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Engineering Study of Tank Fill Alternatives for Closure of Single-Shell Tanks

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Key Words: Single-Shell Tanks, Tank Closure, Tank Fill Alternatives, Gravel Fill, Grout Fill, Concrete Fill

Abstract:

To prepare single-shell tanks for closure, it will be necessary to place some type of load-bearing fill material inside the tanks to support the domes. Provision of internal support permits the simplifying assumption that the combined weight of the dome, the existing operational soil cover, and the surface barrier will eventually transfer to and be carried by the fill. This engineering study provides descriptions and evaluations of four alternative concepts for filling and stabilizing nominally empty SSTs with fill materials. For this study it is assumed that 99 percent (or more) of tank wastes will be retrieved before closure is undertaken. The alternatives are:

Gravel: tanks would be filled with crushed aggregate using a rotating slinger apparatus installed in the central riser.

Grout: tanks would be filled with a pumpable, ex-situ mixed grout formulation.

Hybrid: tanks would be filled first with coarse aggregate, then with grout, producing a pre-placed aggregate concrete material.

Concrete: tanks would be filled with a highly-flowable, ex-situ mixed concrete formulation.

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ENGINEERING STUDY OF TANK-FILL ALTERNATIVES FOR CLOSURE OF SINGLE-SHELL TANKS

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ACRONYMS

ACES	Access Control Entry System
ACI	American Concrete Institute
AGA	Alternatives Generation Analysis
ALARA	as low as reasonably achievable
ALC	air lift circulators
API	American Petroleum Institute
ASTM	American Society for Testing and Materials
BTU	British thermal unit
DOE	U.S. Department of Energy
COE	U.S. Army Corps of Engineers
CPAF	cost plus award fee
CWP	closure work plan
DST	double-shell tank
du Pont	E. I. du Pont de Nemours
HAPO	Hanford Atomic Products Operation
HEPA	high-efficiency particulate air
HLW	high-level waste
HTI	Hanford Tanks Initiative
Ecology	Washington State Department of Ecology
EIS	environmental impact statement
EPA	U.S. Environmental Protection Agency
ICF KH	ICF Kaiser Hanford
ITH	in-tank hardware
ITS	in-tank solidification
LLW	low-level waste
Mgal	million gallons
MYPP	Multi-Year Program Plan
NEPA	*National Environmental Policy Act of 1969*
PUREX	plutonium-uranium extraction
PVC	polyvinyl chloride
REDOX	reduction oxidation
ROD	record of decision
SST	single-shell tank
T	ton
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*
TWRS	Tank Waste Remediation System
WHC	Westinghouse Hanford Company
WAC	Washington Administrative Code

1.0 INTRODUCTION

1.1 BACKGROUND

On January 28, 1994, the U.S. Department of Energy (DOE) announced, via a notice of intent in the *Federal Register* (59 FR 4052), that an environmental impact statement (EIS) would be prepared for disposal of waste in the 149 single-shell tanks (SST), 28 double-shell tanks (DST), 601 strontium fluoride capsules, and 1,328 cesium chloride capsules under the scope of the Tank Waste Remediation System (TWRS). The purpose of the TWRS EIS is to evaluate environmental impacts of reasonable disposal alternatives for the tank wastes and capsules in accordance with the *National Environmental Policy Act of 1969* (NEPA). The TWRS EIS was issued in August 1996 (DOE and Ecology 1996). The EIS evaluates a total of 10 alternatives. The alternatives are as follows:

- No Action--This alternative is identical to the long-term management alternative, except that no new DST construction, transfer of waste from SSTs, or backfilling of SSTs would occur.

- Long-Term Management--New DSTs would be constructed every 50 years. Pumpable liquid waste would be transferred from the SSTs to DSTs. The remaining sludge, salt cake, and interstitial liquids would be left in the SSTs. The SSTs would be backfilled as necessary with basalt gravel to prevent tank dome collapse and subsidence. Contaminated soil sites and tanks would continue to be monitored. Sampling and characterization of the contaminated soil sites would continue. Soil contaminated from tank leaks and spills would be left in place.

- In Situ Fill and Cap--Remaining liquids in SSTs would be removed to the extent practicable by continuation of salt well pumping. SSTs would be filled with basalt gravel to prevent tank dome collapse and subsidence. The remainder of the SST operable unit, including ancillary equipment and contaminated soil, would be closed in accordance with applicable regulations for hazardous chemical and radioactive constituents. A surface barrier and protective marker system would be placed above the SST farms.

- In Situ Vitrification--Remaining liquids in SSTs would be removed to the extent practicable by continuation of salt well pumping. Void space in tanks would be filled with Hanford Site sand, and the residual waste and sand would be immobilized by in situ vitrification. Following vitrification, any void space that might remain in SSTs would be filled with basalt gravel or grout to prevent tank dome collapse and subsidence. The remainder of the SST operable unit, including ancillary equipment and contaminated soil, would be closed in accordance with applicable regulations for hazardous chemical and radioactive constituents. A surface barrier and protective marker system would be placed above the SST farms.

- Ex Situ/In Situ Combination--Two ex situ/in situ alternatives are evaluated in the TWRS EIS. Approximately 30% (in one case) or 50% (in the other case) of tank waste would be retrieved and treated for disposal as in the extensive retrieval alternative. The remaining tank waste would not be retrieved, but would be disposed in place as in the fill and cap alternative. A risk-based approach will be used to determine which tanks fall in each category. Closure of the SST operable units for each category of tanks would be as described above for the ex situ and in situ alternatives.

- Ex Situ Alternatives--Three ex situ disposal alternatives are evaluated in the TWRS EIS. These differ with respect to treatment processes and disposal of treated waste, but do not differ with respect to waste retrieval and closure. For all the ex situ alternatives, as much waste as practicable (nominally 99%) would be retrieved from SSTs and transferred to interim storage in DSTs, or transferred directly to process facilities. The SST operable units, including tanks, residual waste in tanks, ancillary equipment, and contaminated soil would be closed in accordance with appropriate regulations for hazardous chemical and radioactive constituents. A surface protective barrier and marker system would be placed over the SST farms.

- Phased Implementation--Tank waste remediation and tank closure is as described for the ex situ alternatives, but is carried out in two privatization phases. Private companies would construct and operate two facilities for separation and immobilization of low-activity waste and one facility for vitrification of high-level waste (HLW).

A record of decision (ROD) for the TWRS EIS is scheduled to be issued by November 1996.

The TWRS EIS addresses the issues of retrieval and final disposition of Hanford tank wastes. Closure of SST farms also is considered for all the alternatives except no-action disposal to ensure a consistent basis for comparison of all the disposal alternatives. However, alternatives for cleanup, immobilization, or disposal of contaminated soil, ancillary tank farm equipment, residual waste in tanks, and the tanks themselves are not sufficiently developed to permit final decisions on closure configuration and closure technologies in the TWRS EIS. Supplemental NEPA documentation will be prepared as a basis for reaching final decisions on closure.

Tri-Party Agreement Milestone M-45-00 specifies that closure of SST operable units, including contaminated soil and tank farm ancillary equipment, is to be accomplished in accordance with Washington Administrative Code (WAC) regulations and Ecology et al. (1994). Milestone M-45-06, which is an interim milestone, requires submittal of a SST closure work plan (CWP) to serve as a tool for identifying and resolving issues pertaining to closure of SSTs prior to submittal of the actual closure/postclosure plan required by WAC regulations. The purpose of the CWP is to describe the regulatory pathway for closure of SST operable units, define key activities and interfaces, outline the closure strategy, identify major decisions to be made concerning closure configuration, and provide a means for tracking issues resolution. The CWP is to be revised and reissued on a 2-year cycle to reflect the current status of closure strategy and technology and resolution of related issues and uncertainties (DOE-RL 1989).

The *Decision Document for Function 4.2.4 Dispose Waste* provided in Westinghouse Hanford Company [WHC] (1996) addresses immobilization and disposal of tank wastes and closure of the tank farms. Closure options considered included clean closure, landfill closure, and modified closure. Clean closure and modified closure options were eliminated because they are inconsistent with the TWRS EIS and the TWRS planning basis.

1.2 SCOPE OF THIS ENGINEERING STUDY

A number of uncertainties exist regarding the continued structural integrity of the SST and DST domes during postclosure. The duration of the postclosure period for tank farm operable units has not been formally established for performance assessment purposes, but it could extend for 1,000 to 10,000 years. Although concrete has been used in civil construction dating back to the time of the Roman Empire, reliable methods are not available for quantifying aging processes (i.e., chemical alteration and corrosion rates) for steel-reinforced concrete structures over very long time frames.

Extensive documentation is available concerning allowable dome loads for SSTs and DSTs in their current condition (e.g., Ramble 1983). Assuming that engineered surface barriers (such as the Hanford Engineered Surface Barrier) will be constructed over tank farms at closure, it is known that the weight of barrier materials will significantly exceed dome load limits and would almost certainly cause the domes to collapse unless the tanks have been filled with load-bearing materials to support the domes internally and prevent them from failing; therefore, it is essential that some type of load-bearing fill material is provided to prepare tanks for closure. Provision of internal support permits the simplifying assumption that the combined weight of the dome, the existing operational soil cover, and the surface barrier will eventually transfer to and be carried by the fill. Placing load-bearing fill materials in the tanks should also eliminate the need to characterize time-dependent changes in strength of materials within the domes during postclosure.

In the TWRS EIS, the scope of closure consists of filling the 100-Series tanks with crushed aggregate (gravel), filling 200-Series tanks, miscellaneous tanks and ancillary equipment with grout, and constructing engineered surface barriers over SST farms, DST farms, and low-activity waste disposal vaults. No specific effort was made to optimize these activities for the EIS.

This engineering study expands on the treatment of closure in the TWRS EIS by providing descriptions and evaluations of four alternative concepts for filling and stabilizing nominally empty SSTs with load-bearing materials. For this study it is assumed that 99% (or more) of tank wastes will be retrieved before closure is undertaken. The four alternatives are:

- Gravel--Tanks would be filled with crushed aggregate using a rotating slinger apparatus installed in the central riser. (This is the fill method described in the TWRS EIS)

- Grout--Tanks would be filled with a pumpable, ex situ mixed grout formulation

- Hybrid--Tanks first would be filled with coarse aggregate and then with grout, producing a pre-placed aggregate concrete material

- Concrete--Tanks would be filled with a highly-flowable, ex situ mixed concrete formulation.

Conceptual descriptions of the four alternatives are provided in Section 2.0 of this report.

The objective of this study is to evaluate the four tank-fill alternatives according to a set of objective decision criteria, and to document the results for future uses. In *Decision Plan: Filling of the Hanford Site Single-Shell Tanks* (Boothe 1996; Appendix F), the following list of decision criteria was identified:

- Structural performance of fill materials
- Hydrologic performance of fill materials
- Public health risk
- Occupational doses (i.e., worker radiological exposures)
- Comparative dollar costs
- Reversibility.

Structural performance and public health risk will be evaluated by numerical modeling methods and are scheduled as multi-year tasks that will not be complete at the end of FY 1996. Contaminant transport modeling will be carried out as part of the public health risk evaluation to characterize the hydrologic isolation performance of the overall closure system concept. It is presently unknown whether hydrologic performance requirements will need to be assigned to the tank-fill material. It is envisioned that this study will be revised and reissued to summarize the results of these tasks as they are completed.

As indicated in the decision plan (Boothe 1996), the selection of a preferred fill method will be made as one of several final decisions for closure in supplemental NEPA documentation to be developed for the TWRS EIS. It is anticipated that this report will serve as a resource for the NEPA supplement.

As stated in the final TWRS EIS, DOE plans to implement a program, referred to as the Hanford Tanks Initiative (HTI), to gather information and reduce uncertainties associated with tank closure. Information obtained through HTI will be used to establish processes and criteria for evaluating future closure options. The planned scope of HTI includes continued engineering development of tank closure alternatives. A decision process is planned as part of HTI to evaluate tank-fill alternatives as a basis for focusing future engineering development. Results and conclusions from this engineering study will support that process.

1.3 REFERENCES

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Ramble, A. L., 1983, *Single-Shell Waste Tank Load Sensitivity Study*, SD-RE-TI-012, Rev. A-0, Rockwell Hanford Operations, Richland, Washington.

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2.0 DESCRIPTIONS OF ALTERNATIVES

2.1 ALTERNATIVE 1: STABILIZATION OF SSTs WITH CRUSHED AGGREGATE

2.1.1 Process Description

With this alternative (also termed the gravel fill alternative), nominally empty SSTs will be filled (structurally stabilized) with crushed aggregate. The process is an adaptation of commercial materials-handling technology for storage and retrieval of granular solids. The essential equipment components consist of a metering hopper, belt conveyor, and a rotating "rock slinger" apparatus and associated support structure situated in and above the central riser of the tank.

The rock slinger concept was the subject of extensive prototype development activities at Hanford between 1983 and 1985. A centrifugal thrower mechanism was selected for placing and distributing crushed aggregate in SSTs. The specific mechanism used in prototype tests was a 10-in. "swiveloader" manufactured by Stephens-Adamson Mfg. Co. of Aurora, Illinois (see Figure 2-1). The unit provided a material handling capacity of 50 tons (T)/hr for materials with bulk densities of 50 lb/ft^3 or greater. The swiveloader used in prototype testing was equipped with a 5-HP, 3600-rpm drive motor requiring 480-volts alternating current three-phase power. The unit will handle material with a maximum particle size of 3/4 in.

In the prototype arrangement, aggregate was transferred from a stockpile to a metering hopper. An adjustable discharge gate on the hopper could be raised or lowered to control the flowrate of aggregate onto a belt conveyor. The conveyor moved material from the hopper to a bucket elevator that is positioned alongside the centerline of the tank central riser. The bucket elevator was designed to lift and position the aggregate to provide a vertical drop of 20.5 ft. From the bucket elevator, aggregate fell through an extendable fill tube assembly (consisting of 17 ft of 8-in.-diameter pipe and 3.5 ft of transition pieces) suspended in the central riser (see Figure 2-2). Material exiting the fill tube discharged onto the slinger belt. The slinger alters the velocity vector of the aggregate from vertical to near-horizontal.

The filling apparatus is designed to be installed in a 42-in.-diameter riser. The extendable fill tube is functional in risers varying from 4 to 12 ft in length (i.e., maximum extension is 8 ft). The weight of the slinger mechanism is supported by the fill tube assembly. The combined weight of the slinger and the fill tube assembly is carried by a rotating, internal gear bearing at the top of the support structure. A remotely-operated drive motor rotates the slinger. A second remotely operated drive motor, coupled to a ball-screw mechanism, raises or lowers the slinger. The support structure is free-standing and self-supporting. The support structure is designed with manually operated leveling jacks on each leg. The system is designed so that no loads are imposed on the riser (Gilbert and McBeath 1985).

Figure 2-1. Swiveloader, Profile View.
(from Gilbert and Mcbeath, 1985)

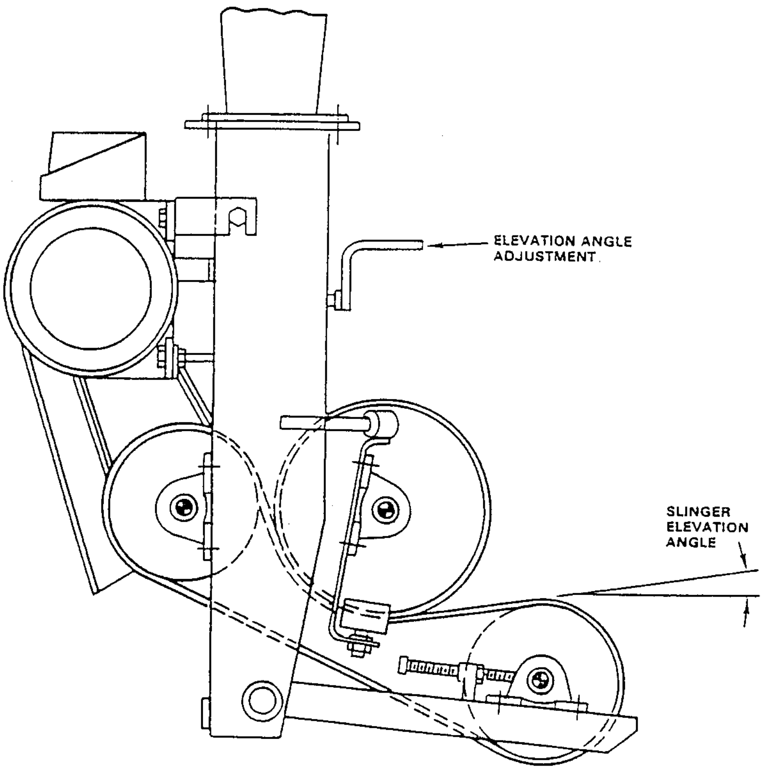
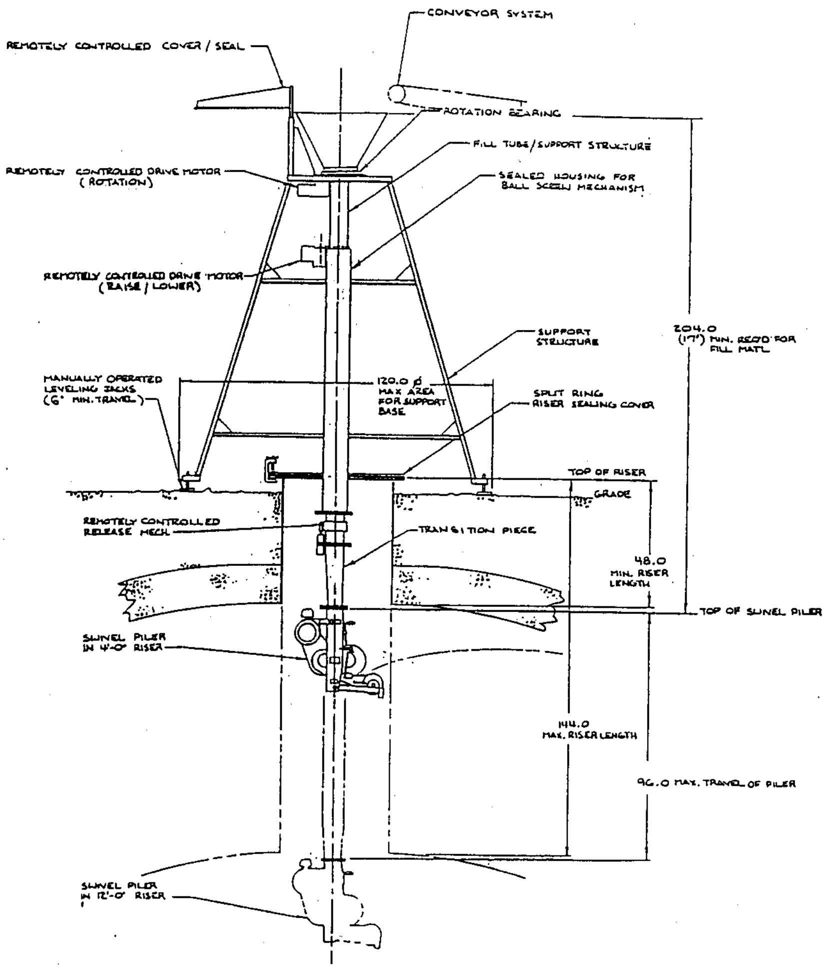


Figure 2-2. Slinger and Support Structure, Illustrating Extension Capability for Installation in Risers of Various Lengths. (from Barker 1985)



Throwing distance and trajectory are a function of the discharge angle and velocity of the slinger belt. The swiveloader's discharge angle can be modified between 0 (horizontal) and 35 degrees (upward). At any given speed, material can be cast further by increasing the discharge angle within the allowable range. In the prototype tests described by Gilbert and McBeath (1985), it was established that 75-ft-diameter tanks could be uniformly and completely filled with crushed aggregate in approximately 100 operating hours, and that the process was readily controllable by varying belt speed and discharge angle within available limits. In particular, the tests showed that aggregate can be placed in uniform close contact with the underside surface of the 100-Series tank domes (i.e., a system of this type is able to completely fill the head space of the tanks). Based on information presented in Table A-1 of Kline et al. (1995), stabilization of SSTs and DSTs would require about 1 million yd^3 (or about 762,000 m^3) of crushed aggregate fill material.

From the prototype testing conducted in 1983 through 1985, a significant amount of useful information is available relating to wear characteristics of the system (Gilbert and McBeath 1985). Abrasion of the slinger belt was a specific concern in the prototype tests. A tank can be filled with aggregate in approximately 100 operating hours, which dictates that belt life should be 100 hours or more. More frequent belt changes could involve radiological exposures to maintenance personnel. Belt speed is variable. When the slinger was operated at 73 ft/sec, severe abrasion of the belt was observed (belt failure occurred after 17 hours of operation). However, abrasion was significantly reduced at lower speeds. Minimal belt wear is achieved when the speed of the belt is set equal to the arrival velocity of the aggregate (approximately 36 ft/sec). Based on the prototype experience, a change to another belt material was recommended, such as a pure gum rubber belt.

The transition sections of the fill tube assembly were another high-wear area of the prototype system. Testing showed that a shallow transition angle was necessary and the components should be fabricated of abrasion-resistant steel. Experience also showed that hopper surfaces should be lined with materials such as ultra-high molecular weight plastics to protect them from abrasion, and that rugged-service belt splices should be used.

2.1.2 Preparation for Fill Emplacement

Prototype testing conducted in 1984 and 1985 established the basic workability of the gravel fill concept. However, it was established in these early tests that "shadowing" effects in fill placement would be created by in-tank hardware (ITH). When aggregate is broadcast into the tank by the slinger mechanism, it ricochets off ITH items, creating a shadow region behind each item. In the shadow regions, the density of the fill ultimately will be lower and filling may be incomplete relative to unobstructed areas. It is likely that small-diameter items would be destroyed by the abrasive action of the gravel within a short time after filling is initiated. Large-diameter items could persist for some time as obstacles to uniform filling of tanks. This issue is significant because it would create non-uniform structural properties in the fill that would be difficult to evaluate.

Large-diameter ITH may have to be disassembled and lowered to the bottom of each tank to ensure that tanks are uniformly and completely filled. For estimating purposes, it is assumed that large-diameter hardware items (defined as greater than 4 in.) can be cut off and lowered to the floor of the tank. It is expected that small-diameter ITH (4 in. and smaller) would quickly be abraded by the aggregate during the fill process and be incorporated into the fill without the need to undertake separate efforts to cut them off. An inventory of large-diameter ITH in SSTs is included in this report as Appendix B.

The swiveloader mechanism is designed to be installed in 100-Series tanks through a 42-in.-diameter central riser. Many 100-Series tanks are not equipped with a 42-in.-diameter central riser. Some tanks were constructed with no central riser access and other tanks have central risers with diameters less than 42 in. There are also cases where tanks have large-diameter risers (up to and including 42-in.) that are not centrally positioned. Riser conditions were summarized by Krieg et al. (1990) (refer to Appendix C of this report). From this assessment, it appears that 64 new 42-in.-diameter risers would have to be constructed in 100-Series SSTs if the gravel fill alternative is selected.

2.1.3 Fill Material

The specified fill material for this alternative is a well-graded crushed aggregate consisting of particle sizes ranging from 3/8 to 3/4 in. Basalt aggregate was used in prototype testing (McKenney 1983). The current concept calls for aggregate to be excavated, crushed, and screened at Pit 30, an onsite borrow located midway between the 200 East Area and 200 West Area. Borrow material from Pit 30 consists of coarse sand, pebbles, and cobbles. A crushed aggregate stockpile will be located outside and adjacent to the perimeter of individual tank farms undergoing closure. The stockpile will be sized to contain sufficient material to completely fill two 100-Series tanks.

2.1.4 Tank Ventilation

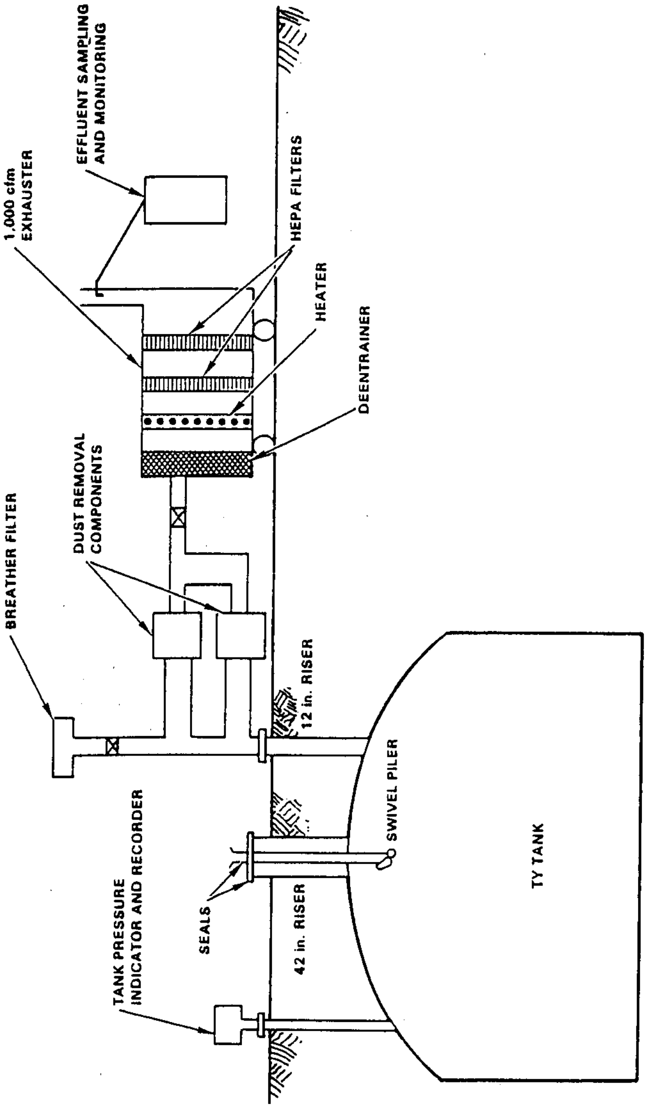
The fill operation will displace vapor from the tank head space and may dislodge contaminants from the tank walls and internals. A high-efficiency particulate air (HEPA) filtration system will be used to minimize radiological emissions. The ventilation concept is based on the 1,000-ft^3/min portable exhausters that are currently used in support of tank farms operations. The HEPA filter(s) will be connected to one riser and will be operated in exhaust mode (i.e., head space pressure will be maintained slightly below ambient atmospheric pressure during the filling operation). A preliminary assessment of particulate emissions for the gravel fill alternative indicated that several pounds of dust would be generated per operating hour (Flyckt 1985). The HEPA filters on the 1,000-ft^3/min exhauster units must be replaced when they accumulate approximately 4 lb of dust. The assessment concluded that some type of prefiltering would be required ahead of the HEPA filters to minimize filter changeouts. Cyclones are included in the ventilation concept for this alternative to control particulates (see Figure 2-3).

2.2 ALTERNATIVE 2: STABILIZATION OF SSTs WITH GROUT

2.2.1 Process Description

Nominally empty SSTs will be filled with grout. The process is an adaptation of methods that are commonly used in mining and civil construction. Grout pipes will be installed in each tank through existing riser penetrations. Grout will be mixed in a portable batch plant set up in close proximity to the tank farm undergoing closure and pumped to individual tanks. Depending on flowability properties of the grout and the number of grout pipes required per tank, a manifold on the pumpline could be used to distribute grout to multiple grout pipes within a single tank.

Figure 2-3. Ventilation Concept to Support Aggregate Fill Option.
(from Flyckt 1985)



Grout will be placed in lifts. A self-leveling cementitious grout formulation will be employed. Because hydration of cement is an exothermic chemical process, grouting in lifts probably will be necessary to limit temperatures and thermal strains within the grout as it cures. The maximum design thickness of individual lifts is dependent on the heat of hydration property for a specified formulation. Lift thickness is to be determined.

The principal dry constituents of grout are sand, cement, and fly ash. For planning and estimating purposes, it is assumed that sand would be produced at Pit 30; cement would be transported to the site by railcar from Durkee, Oregon; and fly ash would be brought in by railcar from Centralia, Washington. Dry storage will be required for cement and fly ash for protection from precipitation and wind dispersion. Depending on the supplier and procurement terms and conditions, bulk storage could either be onsite or offsite. The largest manufacturer and retailer of cement in the Pacific Northwest, Lafarge, has a bulk storage terminal in Pasco, Washington. If cement is purchased from Lafarge, storage requirements could be supported by the Pasco facility with truck delivery of day-use quantities to the Hanford Site. Drop trailers (also known as "guppies") could be delivered and picked up as needed, eliminating the need for onsite cement storage silos. A guppy with a capacity of 4,100 ft^3 is illustrated in Figure 2-4. Fly ash could also be brought in from Centralia by truck rather than rail, in which case the need for storage silos could be eliminated entirely. As an alternative arrangement, bulk dry materials (i.e., cement, fly ash, and bentonite) could be supplied in a pre-mixed form. Dedicated storage for this product could be provided in Pasco. The pre-mixed product would not include sand. The onsite production cost for sand is estimated at $8/ton. Unit costs for materials (based on informal vendor quotes) are identified in Table 2-1.

In Kline et al. (1995), the grout alternative was described as including a central dry materials batch plant for receiving, storage, and mixing of dry materials in correct proportions. Per the original concept, dry mix would be transported by truck to grout plants in the 200 East and 200 West areas as needed. At the grout plants, dry mix would be combined with water and liquid additives, then pumped to individual points of use. The dry mix batch plant was estimated to cost approximately $100,000. Based on updated vendor information, it appears that a separate plant for storage and mixing dry materials is not essential.

Vendors indicate that a portable grout mix plant with a throughput capacity of 150 yd^3/hr (115 m^3/hr) will cost approximately $415,000 (versus an earlier estimate of $500,000 by Kline et al. 1995). The plant configuration would include computerized batch controls, scales, a dust collection system, silos for cement and fly ash, an aggregate bin, a water heater for cold-weather operation, a 10-yd^3 capacity mixer, and a holding hopper (see Figure 2-5). A concrete pump capable of delivering 150 yd^3/hr through 600 ft of 5-in. pumpline will cost approximately $250,000. The pumpline represents an additional cost of $15,000 (replacement interval - once per 100,000 to 200,000 yd^3). Based on information presented in Table A-1 of Kline et al. (1995), stabilization of SSTs would require about 744,000 yd^3 (or about 569,000 m^3) of grout to be mixed, pumped, and placed. This quantity does not include grout for stabilizing ancillary equipment.

2.2.2 Preparation for Fill Emplacement

ITH is not an impediment to filling tanks with grout. Grout may not be able to enter and fill certain hardware items in conjunction with the overall tank-fill operation. For these items, separate efforts would be undertaken to inject grout to fill internal voids in ITH items through existing riser penetrations. No 42-in. risers would have to be constructed to implement this alternative.

Figure 2-4. Typical Storage Tank for Cementitious Materials.
(from Fruehauf Trailer Corp.)

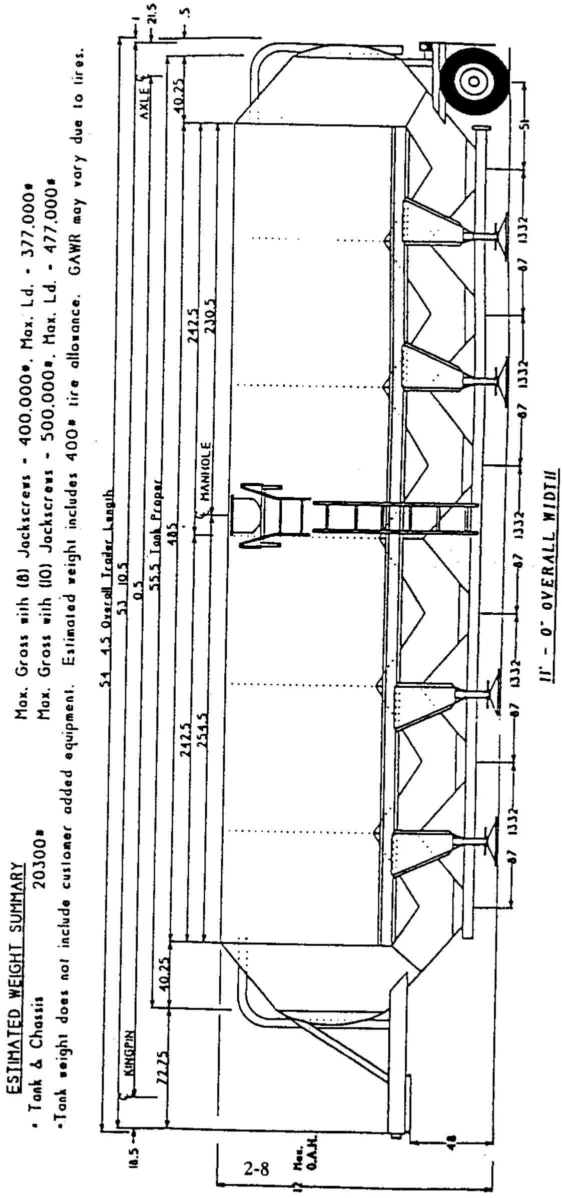


Table 2-1. Cold-Cap Grout Formulation.

Material	Proportion	Cost
API Class H Cement	300 lb/yd^3	$83.00/T
ASTM Class F Fly Ash	1,112 lb/yd^3	$48.60/T
Natural Fine Aggregate (100% passing No. 8 sieve)	1,314 lb/yd^3	$8.00/T
Sodium Bentonite Clay	38 lb/yd^3	$110.00/T
Water	564 lb/yd^3	N/A
High-Range Water-Reducing Admixture (DAXAD19[a])	4.5 oz/yd^3	$5.00/gal

[a]Trademark of W. R. Grace.
API = American Petroleum Institute.
ASTM = American Society for Testing and Materials.

Many of the older SSTs were laid out in cascades. If the grout fill alternative is implemented, it would be necessary to prevent grout from flowing from a tank undergoing closure through an overflow line to an adjacent tank that is not prepared for closure. From drawings, it appears that many or most overflow lines are constructed of 6-in. Schedule 80 carbon-steel pipe. For estimating purposes, it is assumed that overflow lines will be exposed in separate excavations, and a hydraulic crimping tool (e.g., a "jaws of life" apparatus) would be used to pinch them shut.

2.2.3 Fill Material

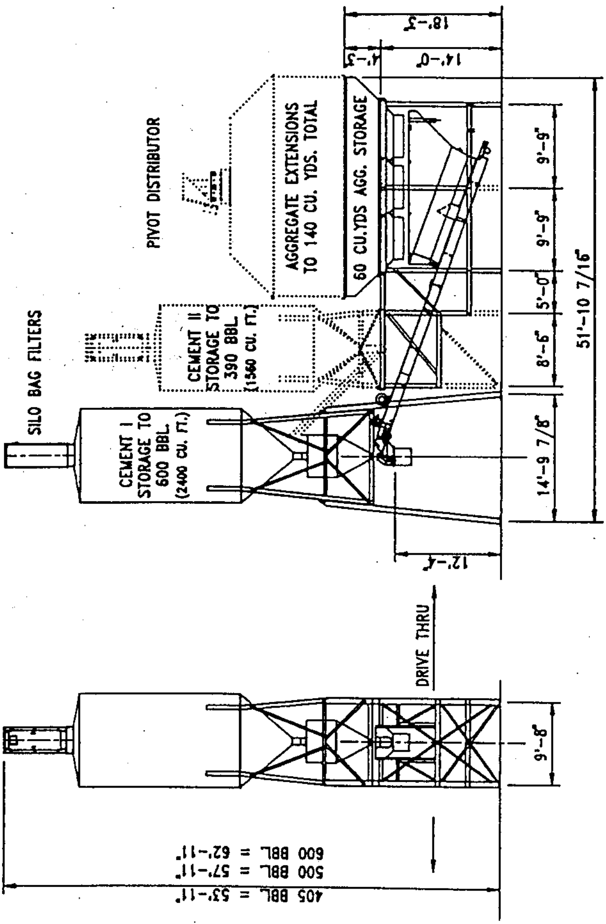
For purposes of concept development, it is assumed that the "cold-cap" (void fill) grout formulation developed by the U.S. Army Corps of Engineers (COE) for the Hanford Grout Vault Program will also be appropriate for stabilizing SSTs and DSTs. The following information is excerpted from COE's technical report on development and testing of cold-cap grout (Wakeley and Ernzen 1992).

Performance requirements for the cold-cap grout were divided into three general categories:

(1) Pumping and placement properties: The grout must be capable of flowing at least 14 ft radially away from each entry point, it must be self-leveling and nonsegregating, and remain pumpable for up to 2 hr after mixing. COE determined that 15- to 18-sec flow times would be required to meet these requirements.

(2) Properties of unhardened grout after placement: The grout must not evolve free water between placement and final set. Free water would have the potential for mobilizing contaminants.

Figure 2-5. Typical Configuration of a Portable Batch Plant with a 150 to 200 yd^3/hr Capacity Rating.



(3) Properties of hardened grout: The grout was required to attain an unconfined compressive strength of 400 $lb/in.^2$ at 28 days. Shrinkage was limited to 0.1%; no expansion was permitted. Limits on temperature rise were specified.
Materials, proportions, and unit costs for cold-cap grout are listed in Table 2-1.

American Petroleum Institute (API) Class H oil-well cement was specified because of its coarse particle size and relatively low rate of heat evolution. Aside from coarseness, Class H cement is chemically similar to Portland Type II and V cements. The chemical composition of Class H cement is given in Table 1 of Wakeley and Ernzen (1992). Composition limits for various types of Portland cement are identified in American Society for Testing and Materials (ASTM) C 150 (ASTM 1995). The low alumina content of Class H cement should provide resistance to sulfates (which are significant constituents in tank waste). ASTM Class F fly ash (a low-calcium ash) was selected over Class C ash for its improved resistance to sulfate attack and reduced early-age heat generation. Wakeley and Ernzen (1992) indicated that Class F fly ash also has beneficial effects on workability, and should enhance chemical stability and leach resistance.

Because sand makes up a significant proportion of the grout volume, volumetric stability of the grout at elevated temperatures is highly dependent on the coefficient of thermal expansion of the sand, which tends to counteract shrinkage of the cement paste as it dries. Local sand that is 100% finer than the No. 8 sieve was specified, principally to enhance flowability of the grout.

Sodium bentonite is included in the formulation to aid pumpability, reduce segregation, and eliminate bleeding. For durability, the weight ratio of water:cementitious materials (i.e., cement and fly ash) in the formulation was limited to 0.4. These proportions necessitate the inclusion of a high-range water-reducing admixture and a set retarder to obtain the required flow properties over the 2-hr time period specified for cold-cap grout. DAXAD19 is a naphthalene-based product marketed by W. R. Grace. The cold-cap grout mix design also included a set retarder (Plastiment). Plastiment is a hydroxylated carboxylic acid salt marketed by Sika Corporation. The set retarder probably would not be required for the tank-fill application.

In general, the cold-cap formulation appears to provide a reasonable initial representation for tank-fill grout. However, for the tank-fill application, the principal attribute of the grout will be its load-bearing capability (strength and stiffness). Tank-fill grout must have adequate strength in compression and shear to prevent fracture under the anticipated loading conditions. The maximum anticipated loading condition can be characterized as follows, assuming that the tank fill eventually will support the full weight of the dome and superimposed soil materials:

Hanford Surface Barrier:	1,800 lb/ft^2
Cover soil: 10 ft @ 100 lb/ft^3:	1,000 lb/ft^2
Tank dome: 1 ft thick @ 150 lb/ft^3:	150 lb/ft^2
Grout fill: 48 ft* @ 140 lb/ft^3:	6,720 lb/ft^2
	9,670 $lb/ft^2/144$ = 67 $lb/in.^2$

* Fill thicknesses for 100-Series tanks vary from a minimum of about 30 ft to a maximum of 48 ft (for DSTs).

For most materials used in structural support applications, this would be regarded as a relatively modest loading condition. However, the grout for the tank-fill application must also be sufficiently stiff that differential surface deflections can be maintained within acceptable limits (currently limited to 6 in. based on the thickness of the low-permeability asphalt layer of the Hanford Engineered Surface Barrier). Based on these considerations, the tank-fill application does not call for a high-strength grout, but it may require a relatively high-modulus material (i.e., grout with a high stress:strain ratio). The modulus requirement is to be determined; bounding values are to be developed by structural numerical modeling.

Tank-fill grout should exhibit a relatively low heat of hydration, as this property directly affects the maximum allowable thickness of individual lifts that can be placed. Additional information from laboratory tests is required to evaluate the adequacy of the cold-cap formulation with respect to this criterion.

A formulation is desired that will evolve little or no free water during curing. Bleed water is undesirable because it creates micro-channels in cement as it is expelled and may weaken the surface layer of each lift (leading to increased permeability). Free water inside the tanks could potentially mobilize residual waste. Cold-cap grout performs adequately in this regard because no bleed water is released.

For the tank-fill application, grout should be free flowing and self leveling to the maximum practical extent. This attribute is controlled by the water:cement ratio, and by additives (e.g., specified fly ash and bentonite clay) that make the material "slicker." Fluidity of cementitious grout mixtures is determined by flow test methods (see ASTM C 939 (ASTM 1994); ASTM C 230 [ASTM 1990]). For 100-Series tanks, flow would be optimal if grout could be placed successfully from a single grout pipe located in the central riser. The cold-cap grout does not appear to satisfy this objective, but probably can be modified to do so.

The cold-cap grout is essentially volume neutral (i.e., free of shrinkage or swelling during curing), which is desirable for the tank-fill application. Appreciable shrinkage would be undesirable because shrinkage could create apertures along the inside surfaces of the tank and/or at lift interfaces that would constitute "preferential pathways" in performance assessment considerations. Ideally, the tank-fill grout should also form a strong, adhesive bond with the tank wall, bottom, and dome. Performance of cold-cap grout in this regard is unknown. There is a type of cement that swells as it cures. Such a material may be useful for placing the final grout lift(s) under the tank dome; moderate, controlled swelling could stress relieve the domes for extended integrity during postclosure.

Tank-fill grout should exhibit resistance to chemical and radiological deterioration to the maximum practical extent. Chemical deterioration of cement generally is traceable to adverse reactions between alkalies in cement (Na_2O and K_2O) and reactive minerals in the aggregate, or to contact with acids and/or sulfate salts. The pH of tank waste is uniformly alkaline, so acid degradation is not anticipated. However, sulfate is a prominent tank waste constituent. Sulfate reaction can be minimized by specifying API Class H or Type V Portland cement, which are low in alumina, the constituent of cement that reacts with sulfate.

Depending on the results of contaminant fate and transport modeling, a hydraulic performance requirement may need to be applied to tank-fill materials. However, no limiting permeability requirement or specification has been assigned at the present time.

2.2.4 Tank Ventilation

The fill operation will displace vapor from the tank head space and could result in suspension of particulates. Therefore, a HEPA filtration system will be used to control radiological emissions. HEPA filter(s) will be connected to one riser and operated in exhaust mode (i.e., head space pressure will be maintained slightly below ambient atmospheric pressure during the grouting operation). This function could be performed with the 1,000-ft^3/min exhausters currently used in conjunction with tank farms maintenance operations. This system is essentially the same as the one proposed for the gravel fill alternative minus the cyclones.

2.3 ALTERNATIVE 3: STABILIZATION OF SSTs WITH GROUT AND UNCRUSHED AGGREGATE

(Also Termed the "Hybrid" or Pre-Placed Aggregate Concrete Alternative)

2.3.1 Process Description

Tanks will be stabilized by (1) filling the tank volume with coarse, uncrushed aggregate, and then (2) injecting grout into the void volume within the aggregate to create a stiff, low-permeability matrix of pre-placed aggregate concrete. Any waste remaining in tanks after retrieval will be effectively immobilized by the grout. The aggregate used in this alternative will consist of coarse, uncrushed river gravels (i.e., rounded aggregate). Aggregate will be screened at the borrow site to eliminate under- and over-size material. Aggregate will not be crushed because angular material tends to achieve greater placement density (i.e., lower void volume and permeability) than material made up of rounded particles of similar size and shape. Maintaining a large, interconnected void volume within the aggregate will facilitate complete void filling with grout.

Aggregate fill material will be produced from an existing borrow site (Pit 30) situated between 200 East and 200 West areas. The aggregate will be screened (and washed as necessary) to eliminate minus 1/2-in. material (refer to Coarse Aggregate Grading 2 in Table 1 of American Concrete Institute [ACI] 304.1R [ACI 1992]). The aggregate also will be scalped to remove cobbles exceeding a specified maximum size (tentatively identified as 3 1/2 in.). The maximum size ultimately will be determined based on the largest size that can be accommodated by placement equipment.

A slinger mechanism similar to the one developed for the "gravel fill" alternative may be used. However, the mechanism tested at Hanford (Gilbert and McBeath 1985) for gravel fill is limited to applications involving smaller particles (i.e., 3/4 in. minus). With the larger particle size aggregate identified for this alternative, excessive mechanical abrasion and belt wear are predictable consequences. Off-the-shelf slinger units that can handle larger particle sizes are too large to be installed in a 42-in.-diameter riser. Consequently, it is likely that an alternate mechanical concept for aggregate placement (perhaps one developed for use in conjunction with a Heavy-Duty Utility Arm) would have to be devised.

For this alternative, there is no need to achieve a specified fill density or degree of compaction during placement of the aggregate. For estimating purposes, it is assumed that aggregate will fill about 55% of the tank void volume (i.e., volume of solids = 0.55; volume of voids (porosity) = 0.45). Maintaining a low relative density within the aggregate should facilitate placement of grout pipes.

Grout pipes will be placed vertically into the aggregate fill through existing risers and supplemental penetrations through the dome drilled as required to achieve a predetermined spacing/arrangement. The pipes will be steel pipe/tube with sleeve ports located at 10-ft intervals for injecting grout. The grout pipe design would enable grouting to be performed in lifts if necessary. Grout pipes will be vibrated into place using resonant sonic drilling equipment. Commercially available sleeve-port pipe for grouting is polyvinyl chloride (PVC) (Figure 2-6). There is no known commercial source of steel sleeve-port pipe suitable for emplacement by resonant sonic drilling equipment; consequently, grout pipes will have to be fabricated. Grout pipe spacing is to be determined; spacing will be based on flowability of the specified grout formulation. For 100-Series tanks, a 10-ft radius of influence would require installing 22 grout pipes; a 15-ft radius would require 12 pipes; a 20-ft radius would require placing only six pipes.

The grout formulation is to be determined. Two candidate formulations have been identified that were developed for other applications. One is the cold-cap grout designed by COE for the Grout Vault Project at Hanford (see Table 2-1). The other candidate is the "saltstone" grout developed for disposal of liquid waste residuals from the Savannah River site's vitrification process. The liquid waste stream is below regulated levels with respect to radionuclides, but does contain elevated nitrate. Saltstone grout was formulated to achieve acceptably low leach rates for nitrate and any other regulated hazardous constituents present.

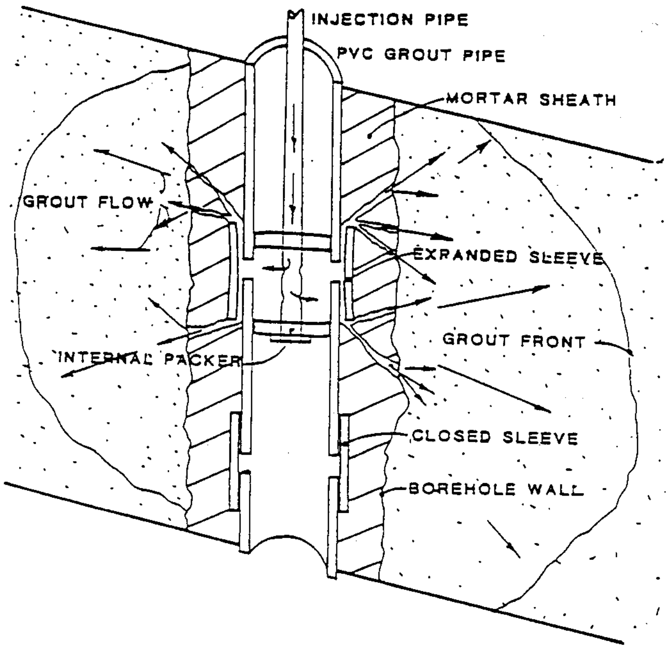
Grout will be placed through sleeve-port pipes in stages beginning with the ports situated closest to the bottom of the tank. The lowest port interval will be packed off in each sleeve-port pipe in the array. Grout will be distributed to all pipes in the array by a manifold arrangement on the pumpline. The grout will be pumped from the packed-off interval out into the aggregate medium. Depending on the pumping rate and the properties of the formulation, it may be necessary to emplace the grout in lifts (of perhaps 5 to 10 ft) to facilitate curing (i.e., to dissipate heat of hydration). This alternative will be supported by the same type of grout mix plant described for the grout fill alternative.

As in other alternatives, stabilization of SSTs will require placing about 744,000 yd^3 (or about 569,000 m^3) of fill material (Table A-1; Kline et al. [1995]). For estimating purposes, it was assumed that approximately 55% of this quantity would be aggregate and 45% would be grout (by volumes).

2.3.2 Preparation for Fill Emplacement

With this alternative, uniform placement of coarse aggregate throughout the tank interior is not essential. Creation of "shadowing" effects by ITH items is not a significant issue because grouting will tend to minimize the structural consequences of inhomogeneities in void volume within the aggregate matrix. Large-diameter ITH would not have to be removed to implement this alternative.

Figure 2-6. Sleeve-port Grout Pipe.



The mechanism employed for distributing aggregate within the tanks will require access through a large-diameter central riser. For estimating purposes, it is assumed that 64 additional 42-in.-diameter risers would have to be constructed in 100-Series SSTs for the hybrid fill alternative (the same number required for the gravel fill alternative). Tanks that would require these riser modifications are listed in Appendix C.

As indicated for the grout fill alternative, it would be necessary to prevent grout from flowing from a tank undergoing closure through an overflow line to an adjacent tank. For estimating purposes, it is assumed that overflow lines will be exposed and a hydraulic crimping tool would be used to pinch them shut.

Grout may not be able to enter and fill certain ITH items in conjunction with the overall tank-fill operation. For these items, separate efforts would be undertaken to inject grout into ITH items through existing riser penetrations.

2.3.3 Fill Material

Tentatively, the gravel fill material is identified as a uniform-graded, uncrushed aggregate consisting of particle sizes ranging from 1/2 to 3 1/2 in. Aggregate is to be excavated and screened at Pit 30. Aggregate will be stockpiled outside and adjacent to the perimeter of the individual tank farm undergoing closure. The stockpile will be sized to hold sufficient material to completely fill two 100-Series tanks in the farm. The grout formulation is to be determined. For estimating purposes, it was assumed that the same grout mix design (COE's cold-cap grout) described under alternative 2 (Section 2.2) would be used.

2.3.4 Tank Ventilation

As with the alternatives described previously, a HEPA filtration system will be used to limit radiological emissions. During the portion of the operation that involves placing coarse aggregate fill in the tanks, elevated levels of particulate emissions are expected. The same type of ventilation scheme proposed for the gravel fill alternative, consisting of HEPA filters with cyclone prefilters, would be used for this alternative (see Figure 2-3).

2.4 ALTERNATIVE 4: STABILIZATION OF SSTs WITH CONCRETE

2.4.1 Process Description

By this alternative, nominally empty SSTs and DSTs will be filled (stabilized) with a highly flowable concrete formulation. This fill method is an application of recent developments in civil construction for placing concrete into formed sections of structures with dense steel reinforcement.

A portable concrete batch plant will be set up outside the tank farm perimeter close enough to the tanks undergoing closure that concrete can be pumped directly to the tanks. The pumpline will extend to the central riser of the tank where it will be connected to a 5-in. hard rubber or PVC tremie pipe suspended in the central riser. The tremie pipe will be positioned so that free fall is limited to 5 ft or less (as recommended by the ACI).

The concrete formulation under consideration includes both a super-plasticizer and a rheological modifier. Superplasticizers sorb onto the surfaces of cement particles and act as dispersing agents. This action contributes to enhanced flowability and workability and reduced water content of the cement paste. However, superplasticizers can also induce excessive bleed water formation and particle segregation. Rheological modifiers, (water-soluble polymers), when added in small concentrations, can dramatically alter the viscosity of cement paste. A properly proportioned cement-based system that includes a superplasticizer and a water-soluble polymer provides greatly enhanced flowability and eliminates the undesirable effects observed when the superplasticizer is used alone.

As with the grout fill alternative, concrete will be placed in lifts. Because hydration of cement is an exothermic chemical process, placement in lifts is necessary to control temperatures and thermal strains within the concrete as it cures. The maximum design thickness of individual lifts is dependent on the heat of hydration property for a specified concrete mix design. Lift thickness is to be determined.

As indicated in Table 2-2, the principal dry constituents of high-flow concrete are cement, fly ash, sand, and coarse aggregate. For planning and estimating purposes, it is assumed that coarse and fine aggregate materials will be excavated and screened at Pit 30; cement will be transported to the Hanford Site by rail from Durkee, Oregon; and fly ash will be brought by rail from Centralia, Washington. Dry materials storage will be required for the cement and fly ash to protect them from precipitation and wind dispersion.

