Report to:

Metro
Regional Environmental Management
Engineering and Analysis Division
600 NE Grand Avenue
Portland, Oregon 97232-2736

WASTE CUTOFF STUDY
ST. JOHNS LANDFILL

March 1999

By

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1. INTRODUCTION

1.1. Introduction

In accordance with Metro's authorization, we have completed a preliminary evaluation of methods to construct an impermeable barrier through a refuse layer located within the northern perimeter dike at the St. Johns Landfill, in Portland, Oregon. This technical memorandum presents conceptual barrier construction (or waste cutoff) techniques, conceptual cost estimates, and our comments regarding the suitability and constructibility for the waste cutoff options.

1.2. Scope of Work

The scope of work for this study included the following work tasks:

- Review Cornforth's files from previous site investigations.
- Evaluate three conceptual waste cutoff techniques, which would minimize the exchange of fluids between the refuse layer and the adjacent North Slough waterway.
- Provide conceptual-level cost estimates for each of the techniques.
- Prepare a report summarizing the conceptual cutoff techniques, analyses and conclusions.

1.3. Background/Previous Investigations

In 1990, our firm performed a leachate migration study of the perimeter dike (report to Metro dated October 1990). As part of the study, a total of 20 borings were performed through the perimeter dike road at varying intervals around the landfill. Two of the borings (J-12 and J-13) located along the North Slough encountered a layer of refuse below the road surface. The refuse layer measured up to 12 feet in thickness. Refuse was also encountered in Boring J-18, which was located along the Blind Slough segment of the dike in the southeast corner of the landfill. The refuse layer discovered in Boring J-18 was approximately 11 feet in thickness.

In 1995, Metro constructed a compacted clay trench barrier through the Blind Slough dike segment to reduce seepage in that area. It is our understanding from conversations with Metro personnel that the clay trench has worked reasonably well in reducing the occurrence of leachate seeps.

Based on the discovery of refuse in Borings J-12 and J-13, Metro asked our firm in November 1997 to perform a test pit investigation to further explore the extent of the refuse along the North Slough. Two test pits (CC-1 and CC-2) were excavated through the road surface at equal spacing intervals between Borings J-12 and J-13. The refuse layer was observed in both test pits, and was measured between 7½ and 9 feet in thickness. The results of the test pit investigation were summarized in a report submitted to Metro titled "North Levee Test Pit Investigation, St. Johns Landfill," dated December 4, 1997.

In March 1998, Metro requested that our firm further investigate the extent of the refuse layer within the north dike by performing another series of borings. A total of 9 borings were performed (Q-1 through Q-9) to determine the lateral extent and depth of the refuse layer beneath the dike alignment. In these Q-series borings, the refuse layer was found to range between 0 and 18 feet in thickness. The results of this investigation were submitted to Metro in a report titled "Phase II Investigation of North Levee, St. Johns Landfill," dated April 3, 1998.

The locations of the borings and test pits from the previous field investigations discussed above are shown on the Site Plan, Figure 1.

1.4. Subsurface Conditions – North Perimeter Dike

General. Within the area of concern along the north dike, the subsurface conditions generally consist of a thin layer of road surfacing aggregate, underlain by a layer of medium stiff, mottled brown and gray, sandy, clayey silt fill material. The silt fill varies in thickness from about 1½ to 6 feet. The road aggregate/silt fill layers are underlain by a layer of refuse, which generally consists of wood, plastic, glass, paper, and occasional pieces of construction debris such as concrete and asphalt. The refuse layer is typically 5 to 10 feet in thickness, but ranges between ½ foot and 18 feet. The refuse layer, in turn, is underlain by native, gray, alluvial soils consisting of soft to medium stiff, slightly clayey silt, to loose, silty fine sand with trace clay. A cross-section through the dike alignment is shown on Figure 2.

Limits of Refuse/Cutoff Length. The information from the borings and test pits indicates that the refuse layer lies within the area bounded by Borings J-11 and Q-9 (see Figure 1). In Boring J-11 the road aggregate/silt fill layers are directly underlain by soft, native silt (alluvium). In Boring Q-9, the aggregate is underlain by stiff, relatively well-compacted dike fill to the maximum depth explored (14 feet). The stiff fill observed in Boring Q-9 appears to be part of the engineered levee that was constructed in the early 1980s to facilitate the landfill expansion. All of the other borings and test pits between J-11 and Q-9 revealed some refuse.

In Boring Q-1 there was only trace refuse observed at a depth of about 5 feet. In Boring Q-2 there was a thin layer of refuse observed at a depth of 6 to 6½ feet. Considering that there was no refuse in J-11, and only trace refuse in Q-1, we estimate that the cutoff barrier would need to extend about 25 feet west of Q-1. Similarly, on the east end of the alignment the refuse layer appears to taper out between Borings Q-8 and Q-9. Therefore, we estimate that the cutoff barrier would need to extend about 15 feet east of Q-8 (Boring Q-9 is located about 15 feet east of Q-8). The total distance between these two ends of the barrier is approximately 1025 feet.

Groundwater/Leachate Levels. During the Q-series borings, groundwater/leachate levels were checked in open auger holes in Borings Q-5 and Q-8. In Boring Q-5 the fluid level was observed at a depth of 12.1 feet below the ground surface, which was just below the base of the refuse layer. In Boring Q-8 the fluid level was observed at a depth of 19.6 feet below the ground surface, which was about 5½ feet above the base of the refuse.

Previous construction work at the landfill has shown that the leachate levels can be variable. During the final cover construction of Subareas 1, 2 and 3 (in 1992 through 1994), a continuous trench was excavated into refuse around the perimeter of the landfill for the installation of a gas collection system. In isolated areas, leachate was observed flowing into the trench through localized zones of refuse which were apparently more conductive. This condition was also observed in Test Pits CC-1 and CC-2. The pits were relatively close together (only 133 feet apart), with similar ground surface elevations and similar refuse base elevations. Despite these similarities, the leachate conditions were quite different. No leachate was observed in CC-1, whereas leachate flowed into CC-2 at a rate of 1 to 2 gallons per minute.

