from geomembrane packaging.

   3. Awareness of techniques to avoid over-stressing of arms, legs, and back during placement operations.

2.2.2 Clothing: All on-site personnel shall wear certain special clothing during lining placement. This includes:

a. Smooth-soled shoes. No shoes with indented patterns shall be worn since small rocks can be trapped in the void areas and inadvertently puncture and tear the lining.

b. Gloves - when handling/pulling lining into places, gloves should be worn to prevent abrasion or other damage to the worker's hands.

c. Each installer shall be inspected to ensure that his clothing and footwear will not damage either the geomembrane or the installer during placement.

2.2.3 Field Panel Identification: The CQA Consultant will document that the Installer labels each field panel with an "identification code" (number or letter-number) consistent with the layout plan. The Construction Manager, Installer, and CQA Consultant will agree upon this identification code. It shall be the responsibility of the Installer to ensure that each field panel placed is marked with the original roll number. The roll number shall be marked at a location agreed upon by the Construction Manager, Installer, and CQA Consultant.

The CQA Consultant will establish a table or chart showing correspondence between roll numbers and field panel identification codes. The field panel identification code will be used for all Quality Assurance records.

2.2.4 Field Panel Placement: The "Daily Panel Placement Log" and "Daily Seaming Log" will be completed daily.

2.2.5 Location: The CQA Consultant will verify that field panels are installed at the location indicated on the Installer's layout plan, as approved or modified.

2.2.6 Installation Schedule: Field panels shall be placed one at a time unless otherwise approved by the CQA Consultant, and each field panel shall be seamed immediately after its placement (in order to minimize the number of unseamed field panels exposed to wind).

It is usually beneficial to "shingle" overlaps in the downward direction to facilitate drainage in the event of precipitation. It is also beneficial to proceed in the direction of prevailing winds. Scheduling decisions must be made during installation, in accordance with varying conditions. In any event, the Installer shall be fully responsible for the decisions made regarding placement procedures.

The CQA Consultant will evaluate every change in the schedule proposed by the Installer and advise the Construction Manager on the acceptability of that change. The CQA Consultant will verify that the condition of the subase has not changed detrimentally during installation.

The CQA Consultant will record the identification code, location, and date of installation of each field panel.

2.2.7 Weather Conditions: Geomembrane placement shall not proceed at an ambient temperature below 50°F or above 104°F unless authorized by the Construction Manager. In addition, the geomembranes shall not be unrolled unless the sheet temperatures are between 32°F and 122°F. If ambient conditions create sheet temperatures below 50°F then panels shall be warmed by artificial means (i.e. hot air guns, heat lamps, space heaters, etc.) prior to seaming. Geomembrane placement shall not be done during any precipitation, in an area of ponded water, or in the presence of excessive winds (i.e. conditions under which the liner may be blown around and/or raised off the ground with workers on the liner, or the liner edges may whip, shred, or rip).

The CQA Consultant will verify that the above conditions are fulfilled. Additionally, the CQA Consultant will verify that the supporting soil has not been damaged by weather conditions.

2.2.8 Method of Placement: The following is the responsibility of the Installer; the CQA Consultant will document that these conditions are satisfied:

a. All placement equipment is on-site and in working order.

b. Any equipment used does not damage the geomembrane by handling, traveling, excessive heat, leakage of hydrocarbons or other means. Utility knives have only hook-type blades. All necessary personnel are on-site.

c. The prepared surface underlying the geomembrane has not deteriorated since previous acceptance, and is still acceptable immediately prior to geomembrane placement.

d. Any geosynthetic elements immediately underlying the geomembrane are clean and free from debris.

e. All personnel working on the geomembrane shall not smoke, wear boots or shoes capable of damaging the geomembrane, or engage in other activities that could damage the geomembrane.

f. The method and equipment used to unroll the panels does not cause scratches or crimps in the geomembrane and does not damage the supporting soil.

g. The method used to place the panels minimizes wrinkles (especially differential wrinkles between adjacent panels). The panels are installed in a relaxed condition, free of tension, stress, folds or bends, and not stretched to fit.

h. Adequate temporary loading and/or anchoring (e.g., sand bags, tires), not likely to damage the geomembrane, is placed to prevent uplift by wind (in case of high winds, continuous loading by adjacent sand bags is recommended along the edges of panels to minimize the risk of wind flow under the panels).

i. Direct contact with the geomembrane is minimized; i.e., the geomembrane is protected by geotextiles, extra geomembrane, or other suitable materials, in areas where excessive traffic may be expected. Materials, equipment and other items are not dragged, allowed to slide, or allowed to impact the geomembrane or other liner system components.

The CQA Consultant will inform the Construction Manager if the above conditions are not fulfilled.

2.2.9 Damage: The CQA Consultant will visually observe every panel, after placement and prior to seaming, for damage. The CQA Consultant will advise the Construction Manager which panels, or portions of panels, should be rejected, repaired, or accepted. Damaged panels or portions of damaged panels that have been rejected will be marked and their removal from the work area recorded by the CQA Consultant. Repairs will be made according to procedures described in Section 2.12.

As a minimum, the CQA Consultant will document that:

a. The panel is placed in such a manner that it is unlikely to be damaged.

b. Any tear, punctures, holes, thin spots, etc. are either marked for repair or the panel is rejected.

2.3 Field Seaming

The "Daily Seaming Log", "Trial Seam Report", "Field Destructive Test Log", and "Non-Destructive Test Log" will be completed for daily seaming operations.

2.3.1 Seam Layout: The Installer shall provide the Construction Manager and the CQA Consultant with a seam layout drawing for the facility, showing all expected seams. The CQA Consultant or the Engineer will review the seam layout drawing and verify that it is consistent with the accepted state of practice and this CQA Plan. No panels may be seamed in the field without the Construction Manager's approval. In addition, no panels not specifically shown on the seam layout drawing may be used without the Construction Manager's prior approval.

In general, field and factory seams should be oriented parallel to the line of maximum slope, i.e., oriented along, not across, the slope. In corners and odd-shaped geometric locations, the number of seams should be minimized. No horizontal seam should be within 10 ft. of the toe of slopes, or areas of potential stress concentrations, unless otherwise authorized.

The completed liner shall not exhibit any "trampolining" during any daylight hours (6:00 a.m. to 8:00 p.m.).

All parties will agree upon a seam numbering system compatible with the panel numbering system.

2.3.2 Requirements of Personnel: The seaming crew for liner installation typically consists of a minimum two-person crew. The project superintendent and all crew foremen shall meet minimum installation experience for linings. The project superintendent shall have installed 2,000,000 sq. ft. of liner. The master seamer shall have installed 1,000,000 sq. ft. of liner. All crew members shall have minimum safety training in handling liner materials.

All personnel performing polyethylene seaming operations will be qualified by experience. Seaming personnel must have seamed at least 10,000 ft. of polyethylene geomembrane seams using the same type of seaming apparatus to be used on this project.

2.3.3 Clothing: All seaming crews shall wear the following special clothing during seaming operations:

a. Smooth-soled shoes or boots - no indented patterns on the soles.

b. Gloves - Leather gloves will protect against hot equipment or other damage.

c. Goggles or suitable protective eyewear during seaming operations.

d. Kneepads - to protect the worker's knees.

2.3.4 Experience: The Installer shall provide the Construction Manager and the CQA Consultant with a list of proposed seaming personnel and their experience records. The Construction Manager and the CQA Consultant will review this document.

2.4 Seaming Equipment and Products

2.4.1 Field Seaming: Approved processes for field seaming of polyethylene are extrusion seaming and fusion seaming. Proposed alternate processes shall be documented and submitted to the Owner or his representative for his approval. Only apparatus that have been specifically approved by make and model shall be used. The Installer shall use a pyrometer to ensure that accurate temperatures are being achieved.

2.4.2 Polyethylene Seaming Techniques - Extrusion Process: The extrusion-seaming apparatus shall be equipped with gauges giving the relevant temperatures of the apparatus such as the temperatures of the extrudate, nozzle, and preheat. The Installer shall provide documentation regarding the extrudate to the Construction Manager and the CQA Consultant and shall certify that the extrudate is compatible with the Specifications, and in any event is comprised of the same resin as the geomembrane sheeting.

The CQA Consultant will log apparatus temperatures, extrudate temperatures, and ambient temperatures at appropriate intervals. Ambient temperatures will be measured 6 in. above the geomembrane surface.

The CQA Consultant will verify that:

a. The Installer maintains on-site a suitable number of spare operable seaming apparatus.

b. Equipment used for seaming is not likely to damage the geomembrane.

c. The extruder is purged prior to beginning a seam until all heat-degraded extrudate has been removed from the barrel.

d. The electric generator is placed on a smooth base such that no damage occurs to the geomembrane.

e. A smooth insulating plate or fabric is placed beneath the hot seaming apparatus after usage.

f. The geomembrane is protected from damage in heavily trafficked areas.

2.4.3 Fusion Process: The fusion-seaming apparatus must be automated vehicular-mounted devices. The fusion-seaming apparatus shall be equipped with gauges giving the applicable temperatures. The Installer prior to each seaming period shall verify pressure settings.

The CQA Consultant will log ambient temperatures, seaming apparatus temperatures, and speeds. Ambient temperatures will be measured 6 in. above the geomembrane surface.

The CQA Consultant will also verify that:

a. The Installer maintains on-site a suitable number of spare operable seaming apparatus.

b. Equipment used for seaming is not likely to damage the geomembrane.

c. For cross seams, the edge of the cross seam is ground to a smooth incline (top and bottom) prior to seaming.

d. The electric generator is placed on a smooth base such that no damage occurs to the geomembrane.

e. A smooth insulating plate or fabric is placed beneath the hot seaming apparatus after usage.

f. The geomembrane is protected from damage in heavily trafficked areas.

g. Build-up of moisture between the sheets is prevented (a movable protective layer may be used as required directly below each overlap of geomembrane that is to be seamed to accomplish this end).

2.5 Seam Preparation

The CQA Consultant will verify that:

a. Prior to seaming, the seam area is clean and free of moisture, dust, dirt, oils, greases, debris of any kind, and foreign material.

b. If seam overlap grinding is required, the process is completed according to the Geomembrane Manufacturer's instructions within one hour of the seaming operation, and in a way that does not damage the geomembrane.

c. The abrading does not extend more than 0.5 in. on either side of the extrusion seam.

d. Seams are aligned with the fewest possible number of wrinkles and "fishmouths".

2.6 Weather Conditions for Seaming

The normally required weather conditions for seaming are as follows:

a. Unless authorized in writing by the Construction Manager, no seaming shall be attempted at an ambient temperature below 50°F or above 104°F. Below 50°F, panels shall be warmed artificially with hot air guns, radiant heaters, heat lamps, space heaters, etc.

b. The geomembrane shall be dry and protected from wind, rain, snow, heavy mist or fog, hail, high or low temperatures, dust, or other adverse environmental conditions.

c. The ambient temperatures shall be measured 6 in. above the geomembrane surface.

If the Installer wishes to use methods which may allow seaming at ambient temperatures below 50°F or above 104°F, the Installer shall demonstrate and certify that such methods produce seams which are entirely equivalent to seams produced at ambient temperatures above 50°F and below 104°F, and that the overall quality of the geomembrane is not adversely affected.

The CQA Consultant will verify that these weather conditions are fulfilled and will advise the Construction Manager if they are not. The Construction Manager will then decide if the installation will be stopped or postponed.

2.7 Overlapping and Temporary Bonding

The Installer shall ensure that, and the CQA Consultant will verify that:

a. The panels of geomembrane have a minimum finished overlap of 4 in. for extrusion and fusion seaming, but in any event sufficient overlap shall be provided to allow peel tests to be performed on the seam.

b. No solvent or adhesive shall be used unless the product is accepted in writing by the Owner (samples shall be submitted to the Owner for testing and evaluation).

c. The procedure used to temporarily bond adjacent panels together shall not damage the geomembrane (in particular, the temperature of hot air at the nozzle of any spot seaming apparatus is controlled such that the geomembrane is not damaged).

The CQA Consultant will log all overlapping and temporary bonding, and will log and report to the Construction Manager any non-compliance.

2.8 Trial Seams

Trial seams shall be made on fragment pieces of geomembrane liner to verify that seaming conditions are adequate. Such trial seams shall be made at the beginning of each seaming period, and at least once every five hours, for each seaming apparatus used in the seaming period. A trial seam also shall be made in the event that the ambient temperature varies more than 18°F since the last passing trial seam. The ambient temperature shall be measured 6 in. above the liner. Also, each seamer or seamer crew shall make at least one trial seam each seaming period, or each 1,000 feet of seam. Trial seams shall be made under the same conditions as actual seams. If any seaming apparatus is turned off for any reason, a new passing trial seam shall be completed for that specific seaming apparatus. The Installer shall provide the tensiometer required for shear and peel testing in the field. The tensiometer shall be automatic and shall have a direct digital readout.

The trial seam sample for polyethylene shall be at least 3 ft. long by 1 ft. (after seaming) with the seam centered lengthwise.

All sample seams shall be cured or aged properly before testing in accordance with the test procedure.

Four specimens of field geomembrane seams shall initially be taken by the Installer and tested. Two specimens shall be tested in shear and two in peel using a field tensiometer, and they should not fail in the seam. Minimum strength requirements for field seams are provided on Table 4. In each type of test, a maximum of one non-FTB failure out of five tests is acceptable provided that the strength requirement is met on that sample. If a specimen fails, the entire operation shall be repeated. If the additional specimen fails, the seaming apparatus and seamer will not be accepted and will not be used for seaming until the deficiencies are corrected and two consecutive successful full trial seams are achieved.

The CQA Consultant will observe all trial seam procedures and record data on the "Trial Seam Report." The remainder of the successful trial seam sample will be assigned a number and marked accordingly by the CQA Consultant, who will also log the date, hour, ambient temperature, seaming unit number, name of seamer, and pass or fail description. The sample itself will be cut into two pieces, one to be retained in the Owner's archives and one to be given to the Installer.

2.9 General Seaming Procedure

Unless otherwise specified, the general seaming procedure used by the Installer shall be as follows:

a. All seaming shall commence from the center to the edges to minimize entrapment of large wrinkles that will require cutting and patching.

b. The working area shall be clean and smooth and have adequate room for maneuvering. A firm surface shall be provided by using a flat board or similar hard surface directly under the seam overlap to achieve proper support.

c. Prior to seaming a lining sheet or patch, all edges shall be free of defects such as blisters and tears. Once the seam is formed, it is desirable that there be no free edge on the upper lining that equipment or other items can catch or snag on, potentially damaging the seam in this location.

d. For fusion seaming of geomembrane, a movable protective layer of plastic may be required directly below each overlap of geomembrane that is to be seamed. This is to help prevent any moisture build-up between the sheets to be seamed.

e. Sandbags shall remain placed on the seaming edges of all sheets until the lining is formally seamed. Sandbags shall be spaced no more than 5 to 6 feet apart.

f. "Fishmouths" or wrinkles at the seam overlaps shall be cut along the ridge of the wrinkle in order to achieve a flat overlap. The cut "fishmouths" or wrinkles shall be seamed and any portion where the overlap is inadequate shall then be patched with an oval or round patch of the same geomembrane extending a minimum of 6 in. beyond the cut in all directions.

g. If seaming operations are carried out at night, adequate illumination shall be provided.

h. Seaming shall extend to the outside edge of panels. No liner edge shall be buried within 30 feet of an "incomplete" field seam. This allows for re-tensioning to remove wrinkles along the seam area.

The CQA Consultant will verify that the above seaming procedures are followed, and will inform the Construction Manager if they are not.

2.10 Non-destructive Seam Continuity Testing

Non-destructive testing of all field seams shall be done to check 100% of all seams. The "Non-Destructive Test Log" shall be completed relative to non-destructive testing. The Installer shall perform non-destructive tests on all field seams over their full length. Fillet-extrusion welds shall be tested with a vacuum chamber in accordance with ASTM D 5641. Hot wedge welds shall be pressure tested, pressurizing the gap created by the split face design of the hot wedge in accordance with ASTM D 5820. A spark test, in accordance with ASTM D 5820, shall be used for all boots. Probe test methods shall not be used. The testing shall be carried out to the accepted standards of the industry. The purpose of non-destructive tests is to check the continuity of seams. It does not provide any information on seam strength. Continuity testing shall be carried out as the seaming work progresses, not at the completion of all field seaming. Non-destructive testing shall not be permitted before sunrise or after sunset unless the Installer demonstrates capabilities to do so.

The CQA Consultant will:

a. Observe all continuity testing.

b. Record location, date, test unit number, name of tester, and outcome of all testing.

c. Inform the Installer and Construction Manager of any required repairs.

The Installer shall complete any required repairs in accordance with Subsection 2.12.

The CQA Consultant will:

a. Observe the repair and retesting of the repair.

b. Mark on the geomembrane that the repair has been made.

c. Document the results.

The Installer shall use the following procedures at locations where seams cannot be non-destructively tested:

a. All such seams shall be cap-stripped with the same geomembrane.

b. If the seam is accessible to testing equipment prior to final installation, the seam shall be non-destructively tested prior to final installation.

c. If the seam cannot be tested prior to final installation, the seaming and cap-stripping operations shall be observed by the CQA Consultant and Installer for uniformity and completeness.

The seam number, date of observation, name of tester, and outcome of the test, or observation will be recorded by the CQA Consultant.