Depending on the supplier and procurement terms and conditions, bulk storage could either be onsite or offsite. The largest supplier of cement in the Pacific Northwest, Lafarge, has a bulk storage terminal in Pasco, Washington. If cement is purchased from Lafarge, storage requirements could be supported by the Pasco facility with truck delivery of day-use quantities to the Hanford Site in guppies. Fly ash might also be trucked from Centralia in guppies, as opposed to rail delivery. Lafarge could also provide cement and fly ash as a pre-mixed material. Dedicated storage for this product would be available in Pasco. The mixture would not include sand or coarse aggregate. Unit costs for materials (based on informal vendor quotes) are listed in Table 2-2.

A portable batch plant with a throughput capacity of 150 yd^3/hr (115 m^3/hr) will cost approximately $415,000. The plant includes computerized batch controls, dust collection system, silos for cement and fly ash, an aggregate bin, a water heater for cold-weather operation, a 10-yd^3 capacity mixer, and a holding hopper. This is essentially the same plant described for the grout alternative. For this application, the aggregate bin would be reconfigured to store and dispense both sand and aggregate. A concrete pump capable of delivering 150 yd^3/hr through 600 ft of 5-in. pumpline costs approximately $250,000. The pumpline represents an additional cost of $15,000 (replacement interval - once per 100,000 to 200,000 yd^3). Based on information presented in Table A-1 of Kline et al. (1995), stabilization of SSTs and DSTs would require about 744,000 yd^3 (or about 569,000 m^3) of concrete to be mixed, pumped, and placed.

Table 2-2. High-Flowability Concrete Formulation, Initial Mix Design.

Material	Proportion	Cost
Type II Portland Cement	557 lb/yd^3	$55.00/T
ASTM Class F Fly Ash	363 lb/yd^3	$48.60/T
Natural Fine Aggregate (100% passing No. 8 sieve)	1,194 lb/yd^3	$8.00/T
Natural Coarse Aggregate (3/4-in. Nominal Size)	1,472 lb/yd^3	$10.00/T
Water	294 lb/yd^3	N/A
Superplasticizer (High-Range Water-Reducing Admixture - DAXAD19)	18.5 oz/yd^3	$5.00/gal
Rheological Modifier (Welan Gum)	0.6 lb/yd^3	$7.40/lb

2.4.2 Preparation for Fill Emplacement

As for the grout fill alternative described previously, individual 100-Series SSTs will be prepared for filling with concrete by isolating all piping connections (overflow lines) to/from adjacent tanks. For estimating purposes, it was assumed that this would be accomplished by excavating to expose the line midway between tanks and then using a hydraulic crimping tool to crimp it shut. No riser modifications to tanks are required for this alternative. ITH does not need to be removed. The properties of high-flow concrete (i.e., low viscosity, low water content, minimal particle segregation) are well suited to filling tanks with congested ITH that could constitute a significant implementation issue for some other tank-fill alternatives. This type of concrete will easily surround and encapsulate any hardware items remaining in SSTs at closure. Grout would be injected into ITH items through existing riser penetrations.

2.4.3 Fill Material

Performance requirements for high-flow tank-fill concrete can be described in terms of the same general categories outlined for grout:

(1) Pumping and placement properties: The concrete must be readily pumpable into tanks through a 5-in. pumpline and tremie pipe. The concrete formulation should be capable of flowing at least 37.5 ft radially away from the entry point and should be self-leveling and nonsegregating. Maximum free fall from the tremie pipe will be limited to 5 ft to deter particle segregation.

(2) Properties of unhardened concrete after placement: The concrete formulation must not evolve free water between placement and final set. Free water would have the potential for mobilizing contaminants.

(3) Properties of hardened concrete: The concrete should develop minimal heat rise to minimize thermal shrinkage and cracking. Shrinkage should be limited to 0.1%; no expansion should be permitted. Limits on temperature rise due to heat of hydration will be specified. Specifications (materials and proportions) for high-flowability concrete are listed in Table 2-2.

Various measures have been recommended for consideration to limit heat of hydration. Type II (or IV) Portland cement is recommended for this application because of its low alumina content. Another approach to limiting heat rise would be to reduce the amount of cement (with a corresponding increase in fly ash content) in the mix design. The concrete formulation provided in Table 2-2 should be readily able to achieve 28-day compressive strength values of 3,000 $lb/in.^2$ or more. Reduced strength (and reduced modulus of elasticity) would be tolerable if a significant reduction in heat of hydration could be achieved. Lowering the cement content also would tend to reduce drying shrinkage. Replacing a portion of the cement in the formulation with an active fly ash also improves the pumping and placement properties of the concrete and may enhance cohesiveness and strength. The addition of fly ash generally is beneficial in reducing the water demand in the mix design, which is reflected in reduced "bleeding" during curing. By replacing 20% of the cement in the formulation with fly ash, heat rise could be reduced by as much as 20°F. Greater heat reduction is achievable with Class F fly ash compared to Class C.

Another recommendation is to minimize the temperature of the fresh concrete at the batch plant by adding shaved ice to the mix water at the batch plant. When ice is used, mixing should be continued until the ice is completely melted. A side benefit of casting concrete at cold temperatures is that fluidity is improved for a given water content, or that a predetermined consistency can be achieved at a reduced water content. A plant to produce shaved ice at a rate that is compatible with the concrete batch plant would cost approximately $350,000. (This cost was not included in the estimate for this alternative reported in Section 6.0.)

The coarse aggregate in the mix design will be limited to 3/4-in. nominal size to ensure that the mix will be easy to pump through 5-in. piping. Rounded (rather than crushed) aggregate is recommended for enhanced workability and reduced water demand. It may be practical to increase the weight fraction of either the fine or the coarse aggregate in the final mix design over the proportions listed in Table 2-2.

2.4.4 Tank Ventilation

The concrete fill operation will displace vapor from the tank. Radioactive particulates could become suspended in the head space during the fill operation. The same type of HEPA filtration system described for the grout fill alternative (Section 2.2.3) would be used for concrete fill.

2.5 REFERENCES

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3.0 HYDRAULIC RESPONSE ANALYSIS OF ALTERNATIVE TANK-FILL MATERIALS

The focus of this section is to compare the hydraulic responses of alternative materials being considered for filling cleaned-out SSTs to prevent tank dome collapse and surface subsidence. Preexisting tank leaks were considered to be outside the scope of this analysis. The hydraulic as well as structural performance of the backfill is an important consideration in selecting a preferred material. Hydraulic response of the backfill affects the ingress and egress of moisture in the tank. Consequently, it affects the potential for long-term migration of residual contamination from the tank and surrounding soil.

The migration of contamination is directly related to the public health risk. Contaminant migration will be analyzed later using transport simulations that include flow results, residual source terms, adsorption, and dispersion. Public health risk then can be evaluated using slope factors for carcinogens and hazard quotients for noncarcinogens.

3.1 OBJECTIVE

The objective of the analysis was to determine the effect of the hydraulic properties of alternative backfill materials on potential movement to the water table of residual contaminants on the tank's inner surface. The geometry of the model domain, the mesh used for discretization of the spatial domain, and values of input parameters are briefly discussed to provide the perspective essential for understanding the results of the numerical simulations. Details on geometry, mesh, and input parameters are provided in Collard and Davis (1996).

PORFLOW (Copyrighted by Analytic and Computational Research, Inc.) technical software (Runchal and Sagar 1992) was used for the simulations. PORFLOW relies on numerical solution of a matrix of complex mathematical equations and has a lengthy history of application at the Hanford Site. In addition, PORFLOW has an extensive bibliography of peer reviews, long-term use by the DOE and industry, and widespread acceptance by regulatory agencies.

Steady-state flow fields were calculated for each backfill material. Analyses were made to compare the hydraulic performance of alternative backfill materials with respect to a common baseline. Two measures of hydraulic performance were used: (1) travel time and (2) flux density (the ratio of the rate of flow through a specified surface area to that surface area). Determinations were made of travel times on particles of water released from the inner surface of a tank and flux densities through the base of a tank.

In conjunction with the baseline analyses, sensitivity analyses were used to assess the relative impacts of changes in input values. Sensitivities of results were analyzed relative to changes in the hydraulic conductivity of tank shell concrete and the effects of constructing a low-infiltration cover over a tank.

3.2 INPUT PARAMETERS

Input parameters for the simulations can be grouped into four categories:

- Geometry

- Material properties
- Boundary conditions
- Initial conditions.

The geometry is depicted by the grid shown in Figure 3-1. The figure identifies the zones used to represent changes in the hydraulic properties of vadose zone sediments, and shows saturated hydraulic conductivities (K_{sat}) and boundary conditions. Initial conditions were assigned to vadose zone sediments assuming a unit hydraulic gradient.

3.2.1 Geometry

The tank and the vadose zone were simulated by means of a two-dimensional (2-D) slice through the center of the tank. This geometry is more conservative than axisymmetric or three-dimensional (3-D) geometries because the volume within which moisture can move is more constrained, thus amplifying vertical flow downward to the water table.

In Figure 3-1 the stratigraphic boundaries of the Hanford and Ringold Formation units between the tank and the water table are shown by the bold, horizontal dashed lines. For purposes of the simulation, the depicted tank is equivalent in design to a 100-Series tank in the 241-A Tank Farm. The dimensions and geometry of the tank were faithfully depicted because the tank dome collects and sheds water from the infiltration of precipitation, creating a region of enhanced recharge around the circumference of the tank. Likewise, the slope of the dome can be critical in causing moisture either to be shed or to enter the dome.

The left edge of the model domain (Figure 3-1) represents a location half-way between the center of a neighboring tank and the center of the simulated tank. The left edge depicts a vertical plane of symmetry, with tanks on either side. The right edge of the model domain represents the centerline of the simulated tank and is a plane of symmetry with respect to the other half of the simulated tank. The bottom of the domain represents the top of the uppermost aquifer beneath the Hanford Site. The top of the domain depicts the current ground surface.

3.2.2 Boundary Conditions

Conditions assigned to the boundaries of the model domain are shown in Figure 3-1 and are as follow:

- Top surface: 5 cm/yr downward flux
- Sides: zero flux
- Bottom surface: zero pressure.

The bottom of the domain is the top of the aquifer (i.e., where atmospheric pressure is present). The pressure at this boundary is taken to be zero. The sides of the model domain represent planes of symmetry where no flux can cross. The boundary condition at the top of the domain represents the average rate of recharge to the aquifer by meteoric water. The assigned value of 5 cm/yr is much higher than the natural recharge rate for undisturbed parts of the Hanford Site. The 5 cm/yr value was assigned to account for the recharge-enhancing effects of the graveled surface of a tank farm.

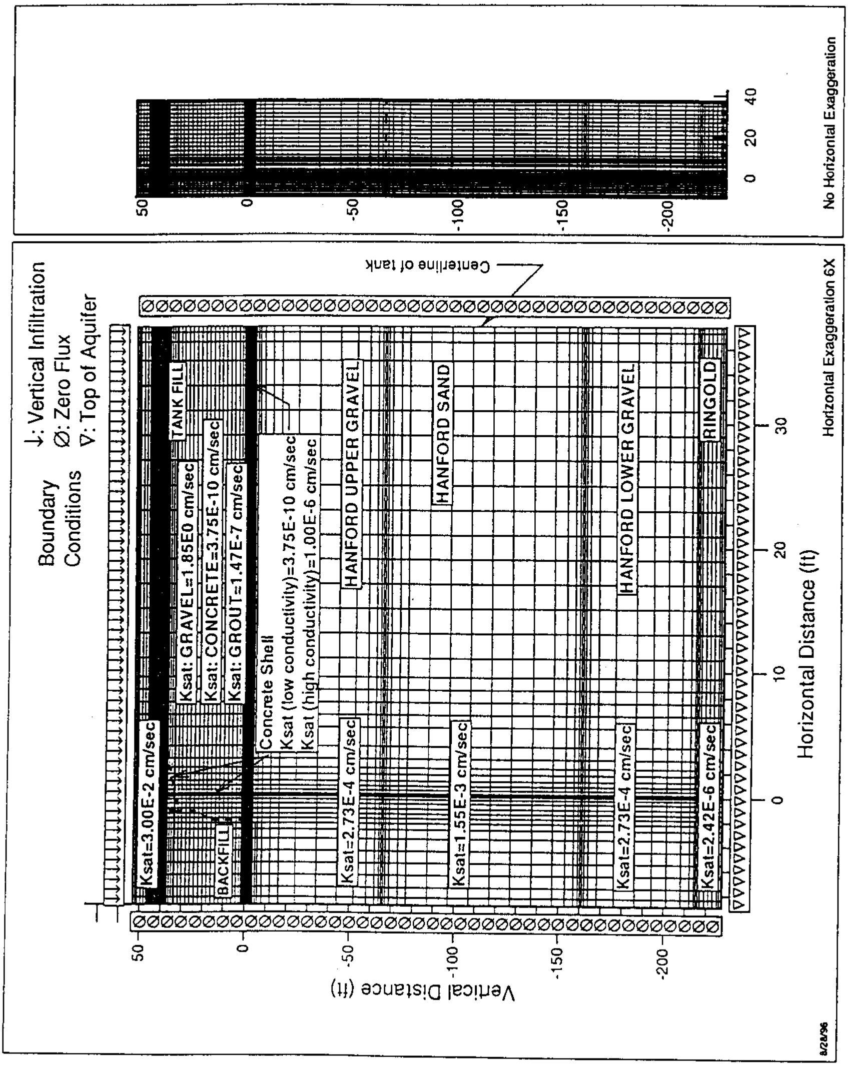

Figure 3-1. Discretization Grid and Geometry of Features in the Model Domain.

Fayer and Walters (1995) reported deep infiltration values of 5.54 cm/yr for disturbed surface areas of the Hanford Site. When blowing sand and silt are considered, it is reasonable to expect that eolian material will fill most gravel interstices over a relatively short time period (i.e., a few hundred years) compared to the simulation period (typically greater than one thousand years). If any vegetation appears, the recharge rate will be driven to a value close to zero. Based on all these factors, an average of 5 cm/yr for the simulation period is considered to be a reasonable value for comparative modeling purposes.

3.2.3 Initial Conditions

Initial hydraulic conditions for the soil column were first assigned assuming the tank was replaced by the surrounding fill material. Assuming a unit hydraulic gradient condition and a flux of 5 cm/yr, the matric potential was calculated for each sediment type and used as input for the pressure equation. A steady-state solution was achieved for this configuration. Subsequently, for each alternative, the tank was simulated with a concrete shell and the appropriate tank-fill material.

Because concrete and grout would be emplaced wet, the initial hydraulic condition for these backfill options was expected essentially to be a saturated state; therefore, an initial pressure of zero was assigned to those materials. The matric potential (suction) for the gravel backfill alternative was set to a high value relative to that of the other backfill materials. The final suction values (after steady-state conditions were achieved) were much lower than the initial conditions.

3.2.4 Sensitivity Cases

Sensitivities of simulation results were evaluated for the presence of a low-infiltration cover over the tank and for changes in hydraulic properties of the concrete forming the tank shell. Cases were evaluated for tank-shell concrete with conductivity-enhancing fractures, and with relatively high- and low-hydraulic conductivities through the concrete pores. Two recharge rates were used to simulate the presence or absence of a low-infiltration cover (0.05 cm/yr and 5.0 cm/yr, respectively).

The more highly conductive condition was used to represent the effects of concrete shell degradation. Hydraulic conductivity values representing this condition are equivalent to those measured for concrete after one day of curing (Whiting et al. 1985). The hydraulic conductivity for fractured concrete was calculated using the formula provided by Piepho (1994) and fracture dimensions used by Lowe et al. (1993).

Fractures in the tank dome were assumed to be located at the periphery and to have the same aperture and length as those in the base of the concrete shell (Lowe et al. 1993). The presence of a low-infiltration cover over the tank was simulated by reducing the flux from the surface to 0.05 cm/yr (0.5 mm/yr). This value is the performance goal for the barrier placed over the B-57 crib and for a modified *Resource Conservation and Recovery Act of 1976* Subtitle C barrier described by Bechtel Hanford Inc. (BHI 1996).

3.2.5 Tank-Fill Alternatives

Four alternative materials for backfilling the tanks were considered:

- Gravel
- Grout
- Concrete
- Hybrid (pre-placed aggregate concrete).

In-tank obstructions (e.g., thermocouple trees, air circulators, etc.) were assumed to have no material effect on the uniformity of backfill emplacement. Hence, they were assumed not to affect the hydraulic performance of one backfill alternative compared to another. A second assumption was that the flow-affecting physical properties of the mix formulation (i.e., the porous media portion of the mix) for the grout backfill and pre-placed aggregate concrete were the same.

Of the four material alternatives, three were simulated for purposes of the baseline analyses. The hybrid alternative, consisting of pre-placed aggregate followed by filling with grout, was not simulated. Compared to the grout fill alternative the presence of aggregate reduces the area of porous material through which flow can occur, so pore velocities increase and travel times decrease. Consequently, this alternative would be a poorer performer in terms of the travel time of groundwater than grout with no aggregate. A direct comparison cannot be made between the hybrid alternative and the concrete alternative because the formulations of cementitious materials in the mixes (and thus the flow-affecting physical properties) are dissimilar.

3.2.6 Scenarios

Variations of the alternative fill materials, recharge rates reflective of the presence or absence of a barrier to infiltration, and concrete tank-shell hydraulic conductivities constitute the 10 scenarios that were simulated. The scenarios were selected based on the expected utility of results, available computer resources, and how rapidly the simulation progressed after the program was executed. Additional sensitivity analyses will be performed in FY 1997 as part of the HTI. The scenarios presented in this report are identified in Table 3-1.

Table 3-1. Matrix of Scenarios Analyzed.

Alternative Conditions	Backfill Alternatives		
	Gravel	Grout	Concrete
High K_{sat} tank shell, with cover[a]	X	X	X
High K_{sat} tank shell, without cover	X	X	X
Low K_{sat}, fractured tank shell, with cover	X		X
Low K_{sat} tank shell, without cover	X		X

[a] Baseline analysis

3.2.7 Program Execution

The program was executed in a transient mode until a steady-state condition was achieved. (Because of the highly non-linear nature of equations describing flow for unsaturated conditions, solutions from executing the program in a steady-state mode proved to be highly inaccurate, often requiring transient time steps of less than 10E-12 yr.) Assumption of steady-state conditions results in an approximation that ignores the lengthy period during which transient conditions occur. Based on typical simulation times required to achieve steady-state conditions, the duration of transient conditions may be several hundred to several thousand years.

The operational history of the tanks was neglected. Consequently, varying levels and temperatures of liquid in the tank were not depicted. Because the operational duration of the tank was short relative to the duration of the simulation, neglect of these factors was not judged to be significant.

For purposes of this engineering study, the presence of the steel tank liner was neglected. The scenario of a buildup of moisture inside a tank with a liner, followed by a sudden release through a single opening in the base of the tank was not analyzed because the probability of such an event is extremely low and it only applies for one of the proposed backfill materials. If the concrete shell has a normal, relatively low-hydraulic conductivity, then the potential for moisture to enter and accumulate at the bottom of a filled-in tank would be minimal. The presence of a low-infiltration cover over a tank would further reduce this potential. In any case, because concrete and grout are emplaced wet and tend to remain saturated, only the gravel fill alternative might present an instance in which the subsequent entry of meteoric water after backfill emplacement could lead to a substantial increase in the level of saturation.

3.3 RESULTS

Plots for each simulation were made from the pore velocity fields (pore velocity represents the average linear velocity of fluid moving through a pore), and show derived information, namely streamlines and time markers, to provide: (1) visual indications that the results were reasonable and (2) the perspectives needed to understand the results. In addition, key flux densities and travel times were tabulated to facilitate direct comparison of the tank-fill material alternatives. Results shown by the figures first are compared in terms of the effects of alternative conditions on each backfill option (Section 3.3.1). Then, in Section 3.3.2, results are discussed in terms of comparative hydraulic performance of the backfill options.

3.3.1 Effects of Alternative Conditions

Figures 3-2 through 3-5 are plots showing streamlines and time markers for the gravel backfill alternative. Figures 3-6 and 3-7 show the same parameters for the grout backfill alternative. Figures 3-8 through 3-11 show results for concrete backfill.

Streamlines are shown as solid lines. Small circles that appear at intervals on the streamlines mark the distance a particle of water is calculated to travel upstream or downstream in the time specified on the figure, up to a time limit of 10,000 yr.

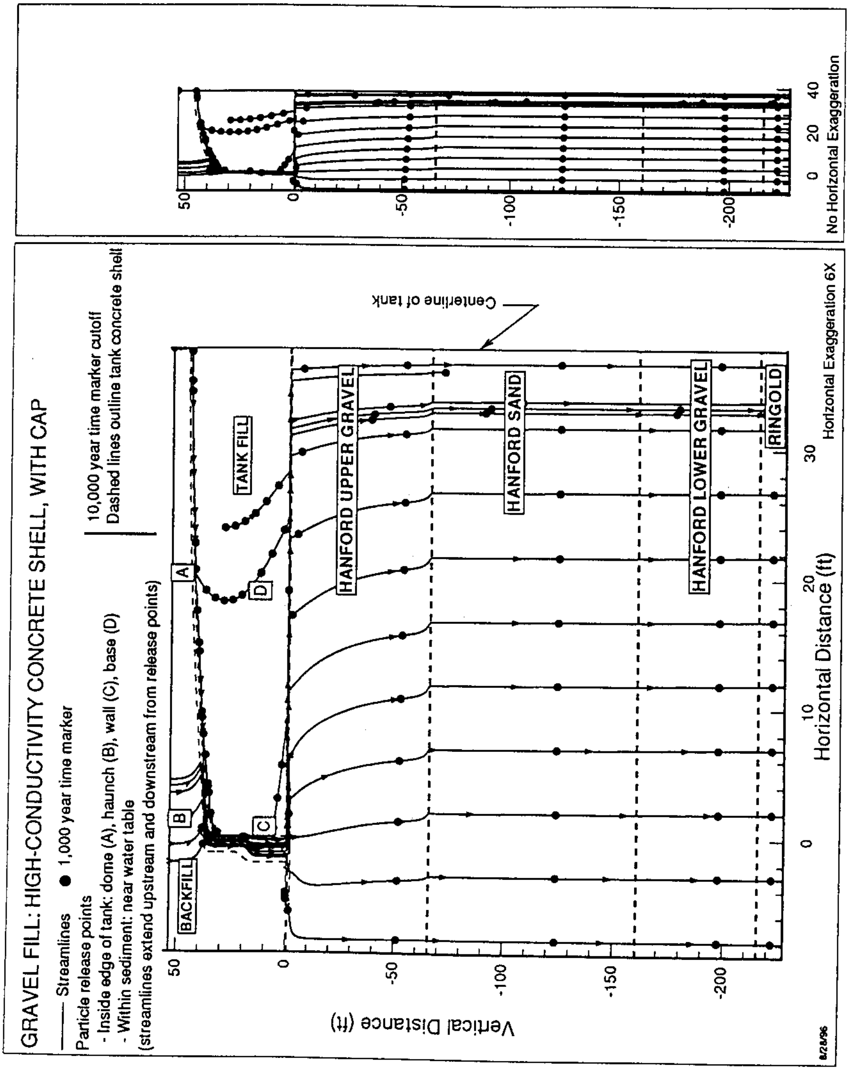

Figure 3-2. Flow Results for Gravel Backfill, Assuming a High K_{sat} Concrete Shell and Low-Infiltration Cover.

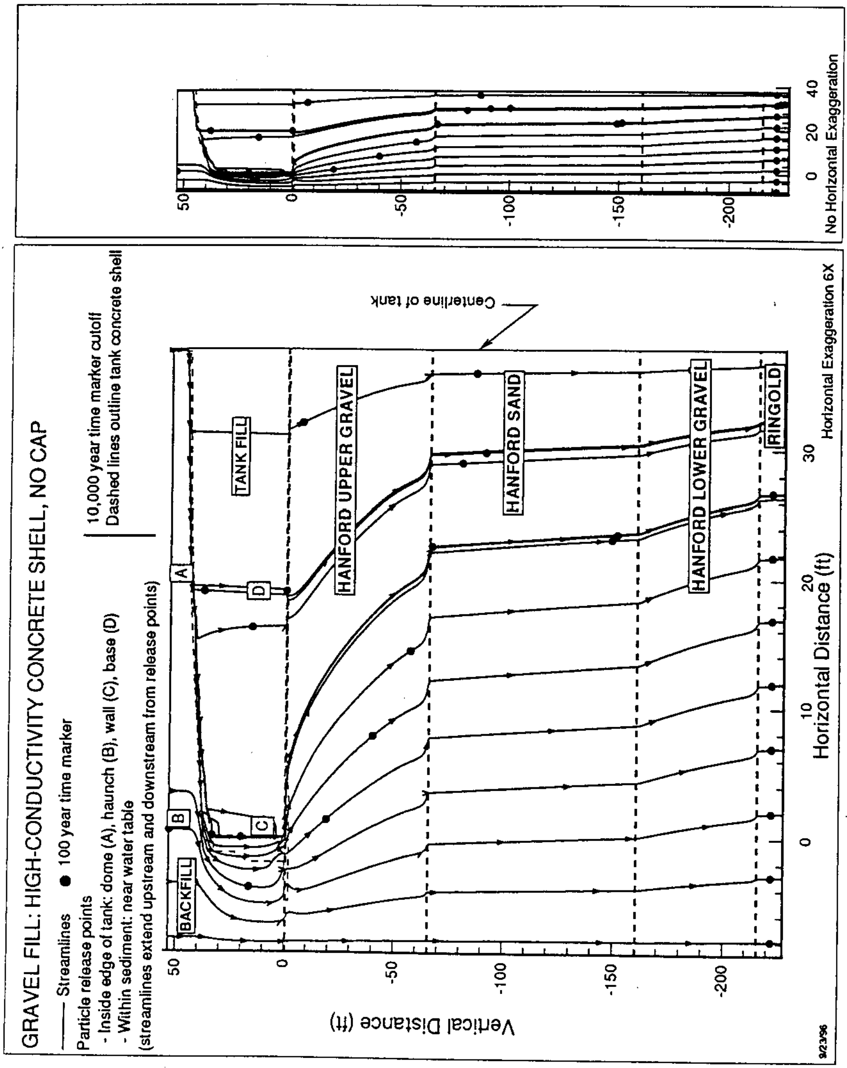

Figure 3-3. Flow Results for Gravel Backfill, Assuming a High K_{sat} Concrete Shell and No Cover.

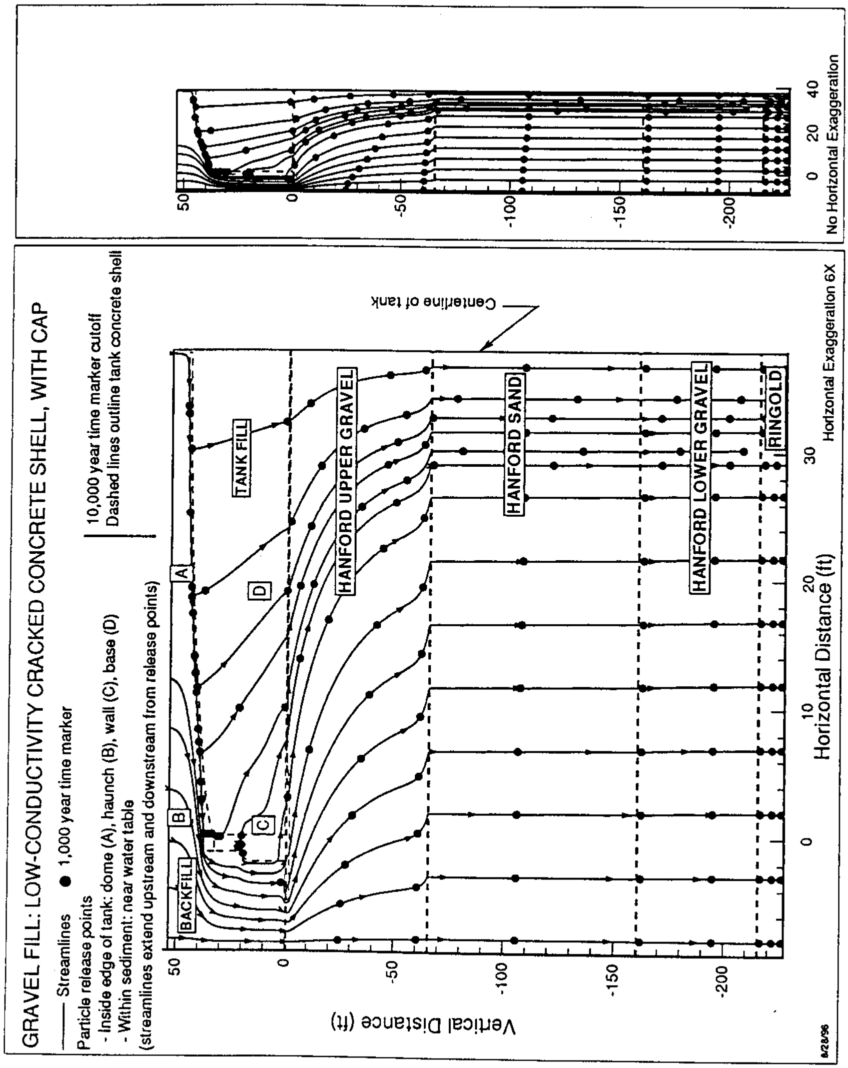

Figure 3-4. Flow Results for Gravel Backfill, Assuming a Low K_{sat}, Fractured Concrete Shell and Low-Infiltration Cover.

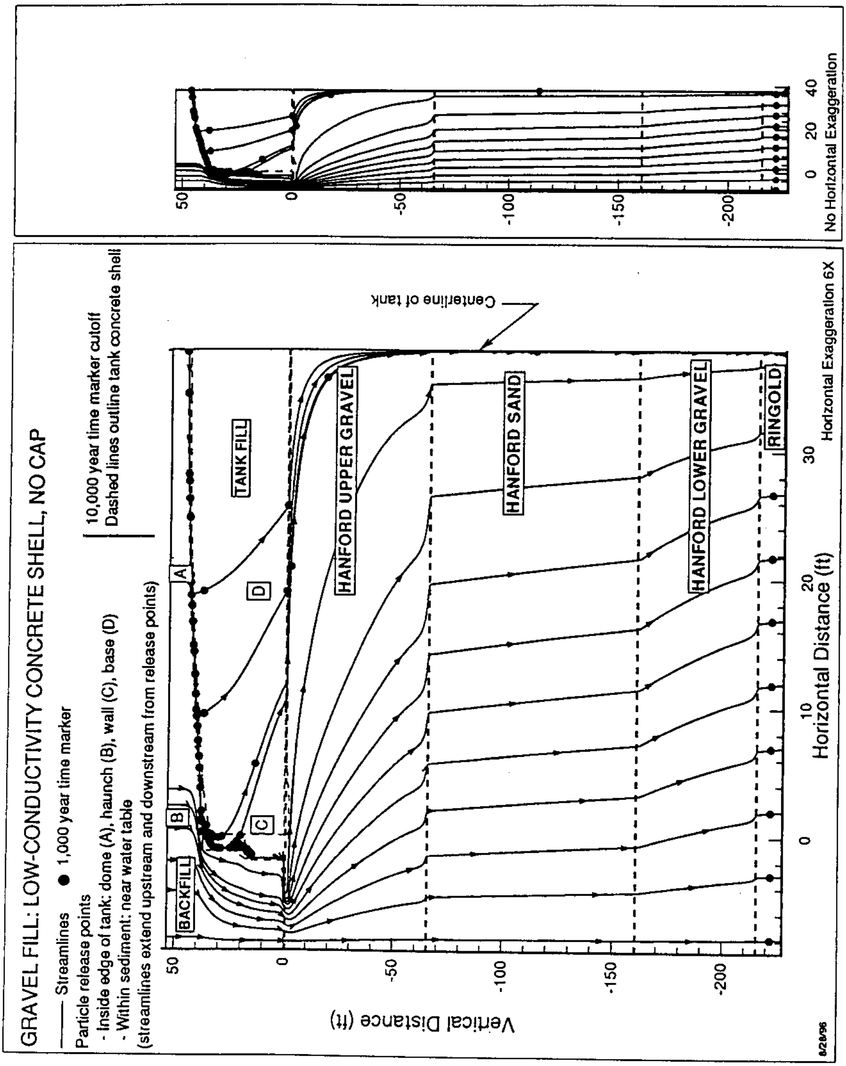

Figure 3-5. Flow Results for Gravel Backfill, Assuming a Low K_{sat} Concrete Shell and No Cover.

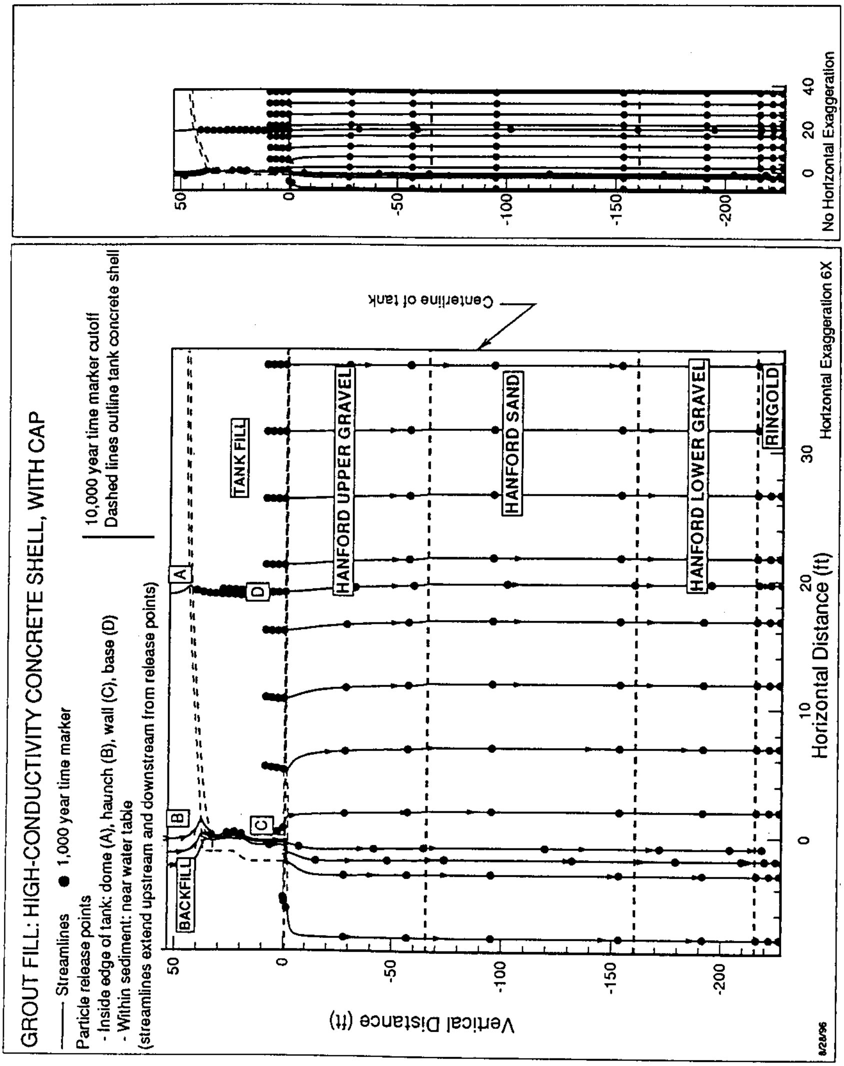

Figure 3-6. Flow Results for Grout Backfill, Assuming a High K_{sat} Concrete Shell and Low-Infiltration Cover.

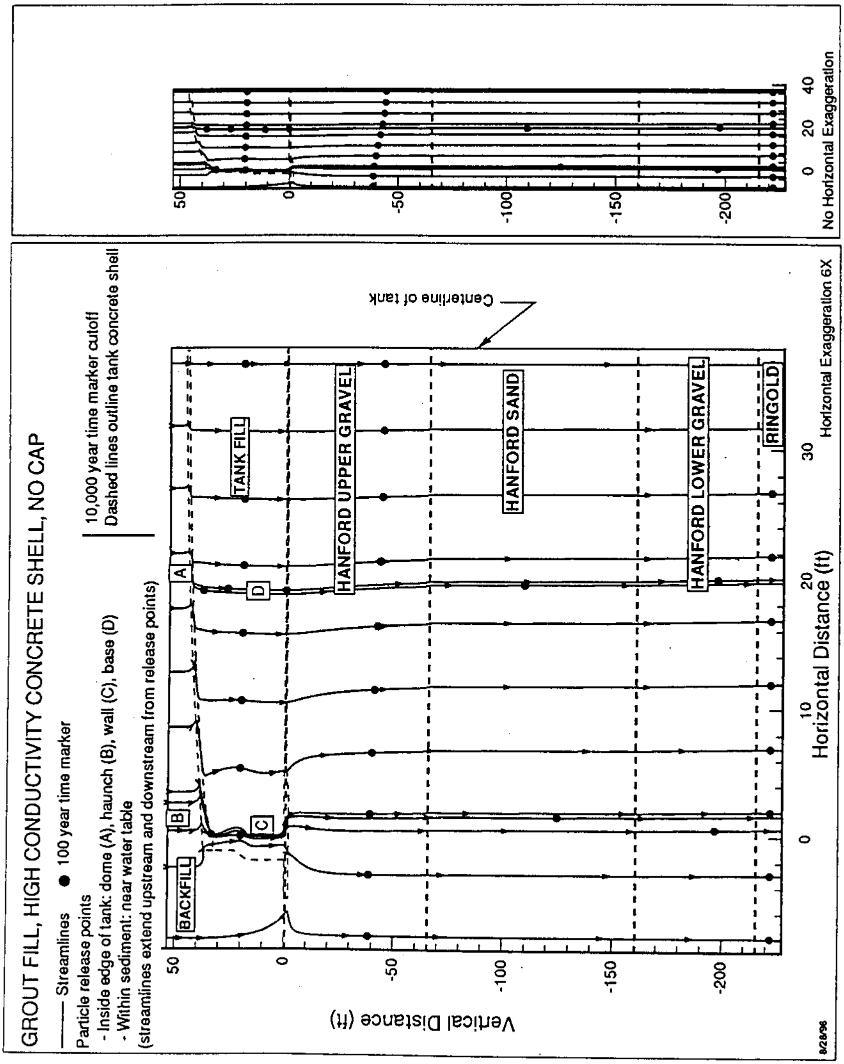

Figure 3-7. Flow Results for Grout Backfill, Assuming a High K_{sat} Concrete Shell and No Cover.

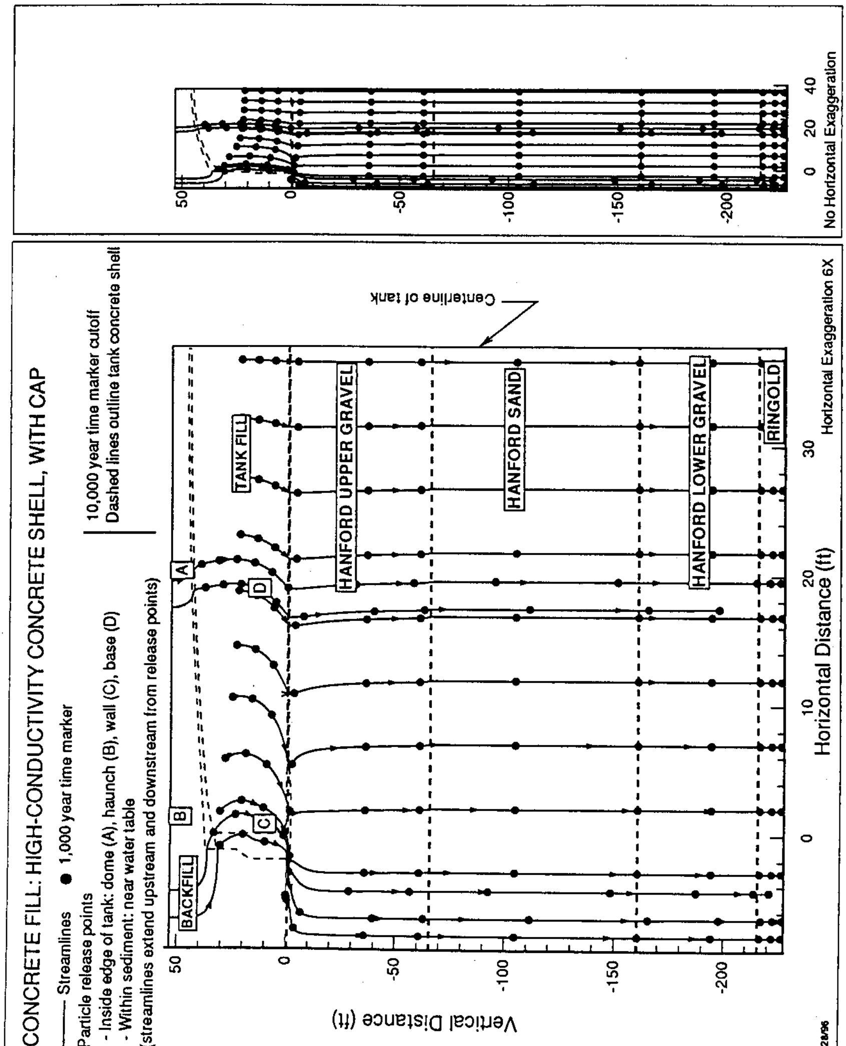

Figure 3-8. Flow Results for Concrete Backfill, Assuming a High K_{sat} Concrete Shell and Low-Infiltration Cover.

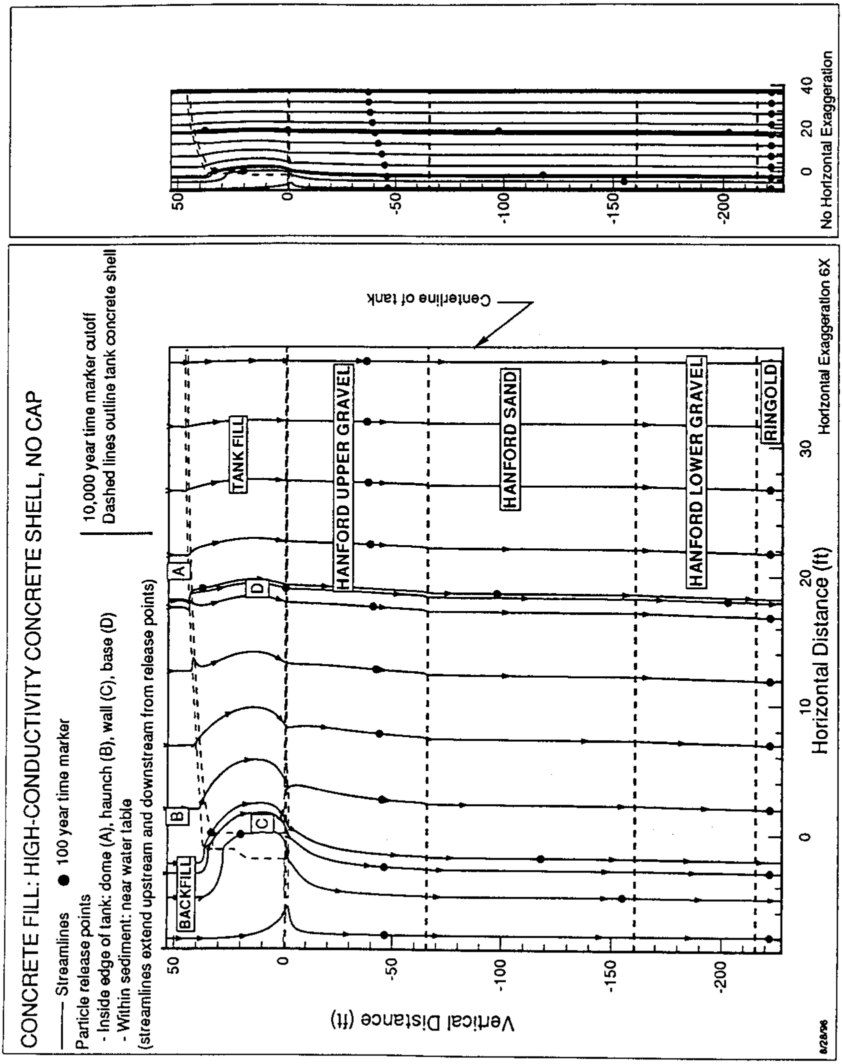

Figure 3-9. Flow Results for Concrete Backfill, Assuming a High K_{sat} Concrete Shell and No Cover.

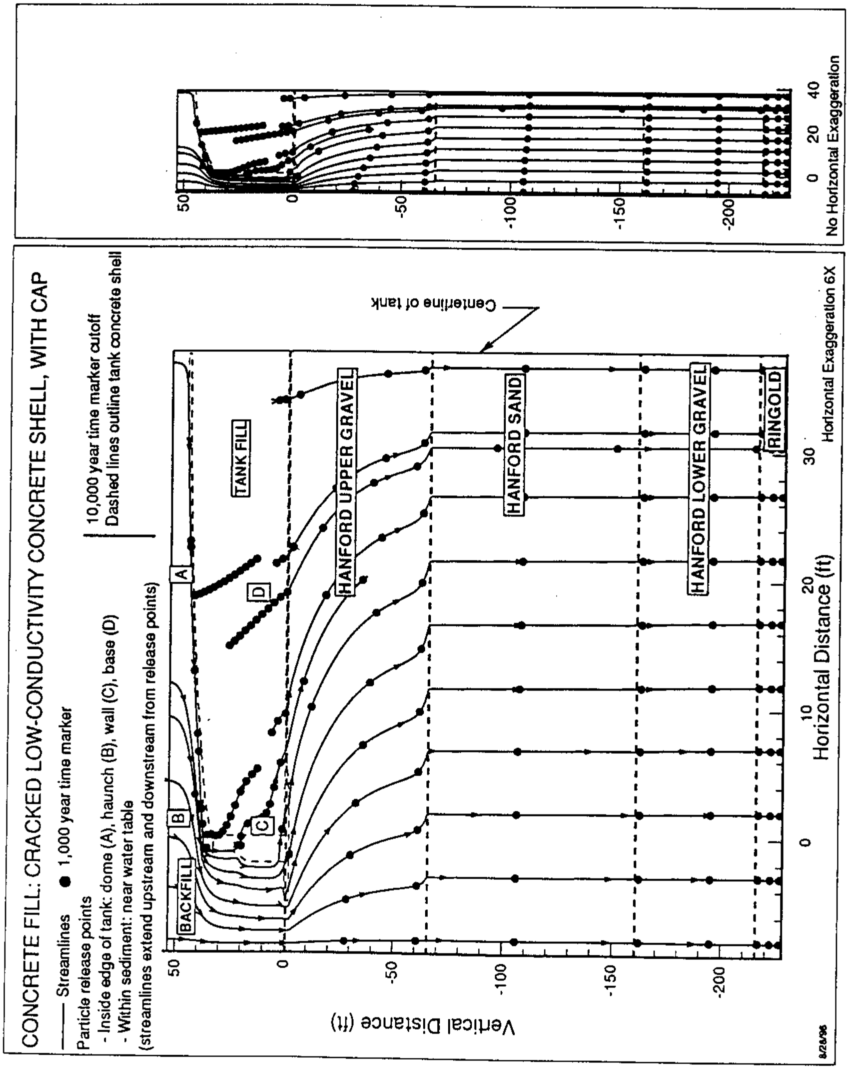

Figure 3-10. Flow Results for Concrete Backfill, Assuming a Low K_{sat}, Fractured Concrete Shell and Low-Infiltration Cover.

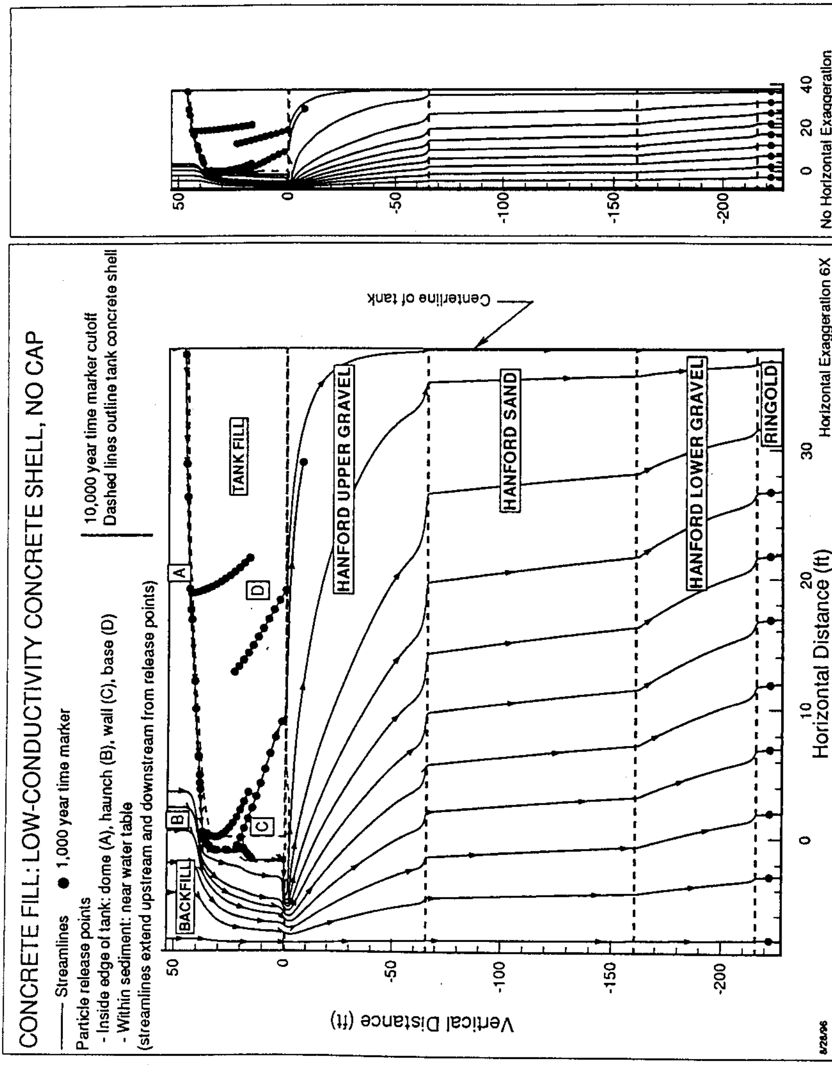

Figure 3-11. Flow Results for Concrete Backfill, Assuming a Low K_{sat} Concrete Shell and No Cover.

The initial circle on a streamline is the release point. Four release points on the inside edge of the tank were selected. They are labeled A, B, C, and D on the figures. Other release points were specified across the width of the model domain in the Ringold Formation near the water table. The purpose of these points was to help describe the upstream and downstream flow of water outside the tank.

Horizontal dashed lines that cross the entire model domain depict the boundaries of hydrogeologic units in the vadose zone. The inner and outer surfaces of the tank are also represented by dashed lines near the top of the model domain.

Figure 3-2 shows results of the gravel backfill alternative for a high K_{sat} concrete tank shell and a barrier installed above the tank to inhibit the infiltration of meteoric water. The results indicate, that with the infiltration barrier present, relatively little water reaches the tank; much of the water that does reach the tank is shed by the tank dome. The runoff water migrates primarily downward.

The tendency for water shed by the tank to migrate horizontally beneath the tank is less pronounced than for instances in which no cover is present (Figure 3-3), or for instances in which the concrete shell, whether fractured or not, has low conductivity (Figures 3-4 and 3-5). This horizontal migration effect can be attributed to the presence of less soil moisture beneath the tank than at its edge. The contrast results both from significantly enhanced tank dome runoff when no cover is present and reduced infiltration through the backfilled tank with a low-conductivity concrete shell.

In Figure 3-2, time markers for streamlines that enter the tank through the dome, and to a lesser extent through the tank sidewalls are relatively closely spaced, indicating that water which enters the tank moves relatively slowly through the gravel backfill before exiting through the floor of the tank. Comparison of the streamlines and time markers for Figures 3-2 through 3-5 suggests that the largest influence on pore-water velocity is whether a barrier to the infiltration of meteoric water is present, followed in importance by the relative hydraulic conductivity of the concrete shell.

Figures 3-6 and 3-7 compare alternative conditions for the grout backfill alternative. Streamlines for both plots indicate that there is relatively little horizontal migration of moisture beneath the tank; infiltrating meteoric water tends to migrate vertically downward within, as well as below the tank. Water enters the tank through both the dome and the wall, moves readily through the grout backfill, and exits through the floor. Comparison of time markers in the two figures indicates that construction of a barrier to infiltrating meteoric water above the tank has a marked influence on reducing the rate of moisture migration within a relatively high-conductivity concrete tank shell backfilled with grout.

Figures 3-8 through 3-11 compare alternative conditions for the concrete backfill alternative. Figure 3-8 shows streamlines and time markers for concrete backfill in a high K_{sat} (i.e., a poor-quality concrete) concrete shell and no cover. Figure 3-9 shows streamlines and time markers for a concrete tank shell with a high K_{sat} tank shell and no cover. Compared to the flow pattern shown in Figure 3-8, the streamlines and time markers in Figure 3-9 indicate that water moves faster through the concrete backfill when no infiltration barrier is present.