Based on the above measurements and observations of leachate levels, it appears likely that leachate would be encountered during the waste cutoff construction. Therefore, for any cutoff method that involves excavation through the refuse, it would be necessary to deal with some groundwater/leachate inflow.

2. WASTE CUTOFF OPTIONS

2.1. General

Based on the results of the field investigations, our knowledge of subsurface conditions at St. Johns Landfill, and our experience with seepage barriers, we recommend the following waste cutoff options: i) compacted clay trench; ii) soil bentonite or cement bentonite slurry wall; and iii) grouted sheet pile wall. Our comments regarding the technical approach, conceptual costs, and advantages and disadvantages for each of these alternatives are presented below.

The conceptual costs presented below include the contractor's mobilization, profit and overhead. They do not include design or administrative costs. Values shown are in 1999 dollars.

2.2. Option 1 – Compacted Clay Trench

A cross-section of the conceptual compacted clay (low permeable soil) trench option is shown on Figure 4.

<u>Technical Approach</u>

- Excavate a trench through the refuse and 3 feet into the underlying alluvium.
- Place 1-foot lifts of imported low permeable soil (clayey silt/silty clay) into the trench, and compact with a sheepsfoot roller attachment connected to a trackhoe.
- Pump groundwater/leachate from low points in the excavation as necessary to compact the low permeable soil in dry conditions.
- Perform the trench excavation and backfill work in short segments (30 feet or less) to minimize sloughing of the trench sidewalls and the temporary destabilizing effect on the dike.
- As an option, prior to backfilling the trench with soil, place either a welded geomembrane or a bentonite mat along the face of the trench on the side closest to the North Slough (Fig.3).

<u>Expected Hydraulic Conductivity of Barrier</u>

- Compacted low permeable soil only: 1×10^{-4} cm/sec to 1×10^{-5} cm/sec.
- With a geomembrane or bentonite mat: 1×10^{-5} cm/sec to 5×10^{-6} cm/sec.

Advantages
- Least cost option.
- Simplicity of construction; no specialty contractors required.
- Method used previously at the Blind Slough with reasonable level of success.

Disadvantages
- Higher hydraulic conductivity than other cutoff methods.
- The alluvium and refuse layers are relatively soft and flexible; therefore, it would be difficult to compact the soil backfill.
- Due to space limitations on top of the dike, it would be difficult install a geomembrane or bentonite mat liner after the excavation has occurred.
- Construction Quality Assurance (CQA) difficulties: considering the trench depth and proximity to refuse and leachate, it would be difficult for personnel to enter the trench and verify that the soil has been properly compacted.
- Method is sensitive to weather. The low permeable soil could not be placed during wet weather.

Conceptual-Level Cost Estimate
- $200,000 to $250,000 (without a bentonite mat or geomembrane liner)
- $225,000 to $275,000 (with either a bentonite mat or a geomembrane liner)

These cost estimates are based on the assumption that the leachate would be disposed of on-site.

2.3. Option 2A – Soil Bentonite Slurry Wall

A cross-section of the conceptual slurry wall options (both soil bentonite and cement bentonite) is shown on Figure 5.

Technical Approach
- Sample the groundwater/leachate in advance to check the compatibility with the soil bentonite mixture.
- Excavate a continuous trench through the refuse and 3 feet into the underlying alluvium.
- Infill the trench temporarily with a bentonite-water slurry to maintain stability of sidewalls.
- Import a silty or clayey soil and mix with bentonite slurry (outside of the trench) to create a low permeable backfill.

- Starting at one end, dump the soil bentonite mixture into the trench and collect any displaced liquid slurry. Continue the process until the wall is complete.

Expected Hydraulic Conductivity of Barrier
- On the order of $1x10^{-7}$ cm/sec.

Advantages
- Low hydraulic conductivity.
- Backfill material has greater resistance to chemical aggression than other options.
- The soil bentonite backfill can be tested after mixing to check that its hydraulic conductivity is appropriate.
- The bentonite-water slurry would minimize the inflow of water into the trench.
- Method has a long history of success at other landfill sites.

Disadvantages
- Requires a specialty contractor.
- The bentonite-water slurry could escape through more conductive zones in the refuse, which would present a risk of it entering the North Slough.
- The soil bentonite backfill would create a very weak zone within the dike; therefore, the long-term stability of the perimeter dike would be impacted to a greater extent than the other methods.
- Settlement problems may occur in the perimeter road surface due to consolidation of the soil bentonite backfill.
- The top surface of the dike rises in elevation from the west to the east ends of the alignment; therefore, it may be necessary to temporarily regrade the surface to keep the bentonite-water slurry from overflowing the trench.

Conceptual-Level Cost Estimate
- $260,000 to $330,000

As a consequence of the weak zone left within the dike, the soil bentonite slurry method would require more effort to stabilize the dike than the other methods. We anticipate that the weak zone could be offset by either flattening the slope (if space allows) or by constructing a buttress at the toe. For preliminary cost estimating purposes, we suggest adding $100,000 to the conceptual estimate shown above for the added slope stabilization work.

2.4. Option 2B – Cement Bentonite Slurry Wall

A cross-section of the conceptual option is shown on Figure 4.

Technical Approach

- Sample the groundwater/leachate in advance to check the compatibility with the cement bentonite mixture.
- Excavate a trench that extends through the refuse and 3 feet into the underlying alluvium.
- Backfill the trench by pumping in a cement-bentonite-water mixture.
- Perform the excavation and backfill work in 30-foot segments to minimize the amount of sidewall sloughing. Continue the work in 30-foot segments until the wall is completed.