2.11 Destructive Testing

2.11.1 Concept: Destructive seam tests will be performed at locations selected by the CQA Consultant. The purpose of these tests is to evaluate seam strength. Seam strength testing will be done as the seaming work progresses, not at the completion of all field seaming. Care will be taken to properly cure all seams and samples according to test procedure requirements.

2.11.2 Location and Frequency: The CQA Consultant will select locations where seam samples will be cut out for laboratory testing. Those locations will be established as follows:

a. A minimum frequency of one test location per 2,000 ft. of seam length.

b. The Installer, Construction Manager, and CQA Consultant will agree upon a maximum frequency.

c. Test locations will be determined during seaming at the CQA Consultant's discretion.

The Installer will not be informed in advance of the locations where the seam samples will be taken.

2.11.3 Sampling Procedure: Samples shall be cut by the Installer as the seaming progresses in order to have laboratory test results before the geomembrane is covered by another material. The CQA Consultant will:

a. Observe sample cutting.

b. Assign a number to each sample, and mark it accordingly.

c. Record the sample location on the layout drawing.

d. Record the reason for taking the sample at this location (e.g., statistical routine, suspicious feature of the geomembrane).

All holes in the geomembrane resulting from destructive seam sampling shall be immediately repaired. The continuity of the new seams in the repaired area shall be tested.

2.11.4 Size of Samples: At a given sampling location, the Installer shall take two types of samples. These specimen sizes may be changed at the advice or recommendation of the CQA Consultant.

First, two specimens shall be taken for field testing. Each of these specimens shall be 1 in. wide by 12 in. long, with the seam centered parallel to the width. The distance between these two specimens shall be 42 in. If both specimens pass the field test described in the next subsection, a sample for laboratory testing shall be taken.

The sample for laboratory testing shall be located between the two specimens for field testing. The destructive sample shall be 12 in wide by 42 in. long with the seam centered lengthwise. The sample shall be cut into three parts and distributed as follows:

a. One portion to the Installer for laboratory testing, 12 in. x 12 in.

b. One portion to the Owner for archive storage, 12 in. x 12 in.

c. One portion for Geosynthetics CQA Laboratory testing, 12 in. x 18 in.

2.11.5 Field Testing: The two 1 in. wide specimens mentioned in Subsection 2.11.4 will be tested in the field, by tensiometer, for peel and shear respectively, and should not fail in the seam. If any field test sample fails to pass, then the procedures outlined in Subsection 2.11.8 will be followed.

The CQA Consultant will witness all field tests and mark all samples and portions with their number. The CQA Consultant will also log the date and time, ambient temperature, seaming unit number, name of technician, apparatus temperatures and speeds, and pass or fail description.

2.11.6 Geosynthetics Construction Quality Assurance Laboratory Testing: Destructive test samples will be packaged and shipped, if necessary, under the responsibility of the CQA Consultant in a manner that will not damage the test sample. The Construction Manager will be responsible for storing the archive samples. Test samples will be tested by the Geosynthetics CQA Laboratory. The Construction Manager will select the Geosynthetics CQA Laboratory.

Testing of polyethylene materials will include "Shear Strength" (ASTM D 6392) and "Peel Strength" (ASTM D 6392). At least 5 specimens will be tested for each test method. A maximum of one non-FTB failure is acceptable provided that strength requirements are met on that sample.

The Geosynthetics CQA Laboratory will provide test results no more than 24 hours after they receive the samples. The CQA Consultant will review laboratory test results as soon as they become available, and make appropriate recommendations to the Construction Manager.

Should field tensiometer testing be carried out, the following procedure should be followed: if the test passes, the sample qualifies for testing in the laboratory; if it fails, the seam should be repaired in accordance with Subsection 2.12.3.

2.11.7 Installer's Laboratory Testing: The Installer's laboratory test results shall be presented to the Construction Manager and the CQA Consultant for review.

2.11.8 Procedures for Destructive Test Failure: The following procedures will apply whenever a sample fails a destructive test, whether that test is conducted by the Geosynthetics CQA Laboratory, the Installer's Laboratory, or by field tensiometer. The Installer has two options:

The Installer can reconstruct the seam between any two passed destructive seam test locations.

The Installer can trace the seaming path to an intermediate location (at 10 ft. minimum from the point of the failed test in each direction) and take a small sample for an additional field test at each location. If these additional samples pass tensiometer testing, then full destructive laboratory samples shall be taken. If these destructive laboratory samples pass the tests, then the seam shall be reconstructed between these locations by capping. If either sample fails, then the process is repeated to establish the zone in which the seam shall be reconstructed.

If a fusion-type seam fails destructive testing and the Installer chooses to cap the seam, the only acceptable capping method is as described in Subsection 2.12.3. Applying topping is not an approved method of capping long lengths of seam.

All acceptable seams shall be bounded by two locations from which destructive samples passing laboratory tests have been taken. In cases exceeding 150 ft. of reconstructed seam, a sample shall be taken from the zone in which the seam has been reconstructed. This sample must pass destructive testing or the procedure outlined in this section shall be repeated.

The CQA Consultant will document all actions taken in conjunction with destructive test failures.

2.12 Defects and Repairs

2.12.1 Identification: All seam and non-seam areas of the geomembrane will be examined by the CQA Consultant for identification of defects, holes, blisters, undispersed raw materials, and any sign of contamination by foreign matter. Because light reflected by the geomembrane helps to detect defects, the surface of the geomembrane shall be clean at the time of examination. The geomembrane surface shall be broomed or washed by the Installer if the amount of dust or mud inhibits examination. Water used for washing shall be directed to a sedimentation control structure prior to discharge.

2.12.2 Evaluation: Each suspect location both in seam and non-seam areas will be non-destructively tested using the methods described in Subsection 2.10 as appropriate. Each location, which fails the non-destructive testing, will be marked by the CQA Consultant and repaired by the Installer. Work shall not proceed with any materials that will cover a repaired location until laboratory test results with passing values are available.

2.12.3 Repair Procedure: Any portion of the geomembrane exhibiting a flaw, or failing a destructive or non-destructive test, shall be repaired. Several procedures exist for the repair of these areas. The final decision as to the appropriate repair procedure will be agreed upon between the Construction Manager, Installer, and CQA Consultant. The procedures available include:

a. Patching, used to repair large holes, tears, undispersed raw materials, and contamination by foreign matter.

b. Grinding and reseaming, used to repair small sections of extruded seams.

c. Spot seaming, used to repair small tears, pinholes or other minor localized flaws.

d. Capping, used to repair large lengths of failed seams.

e. Topping, used to repair areas of inadequate seams, which have an exposed edge.

In addition, the following provisions shall be satisfied:

a. Surfaces of the geomembrane that are to be repaired shall be abraded no more than one hour prior to the repair, if applicable.

b. All surfaces shall be clean and dry at the time of the repair.

c. All seaming material and equipment used in repairing procedures shall be approved.

d. The CQA Consultant and Installer shall approve the repair procedures, materials, and techniques in advance of the specific repair.

e. Patches or caps shall extend at least 6 in. beyond the edge of the defect, and all corners of patches shall be rounded with a radius of at least 3 in.

f. The geomembrane below large caps shall be appropriately cut to avoid water or gas collection between the two sheets.

2.12.4 Verification of Repairs: Each repair will be numbered and logged. Each repair shall be non-destructively tested using the methods described in Subsection 2.10 as appropriate. Repairs that pass the non-destructive test will be taken as an indication of an adequate repair. Large caps may be of sufficient extent to require destructive testing, at the discretion of the CQA Consultant. Failed tests will require the repair to be redone and retested until a passing test result is obtained. The CQA Consultant will observe all non-destructive testing of repairs and will record the date of the repair and test outcome.

2.12.5 Large Wrinkles: When seaming of the geomembrane is completed (or when seaming of a large area of the geomembrane is completed) and prior to placing overlying materials, the CQA Consultant will observe the geomembrane for wrinkles. The CQA Consultant will indicate to the Construction Manager which wrinkles should be cut and reseamed by the Installer. The seam thus produced will be tested like any other seam.

2.13 Backfilling of Anchor Trench

Anchor trenches shall be adequately drained, to prevent ponding or otherwise softening of the adjacent soils while the trench is open. Also, storm water shall not accumulate in the trenches and flow underneath any completed liner sections. Anchor trenches shall be backfilled in accordance with the construction drawings.

Care shall be taken when backfilling the trenches to prevent any damage to the geosynthetics.

The CQA Consultant will observe the backfilling operation and advise the of any problems.

2.14 Liner System Certification/Acceptance

The Installer and the Manufacturer shall retain all ownership and responsibility for the geosynthetics in the disposal site until acceptance by the Owner.

The liner system will be accepted by the Owner when:

a. The installation is finished.

b. Verification of the adequacy of all seams and repairs, including associated testing, is complete.

c. Installer's representative furnishes the Construction Manager with certification that the geomembrane was installed in accordance with the Manufacturer's recommendations as well as the plans and specifications.

d. All documentation of installation is completed, including the CQA Consultant's final report.

e. The Construction Manager has received certification, including Record Drawing (s), sealed by a Professional Engineer.

The CQA Consultant will certify that installation has proceeded in accordance with this CQA Plan for the project, except as noted to the Construction Manager.

2.15 Materials in Contact with the Geomembranes

The quality assurance procedures indicated in this Subsection are only intended to assure that the installation of these materials does not damage the geomembrane. Additional quality assurance procedures are necessary to assure that systems built with these materials will be constructed in such a way to enable proper performance.

2.15.1 Drainage Nets: The CQA Consultant will verify that the drainage nets are installed in accordance with the procedures described in "Geonet Construction Quality Assurance" specification. Extreme care shall be exercised so as not to damage the geomembrane during placement of the drainage nets and the materials overlying the drainage nets.

2.15.2 Appurtenances: A copy of the specifications prepared by the Engineer for appurtenances will be given by the Construction Manager to the CQA Consultant for review.

The CQA Consultant will verify that:

a. Installation of the geomembrane in appurtenant areas and connection of geomembrane to appurtenances have been made according to Specifications.

b. Extreme care is taken while seaming around appurtenances, since neither non-destructive nor destructive testing may be feasible in these areas.

c. The geomembrane has not been visibly damaged while making connections to appurtenances.

d. The CQA Consultant will inform the Construction Manager if the above conditions are not fulfilled.

2.16 Liner System Protective Cover

2.16.1 The geomembrane shall be covered with protective materials as shown on the construction drawings.

2.16.2 Protective Cover Materials: Protective materials shall be placed on the geosynthetics to prevent damage to the liner. The cover materials shall be placed in accordance with the Drawings and shall be placed only after testing and approval by the Owner. Protective cover shall be placedacceptance of all seams and geomembrane placement.

2.16.3 Equipment: Light ground pressure equipment (less than 6 psi contact pressure) shall be operated in a minimum of 12 inches of cover and must not be driven on the geosynthetics. Heavy equipment and trucks shall operate on a minimum of 4 feet of cover.

2.16.4 The cover shall be placed so as not to cause any wrinkles, folds, or bends in the geosynthetics.

2.16.5 Leachate collection system piping shall be placed so that the pipe is in uniform contact with the bedding material.

2.16.6 Cover Procedure: If applicable, cover slopes from the bottom by pushing the cover material upward. This reduces tension on the membrane caused by material falling downhill.

2.16.7 Damage: The CQA Consultant will mark any areas of possible damage. Marked areas shall later be uncovered by hand for inspection and repaired, if necessary.

TABLE 1 – LLDPE MINIMUM MATERIAL REQUIREMENTS			
PROPERTY	TEST METHOD	UNITS	TEXTURED
Gage (nominal)	NA	mils	40
Thickness	ASTM D 5994	mils	40
Asperity Height	GRI GM-12	mils	10
Base Sheet Density	ASTM D 1505	g/cm^3	0.915
Resin – Melt Flow Index	ASTM D 1238	g/10 min.	° 1.0
Carbon Black - Content	ASTM D 4218	percent	2 to 3
Carbon Black - Dispersion	ASTM D 5596	rating	Category 1 or 2
Tensile Properties:			
Stress at Yield	ASTM D 6693	lb/inch	76
Stress at Break	ASTM D 6693	lb/inch	90
Strain at Yield	ASTM D 6693	percent	18
Strain at Break	ASTM D 6693	percent	450
Tear Resistance	ASTM D 1004	lbs.	22
Puncture Resistance	ASTM D 4833	lbs.	48
Oxidative Induction Time	ASTM D 3895	min.	100
Friction Angle between Geomemebrane and Geocomposite interface	ASTM D 5321	degrees	24 (Residual)

TABLE 2 – MANUFACTURER'S TESTING FREQUENCY IN ACCORDANCE WITH GIR GM-17 STANDARDS		
PROPERTY	TEST METHOD	FREQUENCY
Thickness	ASTM D 5994	Per Roll
Tensile Properties	ASTM D 6693	20,000 lb.
Carbon Black Content	ASTM D 4218	45,000 lb.
Carbon Black Dispersion	ASTM D 5596	45,000 lb.
Resin Density	ASTM D 1505	200,000 lb.
Resin Melt Flow Index	ASTM D 1238	Each Batch
Tear Resistance	ASTM D 1004	45,000 lb.
Puncture Resistance	ASTM D 4833	45,000 lb.
Standard OIT	ASTM D 3895	200,000 lb.
Asperity Height	GRI-GM 10	Per 2nd Roll

TABLE 3 – CQA CONFORMANCE TESTING FREQUENCY		
PROPERTY	TEST METHOD	FREQUENCY
Thickness	ASTM D 5994	Every 50,000 ft^2
Tensile Properties	ASTM D 638 (As modified in NSF54)	Every 50,000 ft^2
Tear Resistance	ASTM D 1004	Every 50,000 ft^2
Puncture Resistance	ASTM D 4833	Every 50,000 ft^2
Asperity Height	GRI GM-12	Every 50,000 ft^2
Interface-Friction Angle	ASTM D 5321	Two

TABLE 4 – LLDPE LINER MINIMUM WELD VALUES			
PROPERTY	TEST METHOD	UNITS	TEXTURED/SMOOTH
Shear Strength – Fusion and Extrusion	ASTM D 6392	lb/inch	56 and Film Tear Bond
Peel Strength – Fusion and Extrusion	ASTM D 6392	lb/inch	48 and Film Tear Bond

END

Attachment 2 - Specification KIF-0-TS-02622

ATTACHMENT 2 TO KINGSTON FOSSIL PLANT DREDGE CELL LATERAL EXPANSION QA/QC PLAN

SPECIFICATION KIF-0-TS-02622

REVISION 0

FOR

GEOCOMPOSITE DRAINAGE LAYER CONSTRUCTION QUALITY ASSURANCE

SECTION JOHN-0-TS-02622

GEOCOMPOSITE CONSTRUCTION QUALITY ASSURANCE

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1.0 GEOCOMPOSITES

See Specification 02621 for installation requirements for geocomposite drainage layer.

1.1 MANUFACTURING

The Geocomposite Manufacturer shall provide the Construction Manager with a list of guaranteed properties for the type of geocomposite to be supplied. The Geocomposite Manufacturer shall provide the Construction Manager with a written certification signed by a responsible party that the geocomposite actually delivered have properties that meet or exceed the guaranteed properties. In addition, the manufacturer shall perform the testing required by Table 2 and submit the results along with the delivery of the materials. Also, the manufacturer for the specified geocomposite shall submit for approval a MQA/MQC Plan prior to supplying any geocomposite.

The CQA Consultant will examine all of the manufacturer's certifications and test results to ensure that the property values listed on the certifications meet or exceed those specified. Any deviations will be reported to the Construction Manager.

1.2 LABELING

The Geocomposite Manufacturer shall identify all rolls of geocomposite with at least the following information:

a. Manufacturer's name.

b. Product identification.

c. Lot number.

d. Roll number.

e. Roll dimensions.

The CQA Consultant will examine rolls upon delivery and any deviation from the above requirements will be reported to the Construction Manager.

1.3 SHIPMENT AND STORAGE

Geocomposite cleanliness is essential to their performance and geocomposite rolls shall be wrapped in polyethylene sheets or otherwise protected against dust and dirt during shipping and storage.

The wrapping shall be removed less than one hour before placement. The CQA Consultant will verify that geocomposites are free of dirt and dust just before installation. The CQA Consultant will report the outcome of this verification to the Construction Manager, and if the geocomposites are judged dirty or dusty, they shall be washed by the Installer prior to installation.

The CQA Consultant will observe washing operations and improper washing operations will be reported to the Construction Manager.

1.4 CONFORMANCE TESTING

1.4.1 Tests

Upon delivery of the rolls of geocomposite, the CQA Consultant will ensure that samples are removed and forwarded to the Geosynthetic CQA Laboratory for testing, at the frequency indicated on Table 3, to ensure sufficient conformance to both the Specifications and the list of guaranteed properties.

1.4.2 Sampling Procedures

Samples will be taken across the entire width of the roll and will not include the first three feet. Unless otherwise specified, samples will be 3 ft. long by the roll width. The CQA Consultant will mark the machine direction on the samples with an arrow.

1.4.3 Test Results

The CQA Consultant will examine all results from laboratory conformance testing and will report any nonconformance to the Construction Manager. The minimum standards for the geocomposite are provided in the construction specifications.

1.4.4 Conformance Test Failure

The following procedure will apply whenever a sample fails a conformance test that is conducted by the Geosynthetics CQA Laboratory.