Water exiting the base of the tank with a high K_{sat} concrete shell migrates vertically downward, generally resulting in shorter travel times through the sediments than for the same backfill in a low K_{sat} concrete tank shell (Figures 3-10 and 3-11). Imposition of a low K_{sat} condition for the concrete shell generally results in a pronounced increase in travel times compared to a high K_{sat} condition, whether or not a barrier to infiltration is present.

Figures 3-10 and 3-11 show that most of the water infiltrating from the surface flows around the tank. After passing through the soil between the tank and the left boundary of the model domain, the water is drawn toward the area of lowest soil moisture; hence, it tends to migrate horizontally beneath the tank.

Water enters the tank through the dome and most of the wall. Water exits mostly through the base of the tank but, for the high K_{sat} concrete shell, a small fraction exits through the wall. Water exiting the base of the tank with the low K_{sat} concrete shell encounters tank runoff water that drives the exiting water toward the center of the soil column beneath the tank.

3.3.2 Comparative Hydraulic Performance of Tank-Fill Alternatives

This section compares the relative hydraulic performance of alternative backfill materials. Performance is compared in terms of travel times and flux densities.

3.3.2.1 Travel Times. Figures 3-2 through 3-11 indicate that the alternative backfill materials have major effects on the behavior of infiltrating meteoric water. Effects of the concrete and grout backfill alternatives are similar, while the gravel backfill alternative has a very different effect. Simulation results for some of the scenarios indicate that concrete and grout backfill allow infiltrating water to move through the tank. In contrast, except for the case with a high K_{sat} concrete shell and a low-infiltration barrier, the gravel backfill repels much infiltrating water and fosters horizontal spreading of the dome runoff water beneath the tank.

Travel times from four locations on the inside surface of the concrete tank shell were calculated for steady-state conditions and are given in Table 3-2.

The locations on the inside surface of the tank shell are the same as those discussed in Section 3.3.1 and are as follows:

(A) Dome: about midway between the centerline of the tank and the wall
(B) Haunch: upper-left corner of the shell
(C) Wall: about half-way up the tank wall
(D) Floor: about midway between the center and the perimeter of the tank.

Travel times are strongly dependent on particle release locations. In some instances, the travel time is shorter for a particle starting from the wall or the haunch than for a particle starting from the selected release point on the tank base. This apparent nonsequitur occurs because a particle starting at the wall or the haunch may pass through the tank base at a location close to the perimeter. The vadose zone material underlying the tank has a higher water content and a higher unsaturated hydraulic conductivity near the perimeter. Consequently, the travel time through the vadose zone for a particle entering it near the tank perimeter will be shorter than for a particle entering it near the tank center. A particle starting at the base near the perimeter of the tank will likely have the shortest travel time of any particle released inside the tank.

Table 3-2. Travel Times to the Aquifer (in years).

Scenario	Release Point			
	Dome (A)	Haunch (B)	Wall (C)	Base (D)
Concrete				
Low K_{sat} concrete shell, no cover	>10,000	>10,000	>10,000	929
High K_{sat} concrete shell, no cover	184	178	164	136
High K_{sat} concrete shell, cover	>10,000	>10,000	>10,000	8,391
Fractured, low K_{sat} concrete shell, cover	>10,000	>10,000	>10,000	9,462
Gravel				
Low K_{sat} concrete shell, no cover	2,036	5,322	1,711	1,128
High K_{sat} concrete shell, no cover	209	175	174	204
High K_{sat} concrete shell, cover	>10,000	4,995	4,968	4,824
Fractured, low K_{sat} concrete shell, cover	>10,000	>10,000	9,994	>10,000
Grout				
High K_{sat} concrete shell, no cover	280	173	139	139
High K_{sat} concrete shell, cover	>10,000	>10,000	8,536	8,062

Table 3-2 indicates that, for cases where the tank shell is assigned a low K_{sat} value, the travel times typically range from 1,000 to greater than 10,000 years for all materials. When a cover is simulated the travel times typically range from 5,000 to 10,000 years for all fill materials analyzed. The case with a high K_{sat} tank shell and no cover produced the lowest travel times ranging from about 140 years to 280 years for all fill materials. On the basis of travel times alone, no single backfill material is consistently superior.

3.3.2.2 Flux Densities. Travel times provide information at a specific point that can indicate when vadose zone monitoring might be expected to detect contaminants migrating from residual tank waste and when contamination is likely to initially reach the water table. In contrast, flux densities (i.e., the flow rate divided by the surface area through which flow occurs) provide a more spatially and temporally integrated perspective that indicates the total mass of moisture (or contaminant) exiting the tank in a specified time and area. For this reason, flux densities are much more indicative than travel times of the concentrations of contaminants that can be anticipated. Flux densities through the inside edge of the tank floor for the various scenarios are given in Table 3-3. Because the simulations are 2-D, the flux density has units of length^2/time/length (m^2/yr/m).

Flux density results by row in Table 3-3 show that in most cases gravel backfill significantly reduces the volume of liquid exiting the base of the tank during a specified time period compared to other fill materials. For a high K_{sat} concrete shell, gravel reduces the flux density through the base of the tank by about half an order of magnitude when no cover is present, and by about 0.5 to 1.5 orders of magnitude when a cover is present.

Table 3-3. Flux Densities (m^2/yr/m).

Scenario	Backfill Alternative		
	Gravel	Grout	Concrete
High K_{sat} concrete shell, cover	1.3E-5	5.2E-4	5.5E-4
High K_{sat} concrete shell, no cover	1.2E-2	4.9E-2	5.6E-2
Fractured, low K_{sat} concrete shell, cover	1.6E-4		2.3E-4
Low K_{sat} concrete shell, no cover	1.3E-4		2.0E-4

Results by column in Table 3-3 show that the cover reduces flux densities by about two orders of magnitude for all fill materials. For example, for the case with a high K_{sat} shell and concrete backfill, the flux density is reduced from 6.4E-1 to 6.3E-3. The reduction in flux density is comparable to the reduction in the recharge rate from 5 cm/yr to 0.05 cm/yr when a cover is simulated.

3.4 PLANNED WORK

The hydraulic response analysis is the first major step in determining public health risk. Contaminant transport analysis will be required to evaluate the public health risk and to develop design specifications for fill materials based on hydraulic response considerations. Essential simulation input data include site-specific hydraulic parameters, residual waste source terms (quantity, concentration, and spatial distribution), radiological and chemical background information, and experimental data on hydraulic properties for a range of cementitious mix formulations if grout, concrete, or the hybrid alternative are final candidates.

3.5 REFERENCES

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4.0 OCCUPATIONAL RADIATION DOSES FROM TANK-FILL ALTERNATIVES

After retrieval of waste from SSTs, it will be necessary to fill the tanks with inert materials to prevent excessive settlement or subsidence. It may also be necessary to construct surface barriers over the tank farms to inhibit migration of residual contaminants in the tanks or the surrounding soils. The four fill alternatives under consideration are: gravel, grout, hybrid (i.e., pre-placed aggregate concrete), and concrete. The radiation doses that workers would receive from operations to implement the four alternatives have been estimated (Appendix D). The dose-related activities for grout and concrete fill operations are the same, so they are treated in Appendix D as one case.

4.1 ASSUMPTIONS

In estimating the occupational doses from fill operations and the construction of tank farm barriers, the following general assumptions were made:

(1) Doses will be incurred only for work conducted inside the tank farms. That is, it is assumed that for preparatory work outside the farms, radiation levels are at background. This assumption is generally valid, although there are a few areas slightly above background near some of the tank farm fences.

(2) For the gravel fill alternative, ITH such as instrument trees and liquid observation wells must be removed from the tanks because such hardware will interfere with the uniform emplacement of gravel.

(3) For the gravel fill and hybrid fill alternatives, 64 SSTs must be equipped with large-diameter central access risers for gravel emplacement (Krieg et al. 1990).

(4) Four dose rate categories are identified relative to various types of work that will be performed during tank-fill operations:

- Ambient 200 East Area tank farms: 2.5 mrem/hr, based on the doses received by health physics technicians conducting radiological surveys inside the 200 East Area tank farms
- Ambient 200 West Area tank farms: Doses for surveys by health physics technicians inside the 200 West Area tank farms are normally below the detection level for personnel dosimeters, so the dose rate was assumed to be the same as the radiological control area level of 0.05 mrem/hr
- Pit-type work: 7.7 mrem/hr, based on records of worker doses received from pit-type work listed in the Access Control Entry System (ACES) data base

- Excavating pipelines: 5.0 mrem/hr, based on assumed shielding and other as low as reasonably achievable (ALARA) protective measures; the following general assumptions were made:

  - That worker exposures incurred from tank-fill operations will come from surface contamination, contaminated piping, contaminated pump pits, contaminated soil, and contaminated ancillary equipment, rather than from tank waste residuals. This assumption is made because at least 99% of tank waste will be retrieved prior to closure and because most of the current tank farm worker dose is from these sources. If extensive decontamination of pump pits or other facilities in tank farms is accomplished prior to closure, then doses incurred during closure operations could be lower than the rates assumed for this estimate.

  - That three persons will be exposed during pit-type work (e.g., riser installation and removal of ITH). It is assumed that two persons will be exposed during other identified closure tasks. These numbers do not reflect the number of people involved in a given task, but are estimates of the average number of individuals (i.e., full-time equivalents) exposed to the dose rate for a specified category.

Other assumptions, such as gravel and grout fill rates, barrier construction times, incidental grout fill volumes, etc., are included as notes in Appendix D.

4.2 RESULTS

From Appendix D, the estimated cumulative occupational radiation doses (person/rem) for the four fill alternatives are:

- Gravel fill: 1,320 person/rem
- Hybrid fill: 569 person/rem
- Grout and concrete fill: 119 person/rem.

Surface barrier construction contributes less than 10 person/rem to the cumulative dose totals.

The gravel fill alternative results in the largest cumulative dose because: (1) new risers must be installed for gravel slinging equipment, resulting in a significant dose increment, and (2) ITH that could interfere with the distribution of gravel must be removed, which is another significant dose source. For the hybrid fill (pre-placed aggregate concrete) alternative, new risers must be installed but it is unnecessary to remove ITH. Therefore, the cumulative dose is less for hybrid fill than gravel fill. The cumulative dose is least for grout and concrete fill because no new risers are needed to pump grout into the tanks and because ITH can remain in place in the tanks (i.e., grout and concrete can flow around such equipment).

Cumulative doses will be spread out over the number of years required to complete tank farm closure. The timeframe for closing tank farms is currently not well defined. However, assuming it takes 10 years to complete filling tanks and construction of surface barriers, then the annual cumulative occupational doses for the four alternatives would be:

- Gravel fill: 132 person/rem/yr
- Hybrid fill: 57 person/rem/yr
- Grout and concrete fill: 12 person/rem/yr.

To put these cumulative dose rates into perspective: The total cumulative occupational dose from all Hanford operations in calendar year 1990 was 353 person/rem (DOE 1993). This value is typical of the annual cumulative dose at Hanford during the last few years.

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5.0 REVIEW OF GEOTECHNICAL DESIGN PARAMETERS FOR SST

Structural performance of the various tank-fill alternatives is a key criterion in distinguishing a preferred alternative. Structural performance will be evaluated by numerical modeling methods and is scheduled as a multi-year task. The purpose of structural modeling is to determine how well the tank domes and footings are supported by the various types of fill when the weight of the engineered surface barrier is applied to the tank system. The fill must exhibit adequate rigidity to eliminate the potential for surface subsidence and minimize differential settlement of the surface barrier. Work performed to date consists of (1) a scoping study to identify the numbers and types of numerical models needed to evaluate the alternatives at the appropriate scale and level of detail, and (2) a literature search to characterize structural and geotechnical parameters (i.e., loading conditions and material properties) as inputs to the modeling effort. The scoping study is included as Appendix A of this report. A summary of the literature review is provided in this section.

SST design documentation was reviewed for information applicable to structural modeling of tank-fill alternatives for closure. Structural modeling is a separate activity that is scheduled to be performed during FY 1997. During the review, an effort was made to trace criteria and design changes relating to all imposed loads on the tanks. Geotechnical design parameters relate to the externally imposed soil reactions, namely the footing reaction and lateral earth pressure on the tank cylinder. Other load sources are structural; i.e., the weight of the tank itself including dome-suspended hardware, the weight of the waste (which is a function of specific gravity and the maximum height of waste stored in the tank), and the head space pressure (generally close to ambient atmospheric pressure, but subject to both positive and negative transients). External loads that would be considered structural are the dead and live loads on the dome, consisting of the weight of the cover soil and the allowable load for mobile service equipment.

To provide a historical perspective on tank design issues, SST documentation is reviewed in chronological order. Loading criteria for the various SST farms are summarized in Tables 5-1 to 5-10.

5.1 SEQUENCE OF SST DESIGN AND CONSTRUCTION

The 241-B, -C, -T, and -U tank farms were constructed between 1943 and 1944. A single set of drawings and specifications was prepared for the four tank farms. Layouts and configurations of the tank farms were essentially identical. These "first generation" tank farms each contained 12 100-Series tanks and four 200-Series tanks. The 100-Series tanks were 75 ft in diameter, with a 533,000-gal capacity, and a liner height of 18 ft (204 in.). The 100-Series tanks in the first-generation tank farms were designed with a 12-in. dished bottom and a radiused corner joining the base slab to the cylinder. These tanks were not equipped with a central riser. First-generation tank farms were designed for nonboiling waste from the bismuth phosphate process with a maximum temperature of 220°F. The 100-Series tanks were connected by cascade (overflow) lines in groups of three. The overflow lines were designed to transfer liquid at a height of approximately 191.5 in. above the liner bottom. The 200-Series tanks were provided to function as receiver tanks for the 100-Series cascade lines. They were 20 ft in diameter and had a 55,000-gal capacity.

The 241-BX Tank Farm was constructed between 1946 and 1947 (the first tank farm to be constructed in the post-war period) and consisted of 12 100-Series tanks of the same size and capacity as the tank farms constructed previously. The 241-BX Tank Farm was also a "first generation" design. However, the layout was modified from older tank farms to the extent that the 200-Series tanks were deleted. Operating experience with the bismuth phosphate process and the original tank farms had established that receiver tanks (i.e., 200-Series tanks) were not essential.

The 241-TX Tank Farm was constructed between 1947 and 1948 as Project C-163. The 241-TX Tank Farm contains 18 100-Series tanks of the "second-generation" design. The 241-TX tanks are 75 ft in diameter, with a 12-in. dished bottom and radiused corners, as in the previous design, but capacity was enlarged to 758,000 gal by extending the liner height to 26 ft (312 in.); nominal operating depth was approximately 24 ft (288 in.). Another change in the second-generation design was the reconfiguration of riser penetrations for improved access, including a large-diameter central riser. The 241-TX Tank Farm contains a mixture of three- and four-tank cascades. Overflow elevation is approximately 284 in. above the tank bottom. Like the older tank farms, 241-TX tanks were designed for nonboiling waste with a maximum temperature of 220°F.

The 241-BY Tank Farm was constructed as Project C-271 between 1948 and 1949. The 241-S Tank Farm was constructed as Project C-187D between 1950 and 1951. Both tank farms consist of 12 100-Series tanks of the "second-generation" design. Tanks in 241-BY and 241-S tank farms are arranged in four cascade lines of three tanks each. Both tank farms were designed to store nonboiling waste. However, soon after the 241-S Tank Farm was placed in service in 1951, it began to receive self-boiling waste from the reduction oxidation (REDOX) process. The 241-TY Tank Farm, which was constructed between 1951 and 1952, was the last tank farm to be built to the second-generation design. The 241-TY Tank Farm consists of six tanks arranged in three cascade lines of two tanks.

The 241-SX Tank Farm was the "third-generation" SST design. The 241-SX Tank Farm was constructed between 1953 and 1954 and consists of 15 tanks arranged in five cascade lines of three tanks. The 241-SX tanks were designed to cascade at a level of approximately 373 in. This was the first Hanford Site tank farm specifically designed for self-boiling waste. Third-generation tanks have a diameter of 75 ft, a capacity of 1 million gallons (Mgal), a 12-in. dished bottom, and a 30-ft nominal operating depth (32-ft [384-in.] liner height). The 241-SX tanks were designed to cascade at a level of approximately 373 in. above the tank bottom. The radiused corner treatment used in earlier designs to join the dish and cylinder was eliminated. The 241-SX tanks were designed for REDOX wastes with temperatures to 250°F and a boiling period of 1 to 5 years. The 241-SX tanks were constructed without air lift circulators (ALC). However, ALCs were installed in several 241-SX tanks on an experimental basis to limit thermal gradients in tank waste.

The 241-A Tank Farm was constructed between 1954 and 1955 to a design that is identified as the "fourth generation." The 241-A tanks have the same diameter, nominal capacity, and operating depth as tanks in the 241-SX Tank Farm. The 241-A tanks are designed to overflow at a liquid level of 371 in. The principal feature that distinguished the fourth-generation design was the elimination of the dished bottom; 241-A tanks have flat bottoms. The 241-A Tank Farm was designed to store self-boiling (self-concentrating) wastes from the plutonium-uranium extraction (PUREX) process with a maximum temperature of 250°F and a self-boiling period of 5 to 10 years. The 241-A tanks were the first to be constructed with ALCs installed. The 241-A Tank Farm consists of six tanks arranged in two cascade lines of three tanks. There also was a cascade connection between the last tanks in the two lines. Overflow connections were seldom (if ever) utilized during operation of this tank farm.

The 241-AX Tank Farm was the last SST farm to be built at the Hanford Site. The 241-AX Tank Farm was constructed between 1963 and 1964 and consists of four tanks without cascade connections. Diameter, capacity, and operating depth are the same as 241-A and 241-SX tanks.

The 241-AX tanks also have flat bottoms. However, the design treatment for joining the base slab and the cylinder was modified somewhat from the 241-A Tank Farm design. The 241-AX tanks were not equipped with a large-diameter central riser. A unique feature of 241-AX tanks is the provision of drain slots in the concrete base slab. The principal purpose of this feature was to drain bleed water from the concrete shell to prevent water from flashing to steam between the concrete and steel liner that could potentially distort or rupture the liner. The drain slots also provided a leak detection capability that none of the older tank farms had. This feature was carried over into the design of DSTs. The 241-AX tanks also were equipped with a closely-spaced arrangement of replaceable ALCs (22 per tank) compared to tanks in the 241-A and 241-SX tank farms (four per tank typical).

According to Stivers (1960), PUREX wastes going to 241-AX tanks were much more concentrated than any previous wastes. Heat evolution from the "hottest" tank wastes in 1945 was less than 1 British thermal unit (BTU)/hr/gal. Process improvements resulted in mildly boiling solutions from the REDOX process with heat source values in the range of 2 to 3 BTU/hr/gal. By the time 241-AX Tank Farm was constructed, waste streams from the PUREX process had been concentrated to the extent that heat generation rates were between 10 and 15 BTU/hr/gal. Revised operating specifications were issued for the 241-A and 241-AX tank farms about the same time the 241-AX Tank Farm was placed in service (General Electric Hanford Atomic Products Operation [HAPO] 1965).

5.2 GEOTECHNICAL DESIGN CRITERIA

Design requirements for the original SST farms (241-B, -C, -T, and -U) were developed by E. I. du Pont de Nemours (du Pont). The four tank farms were essentially identical. Each tank farm included 12 100-Series tanks with 533,000-gal capacities and four 200-Series with 55,000-gal capacities. Structural and geotechnical design requirements for the 100-Series tanks are documented in Construction Specification HW-1946 (du Pont 1943a). The corresponding specification for 200-Series tanks is HW-1961 (du Pont 1943b).

For the 100-Series tanks, a bearing capacity of 8,000 lb/ft^3 was required for the foundation soils. Liner height was 18 ft and design liquid specific gravity was 1.25. These values equate to a maximum hydrostatic pressure on the base slab of roughly 10 $lb/in.^2$ or 0.7 T/ft^2 for a tank filled to capacity absent any accumulation of solids. A surcharge load corresponding to 9 ft of cover soil was specified. According to other sources, the existing cover may be somewhat less (between 7 and 8 ft). At a bulk density of 120 lb/ft^3, this condition corresponds to a distributed load of approximately 6.25 $lb/in.^2$ or approximately 0.5 T/ft^2 on the tank domes and an additional load on the footings of approximately 2,000 T. Lateral earth pressure on the tank cylinder was not evaluated in the design. The specification did not designate a design live load condition. However, according to Julyk (1994), an operational live load limit of 17 T is identified in notes on construction drawings. The 241-BX Tank Farm was built to essentially the same specifications. The only change in requirements for the 241-BX Tank Farm from the HW-1946 criteria (du Pont 1943a) was the inclusion of the 17-T operational live load specification. Loading criteria for these tanks are summarized in Tables 5-1 and 5-3.

Bearing capacity, specific gravity, and earth fill properties for the 200-Series tanks were as specified for the larger tanks. Design maximum liquid level was 24 ft. The 200-Series tanks were designed to support 11 ft of cover soil. Criteria for the 200-Series tanks are summarized in Table 5-2.

Construction specifications for SSTs of the second-, third-, and fourth-generation designs (i.e., 241-TX, -BY, -S, -TY, -SX, -A and -AX tank farms) were located and reviewed. These specifications were prepared by HAPO and do not identify structural or geotechnical design requirements. To reconstruct this information, it is necessary to refer to tank farm engineering reports issued during the period of design and construction. Criteria for the tank farms that were constructed as HAPO projects are listed in Tables 5-4 through 5-10.

About the same time that construction was completed on 241-A Tank Farm, a thorough review of SST designs was completed regarding the suitability of SSTs for storing liquid wastes being produced at that time (Smith 1955). This report identified several structural integrity concerns for SSTs. The basis for the concerns was that the properties of tank waste had changed greatly over time reflecting process changes and improvements. Whereas the original tank waste streams had been nonboiling liquids with relatively low-specific gravities (nominally 1.2 or 1.25) and more-or-less constant atmospheric head space pressure, wastes being produced by the mid-1950's were self-boiling, self-concentrating wastes with significantly higher specific gravities, temperatures, and vapor pressure transients. The following revised operating parameters were proposed:

Tank Farm (241-)	Maximum Specific Gravity	Simultaneous Vapor Pressure (lb/in.^{2})
B, C, T, U, BX	1.9	2.5
TX, BY, S, TY	1.2	1.8
SX	1.5	4.8
A	2.2	6.9

For specific gravities less than the values listed above, increases in vapor pressure could be tolerated up to a limit of 10 lb/in.^{2} (gauge). At higher pressures, Smith (1955) indicated that tensile fracturing could occur around the edge of the tank domes due to the limited amount of steel reinforcement in the haunch. Smith (1955) also summarizes the rationale for neglecting consideration of lateral earth pressure on the tank cylinder in SST designs.

While the SST farms were in active operation, and particularly after the REDOX and PUREX processes began to produce self-boiling waste, frequent vapor pressure excursions (termed "bumps") occurred in tanks that had not been envisioned in designing the older tanks. As described by Tomlinson (1955), a typical bump consisted of five to 25 abrupt pressure surges of up to 1.8 lb/in.^{2}, wherein up to 4 million BTU of steam was released. When the 241-SX tanks were placed in service to receive REDOX waste, Merrill (1954) indicated that a peak vapor-evolution rate in the range of 5,000 to 7,000 lb/hr was expected as each tank reached capacity. This rate was 20 to 40 times greater than vapor headers and condensers on the older tanks (designed for nonboiling waste) could accommodate. The 241-SX tanks were the first to be equipped with ALCs to minimize thermal gradients in tank waste.

Isolated incidents also occurred involving liner instability (i.e., sudden upward buckling of the bottom of the steel liner). Tank 241-SX-113 was the first tank where such an event was recognized and evaluated (Brownell 1958). The 241-SX tanks have dished bottoms. However, a departure from previous designs was that 241-SX tanks were constructed without a radiused transition where the dish (i.e., the tank bottom) was joined to the cylinder (i.e., the sidewall). In addition, mastic and gunite materials, which had been used to seat the radiused joint on the older tanks, were eliminated beginning with the 241-SX tank design. Both design changes had the effect of restraining thermal expansion of the steel bottom against the concrete shell when tanks received hot waste. Additionally, when investigating the 241-SX-113 Tank incident it was determined that residual moisture in the 2-in. grout layer between the liner bottom and the base slab had flashed to steam under conditions of elevated waste temperatures and reduced hydrostatic head (i.e., the liquid level in the tank was not sufficient to prevent moisture trapped under the liner from reaching vaporization pressure). In response to bumps and the liner buckling event in Tank 241-SX-113 (which occurred in June 1958), SST operating parameters were redefined several times during the 1950's (e.g., Smith 1955; Tomlinson 1955; Doud and Stivers 1959).

The most prominent SST liner instability event occurred in January 1965 in Tank 241-A-105. In that case, liner instability was accompanied by a violent steam release. The ground in the vicinity of Tank 241-A-105 shook during the event. The vapor pressure excursion in the tank was sufficient to dislodge a riser cover on an adjacent tank, permitting steam from that tank to vent to the atmosphere, and to eject minor amounts of supernate onto the ground surface through piping connections that were not isolated by vapor seals. Inspection afterward revealed that the liner in the floor of Tank 241-A-105 was bulged upward to a height of 8.5 ft at one point creating a void of approximately 80,000 gal between the liner and the base slab. Unlike the earlier incident involving Tank 241-SX-113, the liner in Tank 241-A-105 had been ruptured and permanently deformed. This event also differed from previous incidents in that Tank 241-A-105 had been constructed with ALCs and they were operating normally at the time (Beard et al. 1967). Tank 241-A-105 continued to experience wide liquid-level fluctuations and periodic steam releases (bumps) for some time. Remedial actions were undertaken beginning in late 1965 to decant the supernate and remove the sludge by sluicing. These efforts were complicated by a variety of factors (e.g., the high heat generation rate of the sludge, increasing leakage from the tank during waste retrieval, and uncertainties concerning the quantity and composition of the waste that had moved into the void below the liner). Plans for stabilizing Tank 241-A-105 were still being promulgated almost 10 years after the liner instability event occurred (Metz 1974).

Photographs taken in Tank 241-BY-110 during routine surveillance in 1969 indicated that mastic originally placed between the tank liner and the concrete shell had flowed into the tank through holes in the liner (Godfrey 1969). After the phenomenon was identified and interpreted initially, photographs from other tanks were reexamined and similar conditions were found in other tanks in the 241-BY Tank Farm and a few tanks in the 241-TX Tank Farm. The holes generally were elongated horizontally and typically were located at elevations corresponding to liquid surface levels that had been maintained static for long periods. The hole sites were not associated with welds. The holes were eventually attributed to pitting corrosion of the liner at the liquid-air interface in cool, unagitated tanks. Mastic was not used in construction of the third- and fourth-generation SST farms (241-SX, -A, and -AX) and, therefore, was not a diagnostic aid for locating pitting corrosion sites in those tanks. Operating levels were reduced in several first- and second-generation tanks in response to this finding.

Elastic, thin-wall, isotropic stress analyses of SSTs subjected to active and reactive soil loads were evaluated by Milbradt (1969). This analysis was the first of several structural analyses to identify that vertical tensile fractures could have been created in concrete at the juncture of the tank cylinder and the footing as a result of thermal loading.

Comprehensive reassessments of the structural integrity of SSTs were undertaken in the mid- to late-1970's. Vollert (1979) reported results of ongoing material testing by the Portland Cement Association and structural analyses for 241-AX and 241-U tanks. Vollert (1979) and Ramble (1983) evaluated structural sensitivity of SSTs to soil backfill loads, equipment (i.e., live) loads, hydrostatic loads, and elevated temperatures. Working stresses in tank shells also were compared to predicted stress increases in response to a "safe shutdown earthquake" (characterized by peak particle accelerations of 0.25 g). Loading conditions were compared to acceptable loads cited in national design codes and standards as opposed to failure loads. For 100-Series tanks, soil overburden and thermal loading conditions were determined to be the factors with the largest effect on strength. Live loads and hydrostatic loads were shown to have relatively minor effects on tank integrity. Much of the analysis was done by numerical modeling.

An assessment of tank foundations is included in Appendix D of Ramble (1983). The footing evaluation compared working loads to allowable loads, rather than to loads that would induce actual bearing failures in soil. Since publication, Ramble (1983) has been the principal reference basis for structurally-related tank farm operating limits. Ramble indicated that little of the original SST design criteria documentation could be located at the time his report was prepared.

More recently, the structural integrity of Tank 241-C-106 was evaluated for Project W-320 by numerical modeling methods (Julyk 1994). The primary analytical tool used in that study was the ABAQUS code. Both the reinforced concrete tank and the surrounding soil were represented in the modeling. The soil constitutive relationship selected for the analysis was the Drucker-Prager perfectly plastic model. The results of the analysis indicated that local soil stresses around the haunch and the footing were considerably higher than the free field stresses. Soil stresses beneath the footings did not exceed 8,000 lb/ft^3 in any of the simulations, but did approach that value when ACI load factors were applied (Julyk 1994, p. 8-35). Julyk (1994) includes a historical summary of design documentation for Hanford Site SSTs, with emphasis on Tank 241-C-106.

5.3 MECHANICAL PROPERTIES OF SOIL

During preparation for construction of chemical processing facilities, extensive testing (including borings, test pits, plate bearing tests, and test poles) was performed to evaluate soil types and foundation conditions (du Pont 1945). The borings in the 200 Areas penetrated "sand and gravel with some interbedded silt and clay layers," all of which were reported to exhibit excellent bearing capacity. For all 200 Area chemical processing buildings and large service structures, du Pont's Engineering Division required a minimum bearing capacity of 8,000 lb/ft^2 with no more than 5/16 in. of settlement. Plate bearing tests were performed at the sites of all major structures, including the four original tank farms. Test plates were 12 in. square, loads were applied to undisturbed soil exposed in shallow excavations at depths of 4 to 5 ft, and loads were increased typically in 1,000-lb increments at 24-hr intervals. A total of 72 plate bearing tests were performed for construction of the original 200 Area plant buildings. Of that number, 34 were performed in the 200 East Area and 28 were performed in the 200 West Area. The remaining 10 tests were performed in the 200 North Area. Bearing capacities were determined to be adequate at all of the original tank farm sites. Du Pont (1945) included abbreviated logs of several borings made during initial site characterization, but did not include any plate bearing results. Some of the du Pont plate bearing test data were included in a subsequent HAPO document (Udine 1956). Udine (1956) includes plate test results from the following sites: 221-C Building (4), 202-A (2), 221-U (1), and 222-S Laboratory (1). Construction of 202-A and 222-S were HAPO projects.

Based on existing documentation, it appears there were no foundation investigations for any of the SST farms constructed after World War II. However, investigations were made for some DST farms (e.g., 241-SY Tank Farm; Shannon and Wilson 1974). For the 241-SY Tank Farm, an allowable bearing capacity of 5 T/ft^2 was recommended by the foundation engineer (based on an assumed soil modulus of 10,000 $lb/in.^2$), with an allowable settlement on the foundation ring of 1.0 in. With the tank fully loaded, expected settlements at the center of the slab and on the ring were 2.0 and 2.2 in., respectively. Recommended design values for at rest lateral earth pressure coefficient and backfill unit weight were 0.4 and 115 lb/ft^3, respectively. Shannon and Wilson (1974) included penetration resistance data from one boring.

In the early tank designs, neglecting lateral earth pressure on the tank cylinder was considered to be a conservative design approach, insofar as the at-rest earth pressure outside the tank would tend to counteract the internal hydrostatic pressure. However, after the potential was recognized for significant thermal expansion of the lower portion of the cylinder to occur in tanks containing self-boiling waste, efforts were undertaken to evaluate active and passive earth pressure effects. To support these efforts, Vey and Nelson (1967) developed estimates of various soil properties from borings in the vicinity of tanks 241-A-106, -SX-105, and -SX-110. Initial tangent modulus values of between 30,000 and 40,000 $lb/in.^2$ were measured below the foundation ring at Tank 241-SX-105. Blow counts in the range of 40 to 125 were obtained. Counts above 50 are indicative of very dense sand. It was inferred from the blow count data that ultimate bearing capacities for the tanks investigated could be as high as 27 to 39 T/ft^2. As a consequence of lateral deformation of the soil around the tanks caused by thermal cycling, Vey and Nelson (1967) concluded that strain recovery would be minimal and the lateral earth pressure condition in situ would be best approximated by the active pressure (i.e., 0.25 to 0.3 of the overburden pressure). The authors also noted that the presence of adjacent tanks would induce asymmetrical soil strains during thermal cycling that could induce asymmetrical residual soil stresses.

Bulk density information for tank farm soils has been summarized by Pianka (1994). The most reliable information is from DST farms. During construction of DSTs, backfill was placed to specifications calling for compaction to 85% to 95% of maximum density as determined by ASTM standard methods (Method B; ASTM 1989). For several DST construction projects, quality assurance records of in-place density measurements taken during construction still exist. There is little (if any) comparable information for SSTs. Near-surface soils are coarser in texture and maximum dry density values tend to be higher in the 200 East Area compared to the 200 West Area. Typical dry density values for the 200 West Area are in the range of 112 to 115 lb/ft^3. Comparable values for the 200 East Area range from about 120 to 122 lb/ft^3.

5.4 CONCLUSIONS

The principal purpose of this review was to locate and evaluate sources of geotechnical data that can be applied in the future to model the structural performance of tank-fill alternatives for closure. Structural issues also were reviewed to gain a complete perspective of static loading conditions on tanks. Comprehensive assessments of structural issues are provided elsewhere (e.g., Ramble 1983; Julyk 1994).

An extended effort was made to locate all SST site investigation data and design criteria. However, many of the original records containing geotechnical test data and design criteria for SSTs no longer exist or are not in retrievable form. Extensive geotechnical site evaluations were conducted by du Pont in support of plant construction during and immediately after World War II. However, the information was never summarized by du Pont and only a limited amount of the data was ever published (Udine 1956). As of the mid-1950's, the majority of the original site investigation data had essentially been lost.

Historical documents indicate that there were a variety of significant concerns relating to the structural integrity of SSTs. Most concerns related to safe storage of self-boiling wastes from the REDOX and PUREX processes. There was a continuous evolution in tank designs and tank farm configuration during the 1950's and 1960's in an effort to address various performance issues. However, there is no indication of any tank integrity issues related to soil mechanics or foundation performance. The original site investigations had indicated that soil in the 200 Areas was exceedingly competent as foundation materials. Consequently, du Pont engineers were able to impose a high degree of conservatism on the design of foundations for tanks and other facilities by specifying a bearing capacity value of 4 T/ft^2 with a limit on settlement of 5/16 in., and in neglecting lateral earth pressure on the tank cylinder.

Structural investigations (Ramble 1983; Julyk 1994) have shown that the integrity of tanks in their current configuration is sensitive to the thickness of cover soil. Overburden loading affects tank dome integrity as well as the loading condition on the footings. These investigations also have determined that structural performance and tank integrity are relatively insensitive to lateral earth pressure conditions.

This discussion provides a focus for structural analysis of tank-fill alternatives. Depending on the soil constitutive model(s) selected for the analysis, some additional effort may be required to identify appropriate values for specific input parameters. Geotechnical information from other major construction projects in the 200 Areas will be used if available. Giller (1992) and Shannon and Wilson (1995a and 1995b) contain summaries of relevant data from recent 200 Area investigations.

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Table 5-1. Geotechnical Design Criteria for SSTs, 100-Series Tanks 241-B, -C, -T, and -U Tank Farms.

Constructed 1943-1944

Bearing Capacity for Tank Footings	8,000 lb/ft^2 (6)
Lateral Earth Pressure on Cylinder	None specified (6)
Design Specific Gravity of Contents -Liquid -Sludge	 1.25 (6); Rev. to 1.9 (5,23) None specified (6)
Maximum Liquid Level -Liner Height -Operating (Overflow) Limit	 216 in. (3) 191.5 in. (3)
Design Head Space Pressure Limits -Vapor Pressure -Vacuum	None specified (6) 10 lb/in.^{2} gauge (5) 2.5 lb/in.^{2} gauge (23) None specified (5,6,23)
Operational Soil Cover (Surcharge)	9.0 ft (6) 7.25 ft (3)
Design Live Load Operating Live Load	None specified (6) 34,000 lb Conc. Load (14) 200,000 lb (30)
Fill Properties -Friction Angle -Bulk Density	 26° (6) 100 lb/ft^3 (6)

Numbers in parentheses correspond to numbered references provided in Section 5.5.

Table 5-2. Geotechnical Design Criteria for SSTs, 200-Series Tanks 241-B, -C, -T, and -U Tank Farms.

Constructed 1943-1944

Bearing Capacity for Tank Footings	8,000 lb/ft^2 (7)
Lateral Earth Pressure on Cylinder	None specified (7)
Design Specific Gravity of Contents -Liquid -Sludge	 1.25 (7) None specified (7)
Maximum Liquid Level -Liner Height -Operating (Overflow) Limit	 300 in. (3) 295 in. (3)
Design Head Space Pressure Limits -Vapor Pressure -Vacuum	None specified (7)
Operational Soil Cover (Surcharge)	11.0 ft (7) 11.43 ft (3)
Design Live Load Operating Live Load	None specified (7) 100,000 lb (30)
Fill Properties -Friction Angle -Bulk Density	 26° (7) 100 lb/ft^3 (7)

Numbers in parentheses correspond to numbered references provided in Section 5.5.

Table 5-3. Geotechnical Design Criteria for 241-BX Tank Farm SSTs.

Constructed 1946-1947

Bearing Capacity for Tank Footings	8,000 lb/ft^2 (9)
Lateral Earth Pressure on Cylinder	None specified (9)
Design Specific Gravity of Contents -Liquid -Sludge	 1.25 (9) 1.9 (5,23) None specified (9)
Maximum Liquid Level -Liner Height -Operating (Overflow) Limit	 216 in. (3) 191.5 in. (3)
Design Head Space Pressure Limits -Vapor Pressure -Vacuum	Atmospheric (9) 10 lb/in.^{2} gauge (5) 2.5 lb/in.^{2} gauge (23) None specified (5,9,23)
Operational Soil Cover (Surcharge)	9.0 ft (9) 7.25 ft (3)
Design Live Load Operating Live Load	34,000 lb Conc. Load (9) 200,000 lb (30)
Fill Properties -Friction Angle -Bulk Density	 26° (9) 100 lb/ft^3 (9)

Numbers in parentheses correspond to numbered references provided in Section 5.5.

Table 5-4. Geotechnical Design Criteria for 241-TX Tank Farm SSTs.

Constructed 1947-1948

Bearing Capacity for Tank Footings	Unknown
Lateral Earth Pressure on Cylinder	Not specified
Design Specific Gravity of Contents -Liquid -Sludge	 1.2 revised to 1.9 (5,23) Not specified
Maximum Liquid Level -Liner Height -Operating (Overflow) Limit	 312 in. (3) 283 in. (3)
Design Head Space Pressure Limits -Vapor Pressure -Vacuum	 10 lb/in.^{2} gauge (5) 1.8 lb/in.^{2} gauge (23) 2.1 lb/in.^{2} gauge (10) 0.22 lb/in.^{2} gauge (10)
Operational Soil Cover (Surcharge)	Approx. 8 ft (3) 9.5 ft max (10)
Design Live Load Operating Live Load	92,000 lb less fixed equipment (10) 200,000 lb (30)
Fill Properties -Friction Angle -Bulk Density	None specified (18)

Numbers in parentheses correspond to numbered references provided in Section 5.5.

Table 5-5. Geotechnical Design Criteria for 241-BY Tank Farm SSTs.

Constructed 1948-1949

Bearing Capacity for Tank Footings	Unknown
Lateral Earth Pressure on Cylinder	Not specified
Design Specific Gravity of Contents -Liquid -Sludge	 1.2 revised to 1.9 (5,23) Not specified
Maximum Liquid Level -Liner Height -Operating (Overflow) Limit	 324 in. (3) 284 in. (3)
Design Head Space Pressure Limits -Vapor Pressure -Vacuum	 10 lb/in.^{2} gauge (5) 1.8 lb/in.^{2} gauge (23) 2.1 lb/in.^{2} gauge (10) 0.22 lb/in.^{2} gauge (10)
Operational Soil Cover (Surcharge)	Approx. 8 ft (3) 9.5 ft max (10)
Design Live Load Operating Live Load	92,000 lb less fixed equipment (10) 200,000 lb (30)
Fill Properties -Friction Angle -Bulk Density	None specified (18)

Numbers in parentheses correspond to numbered references provided in Section 5.5.

Table 5-6. Geotechnical Design Criteria for 241-S Tank Farm SSTs.

Constructed 1950-1951

Bearing Capacity for Tank Footings	Unknown
Lateral Earth Pressure on Cylinder	Not specified
Design Specific Gravity of Contents -Liquid -Sludge	 1.2 revised to 1.9 (5,23) Not specified
Maximum Liquid Level -Liner Height -Operating (Overflow) Limit	 312 in. (3) 285.5 in. (3)
Design Head Space Pressure Limits -Vapor Pressure -Vacuum	 10 lb/in.^{2} gauge (5) 1.8 lb/in.^{2} gauge (23) 2.1 lb/in.^{2} gauge (10) 0.22 lb/in.^{2} gauge (10)
Operational Soil Cover (Surcharge)	6.27 ft (3) 9.5 ft max (10)
Design Live Load Operating Live Load	92,000 lb less fixed equipment (10) 200,000 lb (30)
Fill Properties -Friction Angle -Bulk Density	None specified (18)

Numbers in parentheses correspond to numbered references provided in Section 5.5.

Table 5-7. Geotechnical Design Criteria for 241-TY Tank Farm SSTs.

Constructed 1951-1952

Bearing Capacity for Tank Footings	Unknown
Lateral Earth Pressure on Cylinder	Not specified
Design Specific Gravity of Contents -Liquid -Sludge	 1.2 revised to 1.9 (5,23) Not specified
Maximum Liquid Level -Liner Height -Operating (Overflow) Limit	 312 in. (3) 284 in. (3)
Design Head Space Pressure Limits -Vapor Pressure -Vacuum	 10 $lb/in.^2$ gauge (5) 1.8 $lb/in.^2$ gauge (23) 2.1 $lb/in.^2$ gauge (10) 0.22 $lb/in.^2$ (10)
Operational Soil Cover (Surcharge)	Approx. 8 ft (3) 9.5 ft max (10)
Design Live Load Operating Live Load	92,000 lb less fixed equipment (10) 200,000 lb (30)
Fill Properties -Friction Angle -Bulk Density	None specified (18)

Numbers in parentheses correspond to numbered references provided in Section 5.5.

Table 5-8. Geotechnical Design Criteria for 241-SX Tank Farm SSTs.

Constructed 1953-1954

Bearing Capacity for Tank Footings	Unknown
Lateral Earth Pressure on Cylinder	Not specified
Design Specific Gravity of Contents -Liquid -Sludge	 1.68 (5) 1.5 (23) Not specified
Maximum Liquid Level -Liner Height -Operating (Overflow) Limit	 384 in. (3) 373 in. (3)
Design Head Space Pressure Limits -Vapor Pressure -Vacuum	 10 lb/in.^{2} gauge (5) 4.8 lb/in.^{2} gauge (23) Not specified
Operational Soil Cover (Surcharge)	6 ft (3)
Design Live Load Operating Live Load	Unknown 200,000 lb (30)
Fill Properties -Friction Angle -Bulk Density	 Not specified 112.3 lb/ft^3 (18)

Numbers in parentheses correspond to numbered references provided in Section 5.5.

Table 5-9. Geotechnical Design Criteria for 241-A Tank Farm SSTs.

Constructed 1954-1955

Bearing Capacity for Tank Footings	Unknown
Lateral Earth Pressure on Cylinder	Not specified
Design Specific Gravity of Contents -Liquid -Sludge	 1.37 (5) 2.2 (23) Not specified
Maximum Liquid Level -Liner Height -Operating (Overflow) Limit	 384 in. (3) 371 in. (3)
Design Head Space Pressure Limits -Vapor Pressure -Vacuum	 10 lb/in.^{2} gauge (5) 6.9 lb/in.^{2} gauge (23) Not specified
Operational Soil Cover (Surcharge)	7 ft (3)
Design Live Load Operating Live Load	Unknown 200,000 lb (30)
Fill Properties -Friction Angle -Bulk Density	 Not specified 121.7 lb/ft^3 (18)

Numbers in parentheses correspond to numbered references provided in Section 5.5.

Table 5-10. Geotechnical Design Criteria for 241-AX Tank Farm SSTs.

Constructed 1963-1964

Bearing Capacity for Tank Footings	Unknown
Lateral Earth Pressure on Cylinder	Not specified
Design Specific Gravity of Contents -Liquid -Sludge	 1.1 to 1.6 (25) 1.6 to 2.5 (25)
Maximum Liquid Level -Liner Height -Operating (Overflow) Limit	 384 in. (3) (No overflow connections)
Design Head Space Pressure Limits -Vapor Pressure -Vacuum	 17.7 lb/in.^{2} absolute (3 lb/in.^{2} gauge) (25) 13.7 lb/in.^{2} absolute (-1 lb/in.^{2} gauge) (25)
Operational Soil Cover (Surcharge)	6 ft (3)
Design Live Load Operating Live Load	40 lb/ft^2 + 100,000 lb Conc. Load (25) 200,000 lb (30)
Fill Properties -Friction Angle -Bulk Density	 Not specified Not specified (18)

Numbers in parentheses correspond to numbered references provided in Section 5.5.

6.0 CONCEPTUAL COST ESTIMATES FOR ALTERNATIVES

6.1 BACKGROUND

Independent cost estimates have been developed for closing tanks by the four alternate stabilization methods under consideration. For purposes of preparing these estimates, the scope of closure was based on the scope considered in the Draft EIS for the TWRS (DOE and Washington State Department of Ecology [Ecology] 1996). Closure concepts, facilities descriptions and associated estimates of materials, labor, schedules, and costs for the EIS are documented in the Closure Data Package prepared by Kline et al. (1995). In the EIS, the simplifying assumption was made that tanks would be stabilized with crushed aggregate (equivalent to Alternative 1 in this study). Kline et al. (1995) evaluated two tank-fill alternatives equivalent to Alternatives 1 and 2 in this study. During FY 1996, the closure scope and cost estimate in the Multi-Year Program Plan (MYPP) for TWRS were revised to reflect the treatment of closure in the EIS.

The scope of closure in the TWRS EIS and the MYPP closure cost estimate include elements that are outside the scope of this engineering study. The EIS and MYPP estimates include costs for stabilizing SSTs and DSTs and for construction of surface barriers over SSTs, DSTs, and low-activity waste vaults. For this study, the issue of specific interest is the cost comparison for stabilizing SSTs by the four alternative methods described in Section 2.0.

The scope and content of each of the four estimates are summarized in Section 6.2. The results of the cost comparison are reported in Section 6.3. The estimates are reproduced as Appendix E.

6.2 WORK SCOPE ADDRESSED IN COST ESTIMATES

6.2.1 Alternative 1: Gravel Fill

Of the four closure cost estimates, the gravel fill estimate most closely reflects the scope and content of the current TWRS MYPP cost baseline. The MYPP estimate assumes that SSTs and DSTs would be stabilized with gravel fill. In the estimate, costs are developed for five activity categories:

- Definitive design
- Field engineering and inspection
- Construction - cost plus award fee (CPAF)
- Construction - fixed price
- Project management.

Under definitive design, the estimate includes costs for the gravel fill mechanical system and controls; related infrastructure (gravel conveyors, stockpiles, borrow, crushing and screening operations); facilities and equipment for grout filling of auxiliary tanks, ancillary facilities and related piping; removal of ITH; and installation of 42-in.-diameter central risers in SSTs that currently lack serviceable access for gravel fill equipment. Definitive design costs for surface barriers over tank farms are included in construction costs.

Field engineering and inspection costs are included for activities to be performed by plant forces construction crews (i.e., removal of ITH and installation of 42-in. risers). These activities were estimated as plant forces tasks because of the potential for radiological exposures and the need to apply specific radiological controls and surveillance procedures.

CPAF construction items are activities that would be performed by plant forces crews.

Fixed-price construction costs include equipment, labor and materials for the gravel fill operation; infrastructure construction; grouting of ancillary facilities; and surface barrier construction. Costs are also included in this category for placing subcontracts for construction and for construction management.

The estimate includes project management costs for construction of surface barriers and plant forces tasks.

The MYPP baseline does not include costs for removal of ITH items or installation of 42-in. risers. The MYPP baseline also assumes that surface barriers would be constructed to cover entire tank farm operable units. The estimates prepared for this study assume that barriers would be constructed over individual farms.

6.2.2 Alternative 2: Grout Fill

The grout fill estimate includes costs for the same five categories of work activities listed for gravel fill.

The estimate includes definitive design costs for the grout fill operation; related infrastructure (grout plant, delivery and dry storage of materials, pump, pumplines and hard piping, borrow operation for producing sand); related operations for grouting ancillary facilities; and for excavation/construction adjacent to tanks to access overflow lines to crimp them shut.

Field engineering and inspection costs are included for crimping overflow lines between tanks. This activity was costed as plant forces work because of the need to impose radiological controls on the work. Work by plant forces was estimated as CPAF construction.

As above, fixed-price construction costs include equipment, labor and materials for the grout fill operation; infrastructure construction; grouting of ancillary facilities; and surface barrier construction. Definitive design costs for surface barriers over tank farms are included with construction costs. Costs are also included in this category for placement of subcontracts for construction and for construction management. The estimate includes project management costs for construction of surface barriers and work performed by plant forces.

The MYPP baseline does not identify costs for crimping overflow lines between tanks.

6.2.3 Alternative 3: Hybrid Fill

Costs for the hybrid fill alternative are broken down into the same categories of work activities listed for the gravel fill alternative. The hybrid fill estimate includes costs for definitive design of the two-stage tank-fill operation; emplacement of grout tubes into the coarse aggregate fill;

related infrastructure (borrow operations for producing sand and coarse aggregate, aggregate conveyance system, aggregate stockpile, grout plant, delivery and dry storage of materials, pump, pumplines and hard piping); related operations for grouting ancillary facilities; excavation/construction adjacent to tanks to access overflow lines to crimp them shut; and for installation of 42-in.-diameter central risers in SSTs that currently lack serviceable access for aggregate fill equipment.

Field engineering and inspection costs are included for crimping overflow lines between tanks and installation of 42-in. risers. These activities were costed as plant forces work because of radiological issues associated with the work. Work by plant forces was estimated as CPAF construction.

Fixed-price construction costs include equipment, labor and materials for the aggregate and grout fill operations; emplacement of grout tubes; infrastructure construction; grouting of ancillary facilities; and surface barrier construction. Definitive design costs for surface barriers over tank farms are included with construction costs. As indicated previously, costs are included in this category for placement of subcontracts for construction and for construction management and project management costs for construction of surface barriers and work performed by plant forces.

The MYPP baseline does not identify costs for crimping overflow lines between tanks or for installation of 42-in. access risers.

6.2.4 Alternative 4: Concrete Fill

The concrete fill estimate includes costs for the same categories of work described for the previous estimates. Because of similarities in the technologies involved, the concrete fill estimate includes essentially the same activities described above for grout fill.

The estimate includes definitive design costs for the concrete fill operation; related infrastructure (grout plant, delivery and dry storage of materials, pump, pumplines and hard piping, borrow operations for producing sand and gravel); operations for grouting ancillary facilities; and for excavation/construction adjacent to tanks to access overflow lines to crimp them shut.

Field engineering and inspection costs are included for crimping overflow lines between tanks.

Fixed-price construction costs include equipment, labor and materials for the concrete fill operation; infrastructure construction; grouting of ancillary facilities; and surface barrier construction. Definitive design costs for surface barriers over tank farms are included with construction costs. Costs are included for placing subcontracts for construction and for construction management. The estimate includes project management costs for construction of surface barriers and work performed by plant forces.

The MYPP baseline does not identify costs for crimping overflow lines between tanks.

6.3 COMPARISON OF SST STABILIZATION COSTS

To obtain a direct comparison between the costs for stabilizing SSTs, cost elements in the estimates for extraneous activities (i.e., stabilizing DSTs and construction of surface barriers over tank farms and vaults) must be identified and segregated. This was done in the following manner:

- Each estimate was reviewed by activity (i.e., at the level of the work breakdown structure)
- For tank stabilization activities wherein costs for SSTs and DSTs were estimated collectively, costs were allocated to SSTs and DSTs in proportion to the volumes of fill materials required for each group of tanks (see Table A-1 in Kline et al. [1995])
- For activities relating to stabilization of ancillary facilities, costs were allocated to SSTs and DSTs in proportion to the volumes required for each group (see Table A-7 and Section 3.2.3 in Kline et al. [1995])
- For activities relating to surface barrier construction, costs were divided between SSTs, DSTs, and vaults in proportion to construction costs, which were estimated separately for each tank farm.

The resulting cost breakdown is shown in Table 6-1.

Table 6-1. Summary of Closure Costs by Alternative.
(in $Millions)

	Alternative 1 Gravel	Alternative 2 Grout	Alternative 3 Hybrid	Alternative 4 Concrete
SSTs	$232.2	$242.0	$269.3	$232.5
DSTs	58.5	69.3	70.1	66.1
Vaults	46.8	46.8	46.8	46.8
Totals	$337.6	$358.1	$386.2	$345.5

Costs in Table 6-1 for SSTs were broken down a second time to isolate costs associated with stabilization of ancillary facilities and construction of surface barriers. When those items are eliminated, the costs that remain are the costs directly associated with SST stabilization (see Table 6-2).