Expected Hydraulic Conductivity of Barrier

- On the order of $1x10^{-6}$ cm/sec.

Advantages

- Reasonably low hydraulic conductivity.
- Cement bentonite mixture sets in a relatively short period of time to a consistency of medium stiff to stiff clay (15 to 20 psi).
- The added strength of the cement bentonite would improve the stability of the perimeter dike.
- The cement bentonite can be tested in advance to check its properties.
- No need to import soils.
- Fly ash can be added to the mixture to make it less permeable and more resistant to chemical attack.
- Method has been used with success recently on other landfills.

Disadvantages

- Requires a specialty contractor.
- Higher cost than the compacted clay trench and soil bentonite slurry wall options.
- Possibly shorter lifespan than soil bentonite slurry wall.

Conceptual-Level Cost Estimate

- $310,000 to $380,000

2.5. Option 3 – Sheet Pile Wall

A cross-section of the conceptual option is shown on Figure 6.

Technical Approach

- Sample the groundwater/leachate to check the corrosion potential of the steel.
- Drive steel sheet piles through the dike alignment, and extend the sheets at least 3 feet into the underlying alluvium.
- Grout the interlocking connections between the sheet piles (Fig.6).

Expected Hydraulic Conductivity of Barrier

- $1x10^{-7}$ cm/sec or lower.

Advantages

- Very low hydraulic conductivity (if installed without damage).
- No refuse and leachate disposal required.

Disadvantages

- Higher cost.
- May encounter difficult driving through the refuse in local areas due to the presence of construction debris (blocks of concrete, asphalt, wood, etc.)
- Damage from difficult driving could result in separation of the sheets at the interlocks, which would lead to leakage problems.
- Possible corrosion problems.
- Method not commonly used on landfill facilities.

Conceptual Cost Estimate

- \$360,000 to \$450,000

2.6. Longevity of Cutoff Options

The longevity of the cutoff options discussed above is difficult to forecast. In general, the longevity of a hydraulic barrier around a landfill is related to the chemistry of the leachate, and the resistance of the barrier materials to chemical aggression. It is our understanding that the leachate samples which Metro has tested in the past have been relatively neutral (i.e. slightly basic, but pH level near 7). Therefore, this leachate probably would not produce rapid degradation of the barrier materials.

There are different types of bentonite available which are especially resistant to chemical attack. These resistant grades of bentonite are typically used in soil bentonite and cement bentonite slurry walls to prolong their life. Specialty contractors dealing in slurry trench wall construction at heavily contaminated sites generally count on lifespans of 20 to 40 years for soil bentonite walls, and about 20 years for cement bentonite walls. The cement bentonite barrier is expected to be somewhat less durable because cement is more susceptible to chemical attack. Given the neutral nature of the leachate at St. Johns Landfill, we anticipate that either type of bentonite slurry wall could last considerably longer at this site.

We would expect the lifespan of the compacted clay trench to be similar to the slurry wall options, especially if the trench was lined with a bentonite mat or an HDPE geomembrane. Bentonite mats constructed from chemically resistant bentonite are readily available, and HDPE geomembranes are highly resistant to chemical attack.

There is no hard data on the longevity of sheet pile walls at landfill facilities. On typical waterfront projects, the U.S. Corps of Engineers count on sheet pile corrosion rates of 0.004 to 0.005 inches per year. At this corrosion rate, a standard sheet pile measuring ⅜-inch in thickness could last up to 70 years. However, the chemical environment around a landfill could alter the corrosion rate, and could shorten the design life substantially. There are coating materials available that could help reduce the rate of corrosion; however, the coatings are difficult to protect during installation. In order to further evaluate the longevity of a sheet pile barrier, it would be necessary to sample the leachate from St. Johns Landfill and perform laboratory corrosion tests.

2.7. Disposal of Excavated Materials

For the compacted clay trench and slurry wall cutoff options, it would be necessary to excavate a trench through the refuse and into the underlying alluvium. Assuming that the trench would be 1025 feet long, 3 feet wide, and would extend 3 feet into the alluvium, we estimate that the trench volume would be approximately 1,800 cubic yards. Due to sloughing of the trench sidewalls excavated through refuse, it is expected that the trench volume would increase by a factor of 30 to 70 percent. Therefore, the volume of material removed could be on the order of 3,100 cubic yards.

From conversations with Metro personnel, it is our understanding that the material excavated from the trench would likely be kept on-site and used to infill localized sags in the existing landfill cover. After placing the excavated materials into the sags, a new cover layer would be constructed over the materials. The design issues related to the infill of sag areas are beyond the scope of this study; therefore, the cost estimates discussed above do not include the costs for hauling and placing the excavated materials into the sags. However, the estimates do include the costs for loading excavated materials into haul trucks.

2.8. Dike Stability Concerns

In recent years, slope instability problems have occurred along several segments of the perimeter dike. Concurrent to this waste cutoff study, Metro authorized our firm to perform a separate study to evaluate methods for stabilizing the perimeter dike. Work is already underway on the dike stabilization study, and a report will be submitted under separate cover.

With regards to the stability of the perimeter dike, one of the primary areas of concern is the same segment along the North Slough where the waste cutoff is required. The shoreline slope is relatively steep through this area, and the toe of the slope has been heavily undermined by erosion. The conceptual methods and costs for stabilizing this slope will be addressed in the dike stabilization study discussed above. However, as part of the present study, we performed a slope stability analysis on the dike in its existing condition. The stability analysis determined that the excavation for a waste cutoff trench would temporarily destabilize the slope until it was backfilled. The added weight and vibrations from sheet pile driving equipment could also cause the slope to fail. Therefore, we recommend that the slope stabilization work be completed prior to the construction of the waste cutoff barrier.