Two (2) additional samples shall be taken from the roll of geonet that has failed the conformance test. The Geosynthetics CQA Laboratory shall perform two (2) identical retests of the failing test.

a. If both of the two (2) retests on the roll pass, the roll shall be deemed acceptable.

b. If either of the two (2) retests on the roll fail, the Installer shall replace the roll of geocomposite that is in non-conformance with the specifications with a roll that meets the specifications. In addition, the Installer shall remove conformance samples (for testing by the Geosynthetics CQA Laboratory) from the closest numerical roll on both sides of the failed roll. These two samples must both conform to the Specifications. If either one of these samples fail, every roll of geocomposite on site from the same lot and every roll delivered subsequently from the same lot must be tested by the Geosynthetics CQA Laboratory for conformance to the Specifications.

The retesting and additional conformance testing to address a test failure shall be at the expense of the Installer.

The CQA Consultant will document actions taken in conjunction with conformance test failures.

1.5 HANDLING AND PLACEMENT

The Installer shall handle all geocomposites in such a manner as to ensure they are not damaged and shall comply with the following requirements:

a. On slopes, the geocomposites shall be secured in the anchor trench and then rolled down the slope in such a manner as to continually keep the geocomposite sheet in tension. If necessary, the geocomposite shall be positioned by hand after being unrolled to minimize wrinkles.

b. In the presence of wind, all geocomposites shall be weighted with sandbags or the equivalent. Such sandbags shall be installed during placement and shall remain until replaced with overlying material.

c. Unless otherwise specified, geonet shall not be welded to geomembranes. Geonet shall be heat-bonded by the manufacturer to the geotextiles where indicated on the construction Drawings. No burn through geotextiles shall be permitted. No glue or adhesive shall be permitted.

d. The Installer shall take any necessary precautions to prevent damage to the underlying layers during placement of the geocomposite.

e. During placement of geocomposites, care shall be taken not to entrap in the geonet dirt or excessive dust that could cause clogging of the system, and/or stones that could damage the geomembrane. If dirt or excessive dust is entrapped in the geonet, it shall be hosed clean prior to placement of the next material on top of it. In this regard, care shall be taken with the handling of sandbags to prevent rupture or damage of the sandbag.

The CQA Consultant will note any non-compliance and report it to the Construction Manager.

1.6 JOINING

Adjacent geocomposites shall be joined according to the construction Drawings and specifications. As a minimum, the following requirements shall be met:

a. The geonet shall be placed with the long dimension parallel with the slope direction (up and down the slope, not sideways).

b. Adjacent roll <u>edges</u> of geonets shall be overlapped a minimum of 3-inches. The roll <u>ends</u> of geonets shall be overlapped a minimum of 6-inches.

c. All overlaps shall be joined by tying with plastic fasteners or polymeric braid. Metallic ties or fasteners are not allowed.

d. Tying devices shall be white or yellow, as contrasted to the black geonet, for ease of visual inspection.

e. Tie intervals along the roll edges shall be every 5-feet. Tie intervals along the roll ends and in anchor trenches shall be every 6-inches.

f. Where the geonet is bonded to geotextile(s), edges shall be seamed in accordance with the above requirements and item g. Where the geonet is bonded to geotextile(s), ends shall be seamed in accordance with the above requirements, and a geotextile cap shall be heat-bonded over the completed seam. The geotextile cap shall cover the open end of the geonet, the ties, and at least 6 inches of geotextile beyond the ties or geonet end. Heat bonding shall be performed with the utmost of care to prevent damage to any portion of the liner system. No burn through the geotextiles shall be permitted.

g. All geotextiles (top layer of geocomposite) shall be continuously sewn together with a single lock-type stitch seam. The Installer shall pay particular attention at seams to ensure that no protective cover material could inadvertently inserted beneath the geotextiles. Sewing shall be done using polymeric thread.

The CQA Consultant will note any non-compliance and report it to the Construction Manager.

1.7 REPAIR

Any holes or tears in the geocomposite shall be repaired by placing a patch extending 2 ft. beyond edges of the hole or tear. The patch shall be secured to the original geonet by tying every 6 in. If the hole or tear width across the roll is more than 50% the width of the roll, the damaged area shall be cut out and the two portions of the geonet shall be joined.

Where the geonet is bonded to geotextile(s), any holes or tears in the geonet shall be repaired by removing and replacing the damaged section of geocomposite across the full width of the roll.

Where the geonet is bonded to geotextile(s), any holes or tears in the geotextile up to 18 inches in diameter shall be repaired with a patch of the same geotextile. The patch shall be a minimum of 6 inches larger in all directions than the damaged area. The patch shall be heat bonded in place. Heat bonding shall be performed with the utmost of care to prevent damage to any portion of the liner system. No burn through the geotextiles will be permitted. Any holes or tears in the geotextile that are larger than 18 inches in any dimension shall be repaired by removing and replacing the damaged section of geocomposite across the full width of the roll. The CQA Consultant will observe any repair, note any non-compliance with the above requirements and report them to the Construction Manager.

TABLE 1 – GEOCOMPOSITE MATERIAL REQUIREMENTS			
Characteristics	**Test Method**	**Units**	**Criteria (MARV)**
Resin			
Polymer Density	ASTM D 1505	g/cm^3	0.94
Melt Flow Index	ASTM D 1238	g/10 min	≤1.0
Geonet Test			
Carbon Black	ASTM D 1603	%	2.0
Tensile Strength, MD	ASTM D 5035	lbs/ ft	45
Density	ASTM D 1505	g/cm^3	0.94
Thickness	ASTM D 5199	mil	200
Geotextile Tests			
Mass per Unit Area	ASTM D 5261	oz/yd^2	6.0
Grab Tensile	ASTM D 4632	lbs.	170
Puncture	ASTM D 4833	lbs.	90
AOS, US Sieve	ASTM D 4751	mm	70
Water Flow Rate	ASTM D 4491	gpm/ft^2	110
UV Resistance	ASTM D 4355 (after 500 hours)	% retained	70
Geocomposite Tests			
Ply Adhesion	GRI GC-7	lbs/ in.	1.0
Transmissivity*	ASTM D 4716-00	m^2/sec	1×10^{-4}
Interface Friction Testing	ASTM D5321	degrees	22^0 and 24^0 (Residual)

TABLE 2 – MANUFACTURING QUALITY CONTROL TEST FREQUENCIES			
Characteristics	**Test Method**		**FREQUENCY**
Resin			
Polymer Density	ASTM D 1505		Once Per Lot
Melt Flow Index	ASTM D 1238		Once Per Lot
Geonet Test			
Carbon Black	ASTM D 1603		$1/50,000\ ft^2$
Tensile Strength, MD	ASTM D 5035		$1/50,000\ ft^2$
Density	ASTM D 1505		$1/50,000\ ft^2$
Thickness	ASTM D 5199		$1/50,000\ ft^2$
Geotextile Tests			
Mass per Unit Area	ASTM D 5261		$1/90,000\ ft^2$
Grab Tensile	ASTM D 4632		$1/90,000\ ft^2$
Puncture	ASTM D 4833		$1/90,000\ ft^2$
AOS, US Sieve	ASTM D 4751		$1/540,000\ ft^2$
Water Flow Rate	ASTM D 4491		$1/540,000\ ft^2$
UV Resistance	ASTM D 4355 (after 500 hours)		Once per resin formulation
Geocomposite Tests			
Ply Adhesion	GRI GC-7		$1/50,000\ ft^2$
Transmissivity	ASTM D 4716-00		$1/540,000\ ft^2$

TABLE 3 - CQA TESTING FREQUENCY FOR GEOCOMPOSITES

PROPERTY	TEST METHOD	ACCEPTANCE CRITERIA (MINIMUM)	FREQUENCY
Resin Density, g/cm^3	ASTM D 1505	0.94	Every 80,000 $ft.^2$
Thickness, inch	ASTM D 5199	0.20	Every 80,000 $ft.^2$
Tensile Strength, lb./in.	ASTM D 5035	45	Every 80,000 $ft.^2$
Ply Adhesion, lb./in	GRI GC-7	1.0	Every 80,000 $ft.^2$
Interface Friction testing	ASTM D 5321	22^0 and 24^0 (Residual)	Two tests for each interface

END

Attachment 3 – Fly and Bottom Ash Compaction Procedure

SUGGESTED PROCEDURE
DETERMINATION OF MOISTURE COMPACTION WINDOW FOR BOTTOM ASH AND FLYASH

1) Determine current, as-received moisture of material.

2) Run a Proctor point at 80% of Proctor Energy (20 blows/layer at 3 layers in 4-inch mold).

3) Determine density (wet and dry).

4) Evaluate compaction.

    <u>Wet Side</u>
    a) look for pumping
    b) look for bleeding water
    c) typically, the hammer sticks to the material if it is too wet

    <u>Dry Side</u>
    a) look for "fluffing" (i.e. non-compaction)
    b) look at hammer penetration (i.e. deep penetration indicates energy absorption without compaction)
    c) look for dust fluffs

5) Plot moisture vs density and correlate with observations to develop a moisture window.

APPENDIX J

Specifications for Placement of Geosynthetics

SPECIFICATION KIF-0-TS-02621

REVISION 0

FOR

GEOCOMPOSITE DRAINAGE LAYER

SECTION JOHN-0-TS-02621

GEOCOMPOSITE DRAINAGE LAYER

TABLE OF CONTENTS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. This Section covers technical requirements for furnishing and installing the geocomposite drainage layer.

B. This Section includes the following:

1. Geocomposite panel layout.
2. Furnishing and installing geocomposite.
3. Supervision of geocomposite installation by liner manufacturer's representative.
4. Construction of fill to be placed on geocomposite.
5. Submittal of data per Table 02621-1.

1.2 CODES AND STANDARDS

A. The latest edition and published addenda of the following publications in effect on the date of Contract Award are a part of this Section and, where referred to by title or by basic designation only, are applicable to the extent indicated by the specific reference:

1. American Society for Testing and Materials (ASTM):

   a. D 1505, "Standard Test Method for Density of Plastics by the Density-Gradient Technique."

   b. D 1603, "Standard Test Method for Carbon Black in Olefin Plastics."

   c. D 4355, "Standard Test Method for Deterioration of Geotextiles by Exposure to Light, Moisture and Heat in a Xenon Arc Type Apparatus."

   d. D 4491, "Standard Test Method for Water Permeability of Geotextiles by Permittivity."

   e. D 4716, "Standard Test Method for Determining the (In-Plane) Flow Rate Per Unit Width and Hydraulic Transmissivity of a Geosynthetic Using a Constant Head."

   f. D 4751, "Standard Test Method for Determining Apparent Opening Size of a Geotextile."

   g. D 4833, "Standard Test Method for Index Puncture Resistance of Geotextiles, Geomembranes and Related Products."

   h. D 5035, "Standard Test Method for Breaking Force and Elongation of Textile Fabrics (Strip Method)."

i. D 5199, "Standard Test Method for Measuring Nominal Thickness of Geotextiles and Geomembranes."

j. D 5261, "Standard Test Method for Measuring the Mass per Unit Area of Geotextiles."

k. D 5321, "Standard Test Method for Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by the Direct Shear Method."

2. Geosynthetic Research Institute (GRI), GC-7, "Determination of Adhesion and Bond Strength of Geocomposites."

B. Where the above referenced codes and standards contain recommendations in addition to requirements, the recommendations shall be considered requirements and shall be followed unless stated otherwise by this technical specification Section.

C. In the event of any conflict between codes, or Technical Specifications and codes, the more stringent regulation shall apply.

1.3 SUBMITTALS

Submittals shall be as required in Table 02621-1.

1.4 PACKAGING AND DELIVERY

All geocomposites shall be covered during shipment. The geocomposite shall be supplied in rolls, labeled with at least the following information:

Manufacturer's Name

Product Identification

Roll Number

Roll Weight

Roll Dimensions

Date of Manufacture

Geotextile Types

Geotextile Bonding

1.5 HANDLING, STORAGE, AND PROTECTION

A. The geocomposite rolls shall be stored on pallets in a secured area, away from dirt, dust, water, and extreme heat. The storage space shall be protected from theft, vandalism, animals, passage of vehicles, and be adjacent to the area to be lined. Stack geocomposite drainage layer material to a height not exceeding four (4) rolls high. The Contractor shall be responsible for unloading and storing the geocomposite in accordance with the manufacturer's recommendations.

B. Upon arrival at the jobsite, the installer shall conduct a surface inspection of all rolls for defects and damage. This inspection shall be conducted without unrolling or unpacking unless defects or damages are found or suspected. The Contractor shall notify the Owner of any defects or damages.

PART 2 – PRODUCTS

2.1 MATERIALS

A. Manufacturer Requirements

1. The manufacturer of the geocomposite materials shall have had at least 10,000,000 square feet of its material installed for drainage and shall be approved by the Owner.

2. The geocomposite installation shall be performed under the supervision of the manufacturer's field representative or an installer approved by the manufacturer. The method of installation shall be approved by the manufacturer and authorized in writing, and submitted for approval before work begins to ensure that all warranties remain valid.

B. General Requirements

1. Geonet shall be manufactured by extruding two sets of polyethylene strands to form a three dimensional structure to provide planer water flow.

2. The geonet shall contain stabilizers to prevent ultraviolet light degradation.

3. The drainage layer shall be provided as a geocomposite manufactured by heat bonding 6 oz/yd^2 nonwoven geotextiles (both top and bottom) to the geonet. The bond shall be continuous with no unbonded areas. No burn through the geotextiles will be permitted. Glue and adhesives shall not be used.Geocomposite shall be FabriNet as manufactured by GSE Lining Technology, Inc. or approved equivalent. The geocomposite shall meet the following properties:

Characteristics	Test Method	Units	Criteria (MARV)
Resin			
Polymer Density	ASTM D 1505	g/cm^3	0.94
Melt Flow Index	ASTM D 1238	g/10 min	≤1.0
Geonet Test			
Carbon Black	ASTM D 1603	%	2.0
Tensile Strength, MD	ASTM D 5035	lbs/ ft	45
Density	ASTM D 1505	g/cm^3	0.94
Thickness	ASTM D 5199	mil	200
Geotextile Tests			
Mass per Unit Area	ASTM D 5261	oz/yd^2	6.0
Grab Tensile	ASTM D 4632	lbs.	170
Puncture	ASTM D 4833	lbs.	90
AOS, US Sieve	ASTM D 4751	mm	70
Water Flow Rate	ASTM D 4491	gpm/ft^2	110
UV Resistance	ASTM D 4355 (after 500 hours)	% retained	70
Geocomposite Tests			
Ply Adhesion	GRI GC-7	lbs/ in.	1.0
Transmissivity*	ASTM D 4716-00	m^2/sec	1×10^{-4}
Interface-Friction Tests			
Geocomposite/ Cover Soil	ASTM D 5321	degrees	22 (Residual)
Geocomposite/Geomemeb.	ASTM D 5321	degrees	24 (Residual)

*Water at 20° C with a gradient of 0.1 and a load of 10,000 psf between two steel plates for 15 min.

4. Where required on the drawings, geocomposite manufactured with the bottom (ash side) having a woven calendered geotextile heat bonded to the geonet. The upper geotextile shall be a nonwoven geotextile per No. 3 above.

C. Manufacturing Quality Control

1. The geocomposite shall be manufactured in accordance with the Manufacturer's Quality Control Plan submitted to and approved by the Owner.

2. The geocomposite shall be tested according to the test methods and frequencies listed below:

Manufacturing Quality Control Test Frequencies			
Characteristics	**Test Method**		**FREQUENCY**
Resin			
Polymer Density	ASTM D 1505		Once Per Lot
Melt Flow Index	ASTM D 1238		Once Per Lot
Geonet Test			
Carbon Black	ASTM D 1603		1/50,000 ft^2
Tensile Strength, MD	ASTM D 5035		1/50,000 ft^2
Density	ASTM D 1505		1/50,000 ft^2
Thickness	ASTM D 5199		1/50,000 ft^2
Geotextile Tests			
Mass per Unit Area	ASTM D 5261		1/90,000 ft^2
Grab Tensile	ASTM D 4632		1/90,000 ft^2
Puncture	ASTM D 4833		1/90,000 ft^2
AOS, US Sieve	ASTM D 4751		1/540,000 ft^2
Water Flow Rate	ASTM D 4491		1/540,000 ft^2
UV Resistance	ASTM D 4355 (after 500 hours)		Once per resin formulation
Geocomposite Tests			
Ply Adhesion	GRI GC-7		1/50,000 ft^2
Transmissivity	ASTM D 4716-00		1/540,000 ft^2
Interface-Friction Tests*			
Geocomposite/ Cover Soil	ASTM D 5321		two tests
Geocomposite/Geomemb.	ASTM D 5321		two tests

* See NOTE under Table 02621-1 herein.

PART 3 – EXECUTION

3.1 INSTALLER REQUIREMENTS

A. An installer that has previously installed a minimum of 2,000,000 square feet of geocomposite shall perform the installation.

B. The installer's or manufacturer's field representative shall be in attendance full time during the GCL installation.

C. The GCL installer's or manufacturer's field representative shall certify in writing that all materials and shop drawings regarding panel placement, and construction techniques are in compliance with the manufacturer's recommendations and other accepted QA/QC procedures.

3.2 GEOCOMPOSITE DRAINAGE LAYER INSTALLATION

A. General Requirements:

1. The Contractor shall be responsible for the design of the geocomposite panel layout. Panels shall be placed with seams running up and down slopes, not horizontally.