Table 6-2. SST Stabilization Costs by Alternative.
(in $Millions)

	Alternative 1 Gravel	Alternative 2 Grout	Alternative 3 Hybrid	Alternative 4 Concrete
Definitive Design	$21.8	$20.1	$21.9	$18.3
Field Engr./Insp.	2.2	0.7	2.3	0.7
Plant Forces Construction	22.1	6.5	19.9	6.5
Fixed Price Construction	48.6	77.9	86.6	70.3
Project Management	1.7	1.0	2.8	1.0
Totals	$96.4	$106.2	$133.5	$96.7

Comparison of costs in Table 6-2 indicates that two stabilization alternatives, gravel fill and concrete fill, are essentially indistinguishable from one another and both are superior to the grout fill and hybrid fill alternatives, if cost is the sole consideration. Hybrid fill is significantly more costly than the other alternatives. It is also of interest to note that concrete fill offers a cost advantage over grout fill, even though the two alternatives employ similar technologies, equipment, and resources. All costs include a 35% contingency.

6.4 REFERENCES

DOE and Ecology, 1996, *Draft Environmental Impact Statement for the Tank Waste Remediation System*, U.S. Department of Energy and Washington State Department of Ecology, Olympia, Washington.

Kline, P. L., Hampt, H., and W. A. Skelly, 1995, *Closure Technical Data Package for the Tank Waste Remediation System Environmental Impact Statement*, WHC-SD-WM-EV-107, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

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7.0 REVERSIBILITY

Reversibility may be an important attribute for waste disposal decisions since most of the roadblocks to achieving progress in waste disposal are "traceable not to the physical act of placing waste in a secure, engineered facility, but rather to our collective state of mind about attempting to execute a solution that is meant to be permanent and irreversible" (Newberry et al. 1995). Evidence of this view can be found in development of waste remediation strategy at Hanford. In evaluating and comparing tank-fill alternatives, preserving flexibility to reverse a tank closure decision may therefore be an important advantage for gaining regulatory and stakeholder acceptance.

7.1 BACKGROUND

During the mid 1980's, the DOE prepared an EIS (Hanford Defense Waste EIS) to evaluate alternatives for disposal of Hanford defense, high-level, transuranic, and tank wastes. During this process, a citizens advisory group representing the public and stakeholders met periodically to discuss related issues and to provide input to DOE's disposal decisions. In 1988, DOE published its ROD (53 FR 12449), which adopted the public and stakeholder advisory group's recommendation to proceed with retrieval of DST waste and onsite disposal of the separated low-level waste (LLW) fraction in the form of large grout monoliths placed in concrete vaults. In 1989 DOE, the U.S. Environmental Protection Agency (EPA), and Ecology signed the Tri-Party Agreement that clarified the regulatory framework and established schedules for implementing the ROD.

Pursuant to the ROD, the grout project constructed five 1.4-Mgal (5,300-m^3) vaults and filled one with low-activity grout. The project was placed on hold in FY 1993 after new stakeholder concerns were voiced regarding grouted waste. Because of this, and other developments that precluded implementation of the ROD, the Tri-Party Agreement was renegotiated (Ecology et al. 1994). During renegotiations, another citizens advisory group representing the public and stakeholders met to advise DOE, EPA, and Ecology of public values that should be considered in establishing new strategy and schedules related to Hanford cleanup (Hanford Tank Waste Task Force, 1993). Under the category "waste form and storage," the Task Force cited the following "specific implementation-related value:"

> "Put wastes in an environmentally-safe form, using retrievable waste forms when potential hazards from the waste may require future retrieval and when retrievability does not cause inordinate delays in getting on with cleanup."

Following completion of the Tri-Party Agreement renegotiations, the TWRS issued a technical strategy document (DOE and WHC, 1994) to provide a basis for developing revised cost and schedule baselines consistent with the modified Tri-Party Agreement. The strategy for LLW immobilization, as stated in that document, included the following statement incorporating the stakeholder value relating to retrievable waste forms:

> "The vitrified LLW will be placed in an onsite near-surface disposal in a manner that will allow retrieval for placement elsewhere (for up to 50 years from time of emplacement), should that become necessary."

7.2 RETRIEVABILITY ASSESSMENT FOR TANK-FILL ALTERNATIVES

Preserving flexibility to reverse a closure decision can be achieved by using a retrievable tank-fill material. In such case, a decision to place engineered fill in a tank can be viewed as a decision only to provide interim stabilization. A decision on final closure or retrieval could be made at a later time.

Retrievability of tank fill can only be addressed qualitatively at this time. Equipment requirements, cost estimates, safety risks, environmental impacts, or technical feasibility assessments have not been developed or estimated as a basis for ranking or comparing alternatives. For purposes of this study, it is assumed that conventional excavation or decommissioning methods would be used for removing tank fill. For all four tank-fill alternatives, it is assumed that excavation of fill would first require removing the cover soil shielding and then the tank dome itself. It is further assumed that grout injection for the hybrid alternative is required for interim stabilization. In that case, three of the alternatives (concrete, grout, and hybrid fill) would require deploying various types of mechanical abrasion or fragmentation techniques to break up the hard monolith. A crane would then be used to hoist out broken material from the tank. With the cover soil and the domes removed, gravel fill could simply be removed with a crane and clamshell. For this set of assumptions, the four tank-fill alternatives would be ranked as follows:

Tank-Fill Alternative	Retrievability Measure
concrete	poor
grout	poor
gravel	moderate
hybrid	poor

If it is assumed that injection grouting for the hybrid alternative is not required for interim stabilization, but would be performed as part of final closure, then the hybrid option and the gravel fill option would rank equally relative to retrievability, as shown below:

Tank-Fill Alternative	Retrievability Measure
concrete	poor
grout	poor
gravel	moderate
hybrid	moderate

7.3 REFERENCES

53 FR 12449, "Final Environmental Impact Statement for the Disposal of Hanford Defense High-Level, Transuranic and Tank Wastes, Hanford Site, Richland, Washington; Record of Decision," *Federal Register*, Vol. 53, No. 72, pp. 12449-12453, (April 14).

DOE and WHC, 1994, *Hanford Site Tank Waste Remediation System Technical Strategy*, U.S. Department of Energy and Westinghouse Hanford Company, Revision 0, March 18, 1994.

Ecology, EPA, and DOE, 1994, *Hanford Federal Facility Agreement and Consent Order*, Fourth Amendment, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, January 1994.

Hanford Tank Waste Task Force, 1993, *Final Report*, submitted to Washington State Department of Ecology, U.S. Department of Energy, and U.S. Environmental Protection Agency, September 1993.

Newberry, W. F., T. A. Kerr, and D. H. Leroy, 1995, *Assured Storage Facilities: A New Perspective on LLW Management*, Radwaste Magazine, pp. 13-22, September 1995.

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8.0 INTERIM RESULTS AND CONCLUSIONS

8.1 INTRODUCTION

The objective of this study is to evaluate the four tank-fill alternatives described in Section 2.0 according to the criteria identified in the decision plan for this study (Boothe 1996; see Appendix F) and to document the results for future uses. The status of work performed and results obtained to date is summarized below. Assessments of structural and hydrologic performance of tank-fill materials are ongoing. It is envisioned that this study will be revised and reissued to incorporate the results of these tasks as they are completed.

Structural performance of fill materials: Ground work was completed during FY 1996 for structural modeling of tank-fill alternatives, which is scheduled to be initiated in FY 1997. A literature search was completed (see Section 5.0) to identify the nature and extent of internal and external loads on the SSTs. This information is essential for model construction. As a separate effort, a scoping document was prepared that identifies the specific structural issues to be evaluated by numerical modeling methods together with general descriptions of the models needed to examine the issues at the appropriate scale and level of detail; the document is included as Appendix A of this report. No conclusions regarding structural performance of any of the alternatives have been reached to date.

Public health risk: The performance of tank-fill alternatives with respect to public health risk was not included in the scope of work for FY 1996. Work will be initiated as part of the HTI in FY 1997 to address this criterion.

Hydrologic performance of fill materials:

- Travel time: None of the fill materials evaluated offers consistently superior performance in terms of extending travel times to the water table.

- Flux density: For all scenarios evaluated, predicted flux density values immediately below the tank are somewhat lower for gravel fill than for concrete and grout. In some scenarios the differences are not significant. The greatest difference in results is observed in those scenarios where a high K_{sat} value is assigned to the concrete shell.

- Cover: For all fill materials, significant improvements in performance (i.e., longer travel times and lower flux densities) are obtained when a low-infiltration cover is included in the simulation. The cover has a larger impact on overall system performance than the choice of fill material.

Until far-field simulations to evaluate contaminant transport and public health risk are completed, it is unknown whether the hydrologic performance of alternative tank-fill materials will be a significant factor in achieving overall system performance objectives.

Worker radiological exposures: Based on the conceptual descriptions of the alternatives presented in Section 2.0, a scoping study has been completed to evaluate the occupational dose consequences of the various alternatives. This assessment is summarized in Section 4.0. The estimated cumulative occupational radiation doses (person/rem) for the four fill alternatives are:

- Grout and concrete fill: 119 person/rem
- Hybrid fill: 569 person/rem
- Gravel fill: 1,320 person/rem.

Comparative dollar costs: Conceptual cost estimates of the four tank-fill alternatives have been developed as part of this study (see Section 6.0). On the basis of cost, the following comparison was obtained:

- Gravel fill: $ 96.4 Million
- Concrete fill: $ 96.7 Million
- Grout fill: $106.2 Million
- Hybrid fill: $133.5 Million.

Reversibility: Reversibility may be an important attribute in distinguishing a preferred tank-fill alternative for closure. Alternatives that involve filling tanks with cementitious mixtures (i.e., creating monoliths inside the tanks) are undesirable from this perspective. A qualitative rating of the alternatives on the basis of reversibility is as follows:

- Gravel fill: moderate
- Hybrid fill: poor to moderate
- Concrete fill: poor
- Grout fill: poor.

The hybrid option, which is a two-step fill method, would have a "moderate" rating if only the first step (placement of coarse aggregate) is implemented. Once the second step (grout injection to form pre-placed aggregate concrete) is carried out, the fill becomes a monolith like grout or concrete fill, and would have the same "poor" rating.

Selection of a preferred fill method will be made as one of several final decisions for closure in supplemental NEPA documentation to be developed for the TWRS EIS. It is anticipated that this report will serve as a resource for preparing the EIS supplement.

DOE plans to implement a program (HTI) beginning in FY 1997 to gather information and reduce uncertainties associated with tank closure. Information obtained through HTI will be used to establish processes and criteria for evaluating future closure options. The planned scope of HTI includes continued engineering development of tank closure alternatives. A decision process is planned as part of HTI leading to selection of a preferred fill alternative as a basis for focusing future engineering developments. Results and conclusions from this engineering study will support that process.

8.2 REFERENCE

Boothe, G. F., 1996, *Decision Plan: Filling of the Hanford Site Single-Shell Waste Tanks*, WHC-SD-WM-TI-749, Westinghouse Hanford Company, Richland, Washington.

APPENDIX A

STRUCTURAL MODELS FOR CLOSURE OF SINGLE-SHELL TANKS

J. T. Baxter

CONTENTS

FIGURES:

A1.0 PURPOSE

This appendix (formerly published by Baxter, WHC-SD-WM-ES-372) examines three construction scenarios being considered for backfill and closure of the Hanford Site SSTs similar to those described in the closure data package (Kline et al. 1995) for the TWRS EIS. The closure data package identifies the civil/structural functional requirements necessary to ensure acceptable long-term postclosure structural integrity of the tanks and the Hanford Barriers.

Based on these functional requirements, a design analysis strategy is proposed that identifies the civil/structural assumptions and analyses needed to demonstrate long-term postclosure structural integrity of the tanks and barriers. Development of the engineering models for the conduct of these analyses will require field soil investigations at the tank farm sites, laboratory testing of soil samples, and proof-of-process testing for the proposed backfill and closure construction methods to develop mechanics input parameters for the structural models. Additional postclosure settlement or subsidence monitoring will be needed to verify the backfill and closure design during the design verification period subsequent to tank closure. Design verification data collected during this monitoring period will provide a technical basis for the final decision to abandon the tanks.

The backfill and closure construction method and sequence also affect postclosure near-field contaminant transport. Results from numerical models of near-field groundwater flow and contaminant transport for closure conditions at the tank farms may be required to establish the radiological source terms for the overall Hanford Site postclosure performance assessment model. Results from the tank farm and sitewide models will be used to demonstrate compliance with EPA groundwater protection rules and other applicable standards, and will support the decision to close the tank farm operable units.

In addition to the demonstration defining structural models to support tank closure, the closure construction scenarios described in this appendix provide a framework for identifying values of groundwater flow and contaminant transport parameters needed to model the performance of tank farm operable unit closure methods. Proof-of-process testing for the proposed backfill and closure construction methods may include field sampling and laboratory testing to develop values for the transport modeling parameters.

A2.0 SUMMARY AND RECOMMENDATIONS

Disposal plans for non-HLW at the Hanford Site are based on construction of surface barriers over the SST farms after the tanks have been closed. Surface barrier performance objectives are as follows:

- Limit the recharge of water through the waste to the water table to near zero amounts
- Be maintenance free
- Isolate wastes for a minimum of 1,000 years.

These objectives require that the closed tanks and surrounding soils in the foundation zone below the surface barrier be structurally stable. In this case, stability means that the tanks will not collapse and that the settlements in the soils below the surface barrier are limited to ensure continued functionality of the surface barrier.

The preferred alternative for SST closure is to backfill the tanks after remediation to provide long-term structural stability and limit settlements. Three alternatives are being considered for backfill and closure of the SSTs. Candidate backfill materials include gravel, grout, and concrete.

Recommendations were made to develop three numerical models for evaluating and predicting deformations and stresses in the tanks, the backfill, and surrounding soils during closure activities. Settlement calculations are to be used to discriminate between the three backfill alternatives to select the preferred method consistent with acceptable long-term isolation performance requirements for the surface barrier. Gravel backfill would be the most economical alternative; however, it may not have sufficient stiffness when placed with available methods to limit long-term settlements to acceptable ranges. The numerical models will be used to evaluate short- and long-term settlements for each of the backfill alternatives against the functional deformation limits for the overlying surface barrier. Field elevation surveys are recommended during initial closure activities to verify numerical models and the settlement predictions for comparison with the barrier functional deformation limits.

The backfill and closure construction method, and sequence, also affect postclosure near-field contaminant transport. Results from numerical models of near-field groundwater flow and contaminant transport for closure conditions at the tank farms may be required to establish the radiological source terms for the overall Hanford Site postclosure performance assessment model. Results from initial performance assessment modeling may impact the selection of the preferred backfill alternative by imposing additional hydrologic performance requirements on the backfill selection process. The three current candidate backfill materials span the expected range of hydrologic performance requirements that could be required.

A3.0 BACKGROUND AND ASSUMPTIONS

In April 1988, DOE issued a ROD, in accordance with the NEPA, addressing disposal of Hanford's defense, high-level, and transuranic waste (DOE 1988). The *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al. 1994) established a timetable for implementing the disposal strategy described in the ROD (Ecology et al. 1989). Subsequent events have necessitated changes in the tank waste disposal portion of this overall strategy. Consequently, in the TWRS EIS, several alternative tank waste disposal strategies are again being evaluated. Alternatives addressed in the TWRS EIS are the following:

1. **No Action**--Continue existing tank farm operations and maintenance indefinitely, with no new facility construction.

2. **Long-Term Management**--Continue existing tank farm operations and maintenance, with transfer of waste to new tanks every 50 years.

3. **In Situ Fill and Cap**--Dispose of waste in place by filling tanks with gravel to prevent tank dome collapse, and place a surface barrier.

4. **In Situ Vitrification**--Vitrify waste in place, fill remaining volume in tanks with gravel, and place a surface barrier.

5. **Ex Situ Intermediate Separations**--Retrieve 99% of waste volume, separate into HLW and LLW fractions by sludge washing and ion exchange, vitrify both HLW and LLW, dispose of LLW onsite in vaults, send HLW to a geologic repository offsite, fill emptied tanks with gravel and place a surface barrier.

6. **Ex Situ No Separations**--Retrieve 99% of waste volume, vitrify or calcine as HLW, send vitrified waste to a geologic repository offsite, fill emptied tanks with gravel and place a surface barrier.

7. **Ex Situ Extensive Separations**--Retrieve 99% of waste, separate into HLW and LLW fractions by sludge washing, ion exchange, caustic leach, and acid dissolution to minimize volume of HLW, vitrify both HLW and LLW, dispose of LLW onsite in vaults, send HLW to a geologic repository, fill emptied tanks with gravel and place a surface barrier.

8. **Ex Situ/In Situ Combination**--Dispose of approximately 50% of tank waste by "In Situ Fill and Cap," and the balance by "Ex Situ Intermediate Separations."

9. **Phased Implementation**--Dispose of tank waste as in the "Ex Situ Intermediate Separations" alternative, but through privatization in two phases.

The "Ex Situ Intermediate Separations" alternative described above most closely represents the preferred strategy for tank waste disposal that was adopted in Amendment #4 to the Tri-Party Agreement.

Supporting data for the above waste treatment and disposal options are addressed in separate waste treatment data packages that were prepared to serve as the basis for evaluation of environmental impacts. Tank farm closure, which applies to all but two of the alternatives listed above, is discussed in one of those data packages (Kline et al. 1995).

A3.1 BASIS FOR CURRENT CLOSURE SCENARIOS

With the exception of alternatives 1 and 2 above, all the TWRS EIS alternatives require closure activity for the waste tanks. Four of the alternatives (5, 6, 7, and 9) require removal of as much waste as is technically achievable (nominally 99% by volume, based on the Tri-Party Agreement). The balance of the discussion in this appendix is applicable only to these four TWRS EIS alternatives, wherein it is assumed that the condition of SSTs following retrieval satisfies the Tri-Party Agreement Milestone M-45-00 requirement that no more than 360 ft^3 of waste remains in the 75-ft-diameter tanks, nor more than 30 ft^3 in the 20-ft-diameter tanks.

A3.2 CLOSURE/STABILIZATION SCENARIOS

- The nominally empty SSTs will be stabilized by backfilling with gravel, grout, concrete, or some combination of gravel and grout to ensure long-term integrity of the tank domes

- Ancillary equipment will be grout-filled for stabilization. It will not be excavated or packaged

- Permanent isolation surface barriers (Hanford Barriers) will be placed over the backfilled SSTs.

Additional assumptions for the scenarios include:

- Percent waste removal criteria refer to waste volumes in the tanks and do not include excavation of the soil surrounding the tanks, nor excavation of ancillary equipment

- No additional soil remediation activities are required that might impact the general arrangement of the designs being considered, or disturb the barriers after construction

- The Hanford Barrier will meet or exceed performance requirements specified in the closure data package (Kline et al. 1995).

A4.0 SYSTEM FUNCTIONAL REQUIREMENTS FOR CLOSURE

Disposal plans for non-HLW at the Hanford Site are based on the design of a standard permanent isolation surface barrier (Hanford Barrier) (Wing 1993). A cross-section of the Hanford Barrier is shown in Figure A-1. The Hanford Barrier is expected to be used to isolate buried waste exceeding the standards for Class C LLW, related mixed level wastes, and transuranic waste-contaminated soil sites. Preliminary performance objectives for this barrier include:

- Function in a semiarid to subhumid climate

- Limit the recharge of water through the waste to the water table to near zero amounts

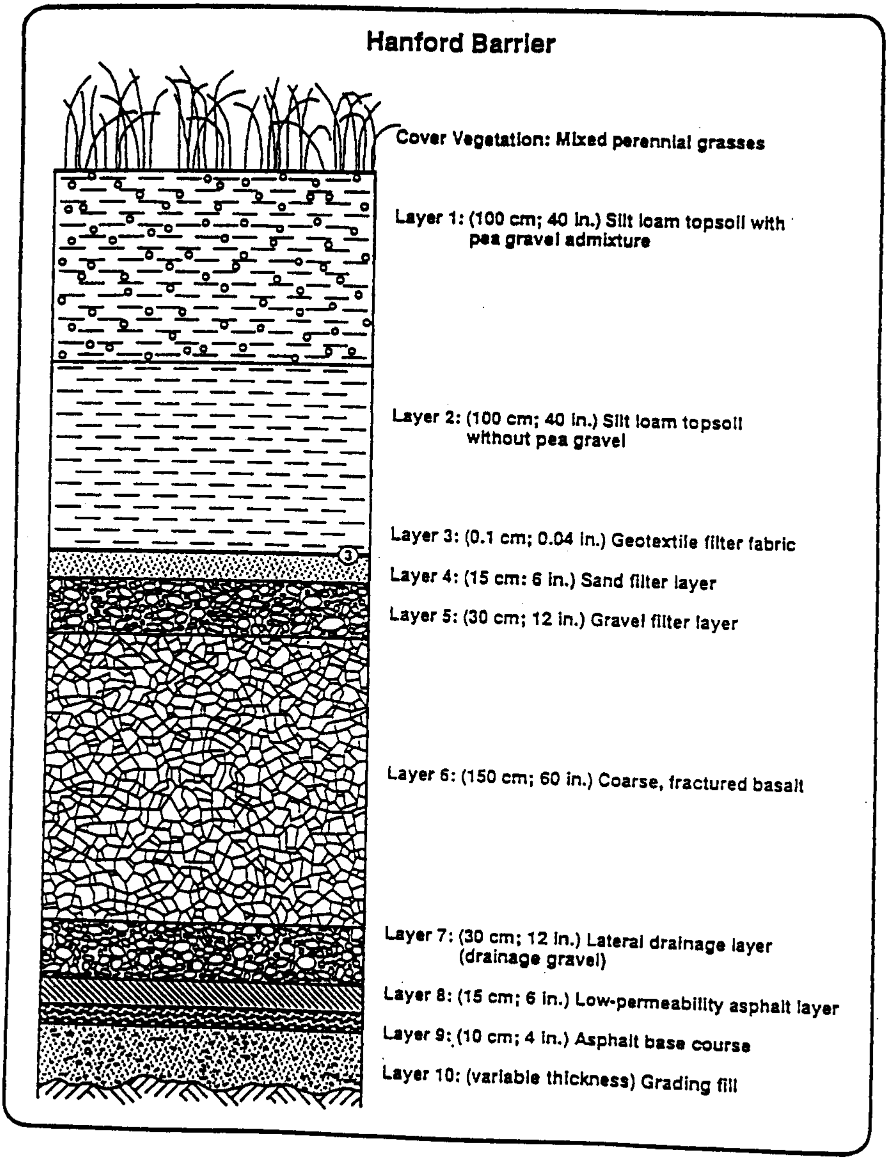
- Maintenance free

- Minimize the likelihood of plant, animal, and human intrusion

- Minimize erosion related problems

- Meet or exceed *Resource Conservation and Recovery Act of 1976* cover performance requirements

Figure A-1. Hanford Barrier Cross-Section.



- Isolate wastes for a minimum of 1,000 years
- Be regulatorily and publicly acceptable.

The Hanford Barrier fulfills these objectives by limiting the downward flow of water from natural precipitation to the waste; and subsequent migration of radioactively- contaminated water to the water table. Each layer shown in Figure A-1 has a specific function. Layers 1 and 2 are fine-grained soils that provide a medium for the growth of native plants and storage of precipitation until the processes of evaporation and transpiration can return the water to the atmosphere. The interfaces between layers 2, 3, and 4 provide a capillary break to prevent water from moving downward. Layer 3, the geotextile layer, is not expected to survive for the entire service life of the barrier. Layers 4 through 6 are standard french drain construction tailored to prevent human intrusion by impeding drilling through the barrier. Layers 7 through 9 form a low-permeability cap for the underlying materials. Gravel in layer 7 provides a drain to channel downward migrating water to the outer edges of the barrier. Layer 8 is a low-permeability barrier that prevents downward movement of water and upward movement of noxious gases from the waste. Layer 10 is the base course used to determine the elevations and slopes for the overall Hanford Barrier. At this time, the Hanford Barrier is considered to represent the upper bound for complexity and expected barrier surcharge weight to be placed over the closed tanks. Other simpler and lighter surface barrier designs are being reviewed.

A4.1 STRUCTURAL STABILITY

During waste disposal operations, surface barriers will be constructed over the top of individual tank farms as described in the closure data package, Table A-1 (Kline et al. 1995). For example, the 241-A Tank Farm consists of six 1-Mgal tanks.

Radioactive waste in the tanks will be retrieved and disposed of under several of the TWRS EIS waste treatment and disposal alternatives. The tanks will then be backfilled, and the operable unit subsequently closed by constructing a Hanford Barrier over the tanks. A preliminary estimate for the design life of the Hanford Barrier and the overall system is 1,000 years. To ensure the long-term continued functioning of the Hanford Barrier, the underlying strata and tanks must provide structural stability. They must prevent subsidence due to collapse of closed tanks and equipment and limit settlement of the overburden to that which maintains the performance of the Hanford Barrier layers 8 and 9; i.e., ensure that these layers are not ruptured by localized differential settlements such as would occur due to collapse of an empty tank or partial collapse of an inadequately backfilled tank. In addition, the drainage slopes for layers 8 and 9 must retain their ability to channel downward migrating water to the outer edges of the barrier. Barrier layers 4, 8, and 9 are the thinnest layers and thus, the most sensitive to overall settlement and differential settlement relative to a given gage length. Functions of the other layers would not be impeded by relatively much larger settlements. Thus, the design for backfill and closure of the tanks must demonstrate, with adequate conservatism, that the tanks will remain structurally stable, and that overall settlements of the backfilled tanks, the surrounding soils, and the overlying Hanford Barrier will be acceptable for a barrier design life of hundreds to possibly 1,000 years.

Two strategies could be adopted to demonstrate long-term structural stability of the Hanford Site waste tanks. The first strategy would demonstrate that the tanks are adequate, as-built, to resist all expected loadings with adequate design margins for an appropriate design life to prevent collapse. There are many impediments to this strategy. For example, none of the tanks were designed to resist the additional dead load of a Hanford Barrier. The SSTs originally were not designed to resist lateral forces due to earthquakes. Extrapolation of past SST and DST performance would require that the current as-built condition be established for the tanks, and that expected aging processes be quantified, including uncertainty, to demonstrate adequate strength and deformation capacity at end-of-life. In this case end-of-life would be hundreds to possibly 1,000 years. All of the above considerations represent formidable engineering tasks, particularly when working in a radioactively-contaminated environment.

A second, and preferred strategy, is to demonstrate long-term structural stability of the Hanford waste tanks by adopting a disposal method which includes backfilling of the tanks with a material designed to provide structural support. Structural backfill would be relied on to provide long-term support for the tank domes and the overlying Hanford Barrier. This strategy is discussed further in this appendix.

A4.2 TANK BACKFILL PROCESSES AND ANTICIPATED SETTLEMENTS

Several alternatives for tank stabilization are proposed in the closure data package (Kline et al. 1995). These alternatives include backfill with gravel, grout, or concrete. Readers are referred to the closure data package for additional process details.

A4.2.1 Gravel Backfill

Gravel is perhaps the simplest process/material proposed to structurally stabilize the tanks. The method referenced by the closure data package is to use a gravel slinger to place well-graded crushed rock throughout the tank, including the dome. This process could easily be adapted to visual inspections to ensure adequate areal coverage without formation of voids and pockets. However, commercial practice generally do not include real-time monitoring of backfill density and degree of compaction. If these measurements are necessary, prototype testing may be required to develop appropriate sensors and supporting instrumentation.

Questions exist as to whether this construction process can adequately backfill the spaces around existing tank internal equipment (e.g., tank risers) and the volume immediately under the tank dome. Proof-of-process testing may be necessary to demonstrate that fill can be adequately placed behind risers and in intimate contact with the underside surface of the dome with adequate compaction. If results of testing indicate its need, an alternate construction procedure may be adopted where the main gravel backfill is placed below the dome volume, followed by a grout-tight membrane and a final grout plug to ensure intimate contact with the underside of the tank dome.

The structural analyses proposed for monitoring this process and to address tank settlement during the backfill process include re-use of the SST finite element models developed for the Phase I Sensitivity Studies that supported the Accelerated Safety Analysis (Hyde et al. 1994). The existing finite element models have to be modified to account for the backfill and the soil mass surrounding and supporting the tanks. An additional larger scale model should be developed to address the question of overall and differential settlements at the scale of an entire tank farm during construction of Hanford Barriers (see Section A5.0).

A4.2.2 Grout Backfill

Grout backfill was proposed as a second alternative in the closure data package. A free-flowing, controlled-density grout was proposed that would be self-leveling. Placement would be performed in a series of lifts designed and timed to limit temperature rise during curing. Lift height and curing time limits are required to ensure acceptable final in-place grout characteristics and to maintain the existing tanks structural integrity. The closure data package (subsection 3.1.1.1) discusses mixing the first lift of grout with the residual waste in the tank. This concept should be approached cautiously because 67 of the 149 SSTs are assumed to have leaked. The number of such tanks is reported in the monthly status report for waste tank operations (Hanlon 1995). Slurrying the residual waste would likely wash a significant portion of the inventory out of the leaking tanks into the surrounding soil columns. Mixing the first lift of grout with the residual waste may in fact be technically unfeasible and/or economically impractical.

Grout backfill provides some advantages relative to gravel because it increases the likelihood of achieving a void-free backfill with intimate contact with the underside of the dome. Grout provides a higher modulus of elasticity backfill compared to compacted gravel, thus limiting settlement due to downward movement of the tank roof. If the last lift of the grout backfill included backfilling the tank risers to the ground surface, it could provide pressure compensation for the original tank dead load, leaving the tank dome in a relatively stress-free condition after closure.

Structural analyses proposed for monitoring this process and to address subsidence and deformation issues include re-use of the SST finite element models developed for the Phase I Sensitivity Studies supporting the Accelerated Safety Analysis (Hyde et al. 1994). The existing finite element models have to be modified to account for the backfill lift placements and the soil mass surrounding and supporting the tanks. An additional larger scale model should be developed to address the overall and differential settlements at the scale of an entire tank farm due to construction of the Hanford Barrier.

A4.2.3 Concrete Backfill

Backfilling the tanks with concrete is a third alternative for providing long-term structural stability for closed tanks. A preplaced aggregate concrete process would entail initial emplacement of a larger gap-graded backfill with a minimum 1/2-in. to 1 1/2-in. aggregate size. The tank would first be backfilled with gravel. Gravel backfill would include placement of vertical steel pipes for placing grout and monitoring grout elevations at horizontal intervals of about 20 ft in both the north-south and east-west directions. After placement of the coarse aggregate, grout would be injected near the bottom of each lift to flow horizontally and then vertically filling the void space in the large aggregate in lifts of about 3 ft. The grout typically includes a uniformly graded distribution of fine aggregate with a gap from the maximum fine aggregate size to the large aggregate size to ensure that the grout can flow through the intersticial spaces between the large aggregate pieces.

The process for emplacing gravel-grout backfill would be developed in accordance with ACI (ACI 1992b) "Preplaced Aggregate Concrete," with modifications as appropriate. Great strength is not essential for the tank backfill. The main concerns for backfill are complete penetration of the grout, limitation of voids, and limiting temperature increases due to heat of hydration to protect the existing tank structures.

Alternatively, a standard portable concrete batch plant could be set up in, or adjacent to a tank farm. Concrete would be mixed in the batch plant and pumped to the tank for placement in lifts. Use of standard batch plant equipment and pumps would constrain the maximum aggregate size and limit the available choices for water-cement ratio to prevent segregation during pumping. The batch plant option will be compared to preplaced aggregate concrete during design of the backfill process.

Structural models required to evaluate this method of backfill are identical to those used to evaluate the first two alternatives.

A4.3 RELATIONSHIP OF CONTAMINANT TRANSPORT MODELS TO THE TANK BACKFILL PROCESS

Each of the alternatives for backfilling the tanks may have different implications for near-field modeling of the residual waste by groundwater transport. The general arrangement of the backfilled tanks, locations of the residual waste, and potential groundwater transport pathways are discussed for each backfill alternative in the following subsections.

A4.3.1 Gravel Backfill

This alternative results in a scenario that the SST has a thin layer of residual radioactive waste on the base slab and by the walls. Based on references cited by the closure data package; the Tri-Party Agreement volume of 360 ft^3 represents approximately a 1-in. layer on the inner surface of the tank liner.

Gravel backfill will be placed in a dry condition and will not be saturated after placement. The void space in the gravel fill will provide a large storage volume within the tank for any downward migrating groundwater that might enter the top or sides of the tank. The void ratio for the compacted fill will be established as part of the specifications for the backfill process.

Downward infiltrating groundwater in the soil overlying the tanks will have two potential paths into the tanks. One path will be the fractures along the interfaces between the piping penetrations into the tanks and grout backfill used to seal the penetrations. A second potential path will be through pores in the dome concrete. The hydraulic conductivity of the concrete should account for the reduced concrete thickness due to cracks in the reinforced concrete under normal, dead, and live loads. The cracking pattern can be estimated from the output of existing structural models (Hyde 1994).

The groundwater pathway out of the tanks will be through existing confinement failures in tanks identified as "leakers" or some combination of mass hydraulic conductivity adjusted for cracking under normal, dead, and live loads as discussed above for the tank dome. Access to these areas of the tanks are restricted, thus characterizing these zones may be difficult or impossible. Consequently, the use of conservative default values for hydraulic conductivity out of the tanks may be required to assess hydraulic performance of tank backfill alternatives.

A4.3.2 Grout Backfill and Concrete Backfill

Groundwater flow paths into and out of tank volumes are similar to those discussed for gravel backfill. Flowpaths inside the tank may be appreciably more anisotropic. Groundwater that enters the tank will have two potential flow paths. The two flow mechanisms are through fractures and through porous media. Fracture flow may occur along the interface between the backfill and the original internal surface of the tank. A second set of horizontal fractures will be present between the individual grout or concrete lifts in the backfill. Both grout and concrete backfills should be considered to be porous media.

A5.0 REQUIRED STRUCTURAL MODELS AND INPUT PARAMETERS

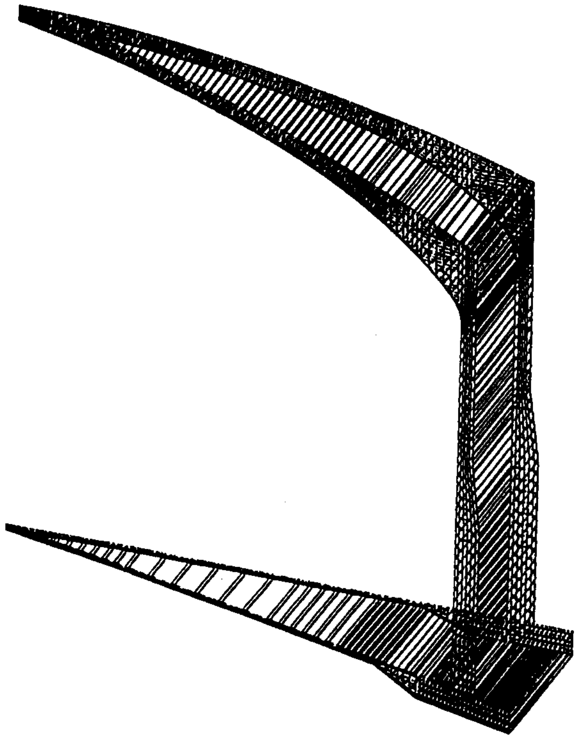
A5.1 EXISTING AND PROPOSED STRUCTURAL MODELS

The preferred option for ensuring long-term structural stability for Hanford tanks, subsequent to retrieval and disposal of the radioactive waste, is backfill with gravel, grout, or concrete as discussed previously. Given an initial estimate of a design life of hundreds to possibly 1,000 years, the backfill will ultimately be required to carry the dome loads at end-of-life. Thus, an analysis is required to evaluate the process of progressive failure of the tank dome structure due to aging and load transfer to the backfill. The primary objective of this analysis is to quantify the expected subsidence of the dome and overlying strata to the extent that this will effect the function of the overlying Hanford Barrier.

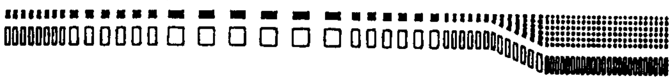
Existing tank analysis "standard models" that have been used for the Phase I and Phase II tank studies to support the Accelerated Safety Analysis (Hyde 1994 and Scott 1995, respectively) can be used as a starting point for performing the necessary analyses. A typical finite element model used for the Phase I studies is shown in Figure A-2(a). This is a 15 degree segment 3-D concrete model for a 1-Mgal SST. It is representative of the more complex "standard models" that have been developed in the Phase I and Phase II tank studies. This model was run using the ANSYS computer code (Swanson 1992). Concrete behavior modeled included linear and nonlinear concrete response (tensile cracking, crushing, and creep) and linear and nonlinear reinforcing steel response (tension, compression, plasticity, and strain hardening). Load cases included dead loads (soil overburden), live loads, construction point loads, dome vapor pressure, waste depth and density, and non-uniform temperature loadings. These are large, fairly complex models using elaborate material models with run times that challenge the currently available computer resources. For example, the current ANSYS tank model for Phase II sensitivity studies requires 30 hours run-time on the Hanford Site UNIX workstations to complete a typical load case solution procedure.

The Phase I and II models were developed with the purpose of evaluating structural adequacy of the Hanford tank structures; thus, the models were not intended to study structural backfill of the tanks and settlement in the soils surrounding the tanks. An axisymmetric plot of the lower tank concrete floor and the underlying soil elements is shown in Figure A-2(b). In this case, the soil elements do not model the soil mass, but are used to represent the soil compliance (subgrade modulus) of the strata underlying the tank. Expansion of the existing models, at the current level of detail, to represent the tank backfill and the soils surrounding the tank would result in models too large to run on the existing available computer systems. This strategy is not necessary.

Figure A-2. Phase I and II Tank Finite Element Models.



(a) 3-D tank concrete element plot for 15 degree sector.



(b) Tank bottom concrete and underlying soil elements.

The first step in addressing settlement questions associated with SST closure should be a complete set of simplified hand calculations to scope the overall problem. Following these initial calculations, an appropriate effort can be specified for additional numerical studies.

Simplification of the existing tank finite element models and additional changes will be necessary to properly represent placement of the backfill and then model the degradation of the concrete tensile reinforcement, due to aging, allowing transfer of the overburden load from the tank dome to the backfill.

It is suggested that initial modeling efforts concentrate on three models, or families of models, to evaluate expected settlements. The first model, a single tank closure model, will be an axisymmetric 3-D model of a SST. It will be used to study the tank structural deformations, stresses and design margins as appropriate, and settlement effects due to backfill and construction of the overlying Hanford Barrier during closure. This model will include the tank, backfill in the tank, the existing overburden, surcharge due to Hanford Barrier construction, and deformations in the surrounding soil and the strata underlying the tank.

The proposed backfill and barrier construction sequence for the gravel backfill alternative will impose higher structural loads on the existing tank footings immediately after closure compared to the grout and concrete backfill alternatives. For the gravel backfill alternative, the existing tank dome structure will carry most of the additional dead load imposed by surface barrier construction to the sidewalls and then down to the footings. The gravel backfill will not pick up the additional vertical dead loads due to Hanford Barrier construction until the dome has aged sufficiently to fail downward and transfer the vertical dead load directly to the gravel backfill. Stresses and deformations in the soil immediately below and surrounding the tank footings will represent a significant component of the overall early settlement due to Hanford Barrier construction for the gravel backfill alternative.

The existing Phase I and II models provide little detail in the "settlement" area. A second detailed 2-D plane strain footing model will be developed to supplement the information obtained from the 3-D axisymmetric single tank model. Parameters to be considered include tank wall loadings, existing tank footing designs, and stiffness and strength of the underlying foundation materials. This model will provide for adequate characterization of the early closure settlements for the gravel backfill alternative due to expected inelastic concrete behavior in the footings and the resulting stress concentration in the soils immediately below the footings.

In contrast, the grout and concrete backfill alternatives form a structural monolith with the existing tank structure immediately after construction. The backfill carries the surcharge dead loads from construction of the Hanford Barrier by direct stress distributing the load over the entire area of the tank base slab. There is no stress concentration effect where the tank structure collects the increased overburden load and delivers it to the footing area only.

The third model is a 2-D cross-section of an entire tank farm. This will include a simplified 2-D model of each tank developed from the 3-D single tank closure model and the 2-D plane strain footing model. A cross-section model is needed to evaluate the overall soil deformations, including differential settlement, across a tank farm during construction of the Hanford Barrier. Backfill specifications used during construction of the tank farms did not require particularly high densities for in-place fill. For example, the foundation investigation for the 241-SY storage tanks (Shannon and Wilson, 1974) recommends compaction of the fill to 70% relative density. Thus, settlements in the existing backfill surrounding the tanks during construction of the Hanford Barrier may in fact exceed the settlements of the tanks during barrier construction. This will be one of the topics studied with this model.

A5.1.1 Single Tank Closure Model

A proposed general layout for the single tank closure model is shown in Figure A-3. Development of the model will require modification of an existing Phase I tank model, selection of appropriate material models for the soil strata and the tank backfill, boundary conditions, and loading conditions. A 1-Mgal SST model should be developed as the first model since it is the largest size SST. Settlements for this model due to backfill surcharge and surcharge from construction of the Hanford Barrier should envelope those for smaller SSTs.

The tank model will be simplified by using a coarser mesh to cut the run time. Mesh size for the backfill and the soil horizons will be much coarser than the existing mesh for the tank models with appropriate mesh transitions. In addition, simpler material models will be used for the tank model to reduce run times. One option is to use a simple linear elastic model for the tank and simulate the roof collapse with a time variant material stiffness.

Parameter estimates will be developed for the load deformation properties of the soils and tank backfill materials, both gravel and grout processes. A Hanford soil model has been developed as support to ongoing tank farm structural analyses (Moore 1995) that provides an adequate idealization for the soils. Settlements in the granular Hanford soils will be comprised principally of short-term elastic and perhaps elasto-plastic components with little or no longer term consolidation and secondary compression effects because of the lack of cohesion in the soils. Load-deformation properties for gravel backfill in the tanks may also be represented by the Hanford soil model; however, the candidate gravel for backfill is
crushed rock. Crushed rock is a highly angular material with sharp asperities that may require the use of an alternate material model to be developed after some literature search. Triaxial laboratory testing will be necessary to properly define the load deformation properties of the gravel at confinement pressures prototypic to the design. Required test outputs will include the angle of internal friction and volumetric changes experienced during deformation as a function of the confining pressure. The modulus of elasticity and other standard properties for the grout, preplaced aggregate grout, or concrete can be adequately developed using the standard expressions in ACI 1992a) and the specified minimum design strength for the grout and/or concrete.

Boundaries for the model will be selected through a process of sensitivity studies. The distance "z" is often selected based on influence coefficients for the stress below a foundation on an elastic halfspace. An example is shown in Figure A-4 from Perloff (1975). The 5% influence coefficient indicates that the distance "z" should be at least five times the foundation effective width "b_e" to limit the boundary effect based on stress increment.

Figure A-3. Single Tank Closure Model.

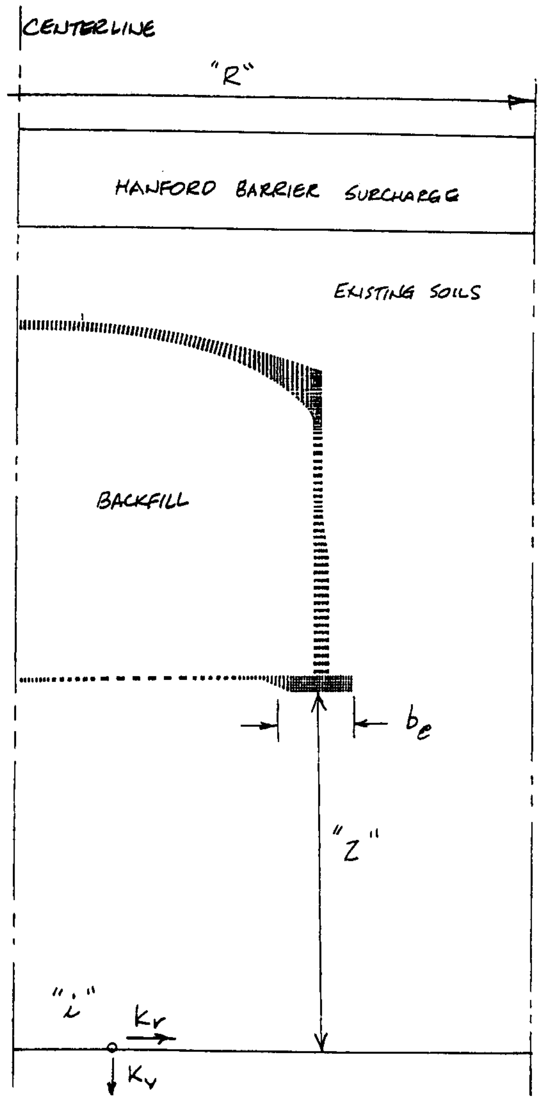
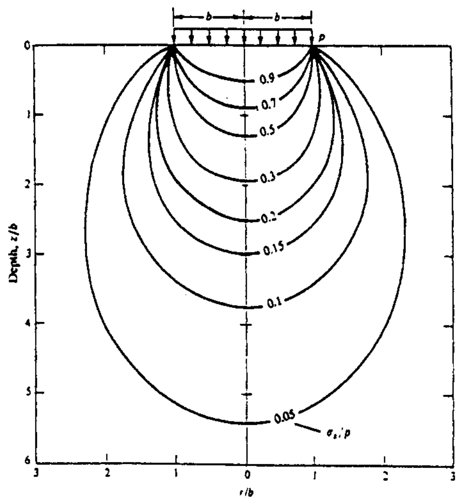


Figure A-4. Contours of Constant Vertical Stress (isobars) Beneath a Uniformly Loaded Circular Disc on a Linear Elastic Halfspace. (from Perloff 1975)



Unfortunately, this is not the case for displacements. Far-field boundary displacements represent a significant portion of the overall displacements for layered soil models. The problem of selecting boundary conditions for geotechnical models was one of the main drivers for the development of boundary element analysis methodology (Manolis and Davies, 1993). Sensitivity studies will be used to develop the model dimension "z" based on stress and displacement influence coefficients "K_{radial} and $K_{vertical}$" for points "i" as shown in Figure A-3. Similar arguments will be used for setting the dimension "R," which may also be set as the distance to the mid-plane between adjacent tanks. Hanford Barrier surcharge loadings to be considered in the tank models are:

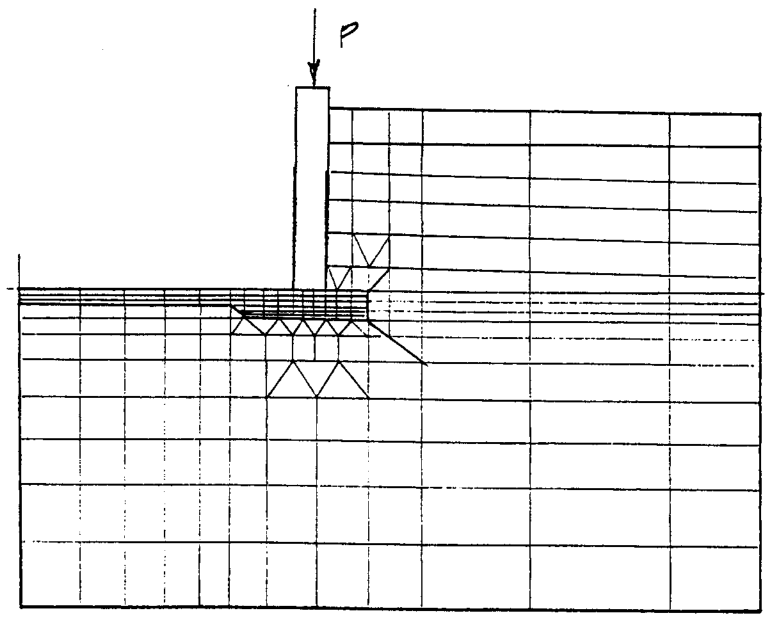
Layer	Thickness (in.)	Unit Weight (lb/ft^3)	Loading (lb/ft^2)
1 - silt	40	87	290
2 - silt	40	90	300
3 - sand filter	6	115	58
4 - gravel filter	12	115	115
5 - basalt	60	125	625
6 - drainage gravel	12	100	100
7 - asphalt	6	90	45
8 - base course	4	120	40
9 - graded fill (varies)	24	120	240
		TOTAL	1,813

A5.1.2 2-D Plane Strain Footing Model

Existing Phase I and II tank models have partially addressed the question of the footing performance under normal operating loads and natural phenomena loadings. Additional analysis will be needed to evaluate footing behavior under overload conditions because of the expected load increases in the tank dome, sidewall, and footings for the gravel backfill alternative. A 2-D plane strain model is suggested as shown in Figure A-5. The purpose for this model is to evaluate the load deformation behavior of the footing and the underlying soils under overload conditions that will exist shortly after closure.

Phase I studies reported that sensitivity studies showed considerable variation in the concrete and reinforcing steel design margins for the footings dependent on the choice of the parameter for the soil springs (subgrade modulus). This new modeling effort will focus on evaluating the ability of the footing to perform its support function as it is loaded beyond the original design loadings. This model will be used to study nonlinear concrete deformations in the footing due to concrete cracking and rebar yielding; and the resulting load redistributions and deformations in the soils immediately underlying the footing. Load deformation data from this model will be combined with the information from the 3-D axisymmetric single tank model to develop the simplified tank models for the 2-D tank farm cross-section model.

Figure A-5. 2-D Plane Strain Footing Model.



Model development should include test cases to be sure that adequate subdivision is made to model the elasto-plastic and brittle concrete deformations in the tank footing. Boundaries must be sufficiently remote to allow adequate modeling of inelastic deformation in the soils immediately below the footings. Soil elements in the near-field to the concrete footing will have to include an appropriate failure criterion. The Phase I and Phase II Hanford soil and concrete material models are adequate for this analysis.

A5.1.3 2-D Tank Farm Cross-Section Model

A prototypic 2-D cross-section model for a tank farm is shown in Figure A-6. The actual number of tanks to be modeled may vary. The smallest SST tank farm is 241-AX with a 2 x 2 array of tanks. The largest is tank farm 241-TX with a 5 x 4 array of tanks. A rationale will be developed during model development demonstrating that the chosen model envelopes the various tank farm configurations for consideration of differential settlement.

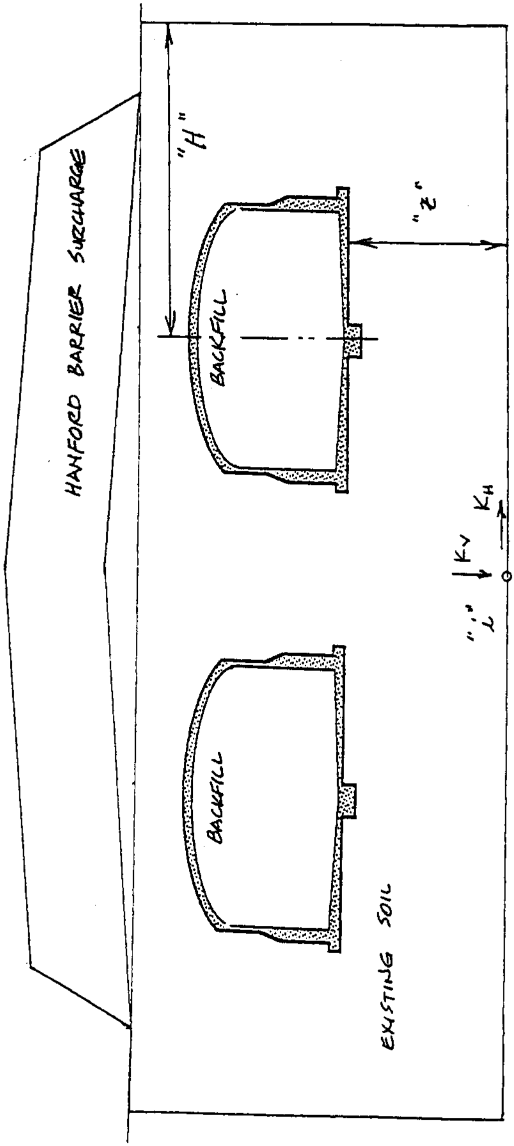
Based on the closure data package, the miscellaneous underground storage tanks, vaults, and other ancillary features are going to be closed by pumping them full of grout. Because of the physical configuration of these facilities, their potential for postclosure settlement after grouting will be less than that of the larger SSTs and DSTs. Thus, the settlement analyses for the tank farms will envelope these other facilities. Calculations considering foundation loadings, fill depths, and potential settlements will be developed to support these simplifications as part of the tank closure structural modeling effort.

A tank farm cross-section model will use many of the same inputs that were developed for the single tank closure model. Parameter estimates for load-deformation characteristics of soils and backfill will be the same based on the same field and laboratory soil studies. Sensitivity studies to develop boundary conditions; for example, dimension "z" and stress and displacement influence coefficients "$K_{horizontal}$ and $K_{vertical}$" are similar to those for the single tank closure model. Horizontal dimension "H" is, however, a different problem. One of the outputs of the sensitivity study on dimension "H" is the required distance from the boundary of the tank farm to provide a stable location for the elevation monument that will be used to monitor post-construction settlements of the closed tank farm and Hanford Barrier. Surcharge loadings are also similar to those used for the single tank closure model, with the exception that the thickness and weight of layer 9 will be a function of the tank farm lateral extent, and expected settlements above and between tanks.