2.9. Summary of Cutoff Options

For comparative purposes, we present below an overall summary of the waste cutoff options. The table includes: (i) the approximate hydraulic conductivity of the cutoff barrier; (ii) the degree of construction difficulty (low, moderate, or high)); (iii) conceptual cost; and (iv) longevity.

Summary of Waste Cutoff Options

Cutoff Option	Hydraulic Conductivity (cm/second)	Construction Difficulty	Approximate Cost	Approximate Lifespan
Compacted Clay Trench	$1x10^{-4}$ to $5x10^{-6}$	Low	$200,000 to $275,000	30⁺ years
Soil Bentonite Slurry Wall	$1x10^{-7}$	Moderate	$260,000 to $330,000	30⁺ years
Cement Bentonite Slurry Wall	$1x10^{-6}$	Moderate	$310,000 to $380,000	30⁺ years
Sheet Pile Wall	$1x10^{-7}$	High	$360,000 to $450,000	Up to 70 years

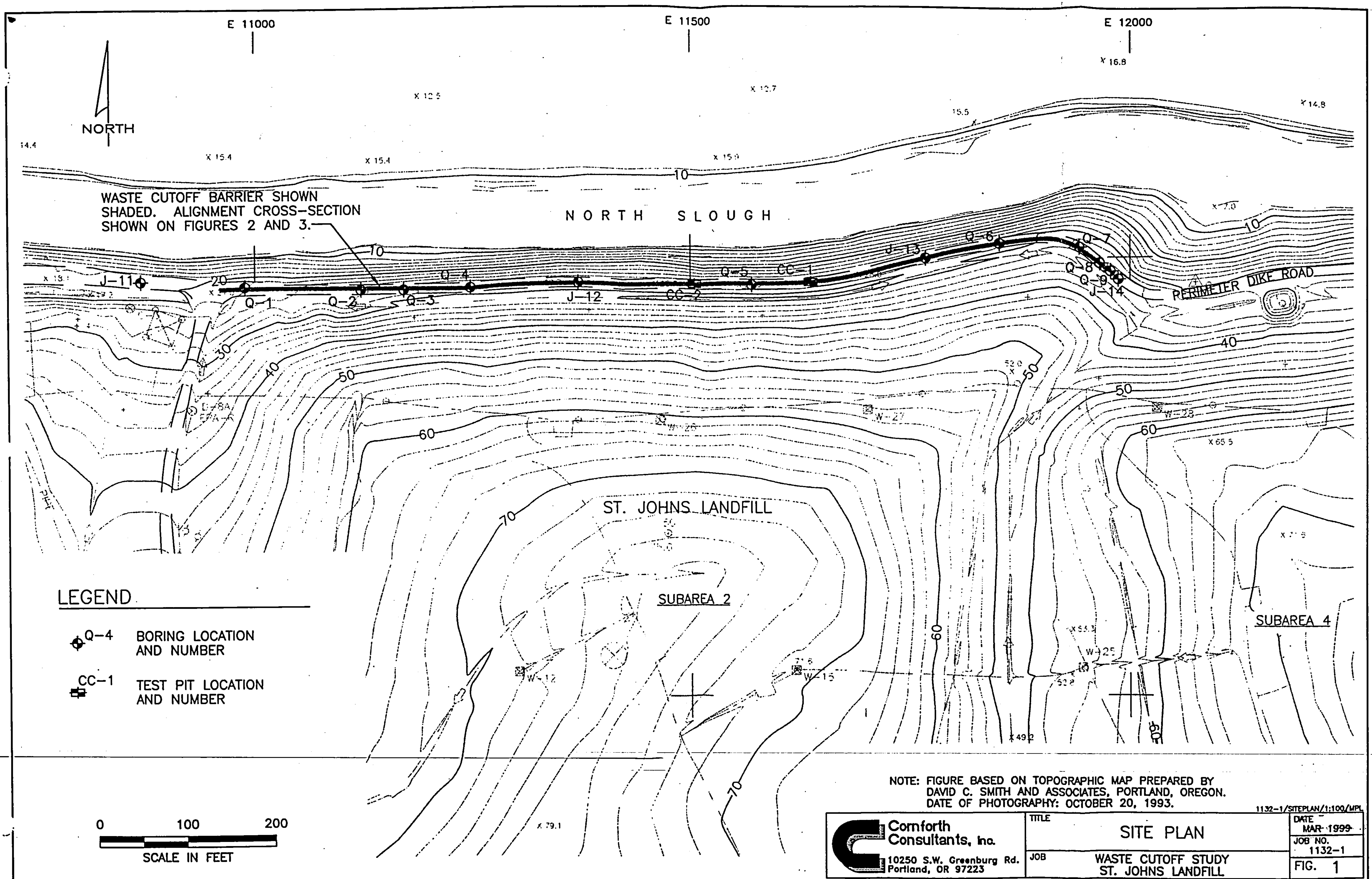
We appreciate the opportunity to be of continued service on this project. If you have any questions, please call.

Very truly yours,

CORNFORTH CONSULTANTS, INC.