2. The fabricator of the geocomposite panels used in the work shall prepare shop drawings with a proposed panel layout to cover the area shown on the Drawings. These drawings shall be submitted for approval prior to fabrication of the geocomposite. The drawings shall be provided in a reproducible hard copy or electronic format.

3. Written specifications for the manufacture, fabrication, installation, and quality assurance/quality control for the geocomposite shall be approved by the Owner prior to start of liner fabrication.

B. Installation Requirements:

1. The geocomposite shall be placed with the long dimension parallel with the slope direction (up and down the slope, not sideways).

2. For long, steep slopes, special care shall be taken so that only full-length rolls are used at the top of the slope.

3. Adjacent roll edges of geocomposite shall be overlapped a minimum of 3-inches. The roll ends of geonets shall be overlapped a minimum of 6-inches.

4. All overlaps shall be joined by tying with plastic fasteners or polymeric braid. Metallic ties or fasteners are not allowed.

5. Tying devices shall be white or yellow, as contrasted to the black geonet, for ease of visual inspection.

6. Tie intervals along the roll edges shall be every 5-feet. Tie intervals along the roll ends shall be every 6-inches.

7. The geocomposite edges shall be seamed in accordance with the above requirements and sewn together. Roll ends shall be seamed in accordance with the above requirements and a geotextile cap shall be heat-bonded over the completed seam. The geotextile cap shall cover the open end of the geonet, the ties, and at least 6 inches of geotextile beyond the ties or geonet end. Heat bonding shall be performed with the utmost of care to prevent damage to any portion of the liner system. No burn through the geotextiles will be permitted.

8. The geocomposite shall be protected at all times during construction from contamination resulting from surface runoff. Any geocomposite so contaminated or otherwise damaged shall be removed and replaced.

9. In the presence of wind, all geocomposites shall be weighted down with sandbags or the equivalent. Such sandbags shall be used during placement and remain until replaced with cover material.

10. The geocomposite shall be properly anchored in the anchor trench to resist sliding. Anchor trench compaction equipment shall not come into contact with the geocomposite.

11. Install anchor trench in accordance with Specification 02778, LLDPE Geomembrane Construction Quality Assurance (Attachment 2 to QA/QC Plan).

3.3 COVER PLACEMENT

A. Cover soils shall be free of angular stones or other foreign matter, which could damage the geocomposite. Cover soils shall be approved by the Owner with respect to particle size, uniformity and chemical compatibility.

B. Soil cover shall be placed over the geocomposite using construction equipment that minimizes stresses on the geocomposite. A minimum of 1 foot of cover shall be maintained between the equipment tires/tracks and the geocomposite at all times during the covering process. This thickness recommendation does not apply to frequently trafficked areas or roadways, for which a minimum thickness of 2 feet shall be required.

C. Soil cover shall be placed in a manner that prevents the soil from entering the geocomposite overlap zones. Cover soil shall be pushed up slopes, not down slopes, to minimize tensile forces on the geocomposite.

D. Although direct vehicular contact with the geocomposite is to be avoided, lightweight, low ground pressure vehicles (such as 4-wheel, all-terrain vehicles) may be used to facilitate the initial placement of cover soil. The geocomposite supplier shall be contacted with specific recommendations on the appropriate procedures in this situation.

3.4 REPAIR

A. Prior to covering the deployed geocomposite, each roll shall be inspected for damage resulting from construction.

B. Any rips, tears or damaged areas on the deployed geocomposite shall be removed and patched. The patch shall be secured to the original geonet by tying every 6 inches with the approved tying devices. If the area to be repaired is more than 50 percent of the width of the panel, the damaged area shall be cut out and the two portions of the geocomposite shall be cut out and the two portions of the geocomposite shall be joined together in accordance with Section 3.3.

3.5 INTERFACE-FRICTION TESTING

A. Laboratory interface friction testing on the geocomposite/cover-soil and geocomposite/geomembrane interfaces shall be performed in accordance with ASTM D5321. Testing shall be performed with representative samples of geocomposite, geomembrane and Random Fill soil that will be compacted to 90% standard Proctor maximum dry density and used for construction of the final cover. For the geocomposite/cover-soil test, the substratum shall be the top surface of the geocomposite and the superstratum shall be the cover soil. For the geocomposite/geomembrane test, the superstratum shall be the geocomposite bottom surface and the substratum shall be the geomembrane top surface. A normal-stress range 0.1 tsf to 1.0 tsf shall be used. The compacted soil sample shall be saturated with water and both the geocomposite and geomembrane surfaces shall be wetted prior to shearing during the test. Both peak and residual shear stresses under each normal stress shall be recorded and friction angle interpreted separately for both peak and residual shear strength.

B The report for the testing shall consist, at a minimum, of sample size, sample origin, sample lot number, illustration of equipment used, summary of test methods employed, strain rate used during shear, shear stress-versus-displacement, normal stress-versus-peak stress and residual stress, peak and residual strength envelope plots. All stress versus displacement tests and all calculations performed to determine the angles of friction shall be corrected for machine resistance.

TABLE 02621-1 - DATA REQUIREMENTS AND SUBMITTAL SCHEDULE

Paragraph - Submittal Requirements		With Proposal	For Approval		For Record	
			Date	Copies	Date	Copies
All	Alternative Materials or Procedures	Yes	-	-	-	-
2.1 A	Manufacturer & Specification Sheet	Yes	-	-	-	-
2.1 B	Material Certification	No	2 Weeks prior to delivery	3	-	-
2.1 C	Manufacturing QC Testing	No	-	-	With delivery of rolls	3
3.1 A	Geocomposite Manufacturer's Experience	Yes	-	-	-	-
3.2 A	Manufacturer's Representative and Installation Requirements	No	2 Weeks prior to delivery	3	-	-
3.2 A	Shop Drawings for Geocomposite Installation	No	2 Weeks prior to Work	3 Prints	-	-
3.1 C	Final Documentation	No	-	-	Within 2 weeks after Work	3 Prints
3.5	Interface Friction Testing	No	*	-	-	-

* NOTE: Interface-friction testing shall be performed by CQA Consultant and the results will be used for approval prior to procurement. Geocomposite and geomemebrane samples shall be provided by the manufacturer(s) and loose soil sample will be provided by TVA.

END

SPECIFICATION KIF-0-TS-02777

REVISION 0

FOR

LLDPE GEOMEMBRANE LINER

KIF-0-TS-02777-R0

LLDPE GEOMEMBRANE LINER

TABLE OF CONTENTS

LIST OF TABLES

1.0 PART 1 – GENERAL

1.1 SECTION INCLUDES

This section includes technical requirements for furnishing and installing the geomembrane liner. The geomembrane liner shall be textured Linear Low Density Polyethylene (LLDPE). This section includes the following:

A. Submittals.

B. Geomembrane liner panel layout.

C. Material conformance testing.

D. Furnishing, installing, sampling, testing, and repairing geomembrane liner and seams, and other incidental items required for installation.

1.2 REFERENCES

A. The latest edition and published addenda of the following publications in effect on the date of the Contract Award are a part of this Section and, where referred to by title or by basic designation only, are applicable to the extent indicated by the specific reference:

1. American Society for Testing and Materials (ASTM):

a. D 1004, "Standard Test Method for Initial Tear Resistance of Plastic Film and Sheeting."

b. D 1204, "Standard Test Method for Linear Dimensional Changes of Nonrigid Thermoplastic Sheeting or Film at Elevated Temperature."

c. D 1238, "Standard Test Method for Flow Rates of Thermoplastics by Extrusion Plastometer."

d. D 1505, "Standard Test Method for Density of Plastics by the Density-Gradient Technique."

e. D 3895, "Standard Test Method for Oxidative-Induction Time of Polyolefin by Differential Scanning Calorimetry."

f. D 4218, "Standard Test Method for Determination of Carbon Black Content in Polyethylene Compounds by the Muffle-Furnace Technique."

g. D 4833, "Standard Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products."

h. D 5199, "Standard Test Method for Measuring Nominal Thickness of Geotextiles and Geomembranes."

i. D 5321, "Test Method for Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by the Direct Shear

Method."

j. D 5397, "Standard Test Method for Evaluation of Stress Crack Resistance of Polyolefin Geomembranes Using Notched Constant Tensile Load Tests."

k. D 5596, "Standard Test Method for Microscopic Evaluation of the Dispersion of Carbon Black Polyolefin Geosynthetics."

l. D 5641, "Standard Practice for Geomembrane Seam Evaluation by Vacuum Chamber."

m. D 5820, "Standard Practice for Pressurized Air Channel Evaluation of Dual Seamed Geomembranes."

n. D 5994, "Standard Test Method for Measuring Core Thickness of Textured Geomembranes."

m. D 6365, "Standard Practice for the Nondestructive Testing of Geomembrane Seams using the Spark Test."

o. D 6392, "Standard Test Method for Determining the Integrity of Non-Reinforced Geomembrane Seams Using Thermo-Fusion Methods."

p. D 6693, "Standard Test Method for Determining Tensile Properties of Non-Reinforced Polyethylene and Non-Reinforced Flexible Polypropylene Geomembranes."

2. Geosynthetic Research Institute (GRI), GM12, "Asperity Measurement of Textured Geomembranes Using a Depth Gauge."

3. United States Environmental Protection Agency (EPA) Method 9090 "Compatibility Test for Wastes and Membrane Liners."

B. Where the above referenced codes and standards contain recommendations in addition to requirements, the recommendations shall be considered requirements and shall be followed unless stated otherwise by this technical specification Section.

C. In the event of any conflict between codes, manufacturer's recommendations, or Technical Specifications and codes, the more stringent regulation shall apply.

1.3 SUBMITTALS

A. Data requirements and submittal schedule are as shown in Table 1.

B. Within two (2) weeks of project completion, the Contractor shall submit a report to the Project Manager. The report shall include at least the following items:

1. ALL manufacturer certifications and testing

2. ALL conformance, installation, sampling, laboratory and field testing records for the entire project as described herein.

3. ALL information addressed in Table 1.

4. The signed warranty

5. Written certification that the liner has been installed in accordance with the Specifications and Drawings.

1.4 DESIGN REQUIREMENTS

A. The Contractor shall prepare shop drawings with the proposed panel and seam layout and shop details of the pipe connections. These drawings shall be submitted for approval prior to fabrication of the liner. The drawings shall be provided in both hardcopy and .pdf format at a minimum scale of 1"= 20'.

B. Written specifications for the manufacture, fabrication, installation, and QA/QC for the geomembrane liner shall be submitted to the Project Manager and approved by the Engineer prior to installation of the liner.

1.5 MARKING AND IDENTIFICATION

Each shipping roll or pallet shall be identified properly with the name of manufacturer, product type and thickness, manufacturer batch code, date of manufacture, physical dimensions, panel number, and directions for unfolding.

1.6 PACKAGING AND DELIVERY

All geomembrane liners shall be covered during shipment.

1.7 HANDLING, STORING, AND PROTECTION

The geomembrane liner panels shall be stored on pallets in a secured area, away from dirt, dust, water, and extreme heat. Rolls of panels shall not be stacked more than four (4) high. The storage space shall be protected from theft, vandalism, animals, passage of vehicles, and be adjacent to the area to be lined. The Contractor shall be responsible for unloading and storing the geomembrane liner.

2.0 PART 2 – PRODUCTS

2.1 MATERIAL REQUIREMENTS

A. GENERAL REQUIREMENTS

1. Liner compound shall be specifically designed for buried and for hydraulic liner installations and be chemically compatible with the anticipated water. The liner shall have been demonstrated by prior use to be suitable and durable for such purposes.

2. The liner shall be produced so as to be free of holes, undispersed raw materials, blisters, or any sign of delamination. Any such defect shall be repaired in accordance with the manufacturer's recommendations and/or Article 3.2.G.

3. The lining material shall be uniform in color, thickness, and size. The liner shall be white to minimize elongation during sunny weather.

4. The liner accessories shall be obtained from manufacturers who have shown their materials to be compatible with the intended use and durability criteria, as well as chemically compatible with the anticipated water.

5. The Contractor shall submit with the proposal the name of the LLDPE liner manufacturer and indicate that the material meets the physical properties as specified herein.

6. Prior to geomembrane liner fabrication, the Contractor shall provide material certification from the liner manufacturer that its liner meets the physical and chemical requirements specified herein. Liner chemical compatibility with the water shall be based on EPA Method 9090 or other documented data.

B. LINEAR LOW DENSITY POLYETHYLENE (LLDPE) GEOMEMBRANE LINER

1. The raw materials for Linear Low Density Polyethylene (LLDPE) Liner manufacture shall be first quality resins containing no more than 2% clean recycled polymer by weight and a maximum of 1% by weight of additives, extenders, and fillers (not including carbon black).

2. The liner shall consist of 40 mil-thick LLDPE, textured similarly on both top and bottom surfaces..

3. The LLDPE lining material shall be manufactured with a minimum 15-ft seamless width. There shall be no factory seams.

4. The LLDPE liner material shall meet the physical property characteristics listed in Table 2. All values are minimum average roll values, unless noted otherwise.

C. CAULK:

Caulk shall be Sika Flex 1A, as manufactured by Sika Corporation or approved equal.

D. MANUFACTURER REQUIRMENTS:

1. The manufacturer of the lining material shall have had at least 10,000,000 square feet of its material installed for linings and shall be approved by the Engineer.

2. The manufacturer shall guarantee in writing that the liner materials and field seam materials will be free of defects for 20 years after delivery to the liner installation location. The workmanship shall be guaranteed for one (1) year.

3.0 PART 3 – EXECUTION

3.1 INSPECTION AND PREPARATION

A. VISUAL INSPECTION

Upon arrival at the jobsite, the Contractor shall conduct a surface inspection of all rolls or pallets for defects and damage. This inspection shall be conducted without unrolling or unpacking unless defects or damages are found or suspected.

B. CONFORMANCE TESTING

Conformance testing will be performed in accordance with the "Geomembrane Construction Quality Assurance" specification.

3.2 INSTALLATION REQUIREMENTS

A. Contractor REQUIREMENTS

1. The full-time supervisor overseeing the LLDPE liner installation shall have 2,000,000 square feet of supervisory liner experience. All field technicians shall have over 1,000,000 square feet of seaming experience.

2. The full-time supervisor shall be certified by the manufacturer. Alternatively, a manufacturer's representative shall be in attendance full-time during the geomembrane liner installation.

3. The supervisor or manufacturer's field representative shall certify in writing that all materials and shop drawings regarding panel placement, seaming locations, and construction techniques are in compliance with the manufacturer's recommendations and other accepted QA/QC procedures and that all field seams are free of defects.

B. GENERAL REQUIREMENTS

1. The Contractor shall inspect the complete subgrade prior to installation of the liner assembly and submit to the Project Manager in writing, prior to commencement of the liner installation, acceptance of the subbase preparation.

2. The Contractor shall be responsible for the field layout of the geomembrane liner panels. Panels shall be placed with seams running up and down slopes, not horizontally.

3. The Contractor shall label each field panel with an "identification code" (number or letter-number) consistent with the layout plan. Each panel shall be marked with the original roll number, and a table or chart showing correspondence between roll numbers and field panel identification codes shall be established by the Contractor. The field panel identification code shall be used for all QA/QC records.

C. LINER INSTALLATION REQUIREMENTS

1. The geomembrane liner shall be placed over the prepared surface to be lined in such a manner as to insure minimum handling and shall be installed in accordance with the manufacturer's recommendations. The prepared subgrade shall be maintained in a smooth, uniform, and compacted condition during installation.

2. The liner shall be installed in a relaxed condition and shall be free of tension and stress upon completion of the installation. The liner shall not be stretched to fit. The liner shall be spread out so there are no folds or bends in the liner.

3. Adequate temporary loading and/or anchoring (e.g., sand bags, tires), that will not damage the geomembrane shall be placed to prevent wind uplift (in case of high winds, continuous loading is recommended along the panel edges to minimize the risk of wind flow under the panels).

4. Materials, equipment, or other items shall not be dragged across the surface of the liner or be allowed to slide down slopes on the lining. Personnel walking upon the lining material shall wear soft-sole shoes. Any portion of the liner damaged during installation by any cause shall be removed or repaired by using an additional piece of liner.

5. The amount of liner placed shall be limited to that which can be seamed on the same day.

6. Repair of damaged liner panels and test strip removal areas shall conform to the manufacturer's recommendations. Any tear, puncture, obvious stress point, seam failure, or hole created by sampling or testing procedures shall be overlaid with liner material of the same type used for liner panel fabrication and seamed as specified herein. No loose panel edges, bubbles, or wrinkles will be permitted in the patches. Each patch seam shall be tested as specified herein.

7. Install anchor trench in accordance with Specification 02778, LLDPE Geomembrane Construction Quality Assurance (Attachment 2 to QA/QC Plan).

D. FIELD SEAMING REQUIREMENTS

1. General Requirements:

   a. The seam area shall be clean and free of moisture, dust, dirt, oils, greases, foreign material, and debris of any kind.

   b. No "fish mouths" shall be allowed within the seam area. Where "fish mouths" do occur, the material shall be cut, lapped, seamed together in the lapped area, and patched in accordance with the manufacturer's requirements.

   c. Seam areas of panels shall be wiped clean to remove all dirt, moisture, or other foreign material in accordance with the material manufacturer's requirements.

d. Individual panels of liner material shall be laid out and overlapped by a minimum of four inches for both double fusion welding (hot wedge weld) and extrusion welding. Typically, all sheeting shall be welded together using the hot wedge welding assembly, except for the areas where this method is not practical. For extrusion welding all sheeting shall be welded together by means of integration of the extrudate bead with the lining material. The composition of the extrudate shall be identical to the lining material.