A5.2 FIELD AND LABORATORY DATA FOR STRUCTURAL MODEL VALIDATION

Field measurements of elastic rebound or heave during waste retrieval and treatment, and of settlement during tank backfill and construction of the Hanford Barrier will ultimately provide confirmatory data on settlement to support the decision for final closure and abandonment of the Hanford tank farms. These measurements will be made using standard surveying techniques to obtain the requisite accuracy and resolution. The purpose of the measurements is to provide assurance that the Hanford Barriers will continue to perform their functions in the time period after abandonment when active monitoring is no longer performed. Settlement of the tanks including the effects of backfill must be evaluated, and settlement of the existing fill around the tanks must be evaluated.

Figure A-6. 2-D Tank Farm Cross-Section Model.



Two measurements are important for evaluating settlement of the tanks themselves and potential impacts on the function of the Hanford Barrier; elevation at the center of the dome and elevation at the side wall, a direct measure of footing elevations. In addition, measurements of elevations in the existing fill between tanks will also be needed to assess the effect of fill settlements on prospective Hanford Barrier performance. Thus, any development program for tank backfill and closure must include adequate provisions for surveying elevations during waste retrieval, backfill placement, and Hanford Barrier construction.

Considerable data are available from prior foundation investigations at Hanford. Test borings and wells, and site-specific foundation excavations including New York type plate-bearing tests (ASTM D1194) were included in the original site investigations for Hanford (du Pont 1945). Plate-bearing test tables were erected and measurements taken for all of the main process facilities in the 200 Areas, including the tank farms, which were identified at that time as "Buildings 241." Stratigraphic information and test data from this work have yet to be considered for use in verifying current soil models.

In addition, several major projects have been constructed in the 200 Areas during the last 10 years have similar data. Soil investigation reports for these projects were delivered to the respective architect-engineers for each project:

- Dames and Moore (1988)
- Dames and Moore (1989)
- Shannon and Wilson (1994a)
- Shannon and Wilson (1994b).

With the exception of Shannon and Wilson (1994a), these reports are not entered into the Hanford Site record system as official records. Available copies are generally personal copies or departmental working copies. This information should formally be entered into the record system.

Laboratory and in-situ field test data from the above reports have not been reviewed and compared to establish "expected values" for the most important soil strength and deformation parameters needed for the structural modeling; nor has effort been made to establish the variability or range of the expected values by means of statistical testing.

Additional technical information is available from the final safety analysis reports for the WNP-2 and WNP-1 and 4 nuclear power projects in the Richland Public Library.

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APPENDIX B

SINGLE-SHELL TANK
IN-TANK HARDWARE INVENTORY

CONTENTS

TABLE

B1.0 SCOPE

Appendix B (previously published as WHC-SD-WM-EL-005) has been prepared in support of an ongoing engineering study to evaluate alternative methods for placing load-bearing fill in empty Hanford SSTs as an aspect of tank closure. For the alternatives that specify natural aggregate as fill material for the 100-Series tanks, large (i.e., greater than 10-cm [4-in.]) ITH items present obstructions that would adversely affect fill placement. Provided is a tabulation of the numbers and types of large ITH items in the 100-Series SSTs that need to be considered in cost-benefit assessments for the engineering study.

B2.0 BACKGROUND

High-level radioactive waste has been produced at the Hanford Site since 1944 as a by-product of processing spent nuclear fuel. From 1943 to 1964, 149 underground SSTs were built for the storage of radioactive waste. These SSTs are located in 12 tank farms of 4 to 18 tanks each in the 200 East and 200 West Areas. The SSTs were removed from service (i.e., no longer authorized to receive waste) in 1980. Pumpable interstitial liquid and supernatant wastes are being removed from SSTs and transferred to DSTs. The 149 SSTs currently contain 136,000 m^3 (36 Mgal) of waste that will be removed prior to closure.

All tanks are constructed with a main concrete structure and an inner steel liner. The 149 SSTs consist of 133 100-Series tanks and 16 200-Series tanks. The 100-Series SSTs range in size from 2,000 m^3 (530,000 gal) to 3,800 m^3 (1 Mgal). During normal operations at the tank farm, many operations required specialized equipment that was installed in the tank for procedures such as pumping, mixing, cooling, heating, and observation. The ITH equipment must be considered when planning the closure effort.

B3.0 APPROACH

This appendix is the product of a search of existing documentation (see Section B5.0, References) concerning SST ITH. No attempt was made to physically verify the information contained in the referenced documentation. The photos in many of theses documents were a main source of information. Some photos are several years old; however, the ITH identified within tanks was assumed to exist unless evidence of removal was found. Most ITH items are identified in more than one reference. Draft references were used only to confirm information from released documents. Occasionally, there were disagreements between references about the size of particular ITH. When this occurred, the larger dimension is reported here. Additional ITH that is not documented in the researched references, photos, and drawings may be present in the tanks.

B4.0 ITH DESCRIPTIONS

The following is a description of all types of ITH that were identified during this study as greater than 10 cm (4 in.) in diameter. A general description of each type of item is provided, including how it was used and if that information was available.

Table B-1 presents a listing, by tank, of the known ITH greater than 10 cm (4 in.) in diameter.

Air Inlet Sweeps:

Air inlet sweeps were used to direct air across the top of the waste. The air inlet sweeps consist of large pipes, approximately 46 cm (18 in.) in diameter, extending down from the riser almost to the top of the maximum waste level. At the bottom of the pipe, a steel plate is welded at an angle over the bottom opening in the pipe. (241-BY, -C, -SX, -TX, and -TY tanks farms)

Air Lift Circulators (ALC):

ALCs were used to mix the waste to keep solids suspended in solution. There are three main types of ALCs:

> The first ACL type was installed through risers after tank construction. These may be found in generation 1 or 2 tanks in groups of up to four. They consist of a truss structure to hold up a larger steel pipe at the end. (241-BY, -SX and -TX tank farms)
>
> The second ACL type was installed in second generation tanks as they were built, using guy wires to hold them up. Generally they were installed in groups of up to four. They consist mainly of large pipes of varying length, supported by the bottom of the tank, with guy wires to help keep then upright. Small air lines, suspended at the dome, led to them. (241-A Tank Farm)
>
> The third ACL type was installed in the third generation tanks, and consist of large pipes of varying length, supported by the bottom of the tank without guy wires, with smaller pipes extending from the top of the large pipes to the tank dome. (241-AX Tank Farm)

Center Riser (Extensions):

Most center risers (large-diameter, open-ended pipes) do not protrude into the tank significantly, but in 241-A Tank Farm, all center 107-cm (42-in.) risers protrude into the tank to the top of the steel liner.

Corrosion Probes:

A corrosion probe is a pipe, approximately 15 cm (6 in.) in diameter, extending from the riser into the waste. (241-S-108 Tank)

Crust Breakers:

Crust breakers were used to break through the top crust on the waste in order to take measurements or samples. Some were simply long steel pipes or rods, while others used an auger screw at the end. (241-SX-104 Tank)

Dry Wells:

Dry wells were used to take radioactivity measurements. The dry wells mainly consisted of a pipe up to 15 cm (6 in.) in diameter that was closed at the bottom end to prevent any waste from seeping in. (241-A, -AX, and -S tank farms)

Heaters:

Steam Coils -

Steam coils were used in some tanks to heat the waste for various reasons. The steam coils are basically a truss structure on top, leading up to a 102-cm (40-in.) diameter coil assembly that would start at the top of the maximum waste line and extend several feet down. (241-A and -AX tank farms)

Immersion Heaters -

Immersion heaters were basically 20-cm (8-in.) diameter electric heaters that performed the same function as steam coils. (241-TX-114 Tank)

In-Tank Solidification Units (ITS):

ITSs were experimental and only used in a few tanks. Each one consists of a complex structure that is approximately 97 cm (38 in.) in diameter extending from the dome to the waste. (241-BY-101, -BY-102, and -BY-112 tanks)

Pumps:

Turbine Pumps -

The majority of the pumps in the tanks are of turbine-type construction. The turbine pumps were used to transfer waste from one tank to another during normal tank operations. These pumps are constructed with the motor above the riser connected to a pump shaft that protrudes down into the tank inside a protective pipe, up to 20 cm (8 in.) diameter, that may or may not be the passage for the pumped waste. At the bottom of the pump is the impeller assembly that pumps the waste up and out of the tank.

Submersible Pumps -

Some pumps are the submersible type that can be lowered into the waste and generally sit just below the waste surface with piping extending up through a riser.

Heel Jet -

A heel jet is simply a jet pump, up to 30 cm (12 in.) in diameter, that was installed in the center of some tanks to pump out the waste in the "heel," the dished portion of the center tank bottom. This pump is structurally complicated and utilizes many smaller pipes inside a large structural pipe.

(Pumps remain in 241-A, -AX, -BX, -BY, -C, -S, -SX, and -U tank farms.)

Salt Well Screen and Pumps:

Salt well pumps are used to pump liquid out of the tanks; the screens are used to keep solids out of the pump impellers. The salt well screens are constructed of 25-cm (10 in.) pipe that leads to a 25-cm (10-in.) diameter screen at the bottom of the tank. The pumps most likely remain within the salt well screens. (All farms and most 100-Series tanks have salt well screens.)

Self Concentrator:

The self concentrator consists of a cylindrical tank with piping and valving installed in the center riser of Tank 241-SX-101, at least 91 cm (36 in.) in diameter.

Sluicing Jets:

Sluicing Jets were used to free up sludge and other solids so that they could be pumped out of waste tanks. They are essentially piping and a high-pressure water nozzle that can be rotated and positioned to cover a large area of the tank. (241-A, -AX, and -BX tank farms)

Unidentified piping:

Various unidentified pipes remain in some tanks. (241-BY and -TX tank farms)

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Table B-1. Listing, by Tank, of the Known ITH Greater than 10 cm (4 in.) in diameter. (sheet 1 of 3)

100-SERIES, SINGLE-SHELL TANK IN-TANK HARDWARE INVENTORY									
TANK	ALC	SALTWELL SCREEN	PUMP	DRYWELL	AIR INLET	MISCELLANEOUS		REFERENCE	COMMENTS
200 East Area									
241- A- 101	4	2		1		3	Steam coil (2), 12" pipe	1,5,8	
241- A- 102	4	1		1				1,5,8	A-Farm 42" center risers extend
241- A- 103	4		1	1				1,5	to top of steel liner.
241- A- 104	4		1	1		1	Steam coil	1	
241- A- 105	4	1	1	1		1	Sluicing jet	1,5,7	
241- A- 106	4		2	1				1	
241- AX- 101	22		1	7		2	Steam coil, sluicing jet	1,5,8	Saltwell screen planned
241- AX- 102	22	1	1	7				1	
241- AX- 103	22	1		7				1	
241- AX- 104	22		1	7		2	Sluicing jets	1	
241- B- 101		1						1,5	
241- B- 102								1,5	
241- B- 103		1						1,5	
241- B- 104		1						1,5	
241- B- 105		1						1,5	
241- B- 106		1						1,5	
241- B- 107		1						1,5	
241- B- 108		1						1,5	
241- B- 109		1						1,5	
241- B- 110		2						1,5	
241- B- 111		1						1,5	
241- B- 112		1						1,5	
241- BX- 101		1	1					1	
241- BX- 102								1,5	
241- BX- 103		1				1	Sluicing jet	1,5	
241- BX- 104			1					1	
241- BX- 105			2					1,5	
241- BX- 106			1					1,5	
241- BX- 107		1						1,5	
241- BX- 108								1,5	
241- BX- 109		1						1	
241- BX- 110		1						1,8	
241- BX- 111		2						1,5,8	
241- BX- 112		2						1	
241- BY- 101		1			1	1	ITS-1	1,5	
241- BY- 102		1	1			1	ITS-1	1,5,8	
241- BY- 103	3	2						1,5,8	
241- BY- 104	3	1			1	1	6" pipe (unidentified)	1,5	
241- BY- 105	3	1			1	1	6" pipe (unidentified)	1,5,8	
241- BY- 106	3	1	1		1			1,5,8	
241- BY- 107	3	1						1,5	
241- BY- 108	3	1						1,5	
241- BY- 109		1						1,5,8	
241- BY- 110	3	1						1,5	
241- BY- 111	3	2						1,5	
241- BY- 112		1				1	ITS-2	1,5	
241- C- 101		1	1					1	
241- C- 102		1						1,5,8	
241- C- 103								1,8	
241- C- 104		1						1	

Table B-1. Listing, by Tank, of the Known ITH Greater than 10 cm (4 in.) in diameter. (sheet 2 of 3)

100-SERIES, SINGLE-SHELL TANK IN-TANK HARDWARE INVENTORY									
TANK	ALC	SALTWELL SCREEN	PUMP	DRYWELL	AIR INLET		MISCELLANEOUS	REFERENCE	COMMENTS
241- C- 105								1,8	
241- C- 106								1,8	
241- C- 107		1						1,8	
241- C- 108			1					1	
241- C- 109								1	
241- C- 110								1,8	
241- C- 111			1					1	
241- C- 112					1			1	
200 West Area									
241- S- 101								3,5,8	Saltwell screen planned
241- S- 102		1						3,5,8	
241- S- 103		1						3,5,8	
241- S- 104		1						3	
241- S- 105		1						3,5	
241- S- 106		1						3,5,8	2nd Saltwell screen planned
241- S- 107		1						3,5,8	
241- S- 108		1				1	corrosion probe (6" pipe)	3,5,8	
241- S- 109		1						3,5,7,8	2nd Saltwell screen planned
241- S- 110		1				2	drywell	3,5,8	
241- S- 111		1	1					3,5,8	2nd Saltwell screen planned
241- S- 112		1						3,5,8	2nd Saltwell screen planned
241- SX- 101					1	1	Self concentrator	3,5,8	Saltwell screen planned
241- SX- 102		1						3,5,8	
241- SX- 103		1						3,5,8	Discarded pump in waste
241- SX- 104		1				1	8" Crust Breaker	3,5,8	
241- SX- 105	2	1						3,5,8	2nd Saltwell screen planned
241- SX- 106		2						3,5,8	3rd Saltwell screen planned
241- SX- 107	4				1			3,5	
241- SX- 108	4		1		1			3,5	
241- SX- 109	4							3,5	
241- SX- 110	4		1					3,5	
241- SX- 111	4	1						3,5	
241- SX- 112	4		1					3,5	
241- SX- 113	4		1					3	
241- SX- 114	4							3,5	
241- SX- 115	4							3	
241- T- 101		1						2,5,7	
241- T- 102		1						2	
241- T- 103								2,5	
241- T- 104		1						2,8	
241- T- 105		1						2	
241- T- 106								2,5	
241- T- 107		1						2,8	
241- T- 108								2,5	
241- T- 109		1						2,5,7	
241- T- 110								2,8	Saltwell screen planned
241- T- 111		1						2,8	
241- T- 112								2,5,8	
241- TX- 101		1						2,5	
241- TX- 102	3	1						2,5	
241- TX- 103		1						2,5	
241- TX- 104								2,5	

Table B-1. Listing, by Tank, of the Known ITH Greater than 10 cm (4 in.) in diameter. (sheet 3 of 3)

100-SERIES, SINGLE-SHELL TANK IN-TANK HARDWARE INVENTORY									
TANK	ALC	SALTWELL SCREEN	PUMP	DRYWELL	AIR INLET		MISCELLANEOUS	REFERENCE	COMMENTS
241- TX- 105		1						2,5	
241- TX- 106	2	1						2,5	
241- TX- 107								2,5	
241- TX- 108		1						2,5	
241- TX- 109		1						2,5	
241- TX- 110	3	1			1			2,5	
241- TX- 111	2	1			1			2,5	
241- TX- 112		1			1	1	10" dia. pipe (LOW)	2,5	
241- TX- 113	3	1			1			2,5	
241- TX- 114	3	1			1	1	Immersion heater	2,5	
241- TX- 115	2	1						2,5	
241- TX- 116		2						2,5	
241- TX- 117		1				1	8" pipe (unidentified)	2,5	
241- TX- 118								2,5	
241- TY- 101		1						2,5	
241- TY- 102					1			2,5	
241- TY- 103		1						2,5	
241- TY- 104								2	
241- TY- 105		1						2,5	
241- TY- 106								2	
241- U- 101								3,5	
241- U- 102			1					3,5,8	Saltwell screen planned
241- U- 103								3,5,8	Saltwell screen planned
241- U- 104								3,5	
241- U- 105		1	1					3,5,8	2nd Saltwell screen planned
241- U- 106			1					3,5,8	Saltwell screen planned
241- U- 107			1					3,5,8	Saltwell screen planned
241- U- 108			1					3,5,8	Saltwell screen planned
241- U- 109								3,5,8	Saltwell screen planned
241- U- 110		2						3,8	
241- U- 111								3,5,8	Saltwell screen planned
241- U- 112		1						3,5	
TOTAL	192	93	28	34	14	23			18 planned saltwell screens

APPENDIX C

THE 75-FT SINGLE-SHELL TANKS WITHOUT 42-IN.-DIAMETER CENTRAL RISERS

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Tank	Nom. Capacity (kgal)	Tank	Nom. Capacity (kgal)
AX-101	1,000	C-105	533
AX-102	1,000	C-106	533
AX-103	1,000	C-107	533
AX-104	1,000	C-108	533
B-101	533	C-109	533
B-102	533	C-110	533
B-103	533	C-111	533
B-104	533	C-112	533
B-105	533	T-101	533
B-106	533	T-102	533
B-107	533	T-103	533
B-108	533	T-104	533
B-109	533	T-105	533
B-110	533	T-106	533
B-111	533	T-107	533
B-112	533	T-108	533
BX-101	533	T-109	533
BX-102	533	T-110	533
BX-103	533	T-111	533
BX-104	533	T-112	533
BX-105	533	U-101	533
BX-106	533	U-102	533
BX-107	533	U-103	533
BX-108	533	U-104	533
BX-109	533	U-105	533
BX-110	533	U-106	533
BX-111	533	U-107	533
BX-112	533	U-108	533
C-101	533	U-109	533
C-102	533	U-110	533
C-103	533	U-111	533
C-104	533	U-112	533

Krieg, S. A., W. W. Jenkins, K. J. Leist, K. G. Squires, and J. F. Thompson, 1990, *Single-Shell Tank Waste Retrieval Study*, WHC-EP-0352, Westinghouse Hanford Company, Richland, Washington.

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APPENDIX D

WORKER EXPOSURE ESTIMATES FOR TANK-FILL ALTERNATIVES

CONTENTS

Gravel Fill Alternative Closure Task(1)	Average mrem/hr(2)	Exposed Persons per Task(3)	Stay Time hours per Tank(4)	Tank Farm Dose (person/rem)(5)
A Tank Farm -- 6 1-Mgal Tanks				
Remove in-tank hardware (4.f)	7.7	3	252.00	34.93
Incidental grout fill (4.b)	2.5	2	1.33	0.04
Incidental gravel fill (4.b)	2.5	2	7.75	0.23
Install gravel fill equipment (4.d)	7.7	3	8.00	1.11
Remove gravel fill equipment (4.d)	2.5	3	4.00	0.18
Set up gravel conveyance (4.e)	2.5	2	5.00	0.15
Move gravel conveyance (4.e)	2.5	2	4.00	0.12
Fill tank with gravel (4.a)	2.5	2	194.10	5.82
Construct engineered barrier (farm) (4.g)	2.5	2	73.76	0.37
A TANK FARM TOTAL				**42.95**
AX Tank Farm -- 4 1-Mgal Tanks				
Remove in-tank hardware (4.f)	7.7	3	252.00	23.28
Incidental grout fill (4.b)	2.5	2	1.32	0.03
Incidental gravel fill (4.b)	2.5	2	7.67	0.23
Install risers (4.c)	7.7	3	276.00	25.50
Install gravel fill equipment (4.d)	7.7	3	8.00	0.74
Remove gravel fill equipment (4.d)	2.5	3	4.00	0.12
Set up gravel conveyance (4.e)	2.5	2	5.00	0.10
Move gravel conveyance (4.e)	2.5	2	4.00	0.08
Fill tank with gravel (4.a)	2.5	2	194.10	3.88
Construct engineered barrier (farm)(4.g)	2.5	2	52.62	0.26
AX TANK FARM TOTAL				**54.23**
B Tank Farm -- 12 530-Kgal Tanks				
Remove in-tank hardware (4.f)	7.7	3	252.00	69.85
Incidental grout fill (4.b)	2.5	2	0.38	0.02
Incidental gravel fill (4.b)	2.5	2	1.83	0.11
Install risers (4.c)	7.7	3	276.00	76.51
Install gravel fill equipment (4.d)	7.7	3	8.00	2.22
Remove gravel fill equipment (4.d)	2.5	3	4.00	0.36
Set up gravel conveyance (4.e)	2.5	2	5.00	0.30
Move gravel conveyance (4.e)	2.5	2	4.00	0.24
Fill tank with gravel (4.a)	2.5	2	102.87	6.17
Construct engineered barrier (farm) (4.g)	2.5	2	164.88	0.82
SUM				**156.61**

Gravel Fill Alternative Closure Task(1)	Average mrem/hr(2)	Exposed Persons per Task(3)	Stay Time hours per Tank(4)	Tank Farm Dose (person/rem)(5)
B Tank Farm -- 4 55-Kgal Tanks (with the gravel alternative 55-Kgal tanks will be filled with grout)				
Install grout fill equipment (4.d)	7.7	3	2.00	0.18
Remove grout fill equipment (4.d)	2.5	3	1.00	0.03
Set up grout conveyance (4.e)	2.5	2	2.00	0.04
Move grout conveyance (4.e)	2.5	2	2.00	0.04
Fill tank with grout (4.a)	2.5	2	17.75	0.35
SUM				**0.65**
B TANK FARM TOTAL				**157.26**
BX Tank Farm -- 12 530-Kgal Tanks				
Remove in-tank hardware (4.f)	7.7	3	252.00	69.85
Incidental grout fill (4.b)	2.5	2	0.31	0.02
Incidental gravel fill (4.b)	2.5	2	1.46	0.09
Install risers (4.c)	7.7	3	276.00	76.51
Install gravel fill equipment (4.d)	7.7	3	8.00	2.22
Remove gravel fill equipment (4.d)	2.5	3	4.00	0.36
Set up gravel conveyance (4.e)	2.5	2	5.00	0.30
Move gravel conveyance (4.e)	2.5	2	4.00	0.24
Fill tank with gravel (4.a)	2.5	2	102.87	6.17
Construct engineered barrier (farm) (4.g)	2.5	2	135.38	0.68
BX TANK FARM TOTAL				**156.43**
BY Tank Farm -- 12 758-Kgal Tanks				
Remove in-tank hardware (4.f)	7.7	3	252.00	69.85
Incidental grout fill (4.b)	2.5	2	0.31	0.02
Incidental gravel fill (4.b)	2.5	2	1.46	0.09
Install gravel fill equipment (4.d)	7.7	3	8.00	2.22
Remove gravel fill equipment (4.d)	2.5	3	4.00	0.36
Set up gravel conveyance (4.e)	2.5	2	5.00	0.30
Move gravel conveyance (4.e)	2.5	2	4.00	0.24
Fill tank with gravel (4.a)	2.5	2	147.13	8.83
Construct engineered barrier (farm) (4.g)	2.5	2	137.25	0.69
BY TANK FARM TOTAL				**82.59**
C Tank Farm -- 12 530-Kgal Tanks				
Remove in-tank hardware (4.f)	7.7	3	252.00	69.85
Incidental grout fill (4.b)	2.5	2	2.29	0.14

Gravel Fill Alternative Closure Task(1)	Average mrem/hr(2)	Exposed Persons per Task(3)	Stay Time hours per Tank(4)	Tank Farm Dose (person/rem)(5)
Incidental gravel fill (4.b)	2.5	2	1.83	0.11
Install risers (4.c)	7.7	3	276.00	76.51
Install gravel fill equipment (4.d)	7.7	3	8.00	2.22
Remove gravel fill equipment (4.d)	2.5	3	4.00	0.36
Set up gravel conveyance (4.e)	2.5	2	5.00	0.30
Move gravel conveyance (4.e)	2.5	2	4.00	0.24
Fill tank with gravel (4.a)	2.5	2	102.87	6.17
Construct engineered barrier (farm) (4.g)	2.5	2	168.80	0.84
SUM				**156.74**
C Tank Farm -- 4 55-Kgal Tanks (with the gravel alternative, 55-Kgal tanks will be filled with grout)				
Install grout fill equipment (4.d)	7.7	3	2.00	0.18
Remove grout fill equipment (4.d)	2.5	3	1.00	0.03
Set up grout conveyance (4.e)	2.5	2	2.00	0.04
Move grout conveyance (4.e)	2.5	2	2.00	0.04
Fill tank with grout (4.a)	2.5	2	17.75	0.35
SUM				**0.65**
C TANK FARM TOTAL				**157.39**
S Tank Farm -- 12 758-Kgal Tanks				
Remove in-tank hardware (4.f)	7.7	3	252.00	69.85
Incidental grout fill (4.b)	2.5	2	0.31	0.02
Incidental gravel fill (4.b)	2.5	2	1.46	0.09
Install gravel fill equipment (4.d)	7.7	3	8.00	2.22
Remove gravel fill equipment (4.d)	2.5	3	4.00	0.36
Set up gravel conveyance (4.e)	2.5	2	5.00	0.30
Move gravel conveyance (4.e)	2.5	2	4.00	0.24
Fill tank with gravel (4.a)	2.5	2	147.13	8.83
Construct engineered barrier (farm) (4.g)	2.5	2	138.89	0.69
S TANK FARM TOTAL				**82.60**
SX Tank Farm -- 15 1-Mgal Tanks				
Remove in-tank hardware (4.f)	7.7	3	252.00	87.32
Incidental grout fill (4.b)	2.5	2	0.31	0.02
Incidental gravel fill (4.b)	2.5	2	1.46	0.11
Install gravel fill equipment (4.d)	7.7	3	8.00	2.77
Remove gravel fill equipment (4.d)	2.5	3	4.00	0.45

Gravel Fill Alternative Closure Task(1)	Average mrem/hr(2)	Exposed Persons per Task(3)	Stay Time hours per Tank(4)	Tank Farm Dose (person/rem)(5)
Set up gravel conveyance (4.e)	2.5	2	5.00	0.38
Move gravel conveyance (4.e)	2.5	2	4.00	0.30
Fill Tank with gravel (4.a)	2.5	2	194.10	14.56
Construct engineered barrier (farm) (4.g)	2.5	2	171.01	0.86
SX TANK FARM TOTAL				**106.76**
T Tank Farm -- 12 530-Kgal Tanks				
Remove in-tank hardware (4.f)	7.7	3	252.00	69.85
Incidental grout fill (4.b)	2.5	2	2.29	0.14
Incidental gravel fill (4.b)	2.5	2	1.83	0.11
Install risers (4.c)	7.7	3	276.00	76.51
Install gravel fill equipment (4.d)	7.7	3	8.00	2.22
Remove gravel fill equipment (4.d)	2.5	3	4.00	0.36
Set up gravel conveyance (4.e)	2.5	2	5.00	0.30
Move gravel conveyance (4.e)	2.5	2	4.00	0.24
Fill tank with gravel (4.a)	2.5	2	102.87	6.17
Construct engineered barrier (farm) (4.g)	2.5	2	164.88	0.82
SUM				**156.72**
T Tank Farm -- 4 55-Kgal Tanks (with the gravel alternative, 55-Kgal tanks will be filled with grout)				
Install grout fill equipment (4.d)	7.7	3	2.00	0.18
Remove grout fill equipment (4.d)	2.5	3	1.00	0.03
Set up grout conveyance (4.e)	2.5	2	2.00	0.04
Move grout conveyance (4.e)	2.5	2	2.00	0.04
Fill tank with grout (4.a)	2.5	2	17.75	0.35
SUM				**0.65**
T TANK FARM TOTAL				**157.37**
TX Tank Farm -- 18 758-Kgal Tanks				
Remove in-tank hardware (4.f)	7.7	3	252.00	104.78
Incidental grout fill (4.b)	2.5	2	0.36	0.03
Incidental gravel fill (4.b)	2.5	2	1.70	0.15
Install gravel fill equipment (4.d)	7.7	3	8.00	3.33
Remove gravel fill equipment (4.d)	2.5	3	4.00	0.54
Set up gravel conveyance (4.e)	2.5	2	5.00	0.45
Move gravel conveyance (4.e)	2.5	2	4.00	0.36
Fill tank with gravel (4.a)	2.5	2	147.13	13.24

Gravel Fill Alternative Closure Task(1)	Average mrem/hr(2)	Exposed Persons per Task(3)	Stay Time hours per Tank(4)	Tank Farm Dose (person/rem)(5)
Construct engineered barrier (farm) (4.g)	2.5	2	222.47	1.11
TX TANK FARM TOTAL				**124.00**
TY Tank Farm -- 6 758-Kgal Tanks				
Remove in-tank hardware (4.f)	7.7	3	252.00	34.93
Incidental grout fill (4.b)	2.5	2	0.27	0.01
Incidental gravel fill (4.b)	2.5	2	2.12	0.06
Install gravel fill equipment (4.d)	7.7	3	8.00	1.11
Remove gravel fill equipment (4.d)	2.5	3	4.00	0.18
Set up gravel conveyance (4.e)	2.5	2	5.00	0.15
Move gravel conveyance (4.e)	2.5	2	4.00	0.12
Fill tank with gravel (4.a)	2.5	2	147.13	4.41
Construct engineered barrier (farm) (4.g)	2.5	2	74.64	0.37
TY TANK FARM TOTAL				**41.34**
U Tank Farm -- 12 530-Kgal Tanks				
Remove in-tank hardware (4.f)	7.7	3	252.00	69.85
Incidental grout fill (4.b)	2.5	2	2.29	0.14
Incidental gravel fill (4.b)	2.5	2	1.83	0.11
Install risers (4.c)	7.7	3	276.00	76.51
Install gravel fill equipment (4.d)	7.7	3	8.00	2.22
Remove gravel fill equipment (4.d)	2.5	3	4.00	0.36
Set up gravel conveyance (4.e)	2.5	2	5.00	0.30
Move gravel conveyance (4.e)	2.5	2	4.00	0.24
Fill tank with gravel (4.a)	2.5	2	102.87	6.17
Construct engineered barrier (farm) (4.g)	2.5	2	160.84	0.80
SUM				**156.70**
U Tank Farm -- 4 55-Kgal Tanks (with the gravel alternative, 55-Kgal tanks will be filled with grout)				
Install grout fill equipment (4.d)	7.7	3	2.00	0.18
Remove grout fill equipment (4.d)	2.5	3	1.00	0.03
Set up grout conveyance (4.e)	2.5	2	2.00	0.04
Move grout conveyance (4.e)	2.5	2	2.00	0.04
Fill tank with grout (4.a)	2.5	2	17.75	0.35
SUM				**0.65**
U TANK FARM TOTAL				**157.35**
TOTAL FOR ALL TANK FARMS				**1,320.28**

Gravel Fill Assumptions/Constants	Value
Gravel fill rate (m^3/hr)	31.2
Incidental grout fill rate (m^3/hr)	30
Pit regime (mrem/hr)	7.7
East tank farm regime (mrem/hr)	2.5
West tank farm regime (mrem/hr)	0.05
Persons to perform pit work	3
Persons to perform non-pit work	2
Hours to install riser/tank	276
Hours to install gravel fill equipment/tank	8
Hours to remove gravel fill equipment/tank	4
Hours to install gravel conveyances/tank	5
Hours to move gravel conveyances/tank	4
Hours to perform gravel prep work/tank	252
Hours to level for engineered barrier/m^2	0.01

Grout Fill and Concrete Fill Alternatives Closure Task(1)	Average mrem/hr(2)	Exposed Persons per Task(3)	Stay Time hours per Tank(4)	Tank Farm Dose (person/rem)(5)
A Tank Farm -- 6 1-Mgal Tanks				
Crimp overflow lines (4.g)	5	2	10	0.1
Incidental grout fill (4.b)	2.5	2	1.33	0.04
Incidental gravel fill (4.b)	2.5	2	7.75	0.23
Install grout fill equipment (4.d)	7.7	3	2.00	0.28
Remove grout fill equipment (4.d)	2.5	3	1.00	0.05
Set up grout conveyance (4.e)	2.5	2	2.00	0.06
Move grout conveyance (4.e)	2.5	2	2.00	0.06
Fill tank with grout (4.a)	2.5	2	201.87	6.06
Construct engineered barrier (farm) (4.g)	2.5	2	73.76	0.37
A TANK FARM TOTAL				**7.24**
AX Tank Farm -- 4 1-Mgal Tanks				
Crimp overflow lines (4.g)	0	0	0.00	0.00
Incidental grout fill (4.b)	2.5	2	1.32	0.03
Incidental gravel fill (4.b)	2.5	2	7.67	0.15
Install grout fill equipment (4.d)	7.7	3	2.00	0.18
Remove grout fill equipment (4.d)	2.5	3	1.00	0.03
Set up grout conveyance (4.e)	2.5	2	2.00	0.04
Move grout conveyance (4.e)	2.5	2	2.00	0.04
Fill tank with grout (4.a)	2.5	2	201.87	4.04
Construct engineered barrier (farm)(4.g)	2.5	2	52.62	0.26
AX TANK FARM TOTAL				**4.78**
B Tank Farm -- 12 530-Kgal Tanks				
Crimp overflow lines (4.g)	5	2	16.00	0.16
Incidental grout fill (4.b)	2.5	2	0.38	0.02
Incidental gravel fill (4.b)	2.5	2	1.83	0.11
Install grout fill equipment (4.d)	7.7	3	2.00	0.55
Remove grout fill equipment (4.d)	2.5	3	1.00	0.09
Set up grout conveyance (4.e)	2.5	2	2.00	0.12
Move grout conveyance (4.e)	2.5	2	2.00	0.12
Fill tank with grout (4.a)	2.5	2	106.99	6.42
Construct engineered barrier (farm) (4.g)	2.5	2	164.88	0.82
SUM				**8.42**

Grout Fill and Concrete Fill Alternatives Closure Task(1)	Average mrem/hr(2)	Exposed Persons per Task(3)	Stay Time hours per Tank(4)	Tank Farm Dose (person/rem)(5)
B Tank Farm -- 4 55-Kgal Tanks				
Install grout fill equipment (4.d)	7.7	3	2.00	0.18
Remove grout fill equipment (4.d)	2.5	3	1.00	0.03
Set up grout conveyance (4.e)	2.5	2	2.00	0.04
Move grout conveyance (4.e)	2.5	2	2.00	0.04
Fill tank with grout (4.a)	2.5	2	17.75	0.35
SUM				**0.65**
B TANK FARM TOTAL				**9.07**
BX Tank Farm -- 12 530-Kgal Tanks				
Crimp overflow lines (4.g)	5	2	16.00	0.16
Incidental grout fill (4.b)	2.5	2	0.31	0.02
Incidental gravel fill (4.b)	2.5	2	1.46	0.09
Install grout fill equipment (4.d)	7.7	3	2.00	0.55
Remove grout fill equipment (4.d)	2.5	3	1.00	0.09
Set up grout conveyance (4.e)	2.5	2	2.00	0.12
Move grout conveyance (4.e)	2.5	2	2.00	0.12
Fill tank with grout (4.a)	2.5	2	106.99	6.42
Construct engineered barrier (farm) (4.g)	2.5	2	135.38	0.68
BX TANK FARM TOTAL				**8.25**
BY Tank Farm -- 12 758-Kgal Tanks				
Crimp overflow lines (4.g)	5	2	16.00	0.16
Incidental grout fill (4.b)	2.5	2	0.31	0.02
Incidental gravel fill (4.b)	2.5	2	1.46	0.09
Install grout fill equipment (4.d)	7.7	3	2.00	0.55
Remove grout fill equipment (4.d)	2.5	3	1.00	0.09
Set up grout conveyance (4.e)	2.5	2	2.00	0.12
Move grout conveyance (4.e)	2.5	2	2.00	0.12
Fill tank with grout (4.a)	2.5	2	153.01	9.18
Construct engineered barrier (farm) (4.g)	2.5	2	137.25	0.46
BY TANK FARM TOTAL				**10.79**
C Tank Farm -- 12 530-Kgal Tanks				
Crimp overflow lines (4.g)	5	2	16.00	0.16
Incidental grout fill (4.b)	2.5	2	0.38	0.02
Incidental gravel fill (4.b)	2.5	2	1.83	0.11
Install grout fill equipment (4.d)	7.7	3	2.00	0.55

Grout Fill and Concrete Fill Alternatives Closure Task(1)	Average mrem/hr(2)	Exposed Persons per Task(3)	Stay Time hours per Tank(4)	Tank Farm Dose (person/rem)(5)
Remove grout fill equipment (4.d)	2.5	3	1.00	0.09
Set up grout conveyance (4.e)	2.5	2	2.00	0.12
Move grout conveyance (4.e)	2.5	2	2.00	0.12
Fill tank with grout (4.a)	2.5	2	106.99	6.42
Construct engineered barrier (farm) (4.g)	2.5	2	168.80	0.84
SUM				**8.28**
C Tank Farm -- 4 55-Kgal Tanks				
Install grout fill equipment (4.d)	7.7	3	2.00	0.18
Remove grout fill equipment (4.d)	2.5	3	1.00	0.03
Set up grout conveyance (4.e)	2.5	2	2.00	0.04
Move grout conveyance (4.e)	2.5	2	2.00	0.04
Fill tank with grout (4.a)	2.5	2	17.75	0.35
SUM				**0.65**
C TANK FARM TOTAL				**8.93**
S Tank Farm -- 12 758-Kgal Tanks				
Crimp overflow lines (4.g)	5	2	16.00	0.16
Incidental grout fill (4.b)	2.5	2	0.31	0.02
Incidental gravel fill (4.b)	2.5	2	1.46	0.09
Install grout fill equipment (4.d)	7.7	3	2.00	0.55
Remove grout fill equipment (4.d)	2.5	3	1.00	0.09
Set up grout conveyance (4.e)	2.5	2	2.00	0.12
Move grout conveyance (4.e)	2.5	2	2.00	0.12
Fill tank with grout (4.a)	2.5	2	153.01	9.18
Construct engineered barrier (farm) (4.g)	2.5	2	138.89	0.69
S TANK FARM TOTAL				**11.03**
SX Tank Farm -- 15 1-Mgal Tanks				
Crimp overflow lines (4.g)	5	2	20.00	0.20
Incidental grout fill (4.b)	2.5	2	0.76	0.06
Incidental gravel fill (4.b)	2.5	2	3.65	0.27
Install grout fill equipment (4.d)	7.7	3	2.00	0.69
Remove grout fill equipment (4.d)	2.5	3	1.00	0.11
Set up grout conveyance (4.e)	2.5	2	2.00	0.15
Move grout conveyance (4.e)	2.5	2	2.00	0.15
Fill Tank with grout (4.a)	2.5	2	201.87	15.14

Grout Fill and Concrete Fill Alternatives Closure Task(1)	Average mrem/hr(2)	Exposed Persons per Task(3)	Stay Time hours per Tank(4)	Tank Farm Dose (person/rem)(5)
Construct engineered barrier (farm) (4.g)	2.5	2	171.01	0.86
SX TANK FARM TOTAL				**17.43**
T Tank Farm -- 12 530-Kgal Tanks				
Crimp overflow lines (4.g)	5	2	16.00	0.16
Incidental grout fill (4.b)	2.5	2	0.38	0.02
Incidental gravel fill (4.b)	2.5	2	1.83	0.11
Install grout fill equipment (4.d)	7.7	3	2.00	0.55
Remove grout fill equipment (4.d)	2.5	3	1.00	0.09
Set up grout conveyance (4.e)	2.5	2	2.00	0.12
Move grout conveyance (4.e)	2.5	2	2.00	0.12
Fill tank with grout (4.a)	2.5	2	106.99	6.42
Construct engineered barrier (farm) (4.g)	2.5	2	164.88	0.82
SUM				**8.42**
T Tank Farm -- 4 55-Kgal Tanks				
Install grout fill equipment (4.d)	7.7	3	2.00	0.18
Remove grout fill equipment (4.d)	2.5	3	1.00	0.03
Set up grout conveyance (4.e)	2.5	2	2.00	0.04
Move grout conveyance (4.e)	2.5	2	2.00	0.04
Fill tank with grout (4.a)	2.5	2	17.75	0.35
SUM				**0.65**
T TANK FARM TOTAL				**9.07**
TX Tank Farm -- 18 758-Kgal Tanks				
Crimp overflow lines (4.g)	5	2	26.00	0.26
Incidental grout fill (4.b)	2.5	2	0.53	0.05
Incidental gravel fill (4.b)	2.5	2	2.56	0.23
Install grout fill equipment (4.d)	7.7	3	2.00	0.83
Remove grout fill equipment (4.d)	2.5	3	1.00	0.14
Set up grout conveyance (4.e)	2.5	2	2.00	0.18
Move grout conveyance (4.e)	2.5	2	2.00	0.18
Fill tank with grout (4.a)	2.5	2	153.01	13.77
Construct engineered barrier (farm) (4.g)	2.5	2	222.47	1.11
TX TANK FARM TOTAL				**16.75**
TY Tank Farm -- 6 758-Kgal Tanks				
Crimp overflow lines (4.g)	5	2	6.00	0.06
Incidental grout fill (4.b)	2.5	2	0.27	0.01

Grout Fill and Concrete Fill Alternatives Closure Task(1)	Average mrem/hr(2)	Exposed Persons per Task(3)	Stay Time hours per Tank(4)	Tank Farm Dose (person/rem)(5)
Incidental gravel fill (4.b)	2.5	2	2.12	0.06
Install grout fill equipment (4.d)	7.7	3	2.00	0.28
Remove grout fill equipment (4.d)	2.5	3	1.00	0.05
Set up grout conveyance (4.e)	2.5	2	2.00	0.06
Move grout conveyance (4.e)	2.5	2	2.00	0.06
Fill tank with grout (4.a)	2.5	2	201.87	6.06
Construct engineered barrier (farm) (4.g)	2.5	2	74.64	0.37
TY TANK FARM TOTAL				**7.00**
U Tank Farm -- 12 530-Kgal Tanks				
Crimp overflow lines (4.g)	5	2	16.00	0.16
Incidental grout fill (4.b)	2.5	2	0.38	0.02
Incidental gravel fill (4.b)	2.5	2	1.83	0.11
Install grout fill equipment (4.d)	7.7	3	2.00	0.55
Remove grout fill equipment (4.d)	2.5	3	1.00	0.09
Set up grout conveyance (4.e)	2.5	2	2.00	0.12
Move grout conveyance (4.e)	2.5	2	2.00	0.12
Fill tank with grout (4.a)	2.5	2	106.99	6.42
Construct engineered barrier (farm) (4.g)	2.5	2	164.88	0.82
SUM				**8.42**
U Tank Farm -- 4 55-Kgal Tanks				
Install grout fill equipment (4.d)	7.7	3	2.00	0.18
Remove grout fill equipment (4.d)	2.5	3	1.00	0.03
Set up grout conveyance (4.e)	2.5	2	2.00	0.04
Move grout conveyance (4.e)	2.5	2	2.00	0.04
Fill tank with grout (4.a)	2.5	2	17.75	0.35
SUM				**0.65**
U TANK FARM TOTAL				**9.07**
TOTAL FOR ALL TANK FARMS				**119.40**

Grout Fill Assumptions/Constants	Value
Grout fill rate (m^3/hr)	30
Incidental gravel fill rate (m^3/hr)	31.2
Pit regime (mrem/hr)	7.7
East tank farm regime (mrem/hr)	2.5
West tank farm regime (mrem/hr)	0.05
Hours to level for engineered barrier/m2	0.01
Persons to perform pit work	3
Persons to perform non-pit work	2
Hours to install grout fill equipment/tank	2
Hours to remove grout fill equipment/tank	1
Hours to install grout conveyances/tank	2
Hours to move grout conveyances/tank	1.5

Hybrid Fill Alternative Closure Task(1)	Average mrem/hr(2)	Exposed Persons per Task(3)	Stay Time hours per Tank(4)	Tank Farm Dose (person/rem)(5)
A Tank Farm -- 6 1-Mgal Tanks				
Crimp overflow lines (4.g)	5	2	10.00	0.10
Incidental grout fill (4.b)	2.5	2	1.33	0.04
Incidental gravel fill (4.b)	2.5	2	7.75	0.23
Install hybrid grout fill equipment (4.d)	7.7	3	2.00	0.28
Remove hybrid grout fill equipment (4.d)	7.7	3	1.00	0.14
Install hybrid aggregate equipment (4.d)	7.7	3	8.00	1.11
Remove hybrid agg. fill equipment (4.d)	7.7	3	4.00	0.55
Set up hybrid grout conveyance (4.e)	2.5	2	3.00	0.09
Move hybrid grout conveyance (4.e)	2.5	2	2.00	0.06
Set up hybrid aggregate conveyance (4.e)	2.5	2	5.00	0.15
Move hybrid aggregate conveyance (4.e)	2.5	2	4.00	0.12
Fill tank with hybrid grout (4.a)	2.5	2	111.03	3.33
Fill tank with hybrid aggregate (4.a)	2.5	2	87.35	2.62
Construct engineered barrier (farm) (4.g)	2.5	2	73.76	0.37
A TANK FARM TOTAL				**9.19**
AX Tank Farm -- 4 1-Mgal Tanks				
Crimp overflow lines (4.g)	0	0	0.00	0.00
Incidental grout fill (4.b)	2.5	2	1.32	0.03
Incidental gravel fill (4.b)	2.5	2	7.67	0.15
Install risers (4.c)	7.7	3	276.00	25.50
Install hybrid grout fill equipment (4.d)	7.7	3	2.00	0.18
Remove hybrid grout fill equipment (4.d)	7.7	3	1.00	0.09
Install hybrid aggregate equipment (4.d)	7.7	3	8.00	0.74
Remove hybrid agg. fill equipment (4.d)	7.7	3	4.00	0.37
Set up hybrid grout conveyance (4.e)	2.5	2	3.00	0.06
Move hybrid grout conveyance (4.e)	2.5	2	2.00	0.04
Set up hybrid aggregate conveyance (4.e)	2.5	2	5.00	0.10
Move hybrid aggregate conveyance (4.e)	2.5	2	4.00	0.08
Fill tank with hybrid grout (4.a)	2.5	2	111.03	2.22
Fill tank with hybrid aggregate (4.a)	2.5	2	87.35	1.75
Construct engineered barrier (farm) (4.g)	2.5	2	52.62	0.26
AX TANK FARM TOTAL				**31.58**

Hybrid Fill Alternative Closure Task(1)	Average mrem/hr(2)	Exposed Persons per Task(3)	Stay Time hours per Tank(4)	Tank Farm Dose (person/rem)(5)
B Tank Farm -- 12 530-Kgal Tanks				
Crimp overflow lines (4.g)	5	2	16.00	0.16
Incidental grout fill (4.b)	2.5	2	0.38	0.02
Incidental gravel fill (4.b)	2.5	2	1.83	0.11
Install risers (4.c)	7.7	3	276.00	76.51
Install hybrid grout fill equipment (4.d)	7.7	3	2.00	0.55
Remove hybrid grout equipment (4.d)	7.7	3	1.00	0.28
Install hybrid aggregate equipment (4.d)	7.7	3	8.00	2.22
Remove hybrid agg. fill equipment (4.d)	7.7	3	4.00	1.11
Set up hybrid grout conveyance (4.e)	2.5	2	3.00	0.18
Move hybrid grout conveyance (4.e)	2.5	2	2.00	0.12
Set up hybrid aggregate conveyance (4.e)	2.5	2	5.00	0.30
Move hybrid aggregate conveyance (4.e)	2.5	2	4.00	0.24
Fill tank with hybrid grout (4.a)	2.5	2	58.84	3.53
Fill tank with hybrid aggregate (4.a)	2.5	2	46.29	2.78
Construct engineered barrier (farm) (4.g)	2.5	2	164.88	0.82
SUM				**88.93**
B Tank Farm -- 4 55-Kgal Tanks (with hybrid alternative, 55-Kgal tanks will be filled with grout)				
Install grout fill equipment (4.d)	7.7	3	2.00	0.18
Remove grout fill equipment (4.d)	2.5	3	1.00	0.03
Set up grout conveyance (4.e)	2.5	2	2.00	0.04
Move grout conveyance (4.e)	2.5	2	2.00	0.04
Fill tank with grout (4.a)	2.5	2	17.75	0.35
SUM				**0.65**
B TANK FARM TOTAL				**89.58**
BX Tank Farm -- 12 530-Kgal Tanks				
Crimp overflow lines (4.g)	5	2	16.00	0.16
Incidental grout fill (4.b)	2.5	2	0.31	0.02
Incidental gravel fill (4.b)	2.5	2	1.46	0.09
Install risers (4.c)	7.7	3	276.00	76.51
Install hybrid grout fill equipment (4.d)	7.7	3	2.00	0.55
Remove hybrid grout fill equipment (4.d)	7.7	3	1.00	0.28
Install hybrid aggregate equipment (4.d)	7.7	3	8.00	2.22
Remove hybrid agg. fill equipment (4.d)	7.7	3	4.00	1.11

Hybrid Fill Alternative Closure Task(1)	Average mrem/hr(2)	Exposed Persons per Task(3)	Stay Time hours per Tank(4)	Tank Farm Dose (person/rem)(5)
Set up hybrid grout conveyance (4.e)	2.5	2	3.00	0.18
Move hybrid grout conveyance (4.e)	2.5	2	2.00	0.12
Set up hybrid aggregate conveyance (4.e)	2.5	2	5.00	0.30
Move hybrid aggregate conveyance (4.e)	2.5	2	4.00	0.24
Fill tank with hybrid grout (4.a)	2.5	2	58.84	3.53
Fill tank with hybrid aggregate (4.a)	2.5	2	46.29	2.78
Construct engineered barrier (farm) (4.g)	2.5	2	135.38	0.68
BX TANK FARM TOTAL				**88.76**
BY Tank Farm -- 12 758-Kgal Tanks				
Crimp overflow lines (4.g)	5	2	16.00	0.16
Incidental grout fill (4.b)	2.5	2	0.31	0.02
Incidental gravel fill (4.b)	2.5	2	1.46	0.09
Install hybrid grout fill equipment (4.d)	7.7	3	2.00	0.55
Remove hybrid grout equipment (4.d)	7.7	3	1.00	0.28
Install hybrid aggregate equipment (4.d)	7.7	3	8.00	2.22
Remove hybrid agg. fill equipment (4.d)	7.7	3	4.00	1.11
Set up hybrid grout conveyance (4.e)	2.5	2	3.00	0.18
Move hybrid grout conveyance (4.e)	2.5	2	2.00	0.12
Set up hybrid aggregate conveyance (4.e)	2.5	2	5.00	0.30
Move hybrid aggregate conveyance (4.e)	2.5	2	4.00	0.24
Fill tank with hybrid grout (4.a)	2.5	2	84.16	5.05
Fill tank with hybrid aggregate (4.a)	2.5	2	66.21	3.97
Construct engineered barrier (farm) (4.g)	2.5	2	137.25	0.69
BY TANK FARM TOTAL				**14.97**
C Tank Farm -- 12 530-Kgal Tanks				
Crimp overflow lines (4.g)	5	2	16.00	0.16
Incidental grout fill (4.b)	2.5	2	0.38	0.02
Incidental gravel fill (4.b)	2.5	2	1.83	0.11
Install risers (4.c)	7.7	3	276.00	76.51
Install hybrid grout fill equipment (4.d)	7.7	3	2.00	0.55
Remove hybrid grout fill equipment (4.d)	7.7	3	1.00	0.28
Install hybrid aggregate equipment (4.d)	7.7	3	8.00	2.22
Remove hybrid agg. fill equipment (4.d)	7.7	3	4.00	1.11
Set up hybrid grout conveyance (4.e)	2.5	2	3.00	0.18
Move hybrid grout conveyance (4.e)	2.5	2	2.00	0.12