By ______________________________
Michael R. Meyer, P.E.
Associate Engineer

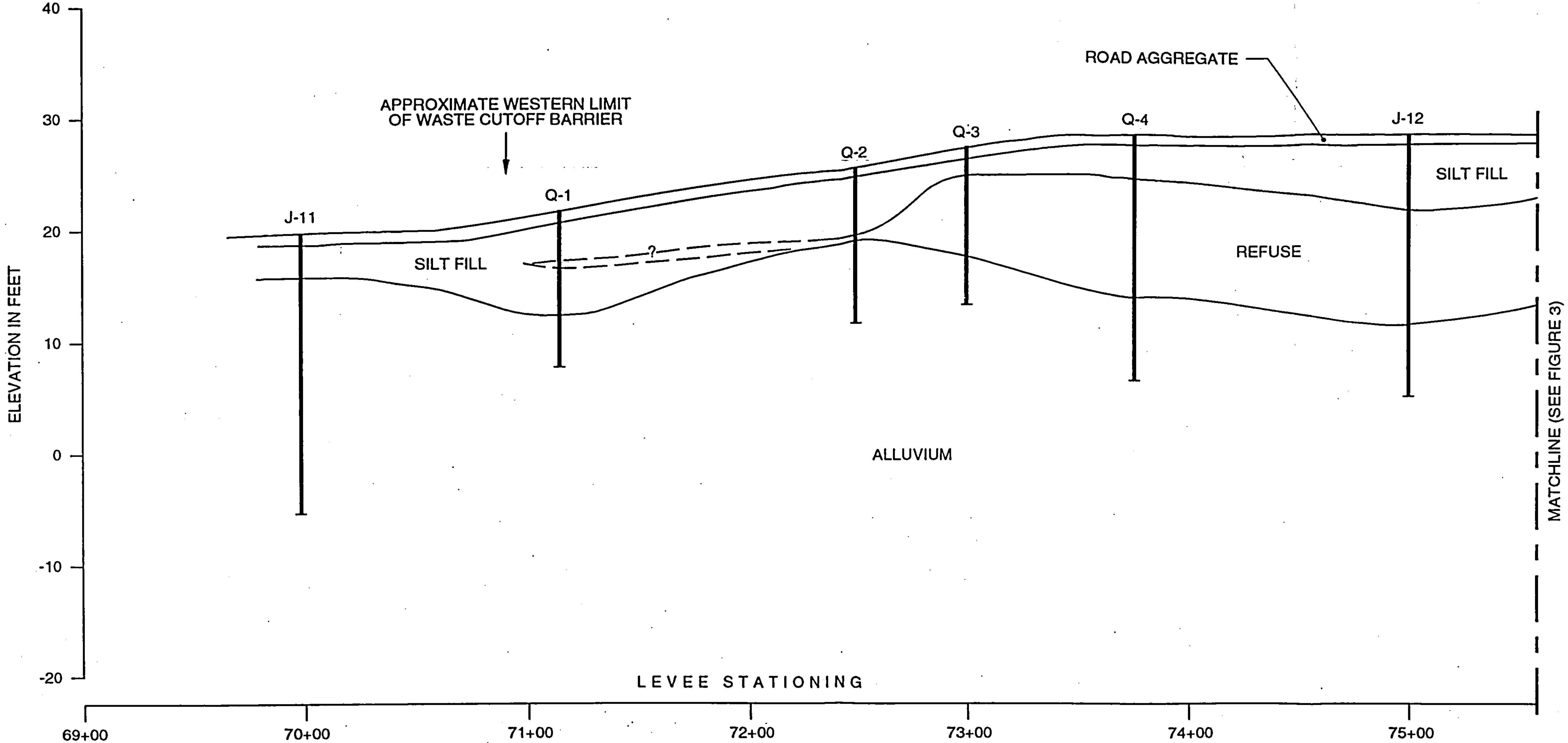
By ______________________________
Ermel Quevedo, P.E.
President



NOTE: FIGURE BASED ON TOPOGRAPHIC MAP PREPARED BY DAVID C. SMITH AND ASSOCIATES, PORTLAND, OREGON. DATE OF PHOTOGRAPHY: OCTOBER 20, 1993.

1132-1/SITEPLAN/1:100/MPL

Cornforth Consultants, Inc. 10250 S.W. Greenburg Rd. Portland, OR 97223	TITLE: SITE PLAN	DATE: MAR 1999
	JOB: WASTE CUTOFF STUDY ST. JOHNS LANDFILL	JOB NO. 1132-1
		FIG. 1