2. Equipment Requirements:

The welding equipment used shall be capable of continuously monitoring and controlling the temperatures in the zone of contact where the machine is actually fusing the lining material so as to ensure that changes in the environmental conditions will not affect the integrity of the weld.

3. Weather Conditions for Seaming:

a. No seaming shall be attempted at an ambient temperature below 50°F or above 104°F. Below 50°F, panels shall be warmed artificially with hot air guns, radiant heaters, heat lamps, space heaters, etc.

b. The geomembrane shall be dry and protected from wind, rain, snow, heavy mist or fog, hail, high or low temperatures, dust, or other adverse environmental conditions.

c. If the Contractor wishes to use methods which may allow seaming at ambient temperatures below 50°F or above 104°F, the Contractor shall demonstrate and certify that such methods produce seams which are entirely equivalent to seams produced at ambient temperatures above 50°F and below 104°F, and that the overall quality of the geomembrane is not adversely affected.

d. The ambient temperatures shall be measured above the geomembrane surface. The Contractor shall demonstrate that these weather conditions are fulfilled.

e. Weather conditions at the time of all installation, seaming, sampling, and testing shall be recorded on the respective QA/QC documents.

E. INSPECTION AND TEST REQUIREMENTS

1. Trial Seams

a. Trial seams shall be made on fragment pieces of geomembrane liner to verify that seaming conditions are adequate. Such trial seams shall be made at the beginning of each seaming period, and at least once every five hours, for each seaming apparatus used in the seaming period. A trial seam also shall be made in the event that the ambient temperature varies more than 18°F since the last passing trial seam. Also, each seamer or seamer crew shall make at least one trial seam each seaming period, or each 1,000 feet of seam. If any seaming apparatus is turned off for any reason, a new passing trial seam shall be completed for that specific seaming apparatus.

b. Trial seams shall be made under the same conditions as actual seams. The trial seam sample shall be at least 3 ft. long by 1 ft. (after seaming) with the seam centered lengthwise.

c. The Contractor shall provide the tensiometer required for shear and peel testing in the field. The tensiometer shall be automatic and shall have a direct digital readout.

d. The tensile strength of the seams shall be greater than the panel tensile strength. The seam failure shall be by Film Tear Bond (FTB) type.

e. Four specimens of field seams shall be taken initially by the Contractor and tested. Two specimens shall be tested in shear and two in peel using a field tensiometer, and they should not fail in the seam. Minimum strength requirements for field seams are provided on Table 2. In each type of test, a maximum of one non-FTB failure out of five tests is acceptable provided that the strength requirement is met on that sample. If a specimen fails, the entire operation shall be repeated. If the additional specimen fails, the seaming apparatus will not be accepted and shall not be used for seaming until the deficiencies are corrected and two consecutive successful full trial seams are achieved.

f. All trial seams shall be in accordance with Table 4.

2. Non-destructive Seam Continuity Testing:

a. Non-destructive testing shall be performed on ALL field seams over their full length. Fillet-extrusion welds shall be tested with a vacuum chamber in accordance with ASTM D 5641. Double fusion (hot wedge) welds shall be pressure tested, pressurizing the gap created by the split face design of the hot wedge in accordance with ASTM D 5820. A spark test shall be used for all boots (in accordance with ASTM D 6365). Probe test methods shall not be used. The purpose of non-destructive tests is to check the continuity of seams. It does not provide any information on seam strength. Continuity testing shall be carried out as the seaming work progresses, not at the completion of all field seaming. Non-destructive testing shall not be permitted before sunrise or after sunset.

b. The Contractor shall complete any required repairs in accordance with Article 3.2.G.

c. All non-destructive test results for each seam shall be documented.

3. Destructive Testing

   a. The purpose of destructive testing is to evaluate seam strength. Seam strength testing shall be conducted as the seaming work progresses, not at the completion of all field seaming. Care shall be taken to properly cure all seams and samples according to test procedure requirements.

   b. Destructive testing shall be in accordance with ASTM D 6392 at a minimum frequency of one test per 2,000 feet of seam length. All field seams shall satisfy the requirements of Table 4.

   c. The welding technician shall not be informed in advance of the locations where the seam samples will be taken.

   d. The installer shall cut samples as the seaming progresses in order to have laboratory test results before the geomembrane is covered by another material. Sampling shall be in accordance with Article 3.2.F.

   e. The destructive testing for conformance will be the responsibility of the CQA Consultant.

F. SAMPLING PROCEDURE

1. An identification number shall be assigned to each sample. Samples shall be marked accordingly (with the locations recorded on the layout drawing), and the date, ambient temperature, and welding machine number recorded.

2. The reason for the chosen sample location shall be stated (e.g., statistical routine, suspicious feature of the geomembrane).

3. Two types of samples shall be taken at each sample location.

4. The first type of sample shall be 1 in. wide by 12 in. long, with the seam centered parallel to the width. Two of these samples shall be taken at a distance of 42 in. apart. Each sample shall be tested using field tensiometer equipment for peel and shear failure, and shall not fail in the seam.

5. If any field test fails, the procedure outlined in Article 3.2.F.8 shall be followed. If the each test passes, the seam location qualifies for lab testing.

6. The second type of sample (for laboratory testing) shall be located between the two specimens for field testing, provided that the two surrounding field tests pass. The lab sample shall be 12 in wide by 42 in. long with the seam centered lengthwise. The sample shall be cut into three parts. One part (12 in x 12 in) shall be retained by the Contractor for laboratory testing, another part (12 in x 12 in) shall be retained for the Owner for archive storage, and a third part (12 in. x 18 in.) shall be retained for independent laboratory testing by the CQA Consultant.

7. Lab test samples shall meet the requirements set forth in Table 4. The testing lab shall provide test results no more than 24 hours after they receive the

samples to allow liner installation to be adjusted as required.

8. In the event of any failing test; the Contractor shall do either of the following:

   a. Reconstruct the seam between any two passed destructive seam test locations.

   b. Trace the seam path to an intermediate location (10 ft. minimum each direction) and take small sample for an additional field test. If this test and the subsequent lab tests pass, the seam shall be reconstructed between these locations by capping. If either fails, the process shall be repeated to establish the zone over which the seam shall be reconstructed.

9. All holes in the geomembrane resulting from destructive seam sampling shall be immediately repaired. The continuity of the new seams in the repaired area shall be tested.

G. DEFECTS AND REPAIRS

1. All seam and non-seam areas of the geomembrane shall be examined for defects, holes, blisters, undispersed raw materials, and any sign of contamination by foreign matter. Because light reflected by the geomembrane helps to detect defects, the surface of the geomembrane shall be clean at the time of examination. The geomembrane surface shall be broomed or washed if the amount of dust or mud inhibits examination. Water used for washing shall be directed to a sedimentation control structure prior to discharge.

2. Each suspect location both in seam and non-seam areas shall be non-destructively tested using the methods described in Article 3.2.E.2 as appropriate. Each location that fails the non-destructive testing shall be marked and repaired.

3. Any portion of the geomembrane exhibiting a flaw, or failing a destructive or non-destructive test shall be repaired. Several procedures exist for the repair of these areas. The available procedures include:

   a. Patching, used to repair large holes, tears, undispersed raw materials, and contamination by foreign matter.

   b. Grinding and reseaming, used to repair small sections of extruded seams.

   c. Spot seaming, used to repair small tears, pinholes or other minor localized flaws.

   d. Capping, used to repair large lengths of failed seams.

   e. Topping, used to repair areas of inadequate seams, which have an exposed edge.

4. In addition, the following provisions shall be satisfied:

   a. Surfaces of the geomembrane that are to be repaired shall be abraded no more than one hour prior to the repair, if applicable.

   b. All surfaces shall be clean and dry at the time of the repair.

   c. All seaming material and equipment used in repairing procedures shall be approved.

   d. The repair procedures, materials, and techniques shall be approved in advance of the specific repair.

   e. Patches or caps shall extend at least 6 in. beyond the edge of the defect, and all corners of patches shall be rounded with a radius of at least 3 in.

   f. The geomembrane below large caps shall be appropriately cut to avoid water or gas collection between the two sheets.

5. Each repair shall be non-destructively tested using the methods described in Article 3.2.E.2 as appropriate. Repairs that pass the non-destructive test will be taken as an indication of an adequate repair. Large caps (over 150 feet) shall require additional destructive testing. Work shall not proceed with any materials that will cover a repaired location until laboratory test results with passing values are available. Failed tests shall require the repair to be redone and retested until a passing test result is obtained.

H. LINER COVERING REQUIREMENTS

No field seam shall be covered or buried until tested and accepted by the CQA Consultant. Liner penetration attachments shall not be covered until inspected and accepted by the CQA Consultant.

3.3 INTERFACE-FRICTION TESTING

A. Refer to the requirements stated in TS-02621 with respect to geocomposite/geomembrane interface-friction testing.

TABLE 1 – DATA REQUIREMENTS AND SUBMITTAL SCHEDULE

Paragraph - Submittal Requirements		With Proposal	For Approval		For Record	
			Date	Copies	Date	Copies
All	Alternative Materials or Procedures	Yes	-	-	-	-
1.4.B	QA/QC Specifications for Liner	No	2 Weeks prior to liner fab.	3	-	-
2.1.A	Material Certification & Chemical Compatibility Tests	No	2 Weeks prior to liner fab.	3	-	-
2.1.B	LLDPE Liner Manufacturer	Yes`	-	-	-	-
2.1.B	LLDPE Liner Physical Property Characteristics	Yes	-	-	2 Weeks prior to Work	3
2.1.C	Caulk – Manufacturer and Type	No	-	-	2 Weeks prior to Work	3
2.1.E	Liner Manufacturer's Experience	Yes	-	-	-	-
2.1.F	Liner Warranty	No	2 Weeks prior to fab.	3	-	-
3.1.A	Report on Inspection of Liner Goods	No	-	-	Within 1 day	3
3.2.A	Installer's Experience or Fabricator's Field Representative (Resumes)	Yes	-	-	-	-

TABLE 1 – DATA REQUIREMENTS AND SUBMITTAL SCHEDULE (CONT.)

Paragraph - Submittal Requirements		With Proposal	For Approval		For Record	
			Date	Copies	Date	Copies
3.2.A	Installer's or Manufacturer's Field Representative Certification of Shop drawings/panel placement	No	2 Weeks prior to Work	3	-	-
3.2.B	Written Acceptance of Subgrade	No	-	-	Within 1 day	3
3.2.A	Field Technical Experience (LLDPE)	No	-	-	2 Weeks prior to Work	3
3.2.E	LLDPE Testing Equipment - Manufacturer & Type	No	-	-	2 Weeks prior to Work	3
3.3	Geocomposite/Geomembrane Interface-Friction Testing	No	Prior to procurement	-	-	-
Attached	Sample QA/QC forms	No	-	-	2 Weeks prior to Work	3

TABLE 2 – LLDPE MINIMUM MATERIAL REQUIREMENTS

PROPERTY	TEST METHOD	UNITS	TEXTURED
Gage (nominal)	NA	mils	40
Thickness	ASTM D 5994	mils	40
Asperity Height	GRI GM-12	mils	10
Base Sheet Density	ASTM D 1505	g/cm^3	0.915
Resin – Melt Flow Index	ASTM D 1238	g/10 min.	° 1.0
Carbon Black - Content	ASTM D 4218	percent	2 to 3
Carbon Black - Dispersion	ASTM D 5596	rating	Category 1 or 2
Tensile Properties:			
Stress at Yield	ASTM D 6693	lb/inch	76
Stress at Break	ASTM D 6693	lb/inch	90
Strain at Yield	ASTM D 6693	percent	18
Strain at Break	ASTM D 6693	percent	450
Tear Resistance	ASTM D 1004	lbs.	22
Puncture Resistance	ASTM D 4833	lbs.	48
Oxidative Induction Time	ASTM D 3895	min.	100
Friction Angle between Geomembrane and Geocomposite	ASTM D 5321	degrees	24 (Residual)

TABLE 3 – CONFORMANCE TESTING FREQUENCY (By CQA Consultant)		
PROPERTY	TEST METHOD	TEST FREQUECY
Thickness	ASTM D 5994	1 TEST PER 50,000 SQUARE FT OF MATERIAL
Tensile Properties	ASTM D 6693	
Tear Resistance	ASTM D 1004	
Puncture Resistance	ASTM D 4833	
Asperity Height	GRI GM-12	
Friction Angle between Geomembrane and Geocomposite Net	ASTM D 5321	Two tests

TABLE 4 – LLDPE LINER MINIMUM WELD VALUES			
PROPERTY	TEST METHOD	UNITS	TEXTURED/SMOOTH
Shear Strength – Fusion and Extrusion	ASTM D 6392	lb/inch	56 and Film Tear Bond
Peel Strength – Fusion and Extrusion	ASTM D 6392	lb/inch	48 and Film Tear Bond

END

ATTACHMENT

Sample QA/QC Forms

LINER PROJECT QA/QC LOG

PROJECT NAME: ____________________

PROJECT NUMBER: __________ ______ INSTALLATION DATE: ________

PROJECT LOCATION: ____________________

PROJECT Owner: ____________________

ADDRESS: ____________________

CONTACT: ______________ ________ PHONE: ________

PROJECT Engineer: ____________________

ADDRESS: ____________________

CONTACT: ______________ ________ PHONE: ________

GENERAL Contractor: ____________________

ADDRESS: ____________________

CONTACT: ____________________ PHONE: ________

SPECIFIED LINER MATERIALS: ________ THICKNESS & TYPE: ________

SUPPLIER OF LINER MATERIALS: ____________________

ADDRESS: ____________________

CONTACT: ____________________ PHONE: ________

MATERIAL CERTIFICATION RECEIVED: ____________________

DATE: ______________ ACCEPTED: ______________

FABRICATOR OF MATERIAL: ____________________

INSTALLER OF MATERIAL: ____________________

QA/QC INSPECTION FIRM: ____________________

ADDRESS: ____________________

CONTACT: ____________________ PHONE: ________

LINER TESTING LABORATORY: ____________________

ADDRESS: ____________________

CONTACT: ____________________ PHONE: ________

SUBGRADE SURFACE ACCEPTANCE
(One per area)

PROJECT NAME: ______________________________

DATE: ______________ PROJECT NUMBER: ______________

GENERAL Contractor: ______________________________

ADDRESS: ______________________________

CITY: ______________ STATE: __________ ZIP: __________

SUPERINTENDENT OF PROJECT: ______________ PHONE: __________

GEOMEMBRANE INSTALLER: ______________________________

ADDRESS: ______________________________

CITY: ______________ STATE: __________ ZIP: __________

SUPERINTENDENT OF PROJECT: ______________ PHONE: __________

CERTIFICATE OF ACCEPTANCE OF SUBBASE SOIL BY INSTALLER

I, the Undersigned, duly authorized representative of __________ do hereby accept the soil surface as being acceptable for the placement of a Geomembrane liner.