Hybrid Fill Alternative Closure Task(1)	Average mrem/hr(2)	Exposed Persons per Task(3)	Stay Time hours per Tank(4)	Tank Farm Dose (person/rem)(5)
Set up hybrid aggregate conveyance (4.e)	2.5	2	5.00	0.30
Move hybrid aggregate conveyance (4.e)	2.5	2	4.00	0.24
Fill tank with hybrid grout (4.a)	2.5	2	58.84	3.53
Fill tank with hybrid aggregate (4.a)	2.5	2	46.29	2.78
Construct engineered barrier (farm) (4.g)	2.5	2	168.80	0.84
SUM				**88.95**
C Tank Farm -- 4 55-Kgal Tanks (with the hybrid alternative, 55-Kgal tanks will be filled with grout)				
Install grout fill equipment (4.d)	7.7	3	2.00	0.18
Remove grout fill equipment (4.d)	2.5	3	1.00	0.03
Set up grout conveyance (4.e)	2.5	2	2.00	0.04
Move grout conveyance (4.e)	2.5	2	2.00	0.04
Fill tank with grout (4.a)	2.5	2	17.75	0.00
SUM				**0.29**
C TANK FARM TOTAL				**89.24**
S Tank Farm -- 12 758-Kgal Tanks				
Crimp overflow lines (4.g)	5	2	16.00	0.16
Incidental grout fill (4.b)	2.5	2	0.31	0.02
Incidental gravel fill (4.b)	2.5	2	1.46	0.09
Install hybrid grout fill equipment (4.d)	7.7	3	2.00	0.55
Remove hybrid grout fill equipment (4.d)	7.7	3	1.00	0.28
Install hybrid aggregate equipment (4.d)	7.7	3	8.00	2.22
Remove hybrid agg. fill equipment (4.d)	7.7	3	4.00	1.11
Set up hybrid grout conveyance (4.e)	2.5	2	3.00	0.18
Move hybrid grout conveyance (4.e)	2.5	2	2.00	0.12
Set up hybrid aggregate conveyance (4.e)	2.5	2	5.00	0.30
Move hybrid aggregate conveyance (4.e)	2.5	2	4.00	0.24
Fill tank with hybrid grout (4.a)	2.5	2	84.16	5.05
Fill tank with hybrid aggregate (4.a)	2.5	2	66.21	3.97
Construct engineered barrier (farm) (4.g)	2.5	2	138.89	0.69
S TANK FARM TOTAL				**14.98**
SX Tank Farm -- 15 1-Mgal Tanks				
Crimp overflow lines (4.g)	5	2	20.00	0.20
Incidental grout fill (4.b)	2.5	2	0.31	0.01
Incidental gravel fill (4.b)	2.5	2	1.46	0.04

Hybrid Fill Alternative Closure Task(1)	Average mrem/hr(2)	Exposed Persons per Task(3)	Stay Time hours per Tank(4)	Tank Farm Dose (person/rem)(5)
Install hybrid grout fill equipment (4.d)	7.7	3	2.00	0.69
Remove hybrid grout fill equipment (4.d)	7.7	3	1.00	0.35
Install hybrid aggregate equipment (4.d)	7.7	3	8.00	2.77
Remove hybrid agg. fill equipment (4.d)	7.7	3	4.00	1.39
Set up hybrid grout conveyance (4.e)	2.5	2	3.00	0.23
Move hybrid grout conveyance (4.e)	2.5	2	2.00	0.15
Set up hybrid aggregate conveyance (4.e)	2.5	2	5.00	0.38
Move hybrid aggregate conveyance (4.e)	2.5	2	4.00	0.30
Fill tank with hybrid grout (4.a)	2.5	2	111.03	8.33
Fill Tank with hybrid aggregate (4.a)	2.5	2	87.35	6.55
Construct engineered barrier (farm) (4.g)	2.5	2	171.01	0.86
SX TANK FARM TOTAL				**22.23**
T Tank Farm -- 12 530-Kgal Tanks				
Crimp overflow lines (4.g)	5	2	16.00	0.16
Incidental grout fill (4.b)	2.5	2	0.38	0.02
Incidental gravel fill (4.b)	2.5	2	1.83	0.11
Install risers (4.c)	7.7	3	276.00	76.51
Install hybrid grout fill equipment (4.d)	7.7	3	2.00	0.55
Remove hybrid grout fill equipment (4.d)	7.7	3	1.00	0.28
Install hybrid aggregate equipment (4.d)	7.7	3	8.00	1.11
Remove hybrid agg. fill equipment (4.d)	7.7	3	4.00	2.22
Set up hybrid grout conveyance (4.e)	2.5	2	3.00	0.18
Move hybrid grout conveyance (4.e)	2.5	2	2.00	0.12
Set up hybrid aggregate conveyance (4.e)	2.5	2	5.00	0.30
Move hybrid aggregate conveyance (4.e)	2.5	2	4.00	0.24
Fill tank with hybrid grout (4.a)	2.5	2	58.84	3.53
Fill tank with hybrid aggregate (4.a)	2.5	2	46.29	2.78
Construct engineered barrier (farm) (4.g)	2.5	2	164.88	0.82
SUM				**88.93**
T Tank Farm -- 4 55-Kgal Tanks (with the hybrid alternative, 55-Kgal tanks will be filled with grout)				
Install grout fill equipment (4.d)	7.7	3	2.00	0.18
Remove grout fill equipment (4.d)	2.5	3	1.00	0.03
Set up grout conveyance (4.e)	2.5	2	2.00	0.04
Move grout conveyance (4.e)	2.5	2	2.00	0.04

Hybrid Fill Alternative Closure Task(1)	Average mrem/hr(2)	Exposed Persons per Task(3)	Stay Time hours per Tank(4)	Tank Farm Dose (person/rem)(5)
Fill tank with grout (4.a)	2.5	2	17.75	0.00
SUM				**0.29**
T TANK FARM TOTAL				**89.22**
TX Tank Farm -- 18 758-Kgal Tanks				
Crimp overflow lines (4.g)	5	2	26.00	0.26
Incidental grout fill (4.b)	2.5	2	0.36	0.03
Incidental gravel fill (4.b)	2.5	2	1.70	0.10
Install hybrid grout fill equipment (4.d)	7.7	3	2.00	0.83
Remove hybrid grout equipment (4.d)	7.7	3	1.00	0.42
Install hybrid aggregate equipment (4.d)	7.7	3	8.00	3.33
Remove hybrid agg. fill equipment (4.d)	7.7	3	4.00	1.66
Set up hybrid grout conveyance (4.e)	2.5	2	3.00	0.27
Move hybrid grout conveyance (4.e)	2.5	2	2.00	0.18
Set up hybrid aggregate conveyance (4.e)	2.5	2	5.00	0.45
Move hybrid aggregate conveyance (4.e)	2.5	2	4.00	0.36
Fill tank with hybrid grout (4.a)	2.5	2	84.16	7.57
Fill tank with hybrid aggregate (4.a)	2.5	2	66.21	5.96
Construct engineered barrier (farm) (4.g)	2.5	2	222.47	1.11
TX TANK FARM TOTAL				**22.54**
TY Tank Farm -- 6 758-Kgal Tanks				
Crimp overflow lines (4.g)	5	2	6.00	0.06
Incidental grout fill (4.b)	2.5	2	0.27	0.01
Incidental gravel fill (4.b)	2.5	2	2.12	0.06
Install hybrid grout fill equipment (4.d)	7.7	3	2.00	0.28
Remove hybrid grout equipment (4.d)	7.7	3	1.00	0.14
Install hybrid aggregate equipment (4.d)	7.7	3	8.00	1.11
Remove hybrid agg. fill equipment (4.d)	7.7	3	4.00	0.55
Set up hybrid grout conveyance (4.e)	2.5	2	3.00	0.09
Move hybrid grout conveyance (4.e)	2.5	2	2.00	0.06
Set up hybrid aggregate conveyance (4.e)	2.5	2	5.00	0.15
Move hybrid aggregate conveyance (4.e)	2.5	2	4.00	0.12
Fill tank with hybrid grout (4.a)	2.5	2	84.16	2.52
Fill tank with hybrid aggregate (4.a)	2.5	2	66.21	1.99
Construct engineered barrier (farm) (4.g)	2.5	2	73.76	0.37
TX TANK FARM TOTAL				**7.51**

Hybrid Fill Alternative Closure Task(1)	Average mrem/hr(2)	Exposed Persons per Task(3)	Stay Time hours per Tank(4)	Tank Farm Dose (person/rem)(5)
U Tank Farm -- 12 530-Kgal Tanks				
Crimp overflow lines (4.g)	5	2	16.00	0.16
Incidental grout fill (4.b)	2.5	2	0.38	0.02
Incidental gravel fill (4.b)	2.5	2	1.83	0.11
Install risers (4.c)	7.7	3	276.00	76.51
Install hybrid grout fill equipment (4.d)	7.7	3	2.00	0.55
Remove hybrid grout equipment (4.d)	7.7	3	1.00	0.28
Install hybrid aggregate equipment (4.d)	7.7	3	8.00	2.22
Remove hybrid agg. fill equipment (4.d)	7.7	3	4.00	1.11
Set up hybrid grout conveyance (4.e)	2.5	2	3.00	0.18
Move hybrid grout conveyance (4.e)	2.5	2	2.00	0.12
Set up hybrid aggregate conveyance (4.e)	2.5	2	5.00	0.30
Move hybrid aggregate conveyance (4.e)	2.5	2	4.00	0.24
Fill tank with hybrid grout (4.a)	2.5	2	58.84	3.53
Fill tank with hybrid aggregate (4.a)	2.5	2	46.29	2.78
Construct engineered barrier (farm) (4.g)	2.5	2	160.84	0.80
SUM				**88.91**
U Tank Farm -- 4 55-Kgal Tanks (with the hybrid alternative, 55-Kgal tanks will be filled with grout)				
Install grout fill equipment (4.d)	7.7	3	2.00	0.18
Remove grout fill equipment (4.d)	2.5	3	1.00	0.03
Set up grout conveyance (4.e)	2.5	2	2.00	0.04
Move grout conveyance (4.e)	2.5	2	2.00	0.04
Fill tank with grout (4.a)	2.5	2	17.75	0.00
SUM				**0.29**
U TANK FARM TOTAL				**89.2**
TOTAL FOR ALL TANK FARMS				**569.01**

Hybrid Assumptions/Constants	Value
Gravel fill rate (m^3/hr)	30
Aggregate fill rate (m^3/hr)	31.2
Incidental gravel fill rate (m^3/hr)	31.2
Pit regime (mrem/hr)	7.7
East tank farm regime (mrem/hr)	2.5
West tank farm regime (mrem/hr)	0.05
Persons to perform pit work	3
Persons to perform non-pit work	2
Hours to install riser/tank	276
Hours to install grout fill equipment/tank	2
Hours to remove grout fill equipment/tank	1
Hours to install agg. fill equipment/tank	8
Hours to remove agg. fill equipment/tank	4
Hours to install agg. conveyance/tank	5
Hours to move agg. conveyance/tank	4
Hours to set up grout conveyance/tank	3
Hours to move grout conveyance/tank	2
Hours for aggregate preparatory work/tank	252
Hours to level for engineered barrier (m^2/hr)	0.01

Ancillary Equipment Void Spaces	Piping (M^3)	Pits (M^3)
A Tank Farm	239.9	1450.4
AX Tank Farm	158.3	957.3
B Tank Farm	137.4	683.4
BX Tank Farm	109.9	546.7
BY Tank Farm	109.9	546.7
C Tank Farm	137.4	683.4
S Tank Farm	109.9	546.7
SX Tank Farm	137.4	683.4
T Tank Farm	137.4	683.4
TX Tank Farm	192.3	956.8
TY Tank Farm	48.5	397.2
U Tank Farm	137.4	683.4

Sizes of Tank Farms	(M^2)
A Tank Farm	7376
AX Tank Farm	5262
B Tank Farm	16488
BX Tank Farm	13538
BY Tank Farm	13725
C Tank Farm	16880
S Tank Farm	13889
SX Tank Farm	17101
T Tank Farm	16488
TX Tank Farm	22247
TY Tank Farm	7464
U Tank Farm	16084

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NOTES: DOSES FOR TANK-FILL ALTERNATIVES

1. The tasks are those that involve entry into tank farms. It is assumed that about 99% of the waste will be removed from the tanks using past practices. That is, retrieval of waste will be through the completion of salt well pumping and then the sluicing of tank waste to the extent practical. It is assumed that instrument trees, liquid observation wells, and other ancillary equipment will be removed as part of closure. This results in a great deal of preparatory work relative to the gravel alternative. In the event that such preparatory work is not necessary, the doses from the three alternatives (gravel, grout, and hybrid) will be much closer. The tasks for a fourth alternative, concrete, would be the same as for grout.

There are 64 of the 149 SSTs that do not have 42-in. central risers (Krieg 1990, Table 2-2). It is assumed that risers will need to be installed on these tanks. It is assumed that the risers on 85 tanks would be clear and available for tank filling after retrieval operations.

2. Three dose rate regimes are assumed:

- Pit regime = 7.7 mrem/hr, based on the ACES data base and doses incurred from past pit work
- East Tank Farm = 2.5 mrem/hr, based on doses incurred from routine radiological surveys
- West Tank Farm = 0.05 mrem/hr, based on doses incurred from routing radiological surveys
- Crimping overflow lines = 5.0 mrem/hr, based on shielding and other ALARA protective measures.

It is assumed that most of the dose from tank farm closure tasks will come from surface contamination of pump pits, soil contamination, and contamination on ancillary equipment. It is assumed that no efforts to decontaminate pump pits will be made prior to closure tasks. If such decontamination efforts are made, the Pit Regime dose rate will be lowered and the gravel and hybrid cases will approach the grout case.

It is assumed that in constructing the engineered barrier, only the leveling operation will incur dose at the Tank Farm Regime dose rates above.

3. It is assumed that three persons will be exposed during pit-type work and that two persons will be exposed during other closure tasks. These numbers do not necessarily reflect the actual number of persons involved in the job, but are estimates of the average number of persons exposed to the dose rate regime.

4. All stay times are per tank in the relevant tank farm, except the engineered barrier stay times are for the entire tank farm. Stay times are computed from data extracted from various documents and other assumptions as described below:

a. Gravel fill rate and grout fill rate = 31.2 m^3/hr and 30.0 m^3/hr, respectively (Boomer et al. 1993). It is assumed that hybrid aggregate fill rate is the same as gravel. The void volumes of the tanks are assumed to be 1.6 times those indicated by the tank farm headers in the first column (e.g., 1.6 x 1-Mgal or 1.6 x 3,780 m^3, etc.). In the hybrid case, it is assumed that 55% of the void volume is grout and 45% is aggregate.

b. Incidental grout fill or gravel fill hours were based on the fill rates given above and the void volumes from WHC-SD-WM-EV-107, page A-17 (Kline et al. 1995). It is assumed that grout will fill piping, miscellaneous underground storage tanks and riser voids, while gravel will fill pits and boxes.

c. It is assumed that a new riser can be installed in 276 exposure hours, based on a mock riser installation (ICF KH 1995).

d. It is assumed that installation of gravel/aggregate fill equipment will take 8 hr per tank and installation of grout fill equipment will take only 2 hr per tank. These numbers are based on estimated times to perform various pit jobs, such as pump pulls, jumper work, etc., documented in the ACES data base. It is assumed that removal of the gravel/aggregate or grout equipment will take only half the time for installation.

e. It is assumed that gravel and aggregate conveyor systems can be set up in 5 hr and moved in 4 hr per tank, while grout conveyance systems can be set up in 3 hr and moved in 2 hr.

f. It is assumed that gravel preparatory work (removal of ancillary in-tank equipment that would interfere with gravel) is necessary for all SSTs. It is assumed that 252 hr per tank will be required for this work and that it is pit-type work.

g. It is assumed that 100 m^2 of surface area can be leveled per hour, in constructing the engineered barrier. This estimate is derived from past decontamination and decommissioning work involving a grader. The surface areas of tank farms were taken from WHC-EP-0616, page M71.

h. With the grout/concrete and hybrid alternatives, it is assumed that cascade lines will need to be crimped. It is assumed that each crimping will involve exposure of 2 individuals for 2 hr at 5 mrem/hr.

5. This is the product of the previous three rows times the number of tanks (except for the barrier calculation).

APPENDIX E

CONCEPTUAL COST ESTIMATES

CONTENTS

ALTERNATIVE 1: GRAVEL FILL

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WESTINGHOUSE HANFORD COMPANY
JOB NO. Z407SAA1/F7K6L5
FILE NO. Z407SAA1

** IEST - INTERACTIVE ESTIMATING **
TWRS CLOSURE FILL ALTERNATIVES - OPTION 1
CRUSHED AGGREGATE STUDY ESTIMATE
DOE_R01 - PROJECT COST SUMMARY

DATE 08/13/96 09:19:32
BY R.OHRT

COST CODE	DESCRIPTION	ESCALATED TOTAL COST	CONTINGENCY %	CONTINGENCY TOTAL	TOTAL DOLLARS
000	ENGINEERING	21,720,000	35	7,600,000	29,320,000
060	PROJECT MANAGEMENT	30,170,000	35	10,560,000	40,730,000
460	IMPROVEMENTS TO LAND	180,820,000	35	63,290,000	244,110,000
700	SPECIAL EQUIP/PROCESS SYSTEMS	17,370,000	35	6,080,000	23,450,000
	(ADJUSTED TO MEET DOE 5100.4)	20,000		<30,000>	<10,000>
	PROJECT TOTAL	250,100,000	35	87,500,000	337,600,000

TYPE OF ESTIMATE	STUDY ESTIMATE	AUGUST 13, 1996
ARCHITECT ENGINEER	[signature]	
OPERATING CONTRACTOR	[signature]	8/14/96

REMARKS:

(ROUNDED/ADJUSTED TO THE NEAREST " 10,000 / 100,000 " - PERCENTAGES NOT RECALCULATED TO REFLECT ROUNDING)

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WESTINGHOUSE HANFORD COMPANY
JOB NO. Z407SAA1/F7K6L5
FILE NO. Z407SAA1

** IEST - INTERACTIVE ESTIMATING **
TWRS CLOSURE FILL ALTERNATIVES - OPTION 1
CRUSHED AGGREGATE STUDY ESTIMATE
DOE_R02 - WORK BREAKDOWN STRUCTURE SUMMARY

DATE 08/13/96 09:19:37
BY R.OHRT

WBS	DESCRIPTION	ESTIMATE SUBTOTAL	ONSITE INDIRECTS	SUB TOTAL	ESCALATION %	ESCALATION TOTAL	SUB TOTAL	CONTINGENCY %	CONTINGENCY TOTAL	TOTAL DOLLARS
110001	DEFINITIVE DESIGN - INFRASTRUCTURE	2112975	0	2112975	0.00	0	2112975	35	739541	2852516
110002	DEFINITIVE DESIGN - GRAVEL FILL	13184477	0	13184477	0.00	0	13184477	35	4614567	17799044
110003	DEFINITIVE DESIGN - ANCILLARY GROUT	138729	0	138729	0.00	0	138729	35	48555	187284
110010	DEFIN.DESIGN - IN-TANK HARDWARE	1626000	0	1626000	0.00	0	1626000	35	569100	2195100
110012	DEFINITIVE DESIGN - 42" RISER	2440300	0	2440300	0.00	0	2440300	35	854105	3294405
110102	DEFINITIVE DESIGN - ESCALATION	594500	0	594500	0.00	0	594500	35	208075	802575
SUBTOTAL 11	DEFINITIVE DESIGN	20096981	0	20096981	0.00	0	20096981	35	7033943	27130924
120010	ENGIN/INSPECT - IN-TANK HARDWARE	651000	0	651000	0.00	0	651000	35	227850	878850
120012	ENGINEERING/INSP. - 42" RISER	976100	0	976100	0.00	0	976100	35	341635	1317735
SUBTOTAL 12	ENGINEERING/INSPECTION	1627100	0	1627100	0.00	0	1627100	35	569485	2196585
SUBTOTAL 1	ENGINEERING	21724081	0	21724081	0.00	0	21724081	35	7603428	29327509
310010	CONSTRUCTION - IN-TANK HARDWARE	6505055	0	6505055	0.00	0	6505055	35	2276769	8781824
310012	CONSTRUCTION - 42" RISER INSTALL	9869600	0	9869600	0.00	0	9869600	35	3454361	13323961
SUBTOTAL 31	FA CONST-ONSITE E/C	16374655	0	16374655	0.00	0	16374655	35	5731130	22105785
320001	CONSTRUCTION - INFRASTRUCTURE	14086624	0	14086624	0.00	0	14086624	35	4930318	19016942
320002	CONSTRUCTION - GRAVEL FILL	29702772	0	29702772	0.00	0	29702772	35	10395970	40098742
320003	CONSTRUCTION - ANCILLARY GROUT	557814	0	557814	0.00	0	557814	35	195234	753048
320004	CONSTRUCTION - BARRIER CAP	130950526	0	130950526	0.00	0	130950526	35	45832684	176783210
321001	SUBCONTRACT MPR - INFRASTRUCTURE	437405	0	437405	0.00	0	437405	35	153092	590497
321002	SUBCONTRACT MPR - GRAVEL FILL	960212	0	960212	0.00	0	960212	35	336074	1296286
321003	SUBCONTRACT MPR - ANCILLARY GROUT	23450	0	23450	0.00	0	23450	35	8208	31658
321004	SUBCONTRACT MPR - BARRIER CAP	4105959	0	4105959	0.00	0	4105959	35	1437086	5543045
322001	PROJECT MANAGEMENT - INFRASTRUCTURE	2817325	0	2817325	0.00	0	2817325	35	986064	3803389
322004	PROJ/CONSTR MGMT - BARRIER CAP	21145687	0	21145687	0.00	0	21145687	35	7400990	28546677
SUBTOTAL 32	CONSTRUCTION-FIXED PRICE	204787774	0	204787774	0.00	0	204787774	35	71675720	276463494
SUBTOTAL 3	CONSTRUCTION	221162429	0	221162429	0.00	0	221162429	35	77406850	298569279
500004	WHC PROJ MGMT - BARRIER CAP	5912400	0	5912400	0.00	0	5912400	35	2069340	7981740

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FILE NO. Z407SAA1

** IEST - INTERACTIVE ESTIMATING **
TWRS CLOSURE FILL ALTERNATIVES - OPTION 1
CRUSHED AGGREGATE STUDY ESTIMATE
DOE_R02 - WORK BREAKDOWN STRUCTURE SUMMARY

DATE 08/13/96 09:19:37
BY R.OHRT

WBS	DESCRIPTION	ESTIMATE SUBTOTAL	ONSITE INDIRECTS	SUB TOTAL	ESCALATION %	ESCALATION TOTAL	SUB TOTAL	CONTINGENCY %	CONTINGENCY TOTAL	TOTAL DOLLARS
500010	WHC PROJ MGMT - IN-TANK HARDWARE	293000	0	293000	0.00	0	293000	35	102550	395550
500012	WHC PROJ MGMT - 42" RISER INSTALL	997000	0	997000	0.00	0	997000	35	348950	1345950
SUBTOTAL 5	OTHER PROJECT COST	7202400	0	7202400	0.00	0	7202400	35	2520840	9723240
PROJECT TOTAL		250,088,910	0	250,088,910	0.00	0	250,088,910	35	87,531,118	337,620,028

1. DOCUMENTS AND DRAWINGS
=====================

DOCUMENTS: PROJECT TIME AND COSTS SPREAD SHEET ESTIMATE, DATED 5/24/96, ICF KAISER HANFORD STUDY ESTIMATE #W340SAA1, DATED 01/12/94, STATEMENT OF WORK DRAFT.

DRAWINGS: NONE

2. MATERIAL PRICES
===============

UNIT COSTS REPRESENT CURRENT PRICES FOR SPECIFIED MATERIAL.

3. LABOR RATES
===========

A.) ICF-KH HOURLY RATES ARE BASED ON THE 1996 FISCAL YEAR BUDGET LIQUIDATION RATES AS ISSUED BY KEH FINANCE (EFFECTIVE 10-17-95). SEE ALSO THE FY 1996 PLANNING RATES * (REPORT BGHB2000 & BGHB2005).
B.) WHC HOURLY RATES ARE BASED UPON THE FY 1996 PLANNING RATES * (REPORT BGHB2001).
C.) IRM HOURLY RATES ARE BASED UPON THE FY 1996 PLANNING RATES * (REPORT BGHB7008).
D.) BASE CRAFT RATES ARE AS ISSUED BY KEH FINANCE (EFFECTIVE 10-17-95). RATES INCLUDE FRINGE BENEFITS, LABOR INSURANCE, TAXES DEPARTMENT OVERHEADS, G&A AND SWS, AND TRAVEL WHERE APPLICABLE, PER HANFORD SITE STABILIZATION AGREEMENT, APPENDIX "A".
* SEE HANFORD SOFT REPORTING, FDS BUDGET GUIDELINE HANDBOOK, SECTION 2 - COMPANY INFORMATION, FY 1996 PLANNING RATES.

4. GENERAL REQUIREMENTS/TECHNICAL SERVICES/OVERHEADS
===

A.) ONSITE CONSTRUCTION FORCES GENERAL REQUIREMENTS, TECHNICAL SERVICES AND CRAFT OVERHEAD COSTS ARE INCLUDED AS A COMPOSITE PERCENTAGE BASED ON THE ICF-KH ESTIMATING FACTOR, REVISION 1, FY96, DATED 1-/-1/95 THE TOTAL COMPOSITE PERCENTAGE APPLIED TO ONSITE CONSTRUCTION FORCES LABOR, FOR THIS PROJECT, IS 52% FOR ALL WORK, WHICH IS REFLECTED IN THE "OH&P/B&I" COLUMN OF THE ESTIMATE DETAIL.

B.) ONSITE CONTRACT ADMINISTRATION AND CONSTRUCTION MANAGEMENT COSTS, ASSOCIATED WITH THE OVERALL MANAGEMENT OF THE FIXED PRICE CONTRACTS, ARE INCLUDED AS A COMPOSITE PERCENTAGE AND LUMP SUM ALLOWANCE (FOR BID PACKAGE PREP) BASED ON THE ESTIMATING FACTOR/BILLING SCHEDULE. THE TOTAL COMPOSITE PERCENTAGE AND LUMP SUM ALLOWANCE ARE APPLIED AGAINST THE TOTAL FIXED PRICE CONTRACT AMOUNT WHICH IS REFLECTED ON THE KEH SUMMARY REPORT DOE_R07, INCLUDED WITH THIS ESTIMATE. (FINAL ESTIMATES MAY BE PARTIALLY MANLOADED AND INCLUDED WITHIN THE ESTIMATE DETAIL)

C.) FIXED PRICE CONTRACTOR OVERHEAD, PROFIT, BOND AND INSURANCE COSTS HAVE BEEN APPLIED AT THE FOLLOWING PERCENTAGES AND ARE REFLECTED IN THE "OH&P/B&I" COLUMN OF THE ESTIMATE DETAIL:
LABOR - 30.4%, MATERIAL - 30.4%, EQUIPMENT USAGE - 30.4%, EQUIPMENT - 30.4%, SUBCONTRACTS - 38.47%.

5. ESCALATION
==========

ESCALATION WAS NOT APPLIED TO THE DOLLAR AMOUNTS FOR FUTURE PROJECTIONS, ALL COSTS HAVE BEEN CONVERTED TO 1996 DOLLARS.

6. ROUNDING
=====================

U.S. DEPARTMENT OF ENERGY - DOE ORDER 5100.4 PAGE I-32 SUBPARAGRAPH (M), REQUIRES ROUNDING OF ALL GENERAL PLANT PROJECTS (GPP'S) AND LINE ITEM (LI) COST ESTIMATES. REFERENCE: DOE 5100.4, FIGURE I-11, DATED 10-31-84.

7. REMARKS
=======

A.) IT WAS ASSUMED THAT BURN-OUT WILL NOT BE EXPERIENCED DURING ANY ACTIVITIES.
B.) ALL SOILS DISTURBED BY CONSTRUCTION ACTIVITIES WILL BE ASSUMED TO GO BACK INTO ORIGINAL PLACE WITHOUT DISPOSAL COSTS INCURRED.
C.) ASSUMED AIRLIFT CIRCULATORS UTILIZE A 12" FLANGED RISER.
D.) INVENTORY FOR IN-TANK HARDWARE BASED ON REPORT "SINGLE-SHELL TANK IN-TANK HARDWARE INVENTORY, BY T.E.RAINEY & M.E.BEAVER.
E.) THE METHOD ASSUMED, FOR THE SAKE OF ESTIMATE, FOR DEALING WITH DOME SUSPENDED HARDWARE IS BASED ON A MODIFIED VERSION OF A PROCESS COVERED BY AN EARLIER DOCUMENT (ATLANTIC RICHFIELD CO) ARH-CD-891 DATED FEB 8, 1977.
F.) ASSUMED THAT ONLY ITH ITEMS LESS THAN 4" DIA WOULD HAVE TO BE REMOVED. SMALLER ITEMS WOULD BE ABRADED OR DISLODGED BY THE AGGREGATE DURING THE FILL OPERATION.
G.) THE COSTS AS REFLECTED IN THE ESTIMATE WBS'110001, 110002, 110003, 110102, 110103, 320001 THRU 320004, 320102, 320103, 321001 THRU 321004, 322001, 322004 AND 500004 COME FROM PROJECT TIME AND COST ESTIMATE DATED 5/24/96 DONE BY LEE SMITH.
H.) WBS 110012, 120012, 200012, 310012 AND 500012 WERE EXTRACTED FROM ICF KAISER HANFORD STUDY ESTIMATE W340SAA1 DATED 1/12/94 WITH ADJUSTMENTS MADE TO REFLECT FY96 LABOR RATES AND ADDERS.
I.) ALL MATERIAL COSTS FROM P.T.& C. COST ESTIMATE INCLUDE SALES TAX.

REFERENCE: ESTIMATE BASIS SHEET PAGE 4 & 5 OF 6

THE U.S. DEPARTMENT OF ENERGY - RICHLAND ORDER 5700.3 "COST ESTIMATING, ANALYSIS AND STANDARDIZATION" DATED 3-27-85, PROVIDES GUIDELINES FOR ESTIMATE CONTINGENCIES. THE GUIDELINE FOR A STUDY ESTIMATE SHOULD HAVE AN OVERALL RANGE OF 20 TO 50%.

CONTINGENCY IS EVALUATED AT THE THIRD COST CODE LEVEL AND SUMMARIZED AT THE PRIMARY AND SECONDARY COST CODE LEVEL OF THE DETAILED COST ESTIMATE.

ENGINEERING

ALL ENGINEERING WAS GIVEN A 35% CONTINGENCY REFLECTIVE OF EITHER THE EARLIER ESTIMATE THAT WAS USED FOR THIS STUDY OR THE AMOUNT OF UNCERTAINTIES SURROUNDING THE NEWLY ADJUSTED WORK SCOPE.

AVERAGE ENGINEERING CONTINGENCY 35%

CONSTRUCTION

CONSTRUCTION COSTS WERE ALL GIVEN A 35% BUFFER BECAUSE OF THE LACK OF DESIGN AND DETAILS AT THIS STAGE OF DEVELOPEMENT. MOST OF THE ENVISIONED WORK WILL BE DONE IN CONDITIONS REMAINING AFTER WASTE RETRIEVAL WORK HAS BEEN COMPLETED, UNTIL THAT TIME MANY UNKNOWNS WILL REMAIN.

AVERAGE CONSTRUCTION CONTINGENCY 35%

AVERAGE PROJECT CONTINGENCY 35%

ICF KAISER HANFORD
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FILE NO. Z407SAA1

** IEST - INTERACTIVE ESTIMATING **
TWRS CLOSURE FILL ALTERNATIVES - OPTION 1
CRUSHED AGGREGATE STUDY ESTIMATE
DOE_R08 - ESTIMATE DETAIL BY WBS / COST CODE

PAGE 1
DATE 08/13/96 09:19:55
BY R.OHRT

ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
110001	DEFINITIVE DESIGN - INFRASTRUCTURE										
110001.00	TECHNICAL SERVICES										
110001.0000001	**************************** INFRASTRUCTURE - DEF.DESIGN ****************************	000	1 L/S	17153	1458005	0	162002	0	0	492968	2112975
110001.0000002	AT 15% OF INFRASTRUCTURE CONSTRUCTION (WBS 320001) PER P.T.&C ESTIMATE DATED 5/24/96.	000	0	0	0	0	0	0	0	0	0
SUBTOTAL	TECHNICAL SERVICES			17,153	1,458,005	0	162,002	0	0	492,968	2,112,975
TOTAL	COST CODE 00000 WBS 110001 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			17,153	1,458,005	0	162,002	0	0	492,968	2,112,975
TOTAL WBS 110001 DEFINITIVE DESIGN - INFRASTRUCTURE				17,153	1,458,005	0	162,002	0	0	492,968	2,112,975

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** IEST - INTERACTIVE ESTIMATING **
TWRS CLOSURE FILL ALTERNATIVES - OPTION 1
CRUSHED AGGREGATE STUDY ESTIMATE
DOE_R08 - ESTIMATE DETAIL BY WBS / COST CODE

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BY R.OHRT

ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
110002	DEFINITIVE DESIGN - GRAVEL FILL										
110002.00	TECHNICAL SERVICES										
110002.0000001	**************************** GRAVEL FILL - DEF.DESIGN ****************************	000	1 L/S	177000	10108470	0	0	0	0	3076007	13184477
110002.0000002	FROM P.T. & C ESTIMATE, DATED 5/24/96.	000	0	0	0	0	0	0	0	0	0
SUBTOTAL	TECHNICAL SERVICES			177,000	10,108,470	0	0	0	0	3,076,007	13,184,477
TOTAL	COST CODE 00000 WBS 110002 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			177,000	10,108,470	0	0	0	0	3,076,007	13,184,477
TOTAL WBS 110002 DEFINITIVE DESIGN - GRAVEL FILL				177,000	10,108,470	0	0	0	0	3,076,007	13,184,477

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FILE NO. Z407SAA1

** IEST - INTERACTIVE ESTIMATING **
TWRS CLOSURE FILL ALTERNATIVES - OPTION 1
CRUSHED AGGREGATE STUDY ESTIMATE
DOE_R08 - ESTIMATE DETAIL BY WBS / COST CODE

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BY R.OHRT

ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
110003	DEFINITIVE DESIGN - ANCILLARY GROUT										
110003.00	TECHNICAL SERVICES										
110003.0000001	*************************** ANCILLARY GROUT - DEF.DESIGN ***************************	000	1 L/S	1782	101770	0	0	0	0	30969	132739
110003.0000002	PER P.T.& C. ESTIMATE, DATED 5/24/96.	000	0	0	0	0	0	0	0	0	0
110003.0000004	*************************** ANCILLARY GROUT - DEF.DESIGN ESCALATION ***************************	000	1 L/S	0	0	0	0	5990	0	0	5990
110003.0000005	ESCALATES PRICES FROM 1994 TO 1996 (5.88%) FOR DEFINITIVE DESIGN. PER P.T. & C. ESTIMATE.	000	0	0	0	0	0	0	0	0	0
SUBTOTAL	TECHNICAL SERVICES			1,782	101,770	0	0	5,990	0	30,969	138,729
TOTAL	COST CODE 00000 WBS 110003 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			1,782	101,770	0	0	5,990	0	30,969	138,729
TOTAL WBS 110003 DEFINITIVE DESIGN - ANCILLARY GROUT				1,782	101,770	0	0	5,990	0	30,969	138,729

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Page E1-10

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FILE NO. Z407SAA1

** IEST - INTERACTIVE ESTIMATING **
TWRS CLOSURE FILL ALTERNATIVES - OPTION 1
CRUSHED AGGREGATE STUDY ESTIMATE
DOE_R08 - ESTIMATE DETAIL BY WBS / COST CODE

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BY R.OHRT

ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
110010	DEFIN.DESIGN - IN-TANK HARDWARE										
110010.00	TECHNICAL SERVICES										
110010.0000000	*************************** DEFINITIVE DESIGN - IN-TANK HARDWARE HANDLING ***************************	000	0	0	0	0	0	0	0	0	0
110010.0000001	AT 25% OF DIRECT CONSTR. (WBS 310010)	000	1 L/S	0	0	0	0	1626000	0	0	1626000
SUBTOTAL	TECHNICAL SERVICES			0	0	0	0	1,626,000	0	0	1,626,000
TOTAL	COST CODE 00000 WBS 110010 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			0	0	0	0	1,626,000	0	0	1,626,000
TOTAL WBS 110010 DEFIN.DESIGN - IN-TANK HARDWARE				0	0	0	0	1,626,000	0	0	1,626,000

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JOB NO. Z407SAA1/F7K6L5
FILE NO. Z407SAA1

** IEST - INTERACTIVE ESTIMATING **
TWRS CLOSURE FILL ALTERNATIVES - OPTION 1
CRUSHED AGGREGATE STUDY ESTIMATE
DOE_R08 - ESTIMATE DETAIL BY WBS / COST CODE

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BY R.OHRT

ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
110012	DEFINITIVE DESIGN - 42" RISER										
110012.00	TECHNICAL SERVICES										
110012.0000000	*************************** DEFINITIVE DESIGN 42" RISER INSTALLATION ***************************	000	1 L/S	0	0	0	0	2440300	0	0	2440300
110012.0000001	25% OF DIRECT CONSTRUCTION (WBS 310012)	000	0	0	0	0	0	0	0	0	0
SUBTOTAL	TECHNICAL SERVICES			0	0	0	0	2,440,300	0	0	2,440,300
TOTAL	COST CODE 00000 WBS 110012 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			0	0	0	0	2,440,300	0	0	2,440,300
TOTAL WBS 110012	DEFINITIVE DESIGN - 42" RISER			0	0	0	0	2,440,300	0	0	2,440,300

ICF KAISER HANFORD
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CRUSHED AGGREGATE STUDY ESTIMATE
DOE_R08 - ESTIMATE DETAIL BY WBS / COST CODE

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DATE 08/13/96 09:19:55
BY R.OHRT

ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
110102	DEFINITIVE DESIGN - ESCALATION										
110102.00	TECHNICAL SERVICES										
110102.0000001	**************************** GRAVEL FILL - DEF.DESIGN ESCALATION ****************************	000	1 L/S	0	0	0	0	594500	0	0	594500
110102.0000002	ESCALATES PRICES FROM 1994 TO 1996 (5.88%) FOR DEFINITIVE DESIGN. PER P.T.& C. ESTIMATE	000	0	0	0	0	0	0	0	0	0
SUBTOTAL	TECHNICAL SERVICES			0	0	0	0	594,500	0	0	594,500
TOTAL	COST CODE 00000 WBS 110102 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			0	0	0	0	594,500	0	0	594,500
TOTAL WBS 110102 DEFINITIVE DESIGN - ESCALATION				0	0	0	0	594,500	0	0	594,500

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120010	ENGIN/INSPECT - IN-TANK HARDWARE										
120010.00	TECHNICAL SERVICES										
120010.0000000	*************************** ENGINEERING/INSPECTION IN-TANK HARDWARE HANDLING ***************************	000	0	0	0	0	0	0	0	0	0
120010.0000001	AT 10% OF DIRECT CONSTR. (WBS 310010)	000	1 L/S	0	0	0	0	651000	0	0	651000
SUBTOTAL	TECHNICAL SERVICES			0	0	0	0	651,000	0	0	651,000
TOTAL	COST CODE 00000 WBS 120010 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			0	0	0	0	651,000	0	0	651,000
TOTAL WBS 120010 ENGIN/INSPECT - IN-TANK HARDWARE				0	0	0	0	651,000	0	0	651,000

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120012	ENGINEERING/INSP. - 42" RISER										
120012.00	TECHNICAL SERVICES										
120012.0000000	*************************** ENGINEERING/INSPECTION 42" RISER INSTALLATION ***************************	000	1 L/S	0	0	0	0	976100	0	0	976100
120012.0000001	AT 10% OF CONSTRUCTION (WBS 310012)	000	0	0	0	0	0	0	0	0	0
SUBTOTAL	TECHNICAL SERVICES			0	0	0	0	976,100	0	0	976,100
TOTAL	COST CODE 00000 WBS 120012 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			0	0	0	0	976,100	0	0	976,100
TOTAL WBS 120012	ENGINEERING/INSP. - 42" RISER			0	0	0	0	976,100	0	0	976,100

ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
310010	CONSTRUCTION - IN-TANK HARDWARE										
310010.01	GENERAL REQUIRMENTS										
310010.0100000	*************************** STEP-OFF PAD / FRESH AIR SUPPORT ***************************	700	0	0	0	0	0	0	0	0	0
310010.0100002	2 MEN FOR STEP-OFF PAD AND FRESH AIR DURING 60,932 MH'S WORK/8 MAN CREW = 15,233 MH	700	1 L/S	15233	572913	0	0	0	0	297915	870828
SUBTOTAL	GENERAL REQUIRMENTS			15,233	572,913	0	0	0	0	297,915	870,828
TOTAL	COST CODE 70001 WBS 310010 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			15,233	572,913	0	0	0	0	297,915	870,828
310010.15	MECHANICAL										
310010.1500000	*************************** IN TANK HARDWARE ***************************	700 M	0	0	0	0	0	0	0	0	0
310010.1500001	INVENTORY FOR ITH BASED ON REPORT "SINGLE-SHELL TANK IN-TANK HARDWARE INVENTORY" BY T.E.RAINEY & M.E.BEAVER.	700 M	0	0	0	0	0	0	0	0	0
310010.1500002	THIS ESTIMATE WILL ASSUME THE DOME SUSPENDED HARDWARE WILL BE DEALT WITH IN A MANNER SIMILAR TO THE	700 M	0	0	0	0	0	0	0	0	0
310010.1500003	PROCESS COVERED BY A DOCU-MENT (ATLANTIC RICHFIELD HANFORD CO) ARH-CD-891 DATED FEB 8, 1977.	700 M	0	0	0	0	0	0	0	0	0
310010.1500010	*MATERIAL*	700 M	0	0	0	0	0	0	0	0	0
310010.1500012	CHAIN, 5/8", 20,300 LB	700 M	50000 LF	1000	47720	0	565000	0	0	24814	637534
310010.1500014	6" BLIND FLANGE, 300 LB, CS	700 M	40 EA	160	8397	0	3880	0	0	4366	16643
310010.1500016	8" BLIND FLANGE, 300 LB, CS	700 M	3 EA	14	735	0	450	0	0	382	1567
310010.1500018	10" BLIND FLANGE, 300 LB, CS	700 M	95 EA	618	32433	0	29450	0	0	16865	78748
310010.1500020	12" BLIND FLANGE, 300 LB, CS	700 M	222 EA	1754	92050	0	92352	0	0	47866	232268
310010.1500022	18" BLIND FLANGE, 300 LB, CS	700 M	15 EA	173	9079	0	15075	0	0	4721	28875
310010.1500024	36" BLIND FLANGE, 300 LB, CS	700 M	1 EA	24	1260	0	4500	0	0	655	6415

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310010.1500026	38" BLIND FLANGE, 300 LB, CS	700 M	3 EA	90	4723	0	14400	0	0	2456	21579
310010.1500028	40" BLIND FLANGE, 300 LB, CS	700 M	4 EA	128	6717	0	22000	0	0	3493	32210
310010.1500100	WELD LIFTING EYE TO TOP OF EXISTING FLANGE, USE 8 MAN CREW AND CRANE, TREPAN EXISTING RISER FLANGE, LOWER	700 M	383 EE	24512	1225600	0	0	0	0	637312	1862912
310010.1500102	I.T.H. TO TANK BOTTOM, UNHOOK CHAIN, COVER RISER WITH NEW BLIND FLANGE AND BOLT-UP.	700 M	0	0	0	0	0	0	0	0	0
SUBTOTAL	MECHANICAL		(MASK)	28,473	1,428,714	0	747,107	0	0	742,930	2,918,751
	SWP 100.00%			28473	1428714						1428714
	GENERAL FOREMAN 7.00 %			3986	200019						200019
	CONSUMABLES 6.00 %						44826				44826
	SALES TAX 8.00 %						63354		0		63354
	WAREHOUSING 16.62 %						131619				131619
	OH&P (ON MARKUPS ONLY)									846941	846941
TOTAL	COST CODE 70015 WBS 310010 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			60,932	3,057,447	0	986,907	0	0	1,589,871	5,634,227
TOTAL WBS 310010 CONSTRUCTION - IN-TANK HARDWARE				76,165	3,630,360	0	986,907	0	0	1,887,786	6,505,055

ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
310012	CONSTRUCTION - 42" RISER INSTALL										
310012.01	GENERAL REQUIRMENTS										
310012.0100007	*************************** SWP AND FRESH AIR SUPPORT ***************************	700	0	0	0	0	0	0	0	0	0
310012.0100010	FRESH AIR SUPPORT LABORER 80,806 MH MASK / 8 MAN CREW = 10,100 MH	700	1 L/S	10100	379861	0	0	0	0	197528	577389
310012.0100012	STEP OFF PAD, LABORER FOR 87,148 MH'S OF SWP OR MASK WORK/8 MAN CREW = 10,894 MH	700	1 L/S	10894	409723	0	0	0	0	213056	622779
SUBTOTAL	GENERAL REQUIRMENTS			20,994	789,584	0	0	0	0	410,584	1,200,168
TOTAL	COST CODE 70001 WBS 310012 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			20,994	789,584	0	0	0	0	410,584	1,200,168
310012.15	MECHANICAL										
310012.1500001	*************************** MATERIAL ***************************	700	0	0	0	0	0	0	0	0	0
310012.1500002	OFFSITE DESIGN OF CORE DRILL BASED ON ESTIMATE FROM WHC ON WEST VALLEY	700	1 L/S	0	0	0	0	300000	0	0	300000
310012.1500005	OFFSITE FAB OF EQUIPMENT BASED ON ESTIMATE FROM WHC ON WEST VALLEY	700	2 EA	0	0	0	0	500000	0	0	500000
310012.1500012	42" CORE DRILL BIT	700	64 EA	0	0	0	416000	0	0	0	416000
310012.1500014	52" CORE DRILL BIT, ASSUME 3 USES EACH.	700	22 EA	0	0	0	176000	0	0	0	176000
310012.1500016	16" CORE DRILL BIT, ASSUME 10 USES PER BIT	700	7 EA	0	0	0	31500	0	0	0	31500
310012.1500018	12" CORE DRILL BIT	700	64 EA	0	0	0	192000	0	0	0	192000
SUBTOTAL	MECHANICAL			0	0	0	815,500	800,000	0	0	1,615,500
	SALES TAX 8.00 %						65240		0		65240
	WAREHOUSING 16.62 %						135536				135536
TOTAL	COST CODE 70015 WBS 310012			0	0	0	1,016,276	800,000	0	0	1,816,276

ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
	(ESCALATION 0.00% - CONTINGENCY 35.00 %)										
310012.15	MECHANICAL										
310012.1500062	*************************** 42" PENETRATION ***************************	700 M	0	0	0	0	0	0	0	0	0
310012.1500064	CORE DRILL 1-1/2" HOLES THROUGH HEEL PIT FLOOR & SOIL TO TANK TOP (5/RISER)	700 M	320 EA	640	24070	0	3200	0	0	12516	39786
310012.1500068	PRESSURE GROUT 1-1/2' HOLES	700 M	320 EA	640	33587	0	3200	0	0	17465	54252
310012.1500070	PERFORM 52" OUTER CASING CORE DRILL FOR CASING	700 M	64 EA	12800	671744	0	0	0	0	349307	1021051
310012.1500072	DRILL & SET ANCHOR BOLTS TO PULL CORE	700 M	64 TKS	512	26870	0	6400	0	0	13972	47242
310012.1500074	SET ANCHOR BOLT ASSY & PULL CORE	700 M	64 TKS	1024	53740	0	0	0	0	27945	81685
310012.1500078	SET CORE INTO TRUCK, HAUL TO DUMP AND DISPOSE (ASSUME THIS CORE CLEAN)	700 M	64 EA	512	22236	0	0	11200	0	11563	44999
310012.1500080	CLEAN EXCESS DEBRIS	700 M	64 TKS	1024	38513	0	0	0	0	20027	58540
310012.1500084	PERFORM 42" CORE DRILL ASSY & PLUG SUPPORT TOOL	700 M	64 EA	12800	671744	0	0	0	0	349307	1021051
310012.1500086	PULL CORE DRILL, LOWER INTO TANK BOTTOM.	700 M	64 EA	2048	107479	0	0	0	0	55889	163368
310012.1500088	DECONTAMINATE EQUIPMENT	700 M	64 EA	2560	96282	0	6400	0	0	50067	152749
310012.1500090	SET NEW 42" RISER	700 M	64 EA	3200	167936	0	32000	0	0	87327	287263
SUBTOTAL	MECHANICAL		(MASK)	37,760	1,914,201	0	51,200	11,200	0	995,385	2,971,986
	SWP 100.00%			37760	1914201						1914201
	GENERAL FOREMAN 7.00 %			5286	267988						267988
	CONSUMABLES 6.00 %						3072				3072
	SALES TAX 8.00 %						4341		0		4341
	WAREHOUSING 25.77 %						13985				13985
	OH&P (ON MARKUPS ONLY)									1134738	1134738
TOTAL	COST CODE 70015 WBS 310012 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			80,806	4,096,390	0	72,599	11,200	0	2,130,123	6,310,313
310012.15	MECHANICAL										
310012.1500100	*************************** CORE DRILLS COOLING	700 W	0	0	0	0	0	0	0	0	0

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	****************************										
310012.1500102	ALLOWANCE FOR WATER FOR CORE DRILLING	700 W	64 EA	5120	268698	0	128000	0	0	0	396698
SUBTOTAL	MECHANICAL		(SWP)	5,120		0		0		0	
					268,698		128,000		0		396,698
	SWP 30.00%			1536	80609						80609
	GENERAL FOREMAN 7.00 %			465	24451						24451
	CONSUMABLES 6.00 %						7680				7680
	SALES TAX 8.00 %						10854		0		10854
	WAREHOUSING 16.62 %						22550				22550
TOTAL	COST CODE 70015			7,121		0		0		0	
	WBS 310012				373,758		169,084		0		542,843
	(ESCALATION 0.00% - CONTINGENCY 35.00 %)										
TOTAL WBS 310012	CONSTRUCTION - 42" RISER INSTALL			108,922		0		811,200		2,540,707	
					5,259,733		1,257,960		0		9,869,600

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ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
320001	CONSTRUCTION - INFRASTRUCTURE										
320001.01	GENERAL REQUIRMENTS										
320001.0100000	*************************** INFRASTRUCTURE - INDIRECTS ***************************	460	0	0	0	0	0	0	0	0	0
320001.0100002	TRAILER OFFICES, PURCHASED AND INSTALED IN 200 EAST AND 200 WEST.	460	4 EA	240	9914	0	40000	0	0	15189	65103
320001.0100004	TEMPORARY POWER.	460	1 L/S	2000	82620	0	40000	0	0	37313	159933
320001.0100006	SMALL TOOLS - ALLOWED AT $1.25/MH	460	1 L/S	0	0	0	104250	0	0	31723	135973
320001.0100008	FUELS (ALLOW)	460	1 L/S	0	0	0	25000	0	0	7608	32608
320001.0100010	SUPERVISION OF CONSTRUCTION, BASED ON 17,000 HOURS AT $57.11/HR.	460	1 L/S	17000	970870	0	0	0	0	295436	1266306
SUBTOTAL	GENERAL REQUIRMENTS			19,240	1,063,404	0	209,250	0	0	387,269	1,659,923
TOTAL	COST CODE 46001 WBS 320001 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			19,240	1,063,404	0	209,250	0	0	387,269	1,659,923
320001.10	SPECIALTIES										
320001.1000000	*************************** GRAVEL SCREENING FACILITY ***************************	460	0	0	0	0	0	0	0	0	0
320001.1000002	SCREEN DEVICES (VIBRATING)	460	1 EA	0	0	0	0	60000	0	18258	78258
320001.1000004	CONVEYORS	460	2 EA	0	0	0	0	13300	0	4047	17347
320001.1000006	LOADING HOPPERS AND MISC.	460	1 EA	0	0	0	0	4000	0	1217	5217
320001.1000100	*************************** GROUT BATCH PLANT ***************************	460	0	0	0	0	0	0	0	0	0
320001.1000102	INSTALL ONE BATCH PLANT FACILITY, ALLOWANCE	460	1 EA	500	20655	0	290000	0	0	94532	405187
320001.1000104	SCREW CONVEYORS	460	2 EA	0	0	0	50000	0	0	15215	65215
320001.1000106	GROUT PUMP AND SLICK LINES	460	2 SET	0	0	0	0	800000	0	243440	1043440
SUBTOTAL	SPECIALTIES			500	20,655	0	340,000	877,300	0	376,709	1,614,664
TOTAL	COST CODE 46010 WBS 320001			500	20,655	0	340,000	877,300	0	376,709	1,614,664

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	(ESCALATION 0.00% - CONTINGENCY 35.00 %)										
320001.14	CONVEYING SYSTEMS										
320001.1400000	*************************** GRAVEL DISTRIBUTION SYSTEMS ONE FOR 200E, ONE FOR 200W ***************************	460	0	0	0	0	0	0	0	0	0
320001.1400002	CONVEYORS, HORIZONTAL	460	184 EA	0	0	0	0	1472000	0	447930	1919930
320001.1400003	CONVEYORS, INCLINED	460	28 EA	0	0	0	0	196000	0	59643	255643
320001.1400004	OTHER EQUIPMENT INCLUDING SPARE BELTS (ALLOW)	460	1 L/S	0	0	0	0	100000	0	30430	130430
320001.1400006	STEEL ROAD CROSSING STRUCTURES	460	56 TON	2240	92534	0	78400	0	0	52015	222949
320001.1400008	FINAL LEGS AT TANKS	460	4 EA	200	8262	0	26600	0	0	10609	45471
320001.1400010	DISCONNECT FOR MOVING TO NEXT TANK	460	160 EA	16000	660960	0	0	0	0	201130	862090
320001.1400100	*************************** GRAVEL SLINGERS ***************************	460	0	0	0	0	0	0	0	0	0
320001.1400102	MOBILE TRAILER UNIT WITH CONTROL PANEL AND 440V MOTORS, ALLOWANCE.	460	2 EA	0	0	0	0	1000000	0	304300	1304300
320001.1400104	OTHER ASSOCIATED EQUIPMENT AND INSTALLATION, SPARE BELTS, ALLOWANCE.	460	18 SET	12600	520506	0	307964	1800000	0	799843	3428313
320001.1400106	BELT CHANGING LABOR	460	644 EA	19320	798109	0	0	0	0	242865	1040974
SUBTOTAL	CONVEYING SYSTEMS			50,360	2,080,371	0	412,964	4,568,000	0	2,148,765	9,210,100
TOTAL	COST CODE 46014 WBS 320001 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			50,360	2,080,371	0	412,964	4,568,000	0	2,148,765	9,210,100
320001.15	MECHANICAL										
320001.1500000	*************************** FILTRATION UNITS ***************************	460	0	0	0	0	0	0	0	0	0
320001.1500002	ASSUMED ONE HEPA FILTER UNIT LOCATED IN EACH TANK FARM, ALLOWANCE.	460	18 EA	0	0	0	0	270000	0	82161	352161
320001.1500004	HEPA FILTERS, ALLOWANCE.	460	1 L/S	0	0	0	66000	0	0	20084	86084