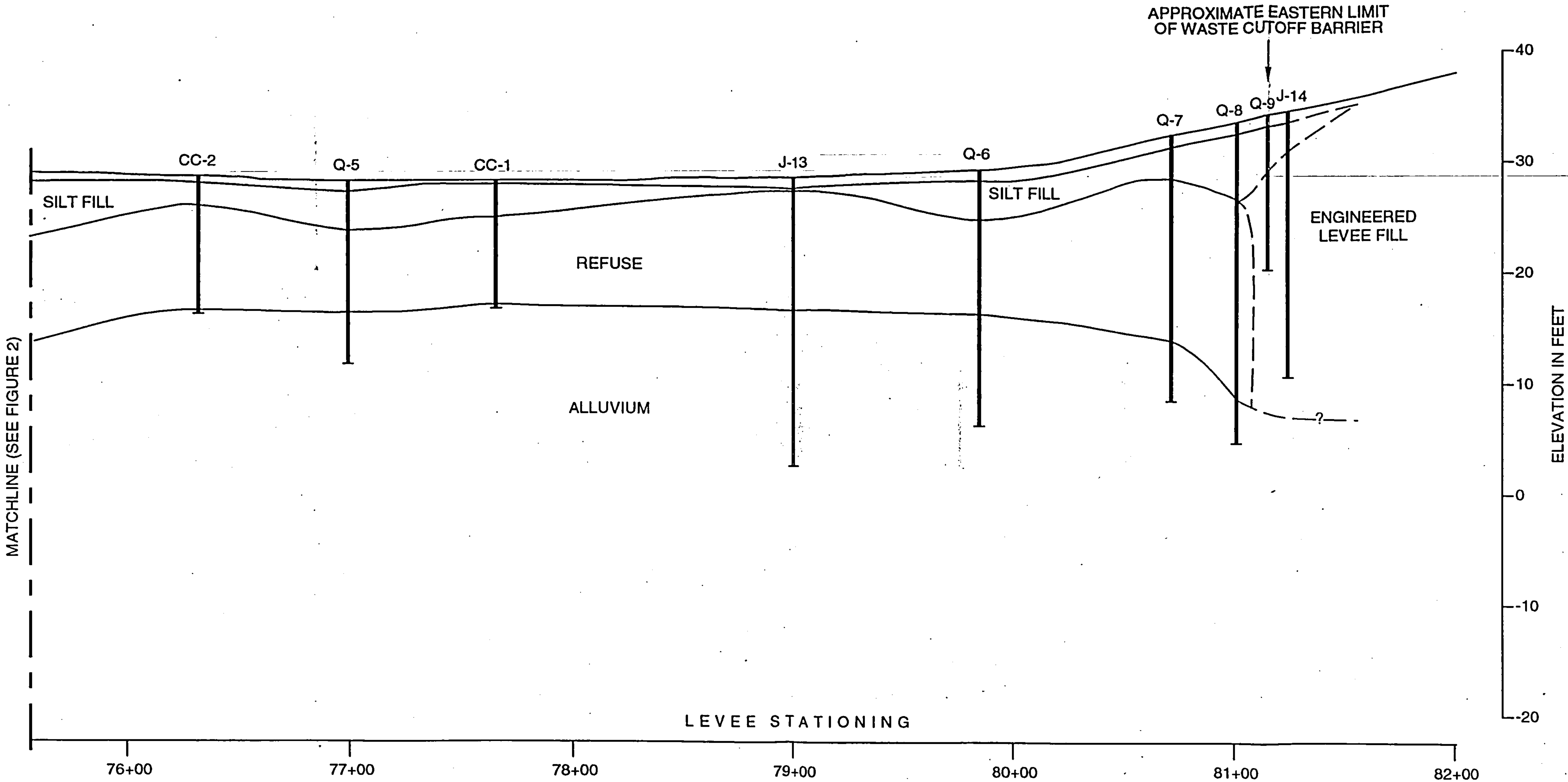


SCALE: HORIZONTAL 1 INCH = 50 FEET
VERTICAL 1 INCH = 10 FEET

NOTE:
1. ELEVATIONS SHOWN BASED ON OCTOBER 1993 TOPOGRAPHIC MAP, SEE FIGURE 1
2. STATIONING BASED ON CORNFORTH CONSULTANTS 1990 LEACHATE MIGRATION STUDY

M11132-1\FIGURE02 LJW

Cornforth Consultants, Inc. 10250 S.W. Greenburg Rd. Portland, OR 97222	TITLE	CROSS SECTION THROUGH DIKE ALIGNMENT	DATE MAR 1999
			JOB NO. 1132-1
	JOB	WASTE CUTOFF STUDY ST. JOHNS LANDFILL	FIG. 2

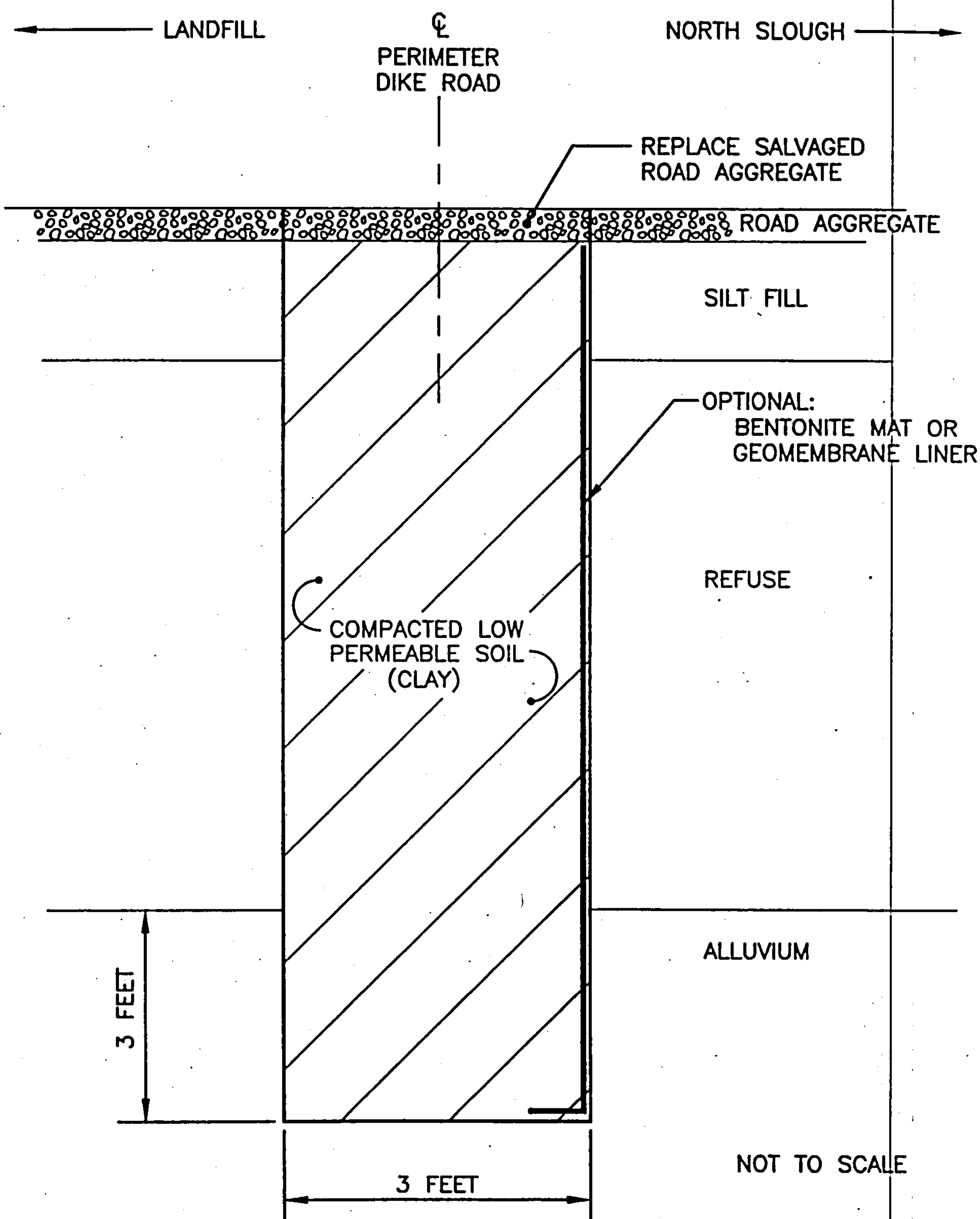


SCALE: HORIZONTAL 1 INCH = 50 FEET
VERTICAL 1 INCH = 10 FEET

NOTE:
1. ELEVATIONS SHOWN BASED ON OCTOBER 1993 TOPOGRAPHIC MAP, SEE FIGURE 1
2. STATIONING BASED ON CORNFORTH CONSULTANTS 1990 LEACHATE MIGRATION STUDY