Name ______________ Signature ______________

Title ______________ Date ______________

Certificate Accepted by Inspector - Company: ______________

Name ______________ Signature ______________

Title ______________ Date ______________

QA/QC INSPECTOR: ______________________________

SITE SUPERVISOR: ______________________________

INSTALLING SUPERVISOR: ______________________________

RECEIVING QA/QC LOG
(One per truck)

PROJECT NAME: ______________________

DATE: __________ TIME: __________ PROJECT NUMBER: __________

TRUCKER'S ID: ______________________

NUMBER OF PIECES ON BOARD: ______________________

AGREE WITH PACKING LIST? ______________________

CONDITION OF PACKAGING: ______________________

VERIFY PROPER MATERIALS: ______________________

VERIFY PROPER THICKNESS: ______________________

IDENTIFY PANEL NUMBERS: ______________________

IDENTIFY ACCESSORIES: (ADHESIVE, BATTENS, BOOTS, ETC.): __________

____

IDENTIFY DAMAGED ITEMS: ______________________

TYPE OF UNLOADING EQUIPMENT USED: ______________________

CONDITION: ______________________

OPERATOR: ______________________

COMMENTS: ______________________

STORAGE AREA

CONDITION (SURFACE): ______________________

LOCATION OF PLACEMENT AREA: ______________________

MATERIAL PROPERLY COVERED: ______________________

WEATHER CONDITIONS: __________ TEMPERATURE: __________

QA/QC INSPECTOR: ______________________

SITE SUPERVISOR: ______________________

PERSONNEL QA/QC LOG
(Installation and Field Seaming Personnel)
(One sheet per mobilization or change of personnel)

PROJECT NAME: ______________________________

DATE: ______________ PROJECT NUMBER: ______________

SAFETY MEETING CONDUCTED ON MATERIALS HANDLING: ______________

GIVEN BY: ______________ DATE: ______________

SUPERINTENDENT OF INSTALLATION: ______________

SEAMING CREW PERSONNEL

#1 Crew Leader: ______________ Helper: ______________

#2 Crew Leader: ______________ Helper: ______________

#3 Crew Leader: ______________ Helper: ______________

#4 Crew Leader: ______________ Helper: ______________

#5 Crew Leader: ______________ Helper: ______________

#6 Crew Leader: ______________ Helper: ______________

#7 Crew Leader: ______________ Helper: ______________

#8 Crew Leader: ______________ Helper: ______________

OTHER CREW MEMBERS

NAME: ______________ NAME: ______________

NAME: ______________ NAME: ______________

NAME: ______________ NAME: ______________

NAME: ______________ NAME: ______________

SIGNED: ______________________
QA/QC INSPECTOR

DAILY PANEL PLACEMENT QA/QC LOG
(Placement of panels for seaming)
(One sheet per day of placement)

PROJECT NAME: ____________________

DATE: ____________ PROJECT NUMBER: ____________

WEATHER: TEMPERATURE - BEGINNING: _____ MID DAY: _____ ENDING: _____

CONDITION: RAIN SNOW CLOUDY SUNNY ____________

ACTUAL HOURS WORKED: ____________________

NUMBER OF CREW: ____________ CREW LEADER: ____________

OTHER ACTIVITIES: (Placement of sand bags, etc.) ____________

TYPE OF PLACEMENT EQUIPMENT: ____________________

OPERATOR: ____________________

CONDITION: ____________________

NUMBER OF PANELS PLACED: ____________ TOTAL S.F. PLACED: ____________

PANEL I.D. NUMBERS: ____________________

____

____

____

COMMENT ON SITE CONDITION: ____________________

____

LINEAL FEET OF ANCHOR TRENCH DUG: ____________________

ACCEPTED: ____________________

SIGNED: ____________________

SEAMING QA/QC LOG
(Field seaming of panels)
(One sheet per seaming crew per day)

PROJECT NAME: ______________________________

DATE: ____________________ PROJECT NUMBER: __________

WEATHER: TEMPERATURE - BEGINNING:____MID DAY:____ENDING:________

CONDITION: RAIN SNOW CLOUDY SUNNY ______________

NUMBER OF CREW __________ CREW LEADER: ______________

TOTAL LINEAL FEET OF FIELD SEAM SEALED: ______________

SEAMS WIDTH MINIMUM: 2" BOND AREA: ________________

HARD WORKING SURFACE: ______________________

TOTAL LINEAL FEET OF FIELD SEAM TESTED: (NONDESTRUCTIVE) - METHOD:

____

NUMBER OF SEAM REPAIRS REQUIRED (LIST LOCATION HERE AND ON AS-BUILT):

____

____

NUMBER OF OTHER REPAIRS REQUIRED (LIST LOCATIONS HERE AND ON AS-BUILT):

____

____

NUMBER OF SEAM SAMPLES MADE OR CUT FOR DESTRUCTIVE TESTING: (LIST LOCATIONS HERE AND ON AS-BUILT):

____

____

DESCRIPTION OF OTHER WORK PERFORMED TODAY: (BOOTS & BATTENS, ETC.):

____

____

SIGNED: ______________________________________
QA/QC INSPECTOR

DAILY QA/QC REPORT - FIELD SEAM SAMPLES
(Field seam test samples)
(One Sheet per sample)

PROJECT NAME: ______________________________

DATE: ______________ TIME: __________ PROJECT NUMBER: ______

TIME SAMPLE MADE AND/OR CUT: ______________________

CREW IDENTIFICATION (CREW LEADER): ______________________

SAMPLE IDENTIFICATION: ______________________

LOCATION OF SEAM: ______________________

WELD TYPE (FUSION/EXTRUSION/CHEMICAL/ADHESIVE): ______________

MACHINE TEMPERATURE: ______________________

WEATHER AT TIME SEAM SAMPLE WAS MADE: TEMPERATURE: ____________

CONDITION: RAIN SNOW CLOUDY SUNNY ____________

HAS A TEST SAMPLE BEEN RETAINED FOR RETESTING? ____________

TEST REQUIRED OF THIS SAMPLE (SHEAR & PEEL):

SHEAR RESULTS:	PEEL RESULTS:
#1 ______________	#1 ______________
#2 ______________	#2 ______________
#3 ______________	#3 ______________
#4 ______________	#4 ______________
#5 ______________	#5 ______________

CONSTRUCTION QA MONITOR ID: ______________________

RETURN RESULTS TO: ______________________

____

SIGNED: ______________________________________
QA/QC INSPECTOR

QA/QC REPORT - PROTECTIVE COVER
(Placement of Cover)
(One sheet per day)

PROJECT NAME: ______________________________

DATE: ______________ PROJECT NUMBER ______________

WEATHER: TEMPERATURE - BEGINNING: ______ MID DAY: ______ ENDING: ____

CONDITION: RAIN SNOW CLOUDY SUNNY ______________

ACTUAL HOURS WORKED: ____________ START: ________ STOP: ________

TYPE OF EQUIPMENT USED FOR HAULING: ______________________

TYPE OF EQUIPMENT USED FOR SPREADING: ______________________

CONDITION OF FILL: ______________________________

COMMENTS: ______________________________

____

DAMAGE TO LINER REPORT

LOCATION: ______________________ SIZE: ____________

CAUSED BY: ______________________________

REPAIRED BY: ______________________________

TESTED BY: ______________________________

LOCATION: ______________________ SIZE: ____________

CAUSED BY: ______________________________

REPAIRED BY: ______________________________

TESTED BY: ______________________________

QA/QC INSPECTOR: ____

APPENDIX K

Seepage Analysis of Existing Dredge Cell Dikes

TABLE OF CONTENTS

DREDGE CELL SEEPAGE ANALYSES

1. INTRODUCTION

The seepage analyses performed in this calculation package deal with the conditions that caused the blow out that around November through December of 2003. It determines the causes of this blow out and graphically shows through diagrams of hydraulic pressures how this failure occurred. The excessive seepage gradient resulted from the raised phreatic surface inside the ash stack as a result of inadequate drainage of both the storm water and water drained from the wet stacking operations. These analyses support the conclusion that the failure was due not to the slope stability but to the piping or the excessive seepage gradient.

Suggestions for corrections are also provided through a series of analyses. In addition, this calculation package reviews what additional seepage pressures would be imposed on the Dredge Cells area following the construction stages shown in Drawing 10W426-1. Drawing 10W426-1 shows the proposed Phase 1, 2 and 3 construction plans for the Dredge Cell Area. The Dredge Cell Area consists of Cells 1, 2 and 3, where ash has been deposited to-date to Elevation (El.) of about **810'**.

This calculation plan is organized as follows:

- SITE HISTORY AND PERTINENT DATA
- SUBSURFACE EXPLORATIONS
- CRITICAL CROSS SECTIONS FOR SEEPAGE EVALUATIONS
- STRATIGRAPY FOR SEEPAGE ANALYSES
- FINITE ELEMENT PROGRAM FOR SEEPAGE ANALYSES
- DESIGN MATERIAL/SOIL PROPERTIES
- SEEPAGE EVALUATION
- RESULTS OF THE SEEPAGE EVALUATION
- CONCLUSION & RECOMMENDATIONS

The sections below describe each of the items above in succeeding order.

2. SITE HISTORY AND PERTINENT DATA

Currently, a new cell area is being created between Dredge Cell Area and Ash Pond Area, located inside Ash Pond Area, where a Stage 1 dike to El. 780' is being constructed. This area is called Phase 1, where ash will be temporarily deposited and later raised to be even with Dredge Cell Area elevation (810').

The original topography of the ash site may be assumed as shown in the Drawing 10N400, Section F (Ref 1.). This drawing shows that the original ground surface (GS) in the eastern half of Cell Area was approximately at El. 730', and dipped gently to El. 724' at its western edge. In Ash Pond Area, the GS dipped gently westward from El. 735' at its east edge to 724' or lower at its western edge. The GS varied from El. 745' to 730' in Stilling Basin Area.

The proposed plan is first to stack ash to Elevation as high as **868 feet** in Dredge Cell Area (i.e., raise the area further by 58 **feet**). Second, stack gypsum and fly ash both to an Elevation of approximately **970 feet** in the Ash Pond Area (i.e., raise the area there further by **210 feet**) as shown on Drawings 10N400 (Section F, Ref 1) and 10W425-34C (Ref. 2). Both ash and gypsum will be placed wet primarily (sluiced in from the plant) until the year 2019 and gypsum will be placed dry thereafter.

3. SUBSURFACE EXPLORATIONS

No deep borings were drilled in the interior cell and ash pond areas during the past investigations. Therefore, an additional subsurface exploration under Parsons direction was undertaken in March 2004 (Mactec, 2004) that consisted of the following:

- Twelve borings (B-1 through B-12),
- Eleven cone-penetrometer (CPT) soundings (CPT-1, 1A, 4, 6, 8, 9, 10, 11, 12A, DN and DS) with pore-water pressure measurement located adjacent to selected boring locations,
- Field permeability testing (at the blowout location), and
- Laboratory testing of disturbed and undisturbed ash and soil samples collected from the borings.

The exploration investigated the subsurface conditions of ash and natural subsoil in the interior areas and attempted to verify those obtained from the past explorations. The data obtained from the 2004 exploration (Mactec, 2004) gives the primary design conditions for the seepage analyses, although the data from the past explorations have been used as appropriate.

4. CRITICAL SECTIONS FOR SEEPAGE EVALUATION

The critical section through existing Dredge Cell Area lies at the "blowout" location as shown in Figure 1. Figure 1 gives a simplified visualization of the stratigraphy based on interpretations of CPT and boring data from the Mactec 2004 report and drawings in Reference 1. These simplifications are needed because of bandwidth difficulties introduced with sharp corners in development of a finite element mesh for the seepage model. The critical section illustrated in Figure 1 will be called the Case 1 analysis.

The critical section for the Stages C, D, and E will be combined into a single Case 2 analysis. Drawing 10W425-6 gives the details of these stages. Figure 2 gives a simplified visualization of the stratigraphy based on similar interpretations of field data and available drawings.

5. STRATIGRAPHY FOR SEEPAGE ANALYSES

We performed an extensive review of data from all past and recent borings and CPT soundings to determine a representative subsurface stratigraphy near the "blowout" for use in a seepage analysis. Generally, data from the past borings matched the subsurface conditions revealed from the investigation performed in 2004. However, unlike the past investigations, the 2004 investigation included CPT soundings. The continuous record of data obtained from these soundings gave a more detailed profile of changes in the stratigraphy. In addition, the CPT probes provided critical data on hydraulic conductivity with depth. Consequently, CPT data were the determining factor in choosing the design profile.

The seepage model for the interior of the existing cells and the stratigraphy at the blowout location uses data from the borings and CPT soundings within Dredge Cell Area; specifically data from B-1 through B-5 and CPT-1, 4 and 6, and Monitoring Wells (MWs) 1, 2, 3, 4B, 6A, 13B, and 16A. The simplified Case 1 blowout seepage model of existing cells for this location is given in Table 1 as follows:

Table 1. Soil Properties for Each Soil Zone.

Soil Zone	Elevation Range	General description
1	810'+ to 771'	Outer Dike - Mixture Rolled & Compacted Fly Ash (FA) and Bottom Ash (BA)
2	810' to 770'	Loose FA
3	770' to 763'	Medium dense to dense FA + BA
4	770' to 763	Outer Dike Dense Compacted FA + BA
5	763' to 725'	Loose FA + BA, Interior
6	763' to 725'	Natural Clay, soft to stiff (CL) at Toe
7	725' to 718'	Natural Clay, soft to stiff (CL)
8	718' to 703'	Clayey Silty Sand, Residuum (SC-SM)
9	Below 703'	Bedrock (Soft Shale)

For the Case 2 analyses where the dredge cells are raised to Elevations 826 and 842 in Stages D and E (See Drawing 10W425-6), the seepage analysis assume that Soil Zones 1 and 2 extend up accordingly.

6. FINITE ELEMENT PROGRAM FOR SEEPAGE ANALYSES

The seepage evaluation uses the TIMES two-dimensional finite element fate and transport model. TIMES is a 32-bit windows program, coded entirely in the object oriented programming language C++. The mesh module is a full feature, interactive, variable density 2D density mesh generator that can generate high quality triangular and quadrilateral elements easily around complex geometry, stress objects such as perimeter wells, funnel and gate systems, blanket drains, etc. TIMES models unsaturated flow, non-aqueous phase liquids (NAPL) flow, vacuum extraction wells, and all boundary conditions can be time dependent. TIMES has four methods for assigning nodal values: uniform, gradient, kriging, and user drawn contours. TIMES's transport module simulates solute transport with absorption and first order decay. •

7. DESIGN MATERIAL/SOIL PROPERTIES

The data for the hydraulic conductivity for the seepage analyses come from CPT hydraulic conductivity measurements with depth at soundings CPT 1, 1A and 4. Freeze and Cherry (Ref. 4) (1979, Pg. 37, Equations 2.31 and 2.32) describe how to calculate equivalent horizontal and vertical hydraulic conductivities for the layers shown in Figure 2. Note that zones of low conductivity will control the vertical conductivity and lead to lower values as in the smallest diameter pipe would control flow through a series of connected pipes. By contrast, the most conductive layers will dominate horizontal flow, as most flow will shift toward these layers as toward the large pipes in a parallel pipe network. Table 2 summarizes the soil properties used in the TIMES model for each of the soil zones. The Ratio K_h / K_v describes how much larger the horizontal hydraulic conductivity is than the vertical hydraulic conductivity. The residual saturation gives the moisture content when unsaturated conditions exist. The final column give the assumed van Genuchten model parameters for the wetting front as water infiltrates in from the pond and by surface infiltration due to rainfall through unsaturated material toward the water table.

Table 2. Design Soil Properties for Use in TIMES Model for Seepage Analyses

Zone	Hydraulic Conductivity		Ratio K_h / K_v	Residual Saturation n	Assumed van Genuchten Model Parameters	
	ft/day	cm/sec			VG alpha 1/ft	VG n
1	16.2	0.0057	35.8	0.15	3.5	1.5
2	20.6	0.0071	222.5	0.15	3.5	1.5
3	7.7	0.0027	700	0.2	3.5	1.5
4	7	0.0025	100	0.2	3.5	1.5
5	31.3	0.0110	439	0.35	3.5	1.5
6	.0028	1.0E-06	10	0.35	3.5	1.5

Note that the seepage model will assume that Soil Zones 7, 8, and 9 combine to represent a vertical no flow boundary because of their low hydraulic conductivities.

8. <u>SEEPAGE EVALUATION</u>

The seepage evaluation examines two main cases:

Case 1. Conditions that exist at the time of the blowout with the stack at Elevation 810 feet (Stage C, that is, Stage 1).

Case 2. Steady state conditions at Stage C to E (Stage 1 to 3) or from Stack Elevation of 810 to 842 feet.

In both of these cases, the model is run in transient mode until a steady state condition is reached. Recommendations are given to reduce the seepage forces within the slope as necessary.

Figure 3 gives the finite element mesh, boundary and initial conditions for Case 1. A pool elevation of four feet has been modeled as a pressure head elevation behind the 810-foot Stage C dike. The hydraulic conductivity of the top layer of soil has been assumed to be equal to 0.028 ft/day (or 1.0E-05 cm/sec). An average daily recharge rate of one sixth of this conductivity has been assumed for the infiltration rate into the surrounding soils and slopes. No flow boundaries have been assumed along the bottom and left sidesl. By contrast, the model assumes no change in heads at the vertical right side of the model from the initial conditions. A similar configuration will be used in Case 2, for the modeling from Stages C to E to a final elevation of 842 feet.

The water table or phreatic surface approximately follows the data given by MWs 1, 2, and 3 as measured in November through December 2003. This seepage model assumes that the initial phreatic surface varies from an Elevation of ~ 783 at MW-3 to over 791' at the left hand side of the grid; i.e., approximately 8 feet above that observed in the monitoring well MW-3 temporarily installed near boring B-3 during the April 2004 investigation. Figure 3 shows the profile and the phreatic surface along the slope based on the data from borings B-1, 2, 3 and monitoring wells MW-1, 2, 3. *(Note that the stack height used for this Case 1 evaluation corresponds to the recent condition under which the blowout occurred and not the future raised-stack condition.)*

9. RESULTS OF THE SEEPAGE EVALUATION

In the Case 1, the seepage analysis looks at taking the existing observed monitoring well conditions back in November and December 2003 to back out an assumed water table and combining that with an assumed pool elevation pressure head of four feet at the top of the dike. As the water seeps through the unsaturated dredged fly and bottom ash materials and moves toward the compacted outer dikes, one sees a rise in the water table pressure contours. Figure 4 shows the Case 1 pressure heads from 0 to 40 feet for the Stage C (Stage 1) Dike that goes up to about 810 feet after flow achieves steady state. By contrast, Figure 4A shows that the total head contours align perpendicularly to the pressure contours and that the flow lines are generally horizontal to the northwest (because on the anisotropic dominance of the horizontal conductivity). While the blow out that occurred in the field probably did not occur under conditions of steady state and we will never know the exact conditions at time of failure, Figures 4 and 4A illustrate conceptually how the failure occurred and why the clay bulge developed above Elevation 771 feet. Once the piping failure had occurred the seepage pressure was temporarily relived.

To reduce these seepage pressures, Figure 5 shows how the installation of slope under drains / bench drains and a composite geonet drainage layer from Elevation 783 to the ditch can solve the problem (See Drawing 10W425-73). The analysis placed the composite geonet drainage layers about 18 inches below the surface and assumed them to be calendered 100-120 AOS with the geotextile side facing down on top of the fly ash/bottom ash. The bench drains were assumed to be about 4 feet below the surface and consist of 6 inch perforated HDPE pipe.