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320001.1500010	CYCLONE SEPARATORS, 2 FOR EAST AND 2 FOR WEST, ALLOWANCE.	460	4 EA	4000	165240	0	80000	0	0	74627	319867
320001.1500100	*************************** INSTRUMENTATION ***************************	460	0	0	0	0	0	0	0	0	0
320001.1500102	MONITOR PANEL, ALLOWANCE	460	18 EA	720	29743	0	90000	0	0	36438	156181
320001.1500104	INSTRUMENTS, ASSUMED 5 PER TANK TO MEASURE COMPACTION, DENSITY, LEVEL, VISUAL AND MAPPING, ALLOWANCE.	460	885 EA	8850	365594	0	88500	0	0	138181	592275
320001.1500106	WIRING AND CONNECTIONS	460	885 EA	1770	73119	0	0	0	0	22250	95369
SUBTOTAL	MECHANICAL			15,340	633,696	0	324,500	270,000	0	373,741	1,601,937
TOTAL	COST CODE 46015 WBS 320001 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			15,340	633,696	0	324,500	270,000	0	373,741	1,601,937
TOTAL WBS 320001 CONSTRUCTION - INFRASTRUCTURE				85,440	3,798,126	0	1,286,714	5,715,300	0	3,286,484	14,086,624

ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
320002	CONSTRUCTION - GRAVEL FILL										
320002.01	GENERAL REQUIRMENTS										
320002.0100000	***************************** GRAVEL FILL - INDIRECTS *****************************	460	0	0	0	0	0	0	0	0	0
320002.0100002	WATER, 8,580,000 GALLONS AT $.02/GAL.	460	1 L/S	0	0	0	171600	0	0	52218	223818
320002.0100004	GASOLINE, FOR PICKUPS	460	107380 GAL	0	0	0	123487	0	0	37577	161064
320002.0100006	SMALL TOOLS AND CONSUMABLES AT $1.25 PER MANHOUR	460	1 L/S	0	0	0	117500	0	0	35755	153255
320002.0100010	SUPERVISION	460	1 L/S	36000	2055960	0	0	0	0	625629	2681589
320002.0100020	***************************** GRAVEL FILL - INDIRECTS ESCALATION *****************************	460	1 L/S	0	0	0	0	145200	0	0	145200
320002.0100022	ESCALATES PRICES FROM 1994 TO 1996 (5.88%) FOR INDIRECT PORTION OF ESTIMATE.	460	0	0	0	0	0	0	0	0	0
SUBTOTAL	GENERAL REQUIRMENTS			36,000	2,055,960	0	412,587	145,200	0	751,179	3,364,926
TOTAL	COST CODE 46001 WBS 320002 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			36,000	2,055,960	0	412,587	145,200	0	751,179	3,364,926
320002.03	CONCRETE										
320002.0300000	***************************** GRAVEL FILL - CONSTRUCTION *****************************	460	0	0	0	0	0	0	0	0	0
320002.0300002	TANK STABILIZATION FILL	460	0	0	0	0	0	0	0	0	0
320002.0300004	GRAVEL	460	756000 CM	0	0	0	16632000	0	0	5061118	21693118
320002.0300020	LABOR - RADIATION WORKER	460	1 L/S	65000	2685150	0	0	0	0	817091	3502241
320002.0300030	***************************** GRAVEL FILL - CONSTRUCTION ESCALATION *****************************	460	1 L/S	0	0	0	0	1142487	0	0	1142487
320002.0300032	ESCALATES PRICES FROM 1994 TO 1996 (5.88%) FOR CONSTR-UCTION PORTION OF ESTIMATE.	460	0	0	0	0	0	0	0	0	0
SUBTOTAL	CONCRETE			65,000	2,685,150	0	16,632,000	1,142,487	0	5,878,209	26,337,846

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ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
TOTAL	COST CODE 46003 WBS 320002 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			65,000	2,685,150	0	16,632,000	1,142,487	0	5,878,209	26,337,846
TOTAL WBS 320002 CONSTRUCTION - GRAVEL FILL				101,000	4,741,110	0	17,044,587	1,287,687	0	6,629,388	29,702,772

ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
320003	CONSTRUCTION - ANCILLARY GROUT										
320003.01	GENERAL REQUIRMENTS										
320003.0100000	*************************** ANCILLARY GROUT - INDIRECTS *************************** PER P.T. & C. ESTIMATE	460	0	0	0	0	0	0	0	0	0
320003.0100002	SUPERVISION	460	1 L/S	630	35979	0	0	0	0	10948	46927
320003.0100004	*************************** ANCILLARY GROUT - INDIRECTS ESCALATION ***************************	460	1 L/S	0	0	0	0	1580	0	0	1580
320003.0100006	ESCALATES PRICES FROM 1994 TO 1996 (5.88%) FOR INDIRECT PORTION OF ESTIMATE. PER P.T. & C. ESTIMATE	460	0	0	0	0	0	0	0	0	0
SUBTOTAL	GENERAL REQUIRMENTS			630	35,979	0	0	1,580	0	10,948	48,507
TOTAL	COST CODE 46001 WBS 320003 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			630	35,979	0	0	1,580	0	10,948	48,507
320003.03	CONCRETE										
320003.0300000	*************************** ANCILLARY GROUT - CONSTR. *************************** PER P.T. & C. ESTIMATE	460	0	0	0	0	0	0	0	0	0
320003.0300002	ANCILLARY EQUIPMENT STABIL-IZATION, SINGLE SHELL TANKS, 10,500 CM OF GROUT FILL.	460	0	0	0	0	0	0	0	0	0
320003.0300004	CEMENT	460	94500 KG	0	0	0	13230	0	0	4026	17256
320003.0300006	SAND	460	4900 CM	0	0	0	90650	0	0	27585	118235
320003.0300008	FLY ASH	460	850500 KG	0	0	0	34020	0	0	10352	44372
320003.0300012	ANCILLARY EQUIPMENT STABIL-IZATION, DOUBLE SHELL TANKS, 7,900 CM OF GROUT FILL.	460	0	0	0	0	0	0	0	0	0
320003.0300014	CEMENT	460	86000 KG	0	0	0	12040	0	0	3664	15704
320003.0300016	SAND	460	4450 CM	0	0	0	82325	0	0	25051	107376
320003.0300018	FLY ASH	460	771850 KG	0	0	0	30874	0	0	9395	40269
320003.0300020	LABOR, RADIATION WORKER	460	1 L/S	1260	52051	0	0	0	0	15839	67890

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ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
320003.0300022	LABOR, NON-RADIATION WORKER	460	1 L/S	1300	53703	0	0	0	0	16342	70045
320003.0300030	*************************** ANCILLARY GROUT - CONSTR. ESCALATION ***************************	460	1 L/S	0	0	0	0	28160	0	0	28160
320003.0300032	ESCALATES PRICES FROM 1994 TO 1996 (5.88%) FOR CONSTR-UCTION PORTION OF ESTIMATE.	460	0	0	0	0	0	0	0	0	0
SUBTOTAL	CONCRETE			2,560	105,754	0	263,139	28,160	0	112,254	509,307
TOTAL	COST CODE 46003 WBS 320003 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			2,560	105,754	0	263,139	28,160	0	112,254	509,307
TOTAL WBS 320003 CONSTRUCTION - ANCILLARY GROUT				3,190	141,733	0	263,139	29,740	0	123,202	557,814

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ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
320004	CONSTRUCTION - BARRIER CAP										
320004.02	SITEWORK										
320004.0200000	*************************** BARRIER CAPS - CONSTRUCTION ***************************	460	0	0	0	0	0	0	0	0	0
320004.0200002	TX FARM	460	1 L/S	0	0	0	0	7414000	0	2852166	10266166
320004.0200004	U FARM	460	1 L/S	0	0	0	0	5565800	0	2141163	7706963
320004.0200006	C FARM	460	1 L/S	0	0	0	0	5807300	0	2234068	8041368
320004.0200008	SX FARM	460	1 L/S	0	0	0	0	5836100	0	2245148	8081248
320004.0200010	BY FARM	460	1 L/S	0	0	0	0	4840900	0	1862294	6703194
320004.0200012	B FARM	460	1 L/S	0	0	0	0	5688500	0	2188366	7876866
320004.0200014	BX FARM	460	1 L/S	0	0	0	0	4784500	0	1840597	6625097
320004.0200016	A FARM	460	1 L/S	0	0	0	0	2858200	0	1099550	3957750
320004.0200018	TY FARM	460	1 L/S	0	0	0	0	2885600	0	1110090	3995690
320004.0200020	AX FARM	460	1 L/S	0	0	0	0	2181000	0	839031	3020031
320004.0200022	T FARM	460	1 L/S	0	0	0	0	5688500	0	2188366	7876866
320004.0200024	S FARM	460	1 L/S	0	0	0	0	4891600	0	1881799	6773399
320004.0200026	AN FARM	460	1 L/S	0	0	0	0	4045000	0	1556112	5601112
320004.0200028	AZ FARM	460	1 L/S	0	0	0	0	1410600	0	542658	1953258
320004.0200030	AY FARM	460	1 L/S	0	0	0	0	1410600	0	542658	1953258
320004.0200032	AP FARM	460	1 L/S	0	0	0	0	3742200	0	1439624	5181824
320004.0200034	AW FARM	460	1 L/S	0	0	0	0	3007100	0	1156831	4163931
320004.0200036	SY FARM	460	1 L/S	0	0	0	0	2239600	0	861574	3101174
320004.0200038	LLW VAULTS	460	1 L/S	0	0	0	0	20272500	0	7798831	28071331
SUBTOTAL	SITEWORK			0	0	0	0	94,569,600	0	36,380,926	130,950,526
TOTAL	COST CODE 46002 WBS 320004 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			0	0	0	0	94,569,600	0	36,380,926	130,950,526
TOTAL WBS 320004 CONSTRUCTION - BARRIER CAP				0	0	0	0	94,569,600	0	36,380,926	130,950,526

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ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
321001	SUBCONTRACT MPR - INFRASTRUCTURE										
321001.15	MECHANICAL										
321001.1500000	***************************** INFRASTRUCTURE - SUB. MPR *****************************	460	0	0	0	0	0	0	0	0	0
321001.1500001	BASED ON 3% OF WBS 110001, 320001 AND 322001.	460	1 L/S	0	0	0	0	437405	0	0	437405
SUBTOTAL	MECHANICAL			0	0	0	0	437,405	0	0	437,405
TOTAL	COST CODE 46015 WBS 321001 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			0	0	0	0	437,405	0	0	437,405
TOTAL WBS 321001 SUBCONTRACT MPR - INFRASTRUCTURE				0	0	0	0	437,405	0	0	437,405

ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
321002	SUBCONTRACT MPR - GRAVEL FILL										
321002.03	CONCRETE										
321002.0300000	*************************** GRAVEL FILL - SUBCONTR. MPR ***************************	460	0	0	0	0	0	0	0	0	0
321002.0300001	BASED ON 3% OF WBS 110002 AND 320002.	460	1 L/S	0	0	0	0	960212	0	0	960212
SUBTOTAL	CONCRETE			0	0	0	0	960,212	0	0	960,212
TOTAL	COST CODE 46003 WBS 321002 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			0	0	0	0	960,212	0	0	960,212
TOTAL WBS 321002 SUBCONTRACT MPR - GRAVEL FILL				0	0	0	0	960,212	0	0	960,212

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ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
321003	SUBCONTRACT MPR - ANCILLARY GROUT										
321003.03	CONCRETE										
321003.0300000	*************************** GROUT FILL - SUBCONTR. MPR ***************************	460	0	0	0	0	0	0	0	0	0
321003.0300001	BASED ON 3% OF WBS 110003 AND 320003.	460	1 L/S	0	0	0	0	23450	0	0	23450
SUBTOTAL	CONCRETE			0	0	0	0	23,450	0	0	23,450
TOTAL	COST CODE 46003 WBS 321003 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			0	0	0	0	23,450	0	0	23,450
TOTAL WBS 321003 SUBCONTRACT MPR - ANCILLARY GROUT				0	0	0	0	23,450	0	0	23,450

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ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
321004	SUBCONTRACT MPR - BARRIER CAP										
321004.02	SITEWORK										
321004.0200100	*************************** BARRIER - SUBCONTRACTOR MPR ***************************	460	0	0	0	0	0	0	0	0	0
321004.0200101	BASED ON 3% OF WBS 320004 AND 500004.	460	1 L/S	0	0	0	0	4105959	0	0	4105959
SUBTOTAL	SITEWORK			0	0	0	0	4,105,959	0	0	4,105,959
TOTAL	COST CODE 46002 WBS 321004 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			0	0	0	0	4,105,959	0	0	4,105,959
TOTAL WBS 321004 SUBCONTRACT MPR - BARRIER CAP				0	0	0	0	4,105,959	0	0	4,105,959

ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
322001	PROJECT MANAGEMENT - INFRASTRUCTURE										
322001.19	PROJECT MANAGEMENT										
322001.1900000	**************************** CONSTRUCTION MANAGEMENT INFRASTRUCTURE ****************************	060	1 L/S	0	0	0	0	2160028	0	657297	2817325
322001.1900001	BASED ON 20% OF CONSTRUCTION	060	0	0	0	0	0	0	0	0	0
SUBTOTAL	PROJECT MANAGEMENT			0	0	0	0	2,160,028	0	657,297	2,817,325
TOTAL	COST CODE 06019 WBS 322001 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			0	0	0	0	2,160,028	0	657,297	2,817,325
TOTAL WBS 322001	PROJECT MANAGEMENT - INFRASTRUCTURE			0	0	0	0	2,160,028	0	657,297	2,817,325

ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
322004	PROJ/CONSTR MGMT - BARRIER CAP										
322004.19	PROJECT MANAGEMENT										
322004.1900000	**************************** PROJECT MGMT & CONSTRUCTION MANAGEMENT - BARRIER CAP ****************************	060	1 L/S	0	0	0	0	21145687	0	0	21145687
322004.1900001	BASED ON 15% OF WBS 320004, 321004 AND 500004.	060	0	0	0	0	0	0	0	0	0
SUBTOTAL	PROJECT MANAGEMENT			0	0	0	0	21,145,687	0	0	21,145,687
TOTAL	COST CODE 06019 WBS 322004 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			0	0	0	0	21,145,687	0	0	21,145,687
TOTAL WBS 322004	PROJ/CONSTR MGMT - BARRIER CAP			0	0	0	0	21,145,687	0	0	21,145,687

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ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
500004	WHC PROJ MGMT - BARRIER CAP										
500004.9000000	**************************** WHC PROJECT MANAGEMENT BARRIER CAP ****************************	060	1 L/S	0	0	0	0	5912400	0	0	5912400
500004.9000001	APPLIED AT 4.5% OF WBS 320004.	060	0	0	0	0	0	0	0	0	0
TOTAL WBS 500004 WHC PROJ MGMT - BARRIER CAP				0	0	0	0	5,912,400	0	0	5,912,400

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ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
500010	WHC PROJ MGMT - IN-TANK HARDWARE										
500010.9000000	**************************** WHC PROJECT MANAGEMENT IN-TANK HARDWARE HANDLING ****************************	060	0	0	0	0	0	0	0	0	0
500010.9000001	AT 4.5% OF CONSTRUCTION	060	1 L/S	0	0	0	0	293000	0	0	293000
TOTAL WBS 500010 WHC PROJ MGMT - IN-TANK HARDWARE				0	0	0	0	293,000	0	0	293,000

ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
500012	WHC PROJ MGMT - 42" RISER INSTALL										
500012.00	TECHNICAL SERVICES										
500012.0000005	WHC PROJECT MANAGEMENT 15% OF DIRECT CONSTR.	700	1 LS	0	0	0	0	997000	0	0	997000
SUBTOTAL	TECHNICAL SERVICES			0	0	0	0	997,000	0	0	997,000
TOTAL	COST CODE 70000 WBS 500012 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			0	0	0	0	997,000	0	0	997,000
TOTAL WBS 500012	WHC PROJ MGMT - 42" RISER INSTALL			0	0	0	0	997,000	0	0	997,000

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ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
REPORT TOTAL				570,652	29,239,308	0	21,001,309	144,742,558	0	55,105,735	250,088,910

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ALTERNATIVE 2: GROUT FILL

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** IEST - INTERACTIVE ESTIMATING **
TWRS CLOSURE FILL ALTERNATIVES - OPTION 2
GROUT FILL STUDY ESTIMATE
DOE_R01 - PROJECT COST SUMMARY

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COST CODE	DESCRIPTION	ESCALATED TOTAL COST	CONTINGENCY %	CONTINGENCY TOTAL	TOTAL DOLLARS
000	ENGINEERING	20,070,000	35	7,020,000	27,090,000
060	PROJECT MANAGEMENT	28,900,000	35	10,110,000	39,010,000
460	IMPROVEMENTS TO LAND	211,460,000	35	74,010,000	285,470,000
700	SPECIAL EQUIP/PROCESS SYSTEMS	4,840,000	35	1,690,000	6,530,000
	(ADJUSTED TO MEET DOE 5100.4)	30,000		<30,000>	
	PROJECT TOTAL	265,300,000	35	92,800,000	358,100,000

TYPE OF ESTIMATE	STUDY ESTIMATE	AUGUST 13, 1996	REMARKS:
ARCHITECT ENGINEER	[signature]		
OPERATING CONTRACTOR	[signature]	8/14/96	

(ROUNDED/ADJUSTED TO THE NEAREST " 10,000 / 100,000 " - PERCENTAGES NOT RECALCULATED TO REFLECT ROUNDING)

WBS	DESCRIPTION	ESTIMATE SUBTOTAL	ONSITE INDIRECTS	SUB TOTAL	ESCALATION %	ESCALATION TOTAL	SUB TOTAL	CONTINGENCY %	CONTINGENCY TOTAL	TOTAL DOLLARS
110001	DEFINITIVE DESIGN - INFRASTRUCTURE	1066500	0	1066500	0.00	0	1066500	35	373275	1439775
110002	DEFINITIVE DESIGN - GROUT TANKS	17172100	0	17172100	0.00	0	17172100	35	6010235	23182335
110003	DEFINITIVE DESIGN - ANCILLARY GROUT	138729	0	138729	0.00	0	138729	35	48555	187284
110011	DEFIN DESIGN - OVERFLOW LINE CRIMP	1210000	0	1210000	0.00	0	1210000	35	423500	1633500
SUBTOTAL 11	DEFINITIVE DESIGN	19587329	0	19587329	0.00	0	19587329	35	6855565	26442894
120011	ENGRG/INSPECT - OVERFLOW LINE CRIMP	484000	0	484000	0.00	0	484000	35	169400	653400
SUBTOTAL 12	ENGINEERING/INSPECTION	484000	0	484000	0.00	0	484000	35	169400	653400
SUBTOTAL 1	ENGINEERING	20071329	0	20071329	0.00	0	20071329	35	7024965	27096294
310011	CONSTRUCTION - OVERFLOW LINE CRIMP	4840587	0	4840587	0.00	0	4840587	35	1694205	6534792
SUBTOTAL 31	FA CONST-ONSITE E/C	4840587	0	4840587	0.00	0	4840587	35	1694205	6534792
320001	CONSTRUCTION - INFRASTRUCTURE	4266172	0	4266172	0.00	0	4266172	35	1493160	5759332
320002	CONSTRUCTION - GROUT FILL TANKS	68688336	0	68688336	0.00	0	68688336	35	24040918	92729254
320003	CONSTRUCTION - ANCILLARY GROUT	557814	0	557814	0.00	0	557814	35	195234	753048
320004	CONSTRUCTION - BARRIER CAP	130950526	0	130950526	0.00	0	130950526	35	45832684	176783210
321001	SUBCONTRACT MPR - INFRASTRUCTURE	267000	0	267000	0.00	0	267000	35	93450	360450
321002	SUBCONTRACT MPR - GROUT FILL TANKS	2603100	0	2603100	0.00	0	2603100	35	911085	3514185
321003	SUBCONTRACT MPR - ANCILLARY GROUT	23450	0	23450	0.00	0	23450	35	8208	31658
321004	SUBCONTRACT MPR - BARRIER CAP	4105959	0	4105959	0.00	0	4105959	35	1437086	5543045
322001	PROJECT MANAGEMENT - INFRASTRUCTURE	1112873	0	1112873	0.00	0	1112873	35	389506	1502379
322004	PROJ/CONSTR MGMT - BARRIER CAP	21145687	0	21145687	0.00	0	21145687	35	7400990	28546677
SUBTOTAL 32	CONSTRUCTION-FIXED PRICE	233720917	0	233720917	0.00	0	233720917	35	81802321	315523238
SUBTOTAL 3	CONSTRUCTION	238561504	0	238561504	0.00	0	238561504	35	83496526	322058030
500004	WHC PROJ MGMT - BARRIER CAP	5912400	0	5912400	0.00	0	5912400	35	2069340	7981740
500011	WHC PROJ MGMT - OVERFLOW LINE CRIMP	726000	0	726000	0.00	0	726000	35	254100	980100
SUBTOTAL 5	OTHER PROJECT COST	6638400	0	6638400	0.00	0	6638400	35	2323440	8961840

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** IEST - INTERACTIVE ESTIMATING **
TWRS CLOSURE FILL ALTERNATIVES - OPTION 2
GROUT FILL STUDY ESTIMATE
DOE_R02 - WORK BREAKDOWN STRUCTURE SUMMARY

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BY R.OHRT

WBS	DESCRIPTION	ESTIMATE SUBTOTAL	ONSITE INDIRECTS	SUB TOTAL	ESCALATION %	ESCALATION TOTAL	SUB TOTAL	CONTINGENCY %	CONTINGENCY TOTAL	TOTAL DOLLARS
	PROJECT TOTAL	265,271,233	0	265,271,233	0.00	0	265,271,233	35	92,844,931	358,116,164

1. DOCUMENTS AND DRAWINGS

DOCUMENTS: PROJECT TIME AND COSTS SPREAD SHEET ESTIMATE, DATED 5/24/96, ICF KAISER HANFORD STUDY ESTIMATE #W340SAA1, DATED 01/12/94, STATEMENT OF WORK DRAFT.

DRAWINGS: NONE

2. MATERIAL PRICES

UNIT COSTS REPRESENT CURRENT PRICES FOR SPECIFIED MATERIAL.

3. LABOR RATES

A.) ICF-KH HOURLY RATES ARE BASED ON THE 1996 FISCAL YEAR BUDGET LIQUIDATION RATES AS ISSUED BY KEH FINANCE (EFFECTIVE 10-17-95). SEE ALSO THE FY 1996 PLANNING RATES * (REPORT BGHB2000 & BGHB2005).
B.) WHC HOURLY RATES ARE BASED UPON THE FY 1996 PLANNING RATES * (REPORT BGHB2001).
C.) IRM HOURLY RATES ARE BASED UPON THE FY 1996 PLANNING RATES * (REPORT BGHB7008).
D.) BASE CRAFT RATES ARE AS ISSUED BY KEH FINANCE (EFFECTIVE 10-17-95). RATES INCLUDE FRINGE BENEFITS, LABOR INSURANCE, TAXES DEPARTMENT OVERHEADS, G&A AND SWS, AND TRAVEL WHERE APPLICABLE, PER HANFORD SITE STABILIZATION AGREEMENT, APPENDIX "A".
* SEE HANFORD SOFT REPORTING, FDS BUDGET GUIDELINE HANDBOOK, SECTION 2 - COMPANY INFORMATION, FY 1996 PLANNING RATES.

4. GENERAL REQUIREMENTS/TECHNICAL SERVICES/OVERHEADS

A.) ONSITE CONSTRUCTION FORCES GENERAL REQUIREMENTS, TECHNICAL SERVICES AND CRAFT OVERHEAD COSTS ARE INCLUDED AS A COMPOSITE PERCENTAGE BASED ON THE ICF-KH ESTIMATING FACTOR, REVISION 1, FY96, DATED 1-/-1/95 THE TOTAL COMPOSITE PERCENTAGE APPLIED TO ONSITE CONSTRUCTION FORCES LABOR, FOR THIS PROJECT, IS 52% FOR ALL WORK, WHICH IS REFLECTED IN THE "OH&P/B&I" COLUMN OF THE ESTIMATE DETAIL.

B.) ONSITE CONTRACT ADMINISTRATION AND CONSTRUCTION MANAGEMENT COSTS, ASSOCIATED WITH THE OVERALL MANAGEMENT OF THE FIXED PRICE CONTRACTS, ARE INCLUDED AS A COMPOSITE PERCENTAGE AND LUMP SUM ALLOWANCE (FOR BID PACKAGE PREP) BASED ON THE ESTIMATING FACTOR/BILLING SCHEDULE. THE TOTAL COMPOSITE PERCENTAGE AND LUMP SUM ALLOWANCE ARE APPLIED AGAINST THE TOTAL FIXED PRICE CONTRACT AMOUNT WHICH IS REFLECTED ON THE KEH SUMMARY REPORT DOE_R07, INCLUDED WITH THIS ESTIMATE. (FINAL ESTIMATES MAY BE PARTIALLY MANLOADED AND INCLUDED WITHIN THE ESTIMATE DETAIL)

C.) FIXED PRICE CONTRACTOR OVERHEAD, PROFIT, BOND AND INSURANCE COSTS HAVE BEEN APPLIED AT THE FOLLOWING PERCENTAGES AND ARE REFLECTED IN THE "OH&P/B&I" COLUMN OF THE ESTIMATE DETAIL:
LABOR - 30.4%, MATERIAL - 30.4%, EQUIPMENT USAGE - 30.4%, EQUIPMENT - 30.4%, SUBCONTRACTS - 38.47%.

5. ESCALATION

ESCALATION WAS NOT APPLIED TO THE DOLLAR AMOUNTS FOR FUTURE PROJECTIONS, ALL COSTS HAVE BEEN CONVERTED TO 1996 DOLLARS.

6. ROUNDING

U.S. DEPARTMENT OF ENERGY - DOE ORDER 5100.4 PAGE I-32 SUBPARAGRAPH (M), REQUIRES ROUNDING OF ALL GENERAL PLANT PROJECTS (GPP'S) AND LINE ITEM (LI) COST ESTIMATES. REFERENCE: DOE 5100.4, FIGURE I-11, DATED 10-31-84.

7. REMARKS
=======

A.) IT WAS ASSUMED THAT BURN-OUT WILL NOT BE EXPERIENCED DURING ANY ACTIVITIES.

B.) ALL SOILS DISTURBED BY CONSTRUCTION ACTIVITIES WILL BE ASSUMED TO GO BACK INTO ORIGINAL PLACE WITHOUT DISPOSAL COSTS INCURRED.

C.) EXCAVATION ACTIVITIES TO UNCOVER UNDERGROUND OVERFLOW LINES WILL BE SEQUENCED IN ORDER TO PREVENT THE NEED TO HAUL MATERIALS OUT OF FARM FOR STOCKPILING.

D.) THE COSTS AS REFLECTED IN THE ESTIMATE WBS'110001, 110002, 110003, 110102, 110103, 320001 THRU 320004, 320102, 320103, 321001 THRU 321004, 322001, 322004 AND 500004 COME FROM PROJECT TIME AND COST ESTIMATE DATED 5/24/96 DONE BY LEE SMITH.

E.) WBS 110012, 120012, 200012, 310012 AND 500012 WERE EXTRACTED FROM ICF KAISER HANFORD STUDY ESTIMATE W340SAA1 DATED 1/12/94 WITH ADJUSTMENTS MADE TO REFLECT FY96 LABOR RATES AND ADDERS.

F.) ALL MATERIAL COSTS FROM P.T.& C. ESTIMATE INCLUDE SALES TAX.

REFERENCE: ESTIMATE BASIS SHEET
COST CODE ACCOUNT SUMMARY

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THE U.S. DEPARTMENT OF ENERGY - RICHLAND ORDER 5700.3 "COST ESTIMATING, ANALYSIS AND STANDARDIZATION" DATED 3-27-85, PROVIDES GUIDELINES FOR ESTIMATE CONTINGENCIES. THE GUIDELINE FOR A STUDY ESTIMATE SHOULD HAVE AN OVERALL RANGE OF 20 TO 50%.

CONTINGENCY IS EVALUATED AT THE THIRD COST CODE LEVEL AND SUMMARIZED AT THE PRIMARY AND SECONDARY COST CODE LEVEL OF THE DETAILED COST ESTIMATE.

ENGINEERING

ALL ENGINEERING WAS GIVEN A 35% CONTINGENCY REFLECTIVE OF EITHER THE EARLIER ESTIMATE THAT WAS USED FOR THIS STUDY OR THE AMOUNT OF UNCERTAINTIES SURROUNDING THE NEWLY ADJUSTED WORK SCOPE.

AVERAGE ENGINEERING CONTINGENCY 35%

CONSTRUCTION

CONSTRUCTION COSTS WERE ALL GIVEN A 35% BUFFER BECAUSE OF THE LACK OF DESIGN AND DETAILS AT THIS STAGE OF DEVELOPEMENT. MOST OF THE ENVISIONED WORK WILL BE DONE IN CONDITIONS REMAINING AFTER W340 WORK HAS BEEN COMPLETED, UNTIL THAT TIME MANY UNKNOWNS WILL REMAIN.

AVERAGE CONSTRUCTION CONTINGENCY 35%

AVERAGE PROJECT CONTINGENCY 35%

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** IEST - INTERACTIVE ESTIMATING **
TWRS CLOSURE FILL ALTERNATIVES - OPTION 2
GROUT FILL STUDY ESTIMATE
DOE_R08 - ESTIMATE DETAIL BY WBS / COST CODE

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ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
110001	DEFINITIVE DESIGN - INFRASTRUCTURE										
110001.00	TECHNICAL SERVICES										
110001.0000001	*************************** INFRASTRUCTURE - DEF.DESIGN ***************************	000	1 L/S	0	0	0	0	1066500	0	0	1066500
110001.0000002	AT 25% OF CONSTRUCTION (WBS 320001)	000	0	0	0	0	0	0	0	0	0
SUBTOTAL	TECHNICAL SERVICES			0	0	0	0	1,066,500	0	0	1,066,500
TOTAL	COST CODE 00000 WBS 110001 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			0	0	0	0	1,066,500	0	0	1,066,500
TOTAL WBS 110001 DEFINITIVE DESIGN - INFRASTRUCTURE				0	0	0	0	1,066,500	0	0	1,066,500

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ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
110002	DEFINITIVE DESIGN - GROUT TANKS										
110002.00	TECHNICAL SERVICES										
110002.0000001	*************************** GROUT FILL TANKS DEFINITIVE DESIGN ***************************	000	1 L/S	0	0	0	0	17172100	0	0	17172100
110002.0000002	AT 25% OF CONSTRUCTION (WBS 320002)	000	0	0	0	0	0	0	0	0	0
SUBTOTAL	TECHNICAL SERVICES			0	0	0	0	17,172,100	0	0	17,172,100
TOTAL	COST CODE 00000 WBS 110002 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			0	0	0	0	17,172,100	0	0	17,172,100
TOTAL WBS 110002	DEFINITIVE DESIGN - GROUT TANKS			0	0	0	0	17,172,100	0	0	17,172,100

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ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
110003	DEFINITIVE DESIGN - ANCILLARY GROUT										
110003.00	TECHNICAL SERVICES										
110003.0000001	**************************** ANCILLARY GROUT FILL DEFINITIVE DESIGN ****************************	000	1 L/S	1782	101770	0	0	0	0	30969	132739
110003.0000002	PER P.T.& C ESTIMATE	000	0	0	0	0	0	0	0	0	0
110003.0000004	**************************** ANCILLARY GROUT - DEF.DESIGN ESCALATION ****************************	000	1 L/S	0	0	0	0	5990	0	0	5990
110003.0000005	ESCALATES PRICES FROM 1994 TO 1996 (5.88%) FOR DEFINITIVE DESIGN. PER P.T. & C. ESTIMATE	000	0	0	0	0	0	0	0	0	0
SUBTOTAL	TECHNICAL SERVICES			1,782	101,770	0	0	5,990	0	30,969	138,729
TOTAL	COST CODE 00000 WBS 110003 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			1,782	101,770	0	0	5,990	0	30,969	138,729
TOTAL WBS 110003 DEFINITIVE DESIGN - ANCILLARY GROUT				1,782	101,770	0	0	5,990	0	30,969	138,729

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ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
110011	DEFIN DESIGN - OVERFLOW LINE CRIMP										
110011.00	TECHNICAL SERVICES										
110011.0000000	*************************** DEFIN. DES. - OVERFLOW CRIMP ***************************	000	1 L/S	0	0	0	0	1210000	0	0	1210000
110011.0000001	AT 25% OF CONSTRUCTION (WBS 310011)	000	0	0	0	0	0	0	0	0	0
SUBTOTAL	TECHNICAL SERVICES			0	0	0	0	1,210,000	0	0	1,210,000
TOTAL	COST CODE 00000 WBS 110011 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			0	0	0	0	1,210,000	0	0	1,210,000
TOTAL WBS 110011	DEFIN DESIGN - OVERFLOW LINE CRIMP			0	0	0	0	1,210,000	0	0	1,210,000

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ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
120011	ENGRG/INSPECT - OVERFLOW LINE CRIMP										
120011.00	TECHNICAL SERVICES										
120011.0000000	*************************** ENGIN./INSP - OVERFLOW CRIMP ***************************	000	1 L/S	0	0	0	0	484000	0	0	484000
120011.0000001	AT 10% OF CONSTRUCTION (WBS 310011)	000	0	0	0	0	0	0	0	0	0
SUBTOTAL	TECHNICAL SERVICES			0	0	0	0	484,000	0	0	484,000
TOTAL	COST CODE 00000 WBS 120011 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			0	0	0	0	484,000	0	0	484,000
TOTAL WBS 120011	ENGRG/INSPECT - OVERFLOW LINE CRIMP			0	0	0	0	484,000	0	0	484,000

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** IEST - INTERACTIVE ESTIMATING **
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DOE_R08 - ESTIMATE DETAIL BY WBS / COST CODE

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ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
310011	CONSTRUCTION - OVERFLOW LINE CRIMP										
310011.01	GENERAL REQUIRMENTS										
310011.0100000	**************************** STEP OFF PAD ****************************	700	0	0	0	0	0	0	0	0	0
310011.0100002	ASSUME ONE MAN REQUIRED AT ALL TIMES FOR STEP OFF PAD, AND 4 MAN WORK CREW EXCEPT AS NOTED.	700	1 L/S	15970	600632	0	0	0	0	0	600632
SUBTOTAL	GENERAL REQUIRMENTS			15,970	600,632	0	0	0	0	0	600,632
TOTAL	COST CODE 70001 WBS 310011 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			15,970	600,632	0	0	0	0	0	600,632
310011.02	SITEWORK										
310011.0200000	**************************** CRIMP OFF OVERFLOW LINES ****************************	700 W	0	0	0	0	0	0	0	0	0
310011.0200002	MACHINE DIG 25' @1/1 SLOPE WITH 10'SQ BOTTOM EXPOSURE, 1325 CY EA X 87 LOCATIONS.	700 W	115275 CY	19597	851098	0	0	0	0	0	851098
310011.0200004	BREAK OUT ENCASEMENT TO EXPOSE PIPE LINE, CRIMP SHUT, ALLOW 8 MAN CREW ONE DAY EACH.	700 W	87 EA	5568	252286	0	0	0	0	0	252286
310011.0200006	BACKFILL AND COMPACT PLUS 20% SWELL.	700 W	138330 CY	41499	1802302	0	0	0	0	0	1802302
310011.0200008	ALLOWANCE FOR SPECIAL EQUIPMENT FOR CRIMPING OPERATION.	700 W	1 L/S	0	0	0	150000	0	0	0	150000
SUBTOTAL	SITEWORK	(SWP)		66,664	2,905,686	0	150,000	0	0	0	3,055,686
	SWP 30.00%			19999	871705						871705
	GENERAL FOREMAN 7.00 %			6066	264417						264417
	CONSUMABLES 6.00 %						9000				9000
	SALES TAX 8.00 %						12720		0		12720
	WAREHOUSING 16.62 %						26425				26425

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** IEST - INTERACTIVE ESTIMATING **
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DOE_R08 - ESTIMATE DETAIL BY WBS / COST CODE

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ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
TOTAL	COST CODE 70002 WBS 310011 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			92,729	4,041,809	0	198,145	0	0	0	4,239,955
TOTAL WBS 310011 CONSTRUCTION - OVERFLOW LINE CRIMP				108,699	4,642,441	0	198,145	0	0	0	4,840,587

ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
320001	CONSTRUCTION - INFRASTRUCTURE										
320001.01	GENERAL REQUIRMENTS										
320001.0100000	**************************** INFRASTRUCTURE - INDIRECTS ****************************	460	0	0	0	0	0	0	0	0	0
320001.0100002	TRAILER OFFICES, PURCHASED AND INSTALED IN 200 EAST AND 200 WEST.	460	4 EA	240	9914	0	40000	0	0	15189	65103
320001.0100004	TEMPORARY POWER.	460	1 L/S	2000	82620	0	40000	0	0	37313	159933
320001.0100006	SMALL TOOLS - ALLOWED AT $1.25/MH	460	1 L/S	0	0	0	104250	0	0	31723	135973
320001.0100008	FUELS (ALLOW)	460	1 L/S	0	0	0	25000	0	0	7608	32608
320001.0100010	SUPERVISION OF CONSTRUCTION, BASED ON 17,000 HOURS AT $57.11/HR.	460	1 L/S	17000	970870	0	0	0	0	295436	1266306
SUBTOTAL	GENERAL REQUIRMENTS			19,240	1,063,404	0	209,250	0	0	387,269	1,659,923
TOTAL	COST CODE 46001 WBS 320001 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			19,240	1,063,404	0	209,250	0	0	387,269	1,659,923
320001.10	SPECIALTIES										
320001.1000100	**************************** GROUT BATCH PLANT ****************************	460	0	0	0	0	0	0	0	0	0
320001.1000102	INSTALL ONE BATCH PLANT FACILITY WITH 150 CY/HR CAPACITY, W/COMPUTERIZED BATCH CONTROLS, SCALES, A	460	1 EA	0	0	0	0	415000	0	126285	541285
320001.1000103	DUST CONTROL SYSTEM, SILOS FOR CEMENT AND FLY ASH, AN AGGREGATE BIN, WATER HEATER, 10 CY MIXER AND HOPPER.	460	0	0	0	0	0	0	0	0	0
320001.1000104	CONCRETE PUMP W/150 CY/HR CAPACITY.	460	1 EA	0	0	0	0	250000	0	76075	326075
320001.1000106	PUMPLINE COST AT $15,000 WITH REPLACEMENTS EACH 150,000 CY (ASSUME 7 TIMES) = $105000	460	1 EA	0	0	0	0	105000	0	31952	136952

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** IEST - INTERACTIVE ESTIMATING **
TWRS CLOSURE FILL ALTERNATIVES - OPTION 2
GROUT FILL STUDY ESTIMATE
DOE_R08 - ESTIMATE DETAIL BY WBS / COST CODE

ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
SUBTOTAL	SPECIALTIES			0	0	0	0	770,000	0	234,312	1,004,312
TOTAL	COST CODE 46010 WBS 320001 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			0	0	0	0	770,000	0	234,312	1,004,312
320001.15	MECHANICAL										
320001.1500000	**************************** FILTRATION UNITS ****************************	460	0	0	0	0	0	0	0	0	0
320001.1500002	ASSUMED ONE HEPA FILTER UNIT LOCATED IN EACH TANK FARM, ALLOWANCE.	460	18 EA	0	0	0	0	270000	0	82161	352161
320001.1500004	HEPA FILTERS, ALLOWANCE.	460	1 L/S	0	0	0	66000	0	0	20084	86084
320001.1500010	CYCLONE SEPARATORS, 2 FOR EAST AND 2 FOR WEST, ALLOWANCE.	460	4 EA	4000	165240	0	80000	0	0	74627	319867
320001.1500100	**************************** INSTRUMENTATION ****************************	460	0	0	0	0	0	0	0	0	0
320001.1500102	MONITOR PANEL, ALLOWANCE	460	18 EA	720	29743	0	90000	0	0	36438	156181
320001.1500104	INSTRUMENTS, ASSUMED 5 PER TANK TO MEASURE COMPACTION, DENSITY, LEVEL, VISUAL AND MAPPING, ALLOWANCE.	460	885 EA	8850	365594	0	88500	0	0	138181	592275
320001.1500106	WIRING AND CONNECTIONS	460	885 EA	1770	73119	0	0	0	0	22250	95369
SUBTOTAL	MECHANICAL			15,340	633,696	0	324,500	270,000	0	373,741	1,601,937
TOTAL	COST CODE 46015 WBS 320001 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			15,340	633,696	0	324,500	270,000	0	373,741	1,601,937
TOTAL WBS 320001 CONSTRUCTION - INFRASTRUCTURE				34,580	1,697,100	0	533,750	1,040,000	0	995,322	4,266,172

ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
320002	CONSTRUCTION - GROUT FILL TANKS										
320002.01	GENERAL REQUIRMENTS										
320002.0100000	**************************** GROUT FILL TANKS - INDIRECTS ****************************	460	0	0	0	0	0	0	0	0	0
320002.0100002	WATER, 9,000,000 GALLONS AT $.02/GAL.	460	1 L/S	0	0	0	180000	0	0	54774	234774
320002.0100004	GASOLINE, FOR PICKUPS	460	107380 GAL	0	0	0	123487	0	0	37577	161064
320002.0100006	SMALL TOOLS AND CONSUMABLES AT $1.25 PER MANHOUR	460	1 L/S	0	0	0	117500	0	0	35755	153255
320002.0100010	SUPERVISION	460	1 L/S	36000	2055960	0	0	0	0	625629	2681589
320002.0100020	**************************** GROUT FILL TANKS - INDIRECTS ESCALATION ****************************	460	1 L/S	0	0	0	0	145644	0	0	145644
320002.0100022	ESCALATES PRICES FROM 1994 TO 1996 (5.88%) FOR INDIRECT PORTION OF ESTIMATE.	460	0	0	0	0	0	0	0	0	0
SUBTOTAL	GENERAL REQUIRMENTS			36,000	2,055,960	0	420,987	145,644	0	753,735	3,376,326
TOTAL	COST CODE 46001 WBS 320002 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			36,000	2,055,960	0	420,987	145,644	0	753,735	3,376,326
320002.03	CONCRETE										
320002.0300000	**************************** GROUT FILL TANKS - CONSTR. ****************************	460	0	0	0	0	0	0	0	0	0
320002.0300002	MATERIAL COSTS FOR 1 MILLION CY OF GROUT:	460	0	0	0	0	0	0	0	0	0
320002.0300004	API CLASS H CEMENT @ 300 LB/CY AND $83/TON.	460	1 L/S	0	0	0	12450000	0	0	3788535	16238535
320002.0300006	ASTM CLASS F FLY ASH, 1112 LB/CY AND $48.60/TON	460	1 L/S	0	0	0	27021600	0	0	8222673	35244273
320002.0300008	NATURAL FINE AGGREGATE 1314 LB/CY AND $8.00/TON	460	1 L/S	0	0	0	5256000	0	0	1599401	6855401
320002.0300010	SODIUM BENTONITE CLAY, 38 LB/CY AND $110.00/TON	460	1 L/S	0	0	0	2090000	0	0	635987	2725987
320002.0300012	HIGH-RANGE WATER-REDUCING ADMIXTURE (DAXAD19) AT	460	1 L/S	0	0	0	176000	0	0	53557	229557

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ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
	4.5 OZ/CY AND $5.00/GAL (35,200 GAL.)										
320002.0300020	LABOR - ASSUME 8 MEN RUNNING OPERATION W/150 CY/HR OUTPUT FOR 6 HR/DAY (4500 CY/WK AND 320 MH/WK), 1 MILLION CY=	460	1 L/S	71360	2947882	0	0	0	0	897040	3844922
320002.0300022	223 WKS X 320 MH = 71360 MHS	460	0	0	0	0	0	0	0	0	0
320002.0300030	*************************** GROUT FILL TKS- CONSTRUCTION ESCALATION ***************************	460	1 L/S	0	0	0	0	173335	0	0	173335
320002.0300032	ESCALATES PRICES FROM 1994 TO 1996 (5.88%) FOR CONSTR-UCTION PORTION OF ESTIMATE, LABOR ONLY, MATERIAL COSTS	460	0	0	0	0	0	0	0	0	0
320002.0300033	WERE CURRENT.	460	0	0	0	0	0	0	0	0	0
SUBTOTAL	CONCRETE			71,360	2,947,882	0	46,993,600	173,335	0	15,197,193	65,312,010
TOTAL	COST CODE 46003 WBS 320002 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			71,360	2,947,882	0	46,993,600	173,335	0	15,197,193	65,312,010
TOTAL WBS 320002 CONSTRUCTION - GROUT FILL TANKS				107,360	5,003,842	0	47,414,587	318,979	0	15,950,928	68,688,336

ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
320003	CONSTRUCTION - ANCILLARY GROUT										
320003.01	GENERAL REQUIRMENTS										
320003.0100000	****************************	460	0	0	0	0	0	0	0	0	0
	ANCILLARY GROUT - INDIRECTS										
	****************************										
	PER P.T. & C. ESTIMATE										
320003.0100002	SUPERVISION	460	1 L/S	630	35979	0	0	0	0	10948	46927
320003.0100004	****************************	460	1 L/S	0	0	0	0	1580	0	0	1580
	ANCILLARY GROUT - INDIRECTS ESCALATION										
	****************************										
320003.0100006	ESCALATES PRICES FROM 1994 TO 1996 (5.88%) FOR INDIRECT PORTION OF ESTIMATE. PER P.T. & C. ESTIMATE.	460	0	0	0	0	0	0	0	0	0
SUBTOTAL	GENERAL REQUIRMENTS			630	35,979	0	0	1,580	0	10,948	48,507
TOTAL	COST CODE 46001 WBS 320003 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			630	35,979	0	0	1,580	0	10,948	48,507
320003.03	CONCRETE										
320003.0300000	****************************	460	0	0	0	0	0	0	0	0	0
	ANCILLARY GROUT - CONSTR.										
	****************************										
320003.0300002	ANCILLARY EQUIPMENT STABILIZATION, SINGLE SHELL TANKS, 10,500 CM OF GROUT FILL.	460	0	0	0	0	0	0	0	0	0
320003.0300004	CEMENT	460	94500 KG	0	0	0	13230	0	0	4026	17256
320003.0300006	SAND	460	4900 CM	0	0	0	90650	0	0	27585	118235
320003.0300008	FLY ASH	460	850500 KG	0	0	0	34020	0	0	10352	44372
320003.0300012	ANCILLARY EQUIPMENT STABILIZATION, DOUBLE SHELL TANKS, 7,900 CM OF GROUT FILL.	460	0	0	0	0	0	0	0	0	0
320003.0300014	CEMENT	460	86000 KG	0	0	0	12040	0	0	3664	15704
320003.0300016	SAND	460	4450 CM	0	0	0	82325	0	0	25051	107376
320003.0300018	FLY ASH	460	771850 KG	0	0	0	30874	0	0	9395	40269
320003.0300020	LABOR, RADIATION WORKER	460	1 L/S	1260	52051	0	0	0	0	15839	67890
320003.0300022	LABOR, NON-RADIATION WORKER	460	1 L/S	1300	53703	0	0	0	0	16342	70045

ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
320003.0300030	***************************** ANCILLARY GROUT - CONSTR. ESCALATION ****************************	460	1 L/S	0	0	0	0	28160	0	0	28160
320003.0300032	ESCALATES PRICES FROM 1994 TO 1996 (5.88%) FOR CONSTR-UCTION PORTION OF ESTIMATE. PER P.T. & C. ESTIMATE	460	0	0	0	0	0	0	0	0	0
SUBTOTAL	CONCRETE			2,560	105,754	0	263,139	28,160	0	112,254	509,307
TOTAL	COST CODE 46003 WBS 320003 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			2,560	105,754	0	263,139	28,160	0	112,254	509,307
TOTAL WBS 320003 CONSTRUCTION - ANCILLARY GROUT				3,190	141,733	0	263,139	29,740	0	123,202	557,814

ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
320004	CONSTRUCTION - BARRIER CAP										
320004.02	SITEWORK										
320004.0200000	***************************	460	0	0	0	0	0	0	0	0	0
	BARRIER CAPS - CONSTRUCTION ***************************										
320004.0200002	TX FARM	460	1 L/S	0	0	0	0	7414000	0	2852166	10266166
320004.0200004	U FARM	460	1 L/S	0	0	0	0	5565800	0	2141163	7706963
320004.0200006	C FARM	460	1 L/S	0	0	0	0	5807300	0	2234068	8041368
320004.0200008	SX FARM	460	1 L/S	0	0	0	0	5836100	0	2245148	8081248
320004.0200010	BY FARM	460	1 L/S	0	0	0	0	4840900	0	1862294	6703194
320004.0200012	B FARM	460	1 L/S	0	0	0	0	5688500	0	2188366	7876866
320004.0200014	BX FARM	460	1 L/S	0	0	0	0	4784500	0	1840597	6625097
320004.0200016	A FARM	460	1 L/S	0	0	0	0	2858200	0	1099550	3957750
320004.0200018	TY FARM	460	1 L/S	0	0	0	0	2885600	0	1110090	3995690
320004.0200020	AX FARM	460	1 L/S	0	0	0	0	2181000	0	839031	3020031
320004.0200022	T FARM	460	1 L/S	0	0	0	0	5688500	0	2188366	7876866
320004.0200024	S FARM	460	1 L/S	0	0	0	0	4891600	0	1881799	6773399
320004.0200026	AN FARM	460	1 L/S	0	0	0	0	4045000	0	1556112	5601112
320004.0200028	AZ FARM	460	1 L/S	0	0	0	0	1410600	0	542658	1953258
320004.0200030	AY FARM	460	1 L/S	0	0	0	0	1410600	0	542658	1953258
320004.0200032	AP FARM	460	1 L/S	0	0	0	0	3742200	0	1439624	5181824
320004.0200034	AW FARM	460	1 L/S	0	0	0	0	3007100	0	1156831	4163931
320004.0200036	SY FARM	460	1 L/S	0	0	0	0	2239600	0	861574	3101174
320004.0200038	LLW VAULTS	460	1 L/S	0	0	0	0	20272500	0	7798831	28071331
SUBTOTAL	SITEWORK			0	0	0	0	94,569,600	0	36,380,926	130,950,526
TOTAL	COST CODE 46002 WBS 320004 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			0	0	0	0	94,569,600	0	36,380,926	130,950,526
TOTAL WBS 320004 CONSTRUCTION - BARRIER CAP				0	0	0	0	94,569,600	0	36,380,926	130,950,526

ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
321001	SUBCONTRACT MPR - INFRASTRUCTURE										
321001.15	MECHANICAL										
321001.1500000	***************************** INFRASTRUCTURE - SUB. MPR *****************************	460	0	0	0	0	0	0	0	0	0
321001.1500001	BASED ON 3% OF WBS 110001, 320001 AND 322001.	460	1 L/S	0	0	0	0	267000	0	0	267000
SUBTOTAL	MECHANICAL			0	0	0	0	267,000	0	0	267,000
TOTAL	COST CODE 46015 WBS 321001 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			0	0	0	0	267,000	0	0	267,000
TOTAL WBS 321001 SUBCONTRACT MPR - INFRASTRUCTURE				0	0	0	0	267,000	0	0	267,000

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ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
321002	SUBCONTRACT MPR - GROUT FILL TANKS										
321002.03	CONCRETE										
321002.0300000	**************************** GROUT FILL TANKS SUBCONTRACTOR MPR ****************************	460	0	0	0	0	0	0	0	0	0
321002.0300001	BASED ON 3% OF WBS 110002 AND 320002.	460	1 L/S	0	0	0	0	2603100	0	0	2603100
SUBTOTAL	CONCRETE			0	0	0	0	2,603,100	0	0	2,603,100
TOTAL	COST CODE 46003 WBS 321002 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			0	0	0	0	2,603,100	0	0	2,603,100
TOTAL WBS 321002 SUBCONTRACT MPR - GROUT FILL TANKS				0	0	0	0	2,603,100	0	0	2,603,100