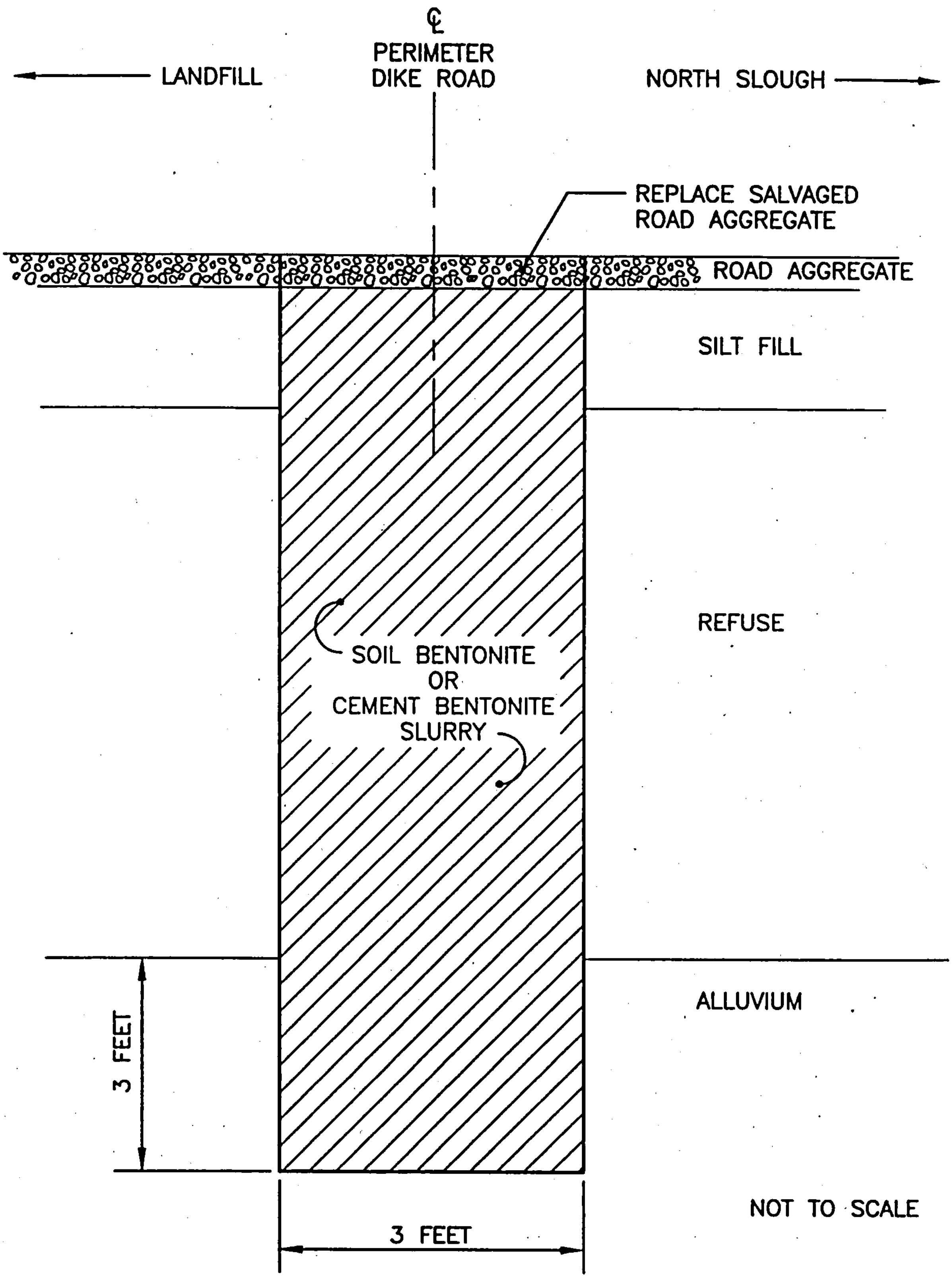
M1132-1\FIGURE03 LJW

Cornforth Consultants, Inc. 10250 S.W. Greenburg Rd. Portland, OR 97222	TITLE CROSS SECTION THROUGH DIKE ALIGNMENT	DATE MAR 1999
		JOB NO. 1132-1
	JOB WASTE CUTOFF STUDY ST. JOHNS LANDFILL	FIG. 3