In Case 2, the seepage analysis looks at what will happen when the dredge cells are raised from Stage C to E (from 1 to 3). Drawing 10W425-6 shows the addition of six more perimeter drains in raising the stack from Stage C to Stage E. Figure 6 shows the seepage analysis of Case 2 for the condition similar to the first Case 1 where no slope or bench drains and composite geonet drainage layers exist on the lower slope. Figure 6 illustrates conceptually how a similar piping failure can occur again with construction of Stages D and E should no measures be undertaken to reduce seepage forces below Elevation 794 feet.

Finally, Figure 7 show that with the installation of slope under / bench drains and composite geonet drainage layers below Elevation 794 down to the ditch reduces the pressure heads to zero at the surface and therefore controls the seepage exit gradients to acceptable levels.

10. CONCLUSIONS AND RECOMMENDATIONS

1. The seepage evaluation for the Stage C (Stage 1)/ Case 1 existing conditions case of the Dredge Cell Area finds that high water table conditions and related seepage forces likely caused the blow up on the northwest side of the dredge cell. Additional analyses suggest that to reduce these seepage forces that slope under drains / bench drains and composite geonets be placed along the slope to prevent the buildup of seepage forces.

2. Specifically, the slopes at and below Elevation 794 feet that have no perimeter drains should be retrofitted with under drains at the base of each slope no longer than 100 feet in length.

3. In addition, from Elevation 783 feet to 760 feet or the ditch, whichever is lower, the slope should be retrofitted with a composite geonet drainage layer to reduce seepage forces. The bottom of the composite geonet must be in contact with the fly ash and bottom ash and be covered with a minimum of soil with a plasticity index (PI) greater than 10, preferably in the range of 20 to 30. The geotextile of the composite geonet drainage layer to be placed against the fly ash and bottom ash must have an AOS greater than 100 and preferably greater than 120 and this geotextile must be calendered.

4. If the remedies are constructed as assumed in the model, the seepage analyses of Case 1 show that these remedies reduce the hydraulic pressures to an acceptable level.

5. Similarly, the seepage evaluation for the Stage E (Stage 3)/ Case 2 existing conditions case of the Dredge Cell Area finds that high water table conditions and related seepage forces would likely cause another blow out on the northwest side of the dredge cell. **Therefore, the succeeding stages must be constructed with the remedial measures described for Stage C (Case 1) as have been already implemented before further staging takes place.** Additional analyses suggest that to reduce these seepage forces that slope under drains / bench drains and composite geonets be placed along the slope to prevent the buildup of seepage forces.

END

11. <u>REFERENCES</u>

1. Drawing Nos. 10W425-6 and 34C (showing proposed Phase 1, 2 and 3 plans).
2. TVA Drawing No. 10N400 – R6, dated 7-5-56 (showing original surface topography).
3. TIMES, TriHydro, 307-745-7474, Fax 307-745-7729, Email: TriHydro@lariat.com.
4. Freeze, R. A., and J. A. Cherry. Groundwater. Prentice-Hall, Inc. Englewood Cliffs, New Jersey 07632.
5. TVA report titled, *Hydro geologic Evaluation of Ash Pond Area*, dated June 1995.
6. Mactec report titled, *REPORT OF GEOTECHNICAL EXPLORATION, ASH DISPOSAL AREA,* dated May 4, 2004.
7. Drawing No. SK PR0637 C80 (showing locations of borings drilled prior to 2004).
8. Mactec report titled, *Laboratory Testing Results – Samples from Gypsum Pond at Cumberland Fossil Plant*, dated May 13, 2004.
9. Drawing No. 10425-73 (showing Existing Dredge Cell Under drain Installation on Existing Slope Elevation from the Ditch ~ 755 or 760 to 790.

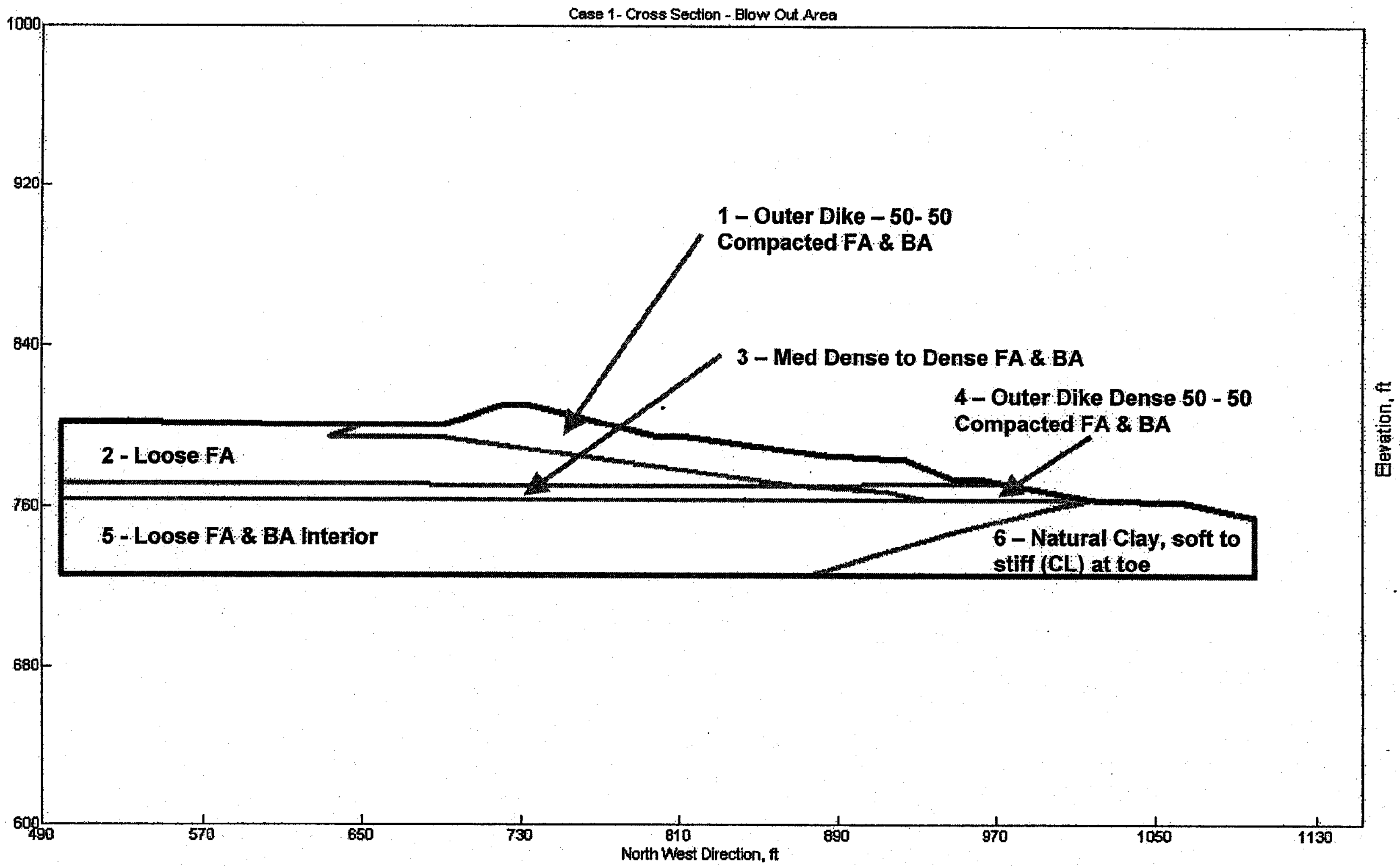

Figure 1. Soil Zones For Case 1 – Stage C at Elevation 810 feet Identified By Number and Brief Description.

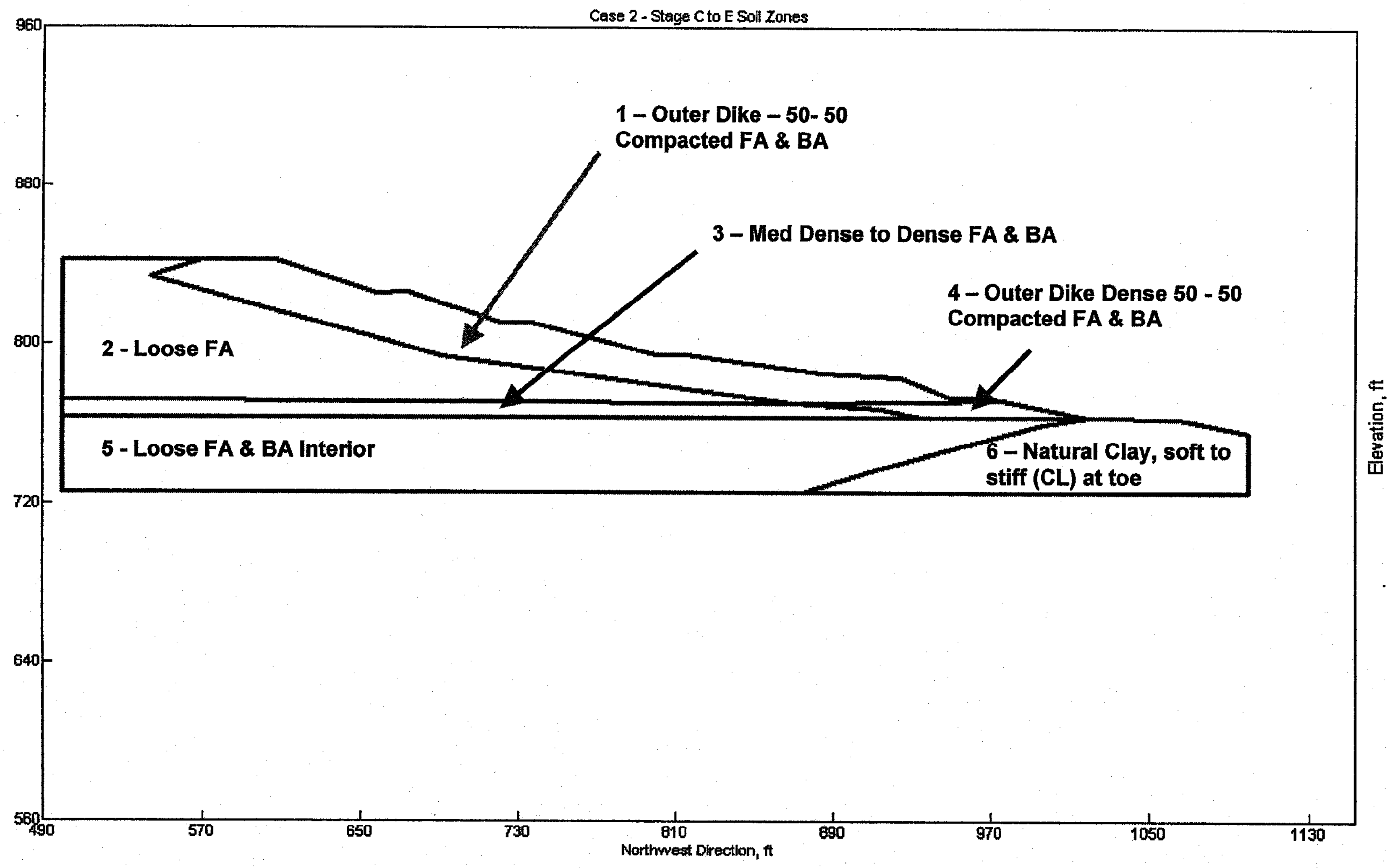

Figure 2. Soil Zones for Case 2 – Stage C to E at Elevation 842 feet Identified By Number and Brief Description.

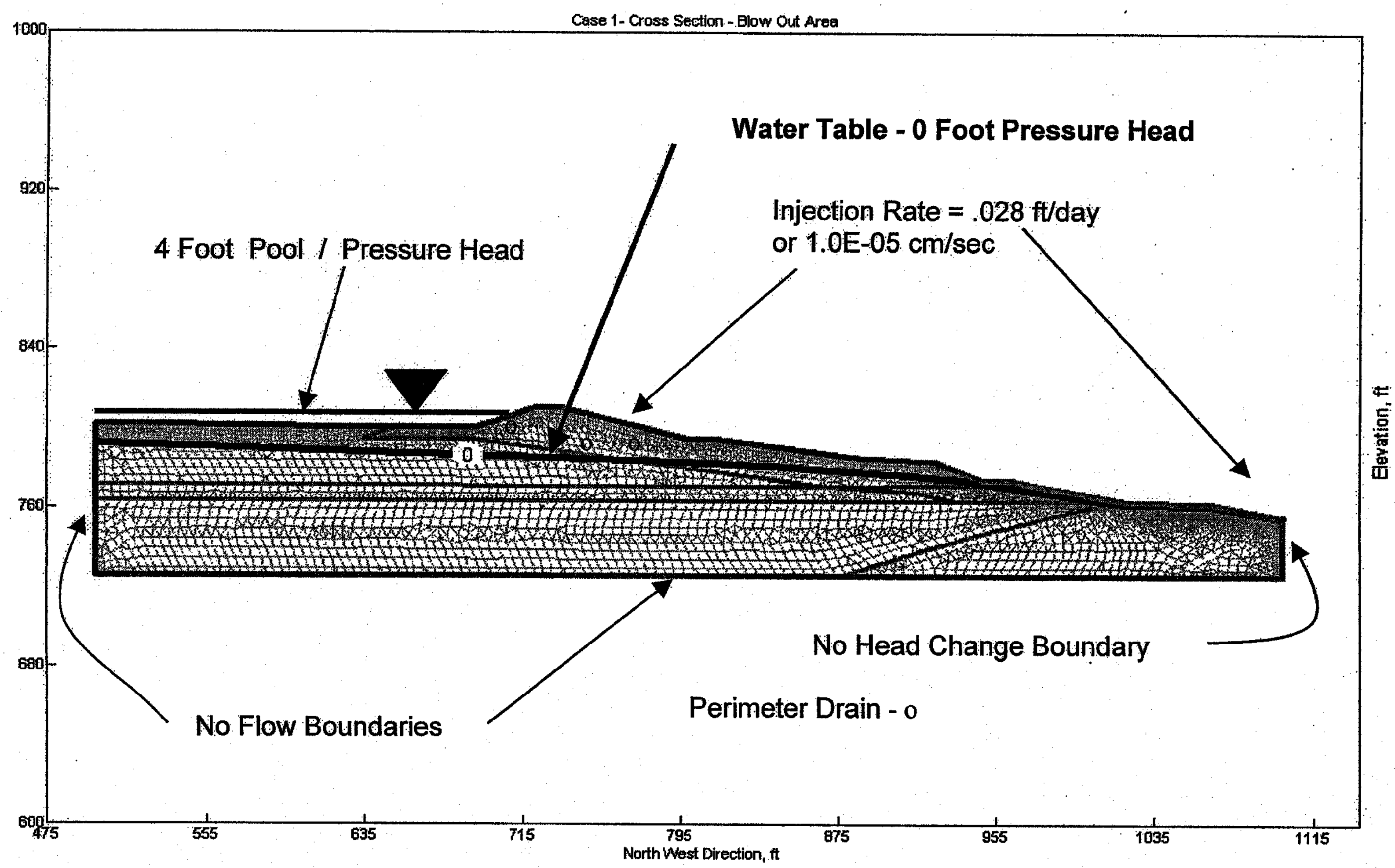

Figure 3. Case 1 Cross Section for Blow Out Area Showing Finite Element Mesh, Boundary and Initial Conditions.

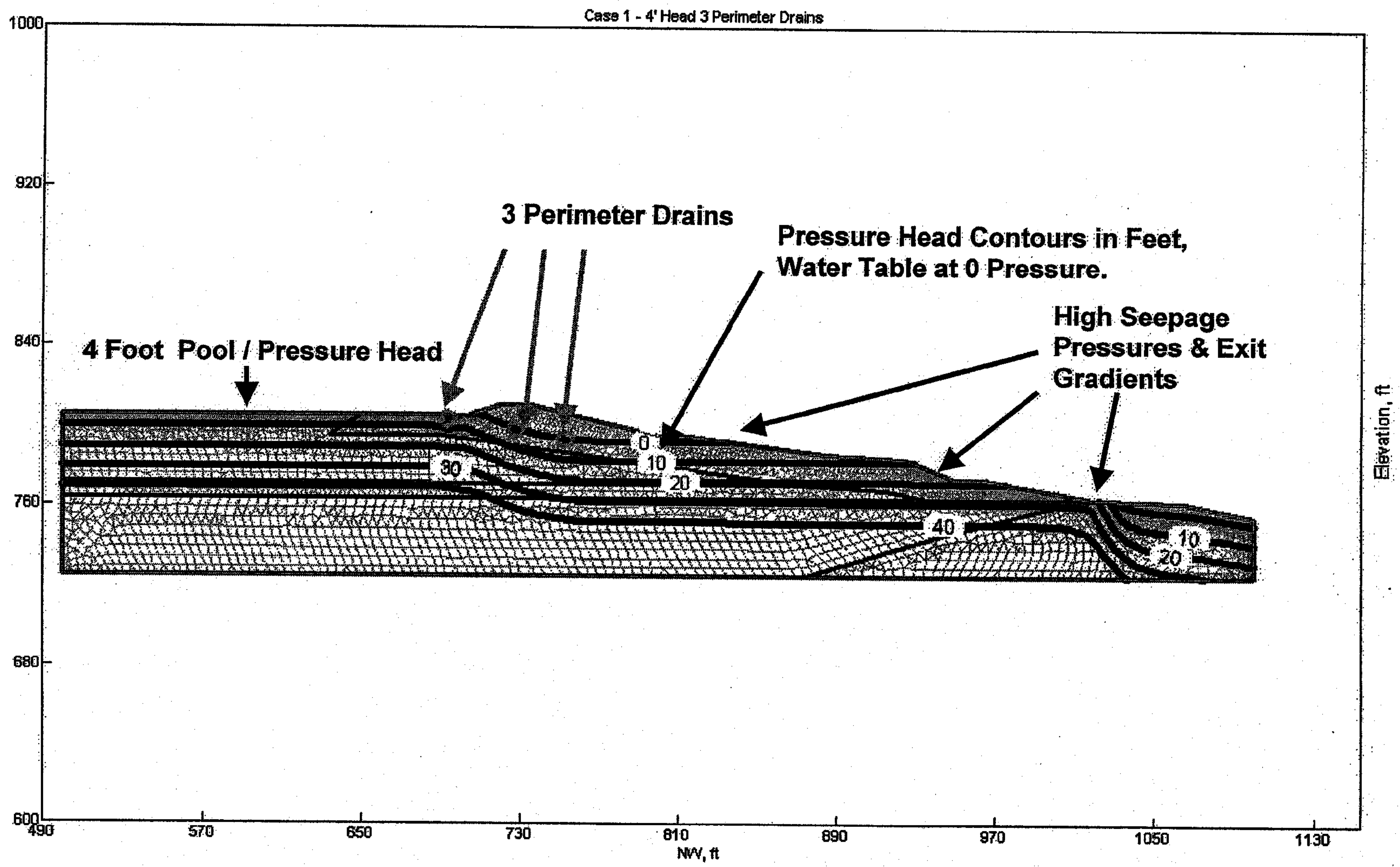

Figure 4. Case 1. Perimeter Drains for Stage C (Stage 1) Still Produce Large Exit Gradients At Steady State.