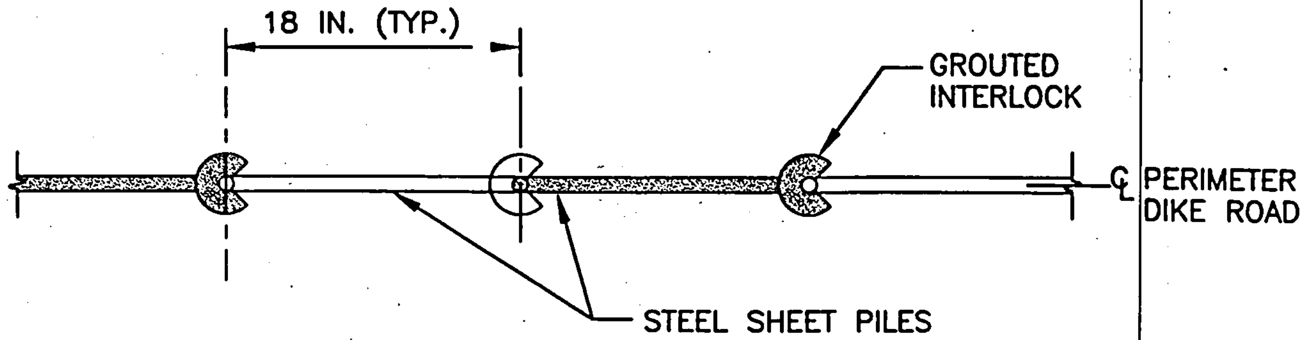
1132-1/FIG03/1:1/MPL

Cornforth Consultants, Inc. 10250 S.W. Greenburg Rd. Portland, OR 97223	TITLE COMPACTED CLAY TRENCH OPTION	DATE MAR 1999
		JOB NO. 1132-1
	JOB WASTE CUTOFF STUDY ST. JOHNS LANDFILL	FIG. 4



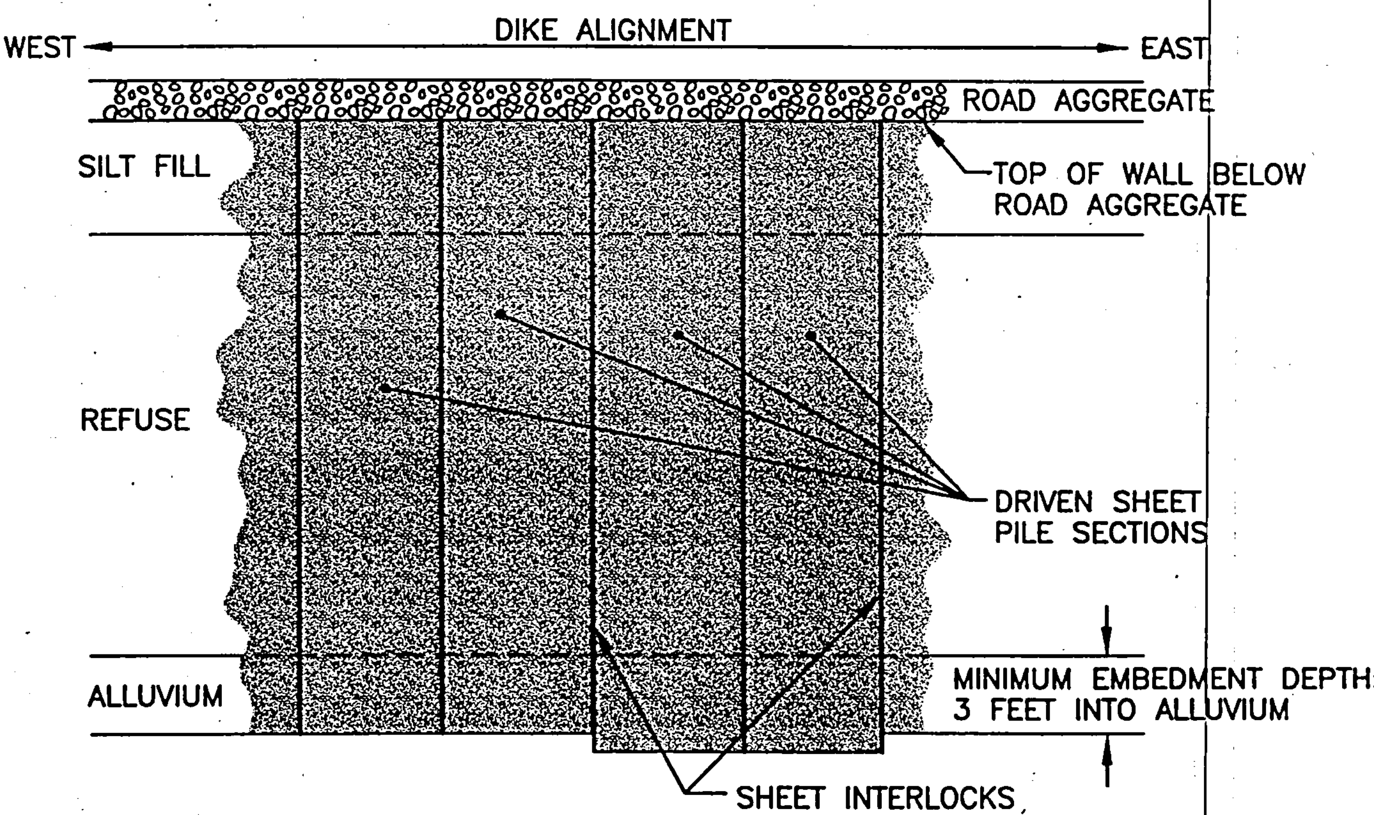
1132-1/FIG04/1:1/MPL

Cornforth Consultants, Inc.	TITLE SLURRY WALL OPTION	DATE MAR 1999
		JOB NO. 1132-1
10250 S.W. Greenburg Rd. Portland, OR 97223	JOB WASTE CUTOFF STUDY ST. JOHNS LANDFILL	FIG. 5



OVERHEAD VIEW OF SHEET PILES

NOT TO SCALE



SIDE VIEW OF DRIVEN SHEET PILE WALL

NOT TO SCALE

1132-1/FIG05/1:1/MPL

Cornforth Consultants, Inc. 10250 S.W. Greenburg Rd. Portland, OR 97223	TITLE DRIVEN SHEET PILE OPTION	DATE MAR 1999
		JOB NO. 1132-1
	JOB WASTE CUTOFF STUDY ST. JOHNS LANDFILL	FIG. 6