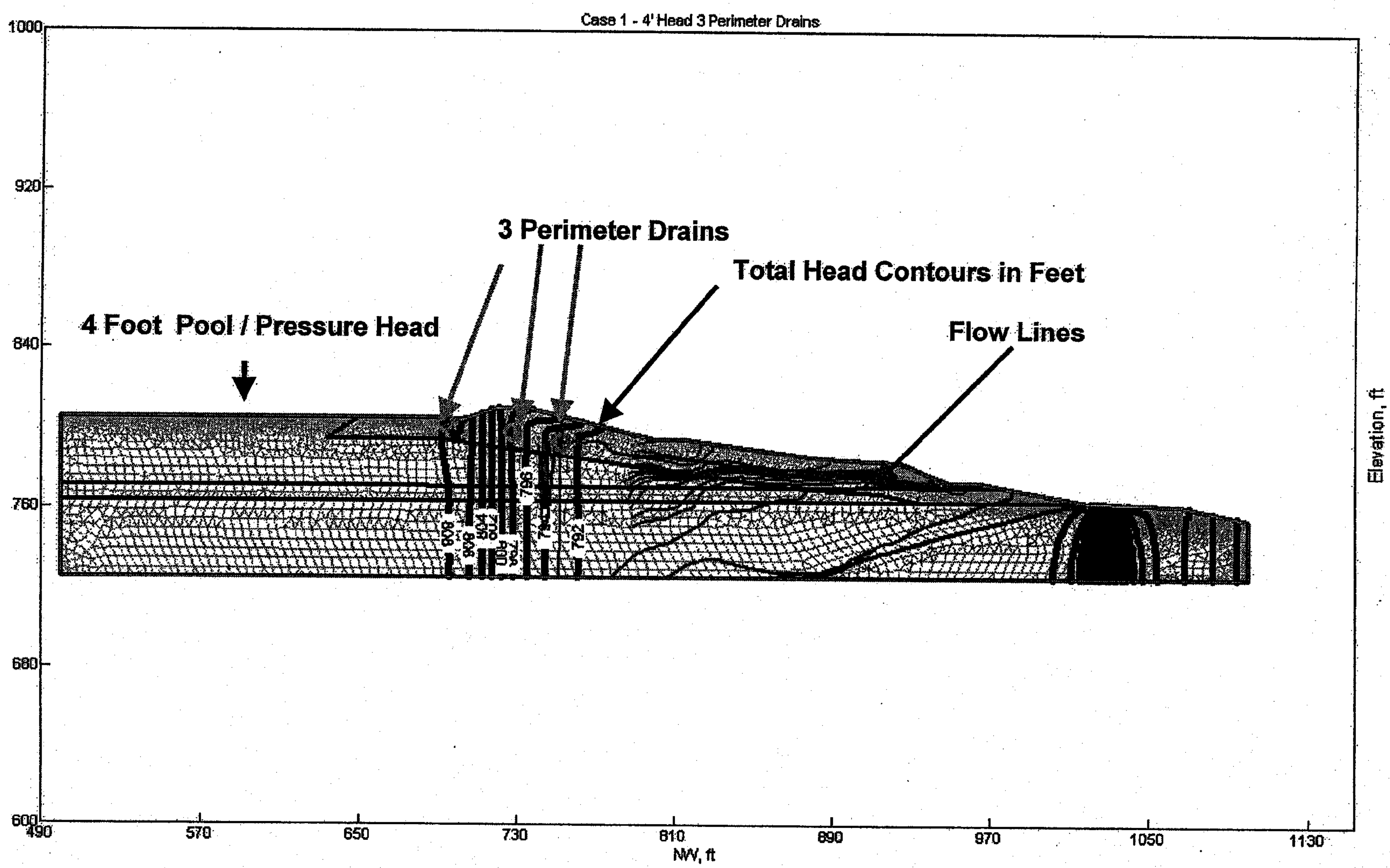

Figure 4A. Case 1. Perimeter Drains for Stage C (Stage 1) Total Heads at Steady State With Flow Lines.

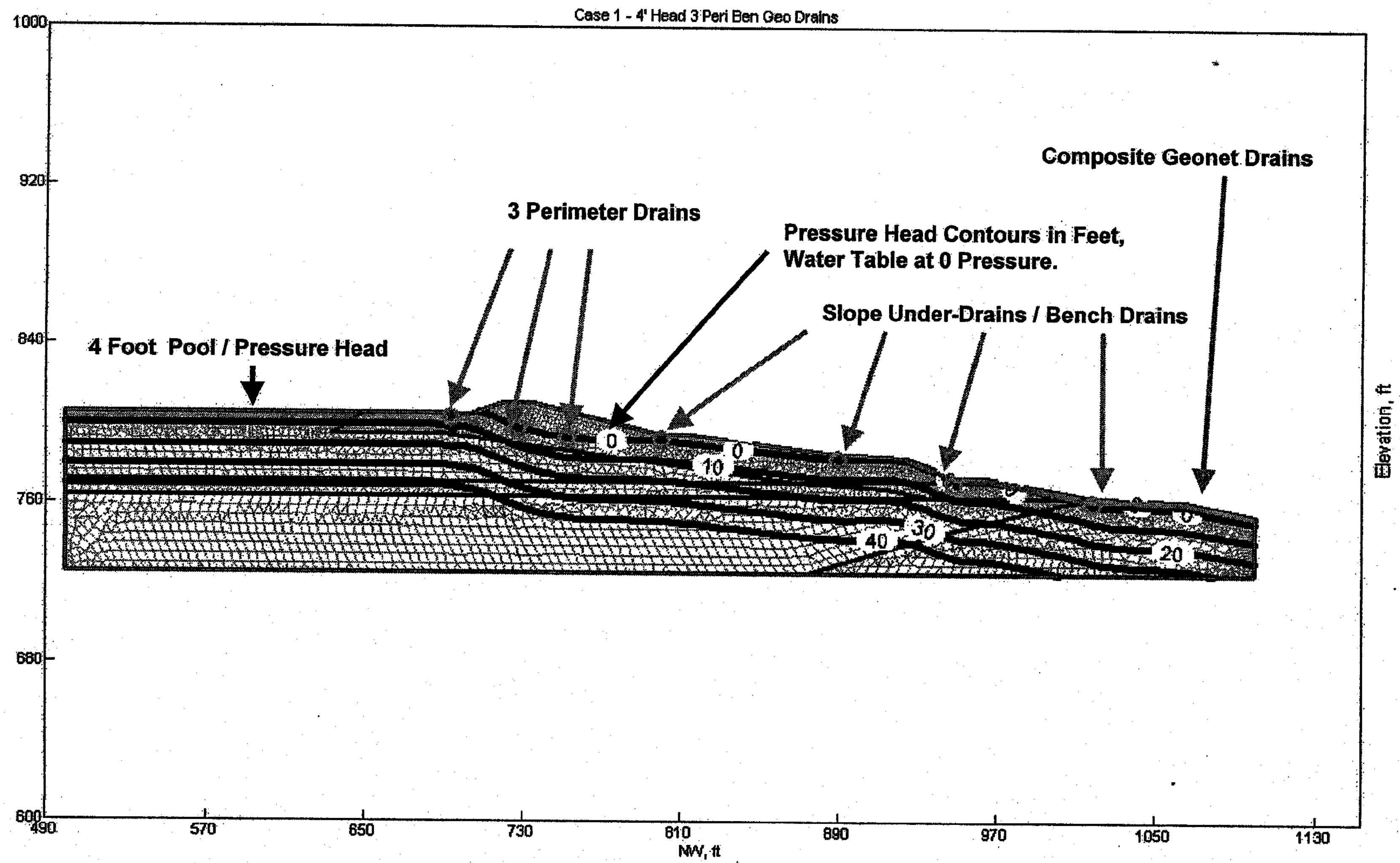

Figure 5. Case 1. Perimeter Drains for Stage C (Stage 1) Control Exit Gradients.

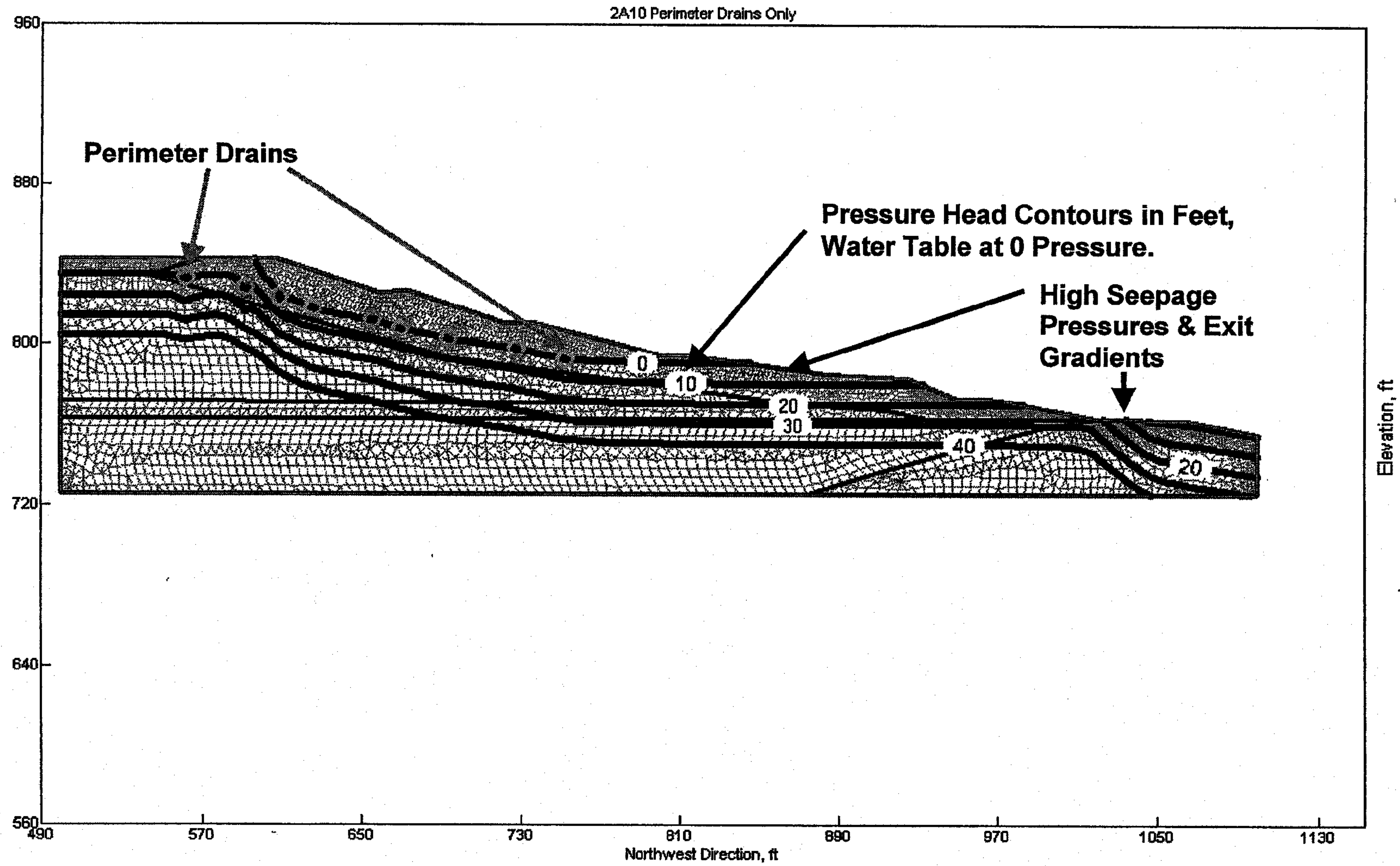

Figure 6. Case 2. Perimeter Drains for Stage E (Stage 3) Still Allow Large Exit Gradients At Steady State.

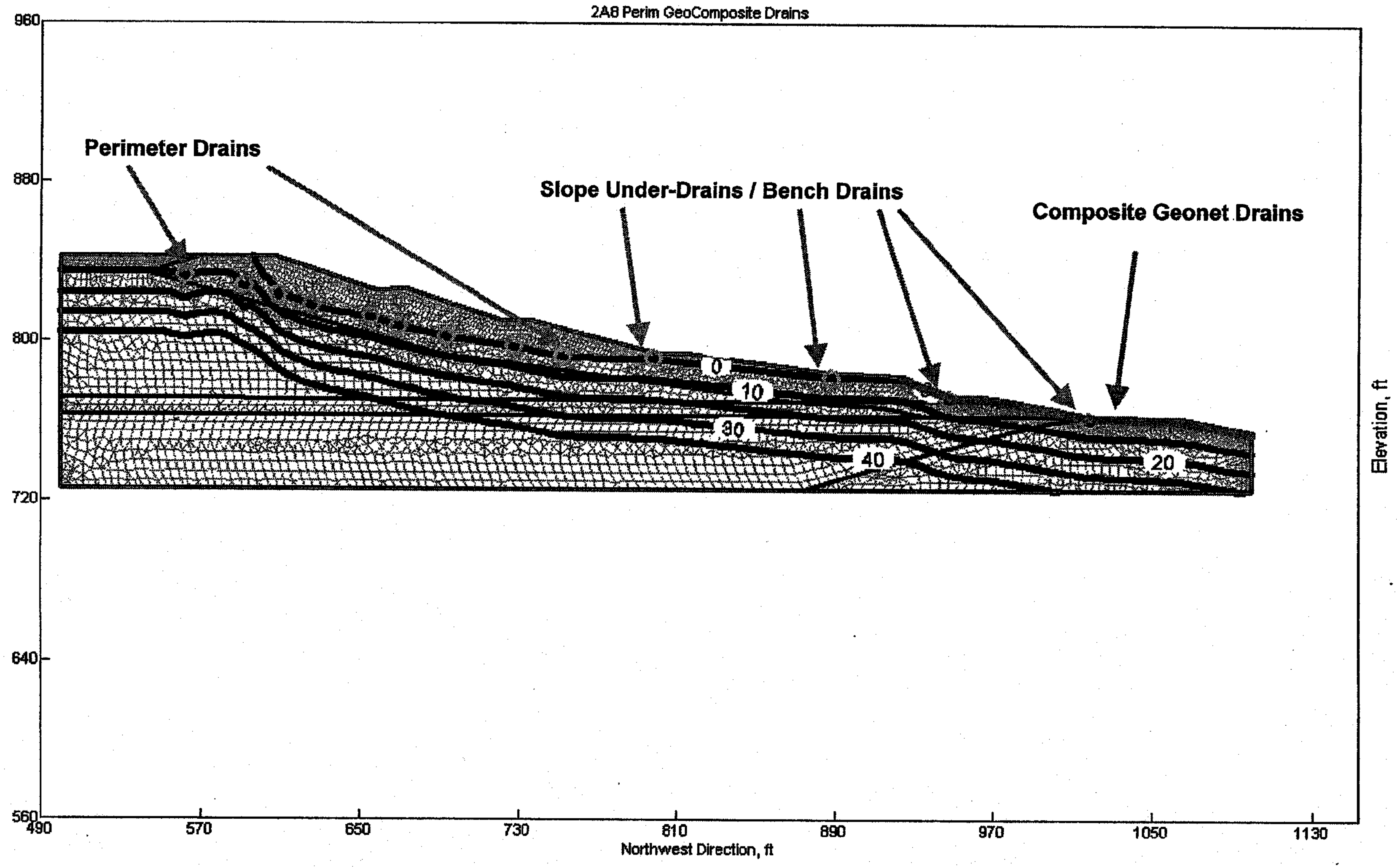

Figure 7. Case 2. Perimeter, Bench, and Composite Geonet Drains for Stage E (Stage E) Control Exit Gradients.