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ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
321003	SUBCONTRACT MPR - ANCILLARY GROUT										
321003.03	CONCRETE										
321003.0300000	*************************** ANCILLARY GROUT SUBCONTRACTOR MPR ***************************	460	0	0	0	0	0	0	0	0	0
321003.0300001	BASED ON 3% OF WBS 110003 AND 320003.	460	1 L/S	0	0	0	0	23450	0	0	23450
SUBTOTAL	CONCRETE			0	0	0	0	23,450	0	0	23,450
TOTAL	COST CODE 46003 WBS 321003 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			0	0	0	0	23,450	0	0	23,450
TOTAL WBS 321003 SUBCONTRACT MPR - ANCILLARY GROUT				0	0	0	0	23,450	0	0	23,450

ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
321004	SUBCONTRACT MPR - BARRIER CAP										
321004.02	SITEWORK										
321004.0200100	**************************** BARRIER - SUBCONTRACTOR MPR ****************************	460	0	0	0	0	0	0	0	0	0
321004.0200101	BASED ON 3% OF WBS 320004 AND 500004. PER P.T.& C. ESTIMATE.	460	1 L/S	0	0	0	0	4105959	0	0	4105959
SUBTOTAL	SITEWORK			0	0	0	0	4,105,959	0	0	4,105,959
TOTAL	COST CODE 46002 WBS 321004 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			0	0	0	0	4,105,959	0	0	4,105,959
TOTAL WBS 321004 SUBCONTRACT MPR - BARRIER CAP				0	0	0	0	4,105,959	0	0	4,105,959

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ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
322001	PROJECT MANAGEMENT - INFRASTRUCTURE										
322001.19	PROJECT MANAGEMENT										
322001.1900000	**************************** CONSTRUCTION MANAGEMENT INFRASTRUCTURE ****************************	060	1 L/S	0	0	0	0	853234	0	259639	1112873
322001.1900001	BASED ON 20% OF CONSTRUCTION (WBS 320001)	060	0	0	0	0	0	0	0	0	0
SUBTOTAL	PROJECT MANAGEMENT			0	0	0	0	853,234	0	259,639	1,112,873
TOTAL	COST CODE 06019 WBS 322001 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			0	0	0	0	853,234	0	259,639	1,112,873
TOTAL WBS 322001 PROJECT MANAGEMENT - INFRASTRUCTURE				0	0	0	0	853,234	0	259,639	1,112,873

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ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
322004	PROJ/CONSTR MGMT - BARRIER CAP										
322004.19	PROJECT MANAGEMENT										
322004.1900000	**************************** PROJECT MGMT & CONSTRUCTION MANAGEMENT - BARRIER CAP ****************************	060	1 L/S	0	0	0	0	21145687	0	0	21145687
322004.1900001	BASED ON 15% OF WBS 320004, 321004 AND 500004. PER P.T.& C. ESTIMATE	060	0	0	0	0	0	0	0	0	0
SUBTOTAL	PROJECT MANAGEMENT			0	0	0	0	21,145,687	0	0	21,145,687
TOTAL	COST CODE 06019 WBS 322004 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			0	0	0	0	21,145,687	0	0	21,145,687
TOTAL WBS 322004	PROJ/CONSTR MGMT - BARRIER CAP			0	0	0	0	21,145,687	0	0	21,145,687

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ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
500004	WHC PROJ MGMT - BARRIER CAP										
500004.9000000	**************************** WHC PROJECT MANAGEMENT BARRIER CAP ****************************	060	1 L/S	0	0	0	0	5912400	0	0	5912400
500004.9000001	APPLIED AT 4.5% OF WBS 320004. PER P.T.& E ESTIMATE	060	0	0	0	0	0	0	0	0	0
TOTAL WBS 500004 WHC PROJ MGMT - BARRIER CAP				0	0	0	0	5,912,400	0	0	5,912,400

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ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
500011	WHC PROJ MGMT - OVERFLOW LINE CRIMP										
500011.9000000	**************************** WHC PROJECT MANAGEMENT CRIMP OFF OVERFLOW LINES ****************************	060	0	0	0	0	0	0	0	0	0
500011.9000001	APPLIED AT 15% OF CONSTR. (WBS 310011)	060	1 L/S	0	0	0	0	726000	0	0	726000
TOTAL WBS 500011 WHC PROJ MGMT - OVERFLOW LINE CRIMP				0	0	0	0	726,000	0	0	726,000

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ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT -	OH&P / B & I	TOTAL DOLLARS
REPORT TOTAL				255,611	11,586,886	0	48,409,621	151,533,739	0	53,740,986	265,271,233

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ALTERNATIVE 3: HYBRID FILL

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** IEST - INTERACTIVE ESTIMATING **
TWRS CLOSURE FILL ALTERNATIVES - OPTION 3
PREPLACED-AGGREGATE CONCRETE STUDY ESTIMATE
DOE_R01 - PROJECT COST SUMMARY

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COST CODE	DESCRIPTION	ESCALATED TOTAL COST	CONTINGENCY %	CONTINGENCY TOTAL	TOTAL DOLLARS
000	ENGINEERING	22,020,000	35	7,710,000	29,730,000
060	PROJECT MANAGEMENT	30,980,000	35	10,840,000	41,820,000
460	IMPROVEMENTS TO LAND	214,360,000	35	75,030,000	289,390,000
700	SPECIAL EQUIP/PROCESS SYSTEMS	18,730,000	35	6,560,000	25,290,000
	(ADJUSTED TO MEET DOE 5100.4)	10,000		<40,000>	<30,000>
	PROJECT TOTAL	286,100,000	35	100,100,000	386,200,000

TYPE OF ESTIMATE	STUDY ESTIMATE	AUGUST 13, 1996
ARCHITECT ENGINEER	[signature]	
OPERATING CONTRACTOR	[signature]	8/14/96

REMARKS:

(ROUNDED/ADJUSTED TO THE NEAREST " 10,000 / 100,000 " - PERCENTAGES NOT RECALCULATED TO REFLECT ROUNDING)

WBS	DESCRIPTION	ESTIMATE SUBTOTAL	ONSITE INDIRECTS	SUB TOTAL	ESCALATION %	ESCALATION TOTAL	SUB TOTAL	CONTINGENCY %	CONTINGENCY TOTAL	TOTAL DOLLARS
110001	DEFINITIVE DESIGN - INFRASTRUCTURE	2112975	0	2112975	0.00	0	2112975	35	739541	2852516
110002	DEFINITIVE DESIGN - AGGREGATE FILL	13778977	0	13778977	0.00	0	13778977	35	4822642	18601619
110003	DEF. DESIGN - ANCILLARY GROUT FILL	138729	0	138729	0.00	0	138729	35	48555	187284
110005	DEFINITIVE DESIGN - GROUT FILL TKS	0	0	0	0.00	0	0	0	0	0
110011	DEFIN DESIGN - OVERFLOW LINE CRIMP	1210000	0	1210000	0.00	0	1210000	35	423500	1633500
110012	DEFINITIVE DESIGN - 42" RISER	2440300	0	2440300	0.00	0	2440300	35	854105	3294405
110013	DEFINITIVE DESIGN - GROUT TUBES	625000	0	625000	0.00	0	625000	35	218750	843750
SUBTOTAL 11	DEFINITIVE DESIGN	20305981	0	20305981	0.00	0	20305981	35	7107093	27413074
120011	ENGRG/INSPECT - OVERFLOW LINE CRIMP	484000	0	484000	0.00	0	484000	35	169400	653400
120012	ENGINEERING/INSP. - 42" RISER	976100	0	976100	0.00	0	976100	35	341635	1317735
120013	ENGRG/INSPECTION - GROUT TUBES	250000	0	250000	0.00	0	250000	35	87500	337500
SUBTOTAL 12	ENGINEERING/INSPECTION	1710100	0	1710100	0.00	0	1710100	35	598535	2308635
SUBTOTAL 1	ENGINEERING	22016081	0	22016081	0.00	0	22016081	35	7705628	29721709
310011	CONSTRUCTION - OVERFLOW LINE CRIMP	4840587	0	4840587	0.00	0	4840587	35	1694205	6534792
310012	CONSTRUCTION - 42" RISER INSTALL	9869600	0	9869600	0.00	0	9869600	35	3454361	13323961
SUBTOTAL 31	FA CONST-ONSITE E/C	14710187	0	14710187	0.00	0	14710187	35	5148566	19858753
320001	CONSTRUCTION - INFRASTRUCTURE	13498836	0	13498836	0.00	0	13498836	35	4724593	18223429
320002	CONSTRUCTION - GRAVEL FILL	29702772	0	29702772	0.00	0	29702772	35	10395970	40098742
320003	CONSTRUCTION - ANCILLARY GROUT FILL	557814	0	557814	0.00	0	557814	35	195234	753048
320004	CONSTRUCTION - BARRIER CAP	130950526	0	130950526	0.00	0	130950526	35	45832684	176783210
320005	CONSTRUCTION - GROUT FILL TANKS	33133458	0	33133458	0.00	0	33133458	35	11596710	44730168
320013	CONSTRUCTION - GROUT TUBES	2500000	522500	3022500	0.00	0	3022500	35	1057875	4080375
321001	SUBCONTRACT MPR - INFRASTRUCTURE	437405	0	437405	0.00	0	437405	35	153092	590497
321002	SUBCONTRACT MPR - GRAVEL FILL	960212	0	960212	0.00	0	960212	35	336074	1296286
321003	SUBCONTRACT MPR - ANCILLARY GROUT	23450	0	23450	0.00	0	23450	35	8208	31658
321004	SUBCONTRACT MPR - BARRIER CAP	4105959	0	4105959	0.00	0	4105959	35	1437086	5543045
321005	SUBCONTRACT MPR - GROUT FILL TANKS	994000	0	994000	0.00	0	994000	35	347900	1341900
322001	PROJECT MANAGEMENT - INFRASTRUCTURE	2817325	0	2817325	0.00	0	2817325	35	986064	3803389
322004	PROJ/CONSTR MGMT - BARRIER CAP	21145687	0	21145687	0.00	0	21145687	35	7400990	28546677
SUBTOTAL 32	CONSTRUCTION-FIXED PRICE	240827444	522500	241349944	0.00	0	241349944	35	84472480	325822424

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TWRS CLOSURE FILL ALTERNATIVES - OPTION 3
PREPLACED-AGGREGATE CONCRETE STUDY ESTIMATE
DOE_R02 - WORK BREAKDOWN STRUCTURE SUMMARY

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WBS	DESCRIPTION	ESTIMATE SUBTOTAL	ONSITE INDIRECTS	SUB TOTAL	ESCALATION %	ESCALATION TOTAL	SUB TOTAL	CONTINGENCY %	CONTINGENCY TOTAL	TOTAL DOLLARS
SUBTOTAL 3	CONSTRUCTION	255537631	522500	256060131	0.00	0	256060131	35	89621046	345681177
500004	WHC PROJ MGMT - BARRIER CAP	5912400	0	5912400	0.00	0	5912400	35	2069340	7981740
500011	WHC PROJ MGMT - OVERFLOW LINE CRIMP	726000	0	726000	0.00	0	726000	35	254100	980100
500012	WHC PROJ MGMT - 42" RISER INSTALL	997000	0	997000	0.00	0	997000	35	348950	1345950
500013	WHC PROJ MGMT - GROUT TUBES	375000	0	375000	0.00	0	375000	35	131250	506250
SUBTOTAL 5	OTHER PROJECT COST	8010400	0	8010400	0.00	0	8010400	35	2803640	10814040
PROJECT TOTAL		285,564,112	522,500	286,086,612	0.00	0	286,086,612	35	100,130,314	386,216,926

1. DOCUMENTS AND DRAWINGS

DOCUMENTS: PROJECT TIME AND COSTS SPREAD SHEET ESTIMATE, DATED 5/24/96, ICF KAISER HANFORD STUDY ESTIMATE #W340SAA1, DATED 01/12/94, STATEMENT OF WORK DRAFT.

DRAWINGS: NONE

2. MATERIAL PRICES

UNIT COSTS REPRESENT CURRENT PRICES FOR SPECIFIED MATERIAL.

3. LABOR RATES

A.) ICF-KH HOURLY RATES ARE BASED ON THE 1996 FISCAL YEAR BUDGET LIQUIDATION RATES AS ISSUED BY KEH FINANCE (EFFECTIVE 10-17-95). SEE ALSO THE FY 1996 PLANNING RATES * (REPORT BGHB2000 & BGHB2005).
B.) WHC HOURLY RATES ARE BASED UPON THE FY 1996 PLANNING RATES * (REPORT BGHB2001).
C.) IRM HOURLY RATES ARE BASED UPON THE FY 1996 PLANNING RATES * (REPORT BGHB7008).
D.) BASE CRAFT RATES ARE AS ISSUED BY KEH FINANCE (EFFECTIVE 10-17-95). RATES INCLUDE FRINGE BENEFITS, LABOR INSURANCE, TAXES DEPARTMENT OVERHEADS, G&A AND SWS, AND TRAVEL WHERE APPLICABLE, PER HANFORD SITE STABILIZATION AGREEMENT, APPENDIX "A".
* SEE HANFORD SOFT REPORTING, FDS BUDGET GUIDELINE HANDBOOK, SECTION 2 - COMPANY INFORMATION, FY 1996 PLANNING RATES.

4. GENERAL REQUIREMENTS/TECHNICAL SERVICES/OVERHEADS

A.) ONSITE CONSTRUCTION FORCES GENERAL REQUIREMENTS, TECHNICAL SERVICES AND CRAFT OVERHEAD COSTS ARE INCLUDED AS A COMPOSITE PERCENTAGE BASED ON THE ICF-KH ESTIMATING FACTOR, REVISION 1, FY96, DATED 1-/-1/95 THE TOTAL COMPOSITE PERCENTAGE APPLIED TO ONSITE CONSTRUCTION FORCES LABOR, FOR THIS PROJECT, IS 52% FOR ALL WORK, WHICH IS REFLECTED IN THE "OH&P/B&I" COLUMN OF THE ESTIMATE DETAIL.

B.) ONSITE CONTRACT ADMINISTRATION AND CONSTRUCTION MANAGEMENT COSTS, ASSOCIATED WITH THE OVERALL MANAGEMENT OF THE FIXED PRICE CONTRACTS, ARE INCLUDED AS A COMPOSITE PERCENTAGE AND LUMP SUM ALLOWANCE (FOR BID PACKAGE PREP) BASED ON THE ESTIMATING FACTOR/BILLING SCHEDULE. THE TOTAL COMPOSITE PERCENTAGE AND LUMP SUM ALLOWANCE ARE APPLIED AGAINST THE TOTAL FIXED PRICE CONTRACT AMOUNT WHICH IS REFLECTED ON THE KEH SUMMARY REPORT DOE_R07, INCLUDED WITH THIS ESTIMATE. (FINAL ESTIMATES MAY BE PARTIALLY MANLOADED AND INCLUDED WITHIN THE ESTIMATE DETAIL)

C.) FIXED PRICE CONTRACTOR OVERHEAD, PROFIT, BOND AND INSURANCE COSTS HAVE BEEN APPLIED AT THE FOLLOWING PERCENTAGES AND ARE REFLECTED IN THE "OH&P/B&I" COLUMN OF THE ESTIMATE DETAIL:
LABOR - 30.4%, MATERIAL - 30.4%, EQUIPMENT USAGE - 30.4%, EQUIPMENT - 30.4%, SUBCONTRACTS - 38.47%.

5. ESCALATION

ESCALATION WAS NOT APPLIED TO THE DOLLAR AMOUNTS FOR FUTURE PROJECTIONS, ALL COSTS HAVE BEEN CONVERTED TO 1996 DOLLARS.

6. ROUNDING

U.S. DEPARTMENT OF ENERGY - DOE ORDER 5100.4 PAGE I-32 SUBPARAGRAPH (M), REQUIRES ROUNDING OF ALL GENERAL PLANT PROJECTS (GPP'S) AND LINE ITEM (LI) COST ESTIMATES. REFERENCE: DOE 5100.4, FIGURE I-11, DATED 10-31-84.

7. REMARKS
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A.) IT WAS ASSUMED THAT BURN-OUT WILL NOT BE EXPERIENCED DURING ANY ACTIVITIES.
B.) ALL SOILS DISTURBED BY CONSTRUCTION ACTIVITIES WILL BE ASSUMED TO GO BACK INTO ORIGINAL PLACE WITHOUT DISPOSAL COSTS INCURRED.
C.) EXCAVATION ACTIVITIES TO UNCOVER UNDERGROUND OVERFLOW LINES WILL BE SEQUENCED IN ORDER TO PREVENT THE NEED TO HAUL MATERIALS OUT OF FARM FOR STOCKPILING.
D.) ASSUMED AIRLIFT CIRCULATORS UTILIZE A 12" FLANGED RISER.
E.) INVENTORY FOR IN-TANK HARDWARE BASED ON REPORT "SINGLE-SHELL TANK IN-TANK HARDWARE INVENTORY, BY T.E.RAINEY & M.E.BEAVER.
F.) THE METHOD ASSUMED, FOR THE SAKE OF ESTIMATE, FOR DEALING WITH DOME SUSPENDED HARDWARE IS BASED ON A MODIFIED VERSION OF A PROCESS COVERED BY AN EARLIER DOCUMENT (ATLANTIC RICHFIELD CO) ARH-CD-891 DATED FEB 8, 1977.
G.) THE COSTS AS REFLECTED IN THE ESTIMATE WBS'110001, 110002, 110003, 110102, 110103, 320001 THRU 320004, 320102, 320103, 321001 THRU 321004, 322001, 322004 AND 500004 COME FROM PROJECT TIME AND COST ESTIMATE DATED 5/24/96 DONE BY LEE SMITH.
H.) WBS 110012, 120012, 200012, 310012 AND 500012 WERE EXTRACTED FROM ICF KAISER HANFORD STUDY ESTIMATE W340SAA1 DATED 1/12/94 WITH ADJUSTMENTS MADE TO REFLECT FY96 LABOR RATES AND ADDERS.

REFERENCE: ESTIMATE BASIS SHEET PAGE 4 & 5 OF 6

THE U.S. DEPARTMENT OF ENERGY - RICHLAND ORDER 5700.3 "COST ESTIMATING, ANALYSIS AND STANDARDIZATION" DATED 3-27-85, PROVIDES GUIDELINES FOR ESTIMATE CONTINGENCIES. THE GUIDELINE FOR A STUDY ESTIMATE SHOULD HAVE AN OVERALL RANGE OF 20 TO 50%.

CONTINGENCY IS EVALUATED AT THE THIRD COST CODE LEVEL AND SUMMARIZED AT THE PRIMARY AND SECONDARY COST CODE LEVEL OF THE DETAILED COST ESTIMATE.

ENGINEERING

ALL ENGINEERING WAS GIVEN A 35% CONTINGENCY REFLECTIVE OF EITHER THE EARLIER ESTIMATE THAT WAS USED FOR THIS STUDY OR THE AMOUNT OF UNCERTAINTIES SURROUNDING THE NEWLY ADJUSTED WORK SCOPE.

AVERAGE ENGINEERING CONTINGENCY 35%

CONSTRUCTION

CONSTRUCTION COSTS WERE ALL GIVEN A 35% BUFFER BECAUSE OF THE LACK OF DESIGN AND DETAILS AT THIS STAGE OF DEVELOPEMENT. MOST OF THE ENVISIONED WORK WILL BE DONE IN CONDITIONS REMAINING AFTER W340 WORK HAS BEEN COMPLETED, UNTIL THAT TIME MANY UNKNOWNS WILL REMAIN.

AVERAGE CONSTRUCTION CONTINGENCY 35%

AVERAGE PROJECT CONTINGENCY 35%

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TWRS CLOSURE FILL ALTERNATIVES - OPTION 3
PREPLACED-AGGREGATE CONCRETE STUDY ESTIMATE
DOE_R08 - ESTIMATE DETAIL BY WBS / COST CODE

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ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
110001	DEFINITIVE DESIGN - INFRASTRUCTURE										
110001.00	TECHNICAL SERVICES										
110001.0000001	****************************	000	1 L/S	17153	1458005	0	162002	0	0	492968	2112975
	INFRASTRUCTURE - DEF.DESIGN										
	****************************										
	AT 15% OF CONSTRUCTION										
SUBTOTAL	TECHNICAL SERVICES			17,153	1,458,005	0	162,002	0	0	492,968	2,112,975
TOTAL	COST CODE 00000			17,153	1,458,005	0	162,002	0	0	492,968	2,112,975
	WBS 110001										
	(ESCALATION 0.00% - CONTINGENCY 35.00 %)										
TOTAL WBS 110001 DEFINITIVE DESIGN - INFRASTRUCTURE				17,153	1,458,005	0	162,002	0	0	492,968	2,112,975

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ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
110002	DEFINITIVE DESIGN - AGGREGATE FILL										
110002.00	TECHNICAL SERVICES										
110002.0000001	**************************** AGGREGATE FILL - DEF.DESIGN ****************************	000	1 L/S	177000	10108470	0	0	0	0	3076007	13184477
110002.0000005	**************************** AGGREGATE FILL - DEF.DESIGN ESCALATION ****************************	000	1 L/S	0	0	0	0	594500	0	0	594500
110002.0000006	ESCALATES PRICES FROM 1994 TO 1996 (5.88%) FOR DEFINITIVE DESIGN.	000	0	0	0	0	0	0	0	0	0
SUBTOTAL	TECHNICAL SERVICES			177,000	10,108,470	0	0	594,500	0	3,076,007	13,778,977
TOTAL	COST CODE 00000 WBS 110002 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			177,000	10,108,470	0	0	594,500	0	3,076,007	13,778,977
TOTAL WBS 110002	DEFINITIVE DESIGN - AGGREGATE FILL			177,000	10,108,470	0	0	594,500	0	3,076,007	13,778,977

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ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
110003	DEF. DESIGN - ANCILLARY GROUT FILL										
110003.00	TECHNICAL SERVICES										
110003.0000001	*************************** ANCILLARY GROUT - DEF.DESIGN ***************************	000	1 L/S	1782	101770	0	0	0	0	30969	132739
110003.0000004	*************************** ANCILLARY GROUT - DEF.DESIGN ESCALATION ***************************	000	1 L/S	0	0	0	0	5990	0	0	5990
110003.0000005	ESCALATES PRICES FROM 1994 TO 1996 (5.88%) FOR DEFINITIVE DESIGN. PER P.T. & C. ESTIMATE.	000	0	0	0	0	0	0	0	0	0
SUBTOTAL	TECHNICAL SERVICES			1,782	101,770	0	0	5,990	0	30,969	138,729
TOTAL	COST CODE 00000 WBS 110003 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			1,782	101,770	0	0	5,990	0	30,969	138,729
TOTAL WBS 110003 DEF. DESIGN - ANCILLARY GROUT FILL				1,782	101,770	0	0	5,990	0	30,969	138,729

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ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
110005	DEFINITIVE DESIGN - GROUT FILL TKS										
110005.00	TECHNICAL SERVICES										
110005.0000001	**************************** GROUT FILL TKS - DEF.DESIGN ****************************	000	1 L/S	0	0	0	0	0	0	0	0
110005.0000005	INCLUDED IN WBS 110002.	000	0	0	0	0	0	0	0	0	0
SUBTOTAL	TECHNICAL SERVICES			0	0	0	0	0	0	0	0
TOTAL	COST CODE 00000 WBS 110005 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			0	0	0	0	0	0	0	0
TOTAL WBS 110005 DEFINITIVE DESIGN - GROUT FILL TKS				0	0	0	0	0	0	0	0

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ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
110011	DEFIN DESIGN - OVERFLOW LINE CRIMP										
110011.00	TECHNICAL SERVICES										
110011.0000000	***************************** DEFIN. DES. - OVERFLOW CRIMP *****************************	000	1 L/S	0	0	0	0	1210000	0	0	1210000
	AT 25% OF CONSTRUCTION										
SUBTOTAL	TECHNICAL SERVICES			0	0	0	0	1,210,000	0	0	1,210,000
TOTAL	COST CODE 00000 WBS 110011 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			0	0	0	0	1,210,000	0	0	1,210,000
TOTAL WBS 110011	DEFIN DESIGN - OVERFLOW LINE CRIMP			0	0	0	0	1,210,000	0	0	1,210,000

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ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
110012	DEFINITIVE DESIGN - 42" RISER										
110012.00	TECHNICAL SERVICES										
110012.0000000	**************************** DEFINITIVE DESIGN 42" RISER INSTALLATION ****************************	000	1 L/S	0	0	0	0	2440300	0	0	2440300
110012.0000001	25% OF DIRECT CONSTRUCTION (WBS 310012)	000	0	0	0	0	0	0	0	0	0
SUBTOTAL	TECHNICAL SERVICES			0	0	0	0	2,440,300	0	0	2,440,300
TOTAL	COST CODE 00000 WBS 110012 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			0	0	0	0	2,440,300	0	0	2,440,300
TOTAL WBS 110012 DEFINITIVE DESIGN - 42" RISER				0	0	0	0	2,440,300	0	0	2,440,300

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ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
110013	DEFINITIVE DESIGN - GROUT TUBES										
110013.00	TECHNICAL SERVICES										
110013.0000000	*************************** DEFINITIVE DESIGN GROUT TUBE PLACEMENT ***************************	000	0	0	0	0	0	0	0	0	0
110013.0000001	AT 25% OF DIRECT CONSTR. (WBS 320013)	000	1 L/S	0	0	0	0	625000	0	0	625000
SUBTOTAL	TECHNICAL SERVICES			0	0	0	0	625,000	0	0	625,000
TOTAL	COST CODE 00000 WBS 110013 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			0	0	0	0	625,000	0	0	625,000
TOTAL WBS 110013	DEFINITIVE DESIGN - GROUT TUBES			0	0	0	0	625,000	0	0	625,000

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ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
120011	ENGRG/INSPECT - OVERFLOW LINE CRIMP										
120011.00	TECHNICAL SERVICES										
120011.0000000	*****************************	000	1 L/S	0	0	0	0	484000	0	0	484000
	ENGIN./INSP - OVERFLOW CRIMP										
	****************************										
	AT 10% OF CONSTRUCTION										
SUBTOTAL	TECHNICAL SERVICES			0	0	0	0	484,000	0	0	484,000
TOTAL	COST CODE 00000			0	0	0	0	484,000	0	0	484,000
	WBS 120011										
	(ESCALATION 0.00% - CONTINGENCY 35.00 %)										
TOTAL WBS 120011	ENGRG/INSPECT - OVERFLOW LINE CRIMP			0	0	0	0	484,000	0	0	484,000

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ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
120012	ENGINEERING/INSP. - 42" RISER										
120012.00	TECHNICAL SERVICES										
120012.0000000	**************************** ENGINEERING/INSPECTION 42" RISER INSTALLATION ****************************	000	1 L/S	0	0	0	0	976100	0	0	976100
120012.0000001	AT 10% OF CONSTRUCTION (WBS 310012)	000	0	0	0	0	0	0	0	0	0
SUBTOTAL	TECHNICAL SERVICES			0	0	0	0	976,100	0	0	976,100
TOTAL	COST CODE 00000 WBS 120012 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			0	0	0	0	976,100	0	0	976,100
TOTAL WBS 120012	ENGINEERING/INSP. - 42" RISER			0	0	0	0	976,100	0	0	976,100

ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
120013	ENGRG/INSPECTION - GROUT TUBES										
120013.00	TECHNICAL SERVICES										
120013.0000000	**************************** ENGIN./INSP - GROUT TUBES **************************** AT 10% OF CONSTRUCTION	000	1 L/S	0	0	0	0	250000	0	0	250000
SUBTOTAL	TECHNICAL SERVICES			0	0	0	0	250,000	0	0	250,000
TOTAL	COST CODE 00000 WBS 120013 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			0	0	0	0	250,000	0	0	250,000
TOTAL WBS 120013	ENGRG/INSPECTION - GROUT TUBES			0	0	0	0	250,000	0	0	250,000

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** IEST - INTERACTIVE ESTIMATING **
TWRS CLOSURE FILL ALTERNATIVES - OPTION 3
PREPLACED-AGGREGATE CONCRETE STUDY ESTIMATE
DOE_R08 - ESTIMATE DETAIL BY WBS / COST CODE

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BY R.OHRT

ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
310011	CONSTRUCTION - OVERFLOW LINE CRIMP										
310011.01	GENERAL REQUIRMENTS										
310011.0100000	**************************** STEP OFF PAD ****************************	700	0	0	0	0	0	0	0	0	0
310011.0100002	ASSUME ONE MAN REQUIRED AT ALL TIMES FOR STEP OFF PAD, AND 4 MAN WORK CREW EXCEPT AS NOTED.	700	1 L/S	15970	600632	0	0	0	0	0	600632
SUBTOTAL	GENERAL REQUIRMENTS			15,970	600,632	0	0	0	0	0	600,632
TOTAL	COST CODE 70001 WBS 310011 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			15,970	600,632	0	0	0	0	0	600,632
310011.02	SITEWORK										
310011.0200000	**************************** CRIMP OFF OVERFLOW LINES ****************************	700 W	0	0	0	0	0	0	0	0	0
310011.0200002	MACHINE DIG 25' @1/1 SLOPE WITH 10'SQ BOTTOM EXPOSURE, 1325 CY EA X 87 LOCATIONS.	700 W	115275 CY	19597	851098	0	0	0	0	0	851098
310011.0200004	BREAK OUT ENCASEMENT TO EXPOSE PIPE LINE, CRIMP SHUT, ALLOW 8 MAN CREW ONE DAY EACH.	700 W	87 EA	5568	252286	0	0	0	0	0	252286
310011.0200006	BACKFILL AND COMPACT PLUS 20% SWELL.	700 W	138330 CY	41499	1802302	0	0	0	0	0	1802302
310011.0200008	ALLOWANCE FOR SPECIAL EQUIPMENT FOR CRIMPING OPERATION.	700 W	1 L/S	0	0	0	150000	0	0	0	150000
SUBTOTAL	SITEWORK	(SWP)		66,664	2,905,686	0	150,000	0	0	0	3,055,686
	SWP 30.00%			19999	871705						871705
	GENERAL FOREMAN 7.00 %			6066	264417						264417
	CONSUMABLES 6.00 %						9000				9000
	SALES TAX 8.00 %						12720		0		12720
	WAREHOUSING 16.62 %						26425				26425

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ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
TOTAL	COST CODE 70002 WBS 310011 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			92,729	4,041,809	0	198,145	0	0	0	4,239,955
TOTAL WBS 310011 CONSTRUCTION - OVERFLOW LINE CRIMP				108,699	4,642,441	0	198,145	0	0	0	4,840,587

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ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
310012	CONSTRUCTION - 42" RISER INSTALL										
310012.01	GENERAL REQUIRMENTS										
310012.0100007	*************************** SWP AND FRESH AIR SUPPORT ***************************	700	0	0	0	0	0	0	0	0	0
310012.0100010	FRESH AIR SUPPORT LABORER 80,806 MH MASK / 8 MAN CREW = 10,100 MH	700	1 L/S	10100	379861	0	0	0	0	197528	577389
310012.0100012	STEP OFF PAD, LABORER FOR 87,148 MH'S OF SWP OR MASK WORK/8 MAN CREW = 10,894 MH	700	1 L/S	10894	409723	0	0	0	0	213056	622779
SUBTOTAL	GENERAL REQUIRMENTS			20,994	789,584	0	0	0	0	410,584	1,200,168
TOTAL	COST CODE 70001 WBS 310012 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			20,994	789,584	0	0	0	0	410,584	1,200,168
310012.15	MECHANICAL										
310012.1500001	*************************** MATERIAL ***************************	700	0	0	0	0	0	0	0	0	0
310012.1500002	OFFSITE DESIGN OF CORE DRILL BASED ON ESTIMATE FROM WHC ON WEST VALLEY	700	1 L/S	0	0	0	0	300000	0	0	300000
310012.1500005	OFFSITE FAB OF EQUIPMENT BASED ON ESTIMATE FROM WHC ON WEST VALLEY	700	2 EA	0	0	0	0	500000	0	0	500000
310012.1500012	42" CORE DRILL BIT	700	64 EA	0	0	0	416000	0	0	0	416000
310012.1500014	52" CORE DRILL BIT, ASSUME 3 USES EACH.	700	22 EA	0	0	0	176000	0	0	0	176000
310012.1500016	16" CORE DRILL BIT, ASSUME 10 USES PER BIT	700	7 EA	0	0	0	31500	0	0	0	31500
310012.1500018	12" CORE DRILL BIT	700	64 EA	0	0	0	192000	0	0	0	192000
SUBTOTAL	MECHANICAL			0	0	0	815,500	800,000	0	0	1,615,500
	SALES TAX 8.00 %						65240		0		65240
	WAREHOUSING 16.62 %						135536				135536
TOTAL	COST CODE 70015 WBS 310012			0	0	0	1,016,276	800,000	0	0	1,816,276

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ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
	(ESCALATION 0.00% - CONTINGENCY 35.00 %)										
310012.15	MECHANICAL										
310012.1500062	*************************** 42" PENETRATION ***************************	700 M	0	0	0	0	0	0	0	0	0
310012.1500064	CORE DRILL 1-1/2" HOLES THROUGH HEEL PIT FLOOR & SOIL TO TANK TOP (5/RISER)	700 M	320 EA	640	24070	0	3200	0	0	12516	39786
310012.1500068	PRESSURE GROUT 1-1/2' HOLES	700 M	320 EA	640	33587	0	3200	0	0	17465	54252
310012.1500070	PERFORM 52" OUTER CASING CORE DRILL FOR CASING	700 M	64 EA	12800	671744	0	0	0	0	349307	1021051
310012.1500072	DRILL & SET ANCHOR BOLTS TO PULL CORE	700 M	64 TKS	512	26870	0	6400	0	0	13972	47242
310012.1500074	SET ANCHOR BOLT ASSY & PULL CORE	700 M	64 TKS	1024	53740	0	0	0	0	27945	81685
310012.1500078	SET CORE INTO TRUCK, HAUL TO DUMP AND DISPOSE (ASSUME THIS CORE CLEAN)	700 M	64 EA	512	22236	0	0	11200	0	11563	44999
310012.1500080	CLEAN EXCESS DEBRIS	700 M	64 TKS	1024	38513	0	0	0	0	20027	58540
310012.1500084	PERFORM 42" CORE DRILL ASSY & PLUG SUPPORT TOOL	700 M	64 EA	12800	671744	0	0	0	0	349307	1021051
310012.1500086	PULL CORE DRILL, LOWER INTO TANK BOTTOM.	700 M	64 EA	2048	107479	0	0	0	0	55889	163368
310012.1500088	DECONTAMINATE EQUIPMENT	700 M	64 EA	2560	96282	0	6400	0	0	50067	152749
310012.1500090	SET NEW 42" RISER	700 M	64 EA	3200	167936	0	32000	0	0	87327	287263
SUBTOTAL	MECHANICAL		(MASK)	37,760		0		11,200		995,385	
					1,914,201		51,200		0		2,971,986
	SWP 100.00%			37760	1914201						1914201
	GENERAL FOREMAN 7.00 %			5286	267988						267988
	CONSUMABLES 6.00 %						3072				3072
	SALES TAX 8.00 %						4341		0		4341
	WAREHOUSING 25.77 %						13985				13985
	OH&P (ON MARKUPS ONLY)									1134738	1134738
TOTAL	COST CODE 70015			80,806		0		11,200		2,130,123	
	WBS 310012				4,096,390		72,599		0		6,310,313
	(ESCALATION 0.00% - CONTINGENCY 35.00 %)										
310012.15	MECHANICAL										
310012.1500100	*************************** CORE DRILLS COOLING	700 W	0	0	0	0	0	0	0	0	0

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ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
	***************************										
310012.1500102	ALLOWANCE FOR WATER FOR CORE DRILLING	700 W	64 EA	5120	268698	0	128000	0	0	0	396698
SUBTOTAL	MECHANICAL		(SWP)	5,120		0		0		0	
					268,698		128,000		0		396,698
	SWP 30.00%			1536	80609						80609
	GENERAL FOREMAN 7.00 %			465	24451						24451
	CONSUMABLES 6.00 %						7680				7680
	SALES TAX 8.00 %						10854		0		10854
	WAREHOUSING 16.62 %						22550				22550
TOTAL	COST CODE 70015			7,121		0		0		0	
	WBS 310012				373,758		169,084		0		542,843
	(ESCALATION 0.00% - CONTINGENCY 35.00 %)										
TOTAL WBS 310012	CONSTRUCTION - 42" RISER INSTALL			108,922		0		811,200		2,540,707	
					5,259,733		1,257,960		0		9,869,600

ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
320001	CONSTRUCTION - INFRASTRUCTURE										
320001.01	GENERAL REQUIRMENTS										
320001.0100000	***************************** INFRASTRUCTURE - INDIRECTS *****************************	460	0	0	0	0	0	0	0	0	0
320001.0100002	TRAILER OFFICES, PURCHASED AND INSTALED IN 200 EAST AND 200 WEST.	460	4 EA	240	9914	0	40000	0	0	15189	65103
320001.0100004	TEMPORARY POWER.	460	1 L/S	2000	82620	0	40000	0	0	37313	159933
320001.0100006	SMALL TOOLS - ALLOWED AT $1.25/MH	460	1 L/S	0	0	0	104250	0	0	31723	135973
320001.0100008	FUELS (ALLOW)	460	1 L/S	0	0	0	25000	0	0	7608	32608
320001.0100010	SUPERVISION OF CONSTRUCTION, BASED ON 17,000 HOURS AT $57.11/HR.	460	1 L/S	17000	970870	0	0	0	0	295436	1266306
SUBTOTAL	GENERAL REQUIRMENTS			19,240	1,063,404	0	209,250	0	0	387,269	1,659,923
TOTAL	COST CODE 46001 WBS 320001 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			19,240	1,063,404	0	209,250	0	0	387,269	1,659,923
320001.10	SPECIALTIES										
320001.1000000	***************************** AGGREGATE SCREENING FACILITY *****************************	460	0	0	0	0	0	0	0	0	0
320001.1000002	SCREEN DEVICES (VIBRATING)	460	1 EA	0	0	0	0	60000	0	18258	78258
320001.1000004	CONVEYORS	460	2 EA	0	0	0	0	13300	0	4047	17347
320001.1000006	LOADING HOPPERS AND MISC.	460	1 EA	0	0	0	0	4000	0	1217	5217
320001.1000100	***************************** GROUT BATCH PLANT *****************************	460	0	0	0	0	0	0	0	0	0
320001.1000102	INSTALL ONE BATCH PLANT FACILITY WITH 150 CY/HR CAPACITY, W/COMPUTERIZED BATCH CONTROLS, SCALES, A	460	1 EA	0	0	0	415000	0	0	126285	541285
320001.1000103	DUST CONTROL SYSTEM, SILOS FOR CEMENT AND FLY ASH, AN AGGREGATE BIN, WATER HEATER, 10CY MIXER AND HOPPER.	460	0	0	0	0	0	0	0	0	0

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ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
320001.1000104	CONCRETE PUMP W/150 CY/HR CAPACITY.	460	1 EA	0	0	0	250000	0	0	76075	326075
320001.1000106	PUMPLINE COST AT $15,000 WITH REPLACEMENTS EACH 150,000 CY (ASSUME 3 TIMES) = $45,000.	460	1 EAT	0	0	0	0	45000	0	13694	58694
SUBTOTAL	SPECIALTIES			0	0	0	665,000	122,300	0	239,576	1,026,876
TOTAL	COST CODE 46010 WBS 320001 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			0	0	0	665,000	122,300	0	239,576	1,026,876
320001.14	CONVEYING SYSTEMS										
320001.1400000	*************************** AGGREGATE DISTRIBUTION SYS. ONE FOR 200E, ONE FOR 200W ***************************	460	0	0	0	0	0	0	0	0	0
320001.1400002	CONVEYORS, HORIZONTAL	460	184 EA	0	0	0	0	1472000	0	447930	1919930
320001.1400003	CONVEYORS, INCLINED	460	28 EA	0	0	0	0	196000	0	59643	255643
320001.1400004	OTHER EQUIPMENT INCLUDING SPARE BELTS (ALLOW)	460	1 L/S	0	0	0	0	100000	0	30430	130430
320001.1400006	STEEL ROAD CROSSING STRUCTURES	460	56 TON	2240	92534	0	78400	0	0	52015	222949
320001.1400008	FINAL LEGS AT TANKS	460	4 EA	200	8262	0	26600	0	0	10609	45471
320001.1400010	DISCONNECT FOR MOVING TO NEXT TANK	460	160 EA	16000	660960	0	0	0	0	201130	862090
320001.1400100	*************************** AGGREGATE SLINGERS ***************************	460	0	0	0	0	0	0	0	0	0
320001.1400102	MOBILE TRAILER UNIT WITH CONTROL PANEL AND 440V MOTORS, ALLOWANCE.	460	2 EA	0	0	0	0	1000000	0	304300	1304300
320001.1400104	OTHER ASSOCIATED EQUIPMENT AND INSTALLATION, SPARE BELTS, ALLOWANCE.	460	18 SET	12600	520506	0	307964	1800000	0	799843	3428313
320001.1400106	BELT CHANGING LABOR	460	644 EA	19320	798109	0	0	0	0	242865	1040974
SUBTOTAL	CONVEYING SYSTEMS			50,360	2,080,371	0	412,964	4,568,000	0	2,148,765	9,210,100
TOTAL	COST CODE 46014 WBS 320001			50,360	2,080,371	0	412,964	4,568,000	0	2,148,765	9,210,100

ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
	(ESCALATION 0.00% - CONTINGENCY 35.00 %)										
320001.15	MECHANICAL										
320001.1500000	*************************** FILTRATION UNITS ***************************	460	0	0	0	0	0	0	0	0	0
320001.1500002	ASSUMED ONE HEPA FILTER UNIT LOCATED IN EACH TANK FARM, ALLOWANCE.	460	18 EA	0	0	0	0	270000	0	82161	352161
320001.1500004	HEPA FILTERS, ALLOWANCE.	460	1 L/S	0	0	0	66000	0	0	20084	86084
320001.1500010	CYCLONE SEPARATORS, 2 FOR EAST AND 2 FOR WEST, ALLOWANCE.	460	4 EA	4000	165240	0	80000	0	0	74627	319867
320001.1500100	*************************** INSTRUMENTATION ***************************	460	0	0	0	0	0	0	0	0	0
320001.1500102	MONITOR PANEL, ALLOWANCE	460	18 EA	720	29743	0	90000	0	0	36438	156181
320001.1500104	INSTRUMENTS, ASSUMED 5 PER TANK TO MEASURE COMPACTION, DENSITY, LEVEL, VISUAL AND MAPPING, ALLOWANCE.	460	885 EA	8850	365594	0	88500	0	0	138181	592275
320001.1500106	WIRING AND CONNECTIONS	460	885 EA	1770	73119	0	0	0	0	22250	95369
SUBTOTAL	MECHANICAL			15,340	633,696	0	324,500	270,000	0	373,741	1,601,937
TOTAL	COST CODE 46015 WBS 320001 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			15,340	633,696	0	324,500	270,000	0	373,741	1,601,937
TOTAL WBS 320001 CONSTRUCTION - INFRASTRUCTURE				84,940	3,777,471	0	1,611,714	4,960,300	0	3,149,351	13,498,836

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ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
320002	CONSTRUCTION - GRAVEL FILL										
320002.01	GENERAL REQUIRMENTS										
320002.0100000	**************************** AGGREGATE FILL - INDIRECTS ****************************	460	0	0	0	0	0	0	0	0	0
320002.0100002	WATER, 8,580,000 GALLONS AT $.02/GAL.	460	1 L/S	0	0	0	171600	0	0	52218	223818
320002.0100004	GASOLINE, FOR PICKUPS	460	107380 GAL	0	0	0	123487	0	0	37577	161064
320002.0100006	SMALL TOOLS AND CONSUMABLES AT $1.25 PER MANHOUR	460	1 L/S	0	0	0	117500	0	0	35755	153255
320002.0100010	SUPERVISION	460	1 L/S	36000	2055960	0	0	0	0	625629	2681589
320002.0100020	**************************** AGGREGATE FILL - INDIRECTS ESCALATION ****************************	460	1 L/S	0	0	0	0	145200	0	0	145200
320002.0100022	ESCALATES PRICES FROM 1994 TO 1996 (5.88%) FOR INDIRECT PORTION OF ESTIMATE.	460	0	0	0	0	0	0	0	0	0
SUBTOTAL	GENERAL REQUIRMENTS			36,000	2,055,960	0	412,587	145,200	0	751,179	3,364,926
TOTAL	COST CODE 46001 WBS 320002 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			36,000	2,055,960	0	412,587	145,200	0	751,179	3,364,926
320002.03	CONCRETE										
320002.0300000	**************************** AGGREGATE FILL- CONSTRUCTION ****************************	460	0	0	0	0	0	0	0	0	0
320002.0300002	TANK STABILIZATION FILL	460	0	0	0	0	0	0	0	0	0
320002.0300004	GRAVEL	460	756000 CM	0	0	0	16632000	0	0	5061118	21693118
320002.0300020	LABOR - RADIATION WORKER	460	1 L/S	65000	2685150	0	0	0	0	817091	3502241
320002.0300030	**************************** AGGREGATE FILL - CONSTR. ESCALATION ****************************	460	1 L/S	0	0	0	0	1142487	0	0	1142487
320002.0300032	ESCALATES PRICES FROM 1994 TO 1996 (5.88%) FOR CONSTRUCTION PORTION OF ESTIMATE.	460	0	0	0	0	0	0	0	0	0
SUBTOTAL	CONCRETE			65,000	2,685,150	0	16,632,000	1,142,487	0	5,878,209	26,337,846

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ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
TOTAL	COST CODE 46003 WBS 320002 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			65,000	2,685,150	0	16,632,000	1,142,487	0	5,878,209	26,337,846
TOTAL WBS 320002 CONSTRUCTION - GRAVEL FILL				101,000	4,741,110	0	17,044,587	1,287,687	0	6,629,388	29,702,772

ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
320003	CONSTRUCTION - ANCILLARY GROUT FILL										
320003.01	GENERAL REQUIRMENTS										
320003.0100000	**************************** ANCILLARY GROUT - INDIRECTS **************************** PER P.T. & C. ESTIMATE	460	0	0	0	0	0	0	0	0	0
320003.0100002	SUPERVISION	460	1 L/S	630	35979	0	0	0	0	10948	46927
320003.0100004	**************************** ANCILLARY GROUT - INDIRECTS ESCALATION ****************************	460	1 L/S	0	0	0	0	1580	0	0	1580
320003.0100006	ESCALATES PRICES FROM 1994 TO 1996 (5.88%) FOR INDIRECT PORTION OF ESTIMATE. PER P.T. & C. ESTIMATE	460	0	0	0	0	0	0	0	0	0
SUBTOTAL	GENERAL REQUIRMENTS			630	35,979	0	0	1,580	0	10,948	48,507
TOTAL	COST CODE 46001 WBS 320003 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			630	35,979	0	0	1,580	0	10,948	48,507
320003.03	CONCRETE										
320003.0300000	**************************** AMCILLARY FILL- CONSTRUCTION **************************** PER P.T. & C. ESTIMATE	460	0	0	0	0	0	0	0	0	0
320003.0300002	ANCILLARY EQUIPMENT STABIL-IZATION, SINGLE SHELL TANKS, 10,500 CM OF GROUT FILL.	460	0	0	0	0	0	0	0	0	0
320003.0300004	CEMENT	460	94500 KG	0	0	0	13230	0	0	4026	17256
320003.0300006	SAND	460	4900 CM	0	0	0	90650	0	0	27585	118235
320003.0300008	FLY ASH	460	850500 KG	0	0	0	34020	0	0	10352	44372
320003.0300012	ANCILLARY EQUIPMENT STABIL-IZATION, DOUBLE SHELL TANKS, 7,900 CM OF GROUT FILL.	460	0	0	0	0	0	0	0	0	0
320003.0300014	CEMENT	460	86000 KG	0	0	0	12040	0	0	3664	15704
320003.0300016	SAND	460	4450 CM	0	0	0	82325	0	0	25051	107376
320003.0300018	FLY ASH	460	771850 KG	0	0	0	30874	0	0	9395	40269
320003.0300020	LABOR, RADIATION WORKER	460	1 L/S	1260	52051	0	0	0	0	15839	67890

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320003.0300022	LABOR, NON-RADIATION WORKER	460	1 L/S	1300	53703	0	0	0	0	16342	70045
320003.0300030	**************************** GROUT FILL - CONSTRUCTION ESCALATION ****************************	460	1 L/S	0	0	0	0	28160	0	0	28160
320003.0300032	ESCALATES PRICES FROM 1994 TO 1996 (5.88%) FOR CONSTR-UCTION PORTION OF ESTIMATE.	460	0	0	0	0	0	0	0	0	0
SUBTOTAL	CONCRETE			2,560	105,754	0	263,139	28,160	0	112,254	509,307
TOTAL	COST CODE 46003 WBS 320003 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			2,560	105,754	0	263,139	28,160	0	112,254	509,307
TOTAL WBS 320003 CONSTRUCTION - ANCILLARY GROUT FILL				3,190	141,733	0	263,139	29,740	0	123,202	557,814

ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
320004	CONSTRUCTION - BARRIER CAP										
320004.02	SITEWORK										
320004.0200000	*************************** BARRIER CAPS - CONSTRUCTION ***************************	460	0	0	0	0	0	0	0	0	0
320004.0200002	TX FARM	460	1 L/S	0	0	0	0	7414000	0	2852166	10266166
320004.0200004	U FARM	460	1 L/S	0	0	0	0	5565800	0	2141163	7706963
320004.0200006	C FARM	460	1 L/S	0	0	0	0	5807300	0	2234068	8041368
320004.0200008	SX FARM	460	1 L/S	0	0	0	0	5836100	0	2245148	8081248
320004.0200010	BY FARM	460	1 L/S	0	0	0	0	4840900	0	1862294	6703194
320004.0200012	B FARM	460	1 L/S	0	0	0	0	5688500	0	2188366	7876866
320004.0200014	BX FARM	460	1 L/S	0	0	0	0	4784500	0	1840597	6625097
320004.0200016	A FARM	460	1 L/S	0	0	0	0	2858200	0	1099550	3957750
320004.0200018	TY FARM	460	1 L/S	0	0	0	0	2885600	0	1110090	3995690
320004.0200020	AX FARM	460	1 L/S	0	0	0	0	2181000	0	839031	3020031
320004.0200022	T FARM	460	1 L/S	0	0	0	0	5688500	0	2188366	7876866
320004.0200024	S FARM	460	1 L/S	0	0	0	0	4891600	0	1881799	6773399
320004.0200026	AN FARM	460	1 L/S	0	0	0	0	4045000	0	1556112	5601112
320004.0200028	AZ FARM	460	1 L/S	0	0	0	0	1410600	0	542658	1953258
320004.0200030	AY FARM	460	1 L/S	0	0	0	0	1410600	0	542658	1953258
320004.0200032	AP FARM	460	1 L/S	0	0	0	0	3742200	0	1439624	5181824
320004.0200034	AW FARM	460	1 L/S	0	0	0	0	3007100	0	1156831	4163931
320004.0200036	SY FARM	460	1 L/S	0	0	0	0	2239600	0	861574	3101174
320004.0200038	LLW VAULTS	460	1 L/S	0	0	0	0	20272500	0	7798831	28071331
SUBTOTAL	SITEWORK			0	0	0	0	94,569,600	0	36,380,926	130,950,526
TOTAL	COST CODE 46002 WBS 320004 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			0	0	0	0	94,569,600	0	36,380,926	130,950,526
TOTAL WBS 320004 CONSTRUCTION - BARRIER CAP				0	0	0	0	94,569,600	0	36,380,926	130,950,526

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320005	CONSTRUCTION - GROUT FILL TANKS										
320005.01	GENERAL REQUIRMENTS										
320005.0100000	*************************** GROUT FILL TANKS - INDIRECTS ***************************	460	0	0	0	0	0	0	0	0	0
320005.0100002	WATER, 9,000,000 GALLONS AT $.02/GAL.	460	1 L/S	0	0	0	81000	0	0	24648	105648
320005.0100004	GASOLINE FOR PICKUPS	460	48320 GAL	0	0	0	55568	0	0	16909	72477
320005.0100006	SMALL TOOLS AND CONSUMABLES AT $1.25/MANHOUR.	460	1 L/S	0	0	0	52900	0	0	16097	68997
320005.0100008	SUPERVISION	460	1 L/S	16200	925198	0	0	0	0	281538	1206736
320005.0100020	*************************** GROUT FILL TANKS - INDIRECTS ESCALATION ***************************	460	1 L/S	0	0	0	0	65540	0	0	65540
320005.0100022	ESCALATES PRICES FROM 1994 TO 1996 (5.88%) FOR INDIRECT PORTION OF ESTIMATE.	460	0	0	0	0	0	0	0	0	0
SUBTOTAL	GENERAL REQUIRMENTS			16,200	925,198	0	189,468	65,540	0	339,192	1,519,398
	SALES TAX 8.00 %						15157		0		15157
	OH&P (ON MARKUPS ONLY)									4612	4612
TOTAL	COST CODE 46001 WBS 320005 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			16,200	925,198	0	204,625	65,540	0	343,804	1,539,167
320005.03	CONCRETE										
320005.0300000	*************************** GROUT FILL TANKS - CONSTR. ***************************	460	0	0	0	0	0	0	0	0	0
320005.0300002	MATERIAL COSTS FOR 450,000 CUBIC YARDS OF GROUT:	460	0	0	0	0	0	0	0	0	0
320005.0300004	API CLASS H CEMENT @ 300 LB/CY AND $83/TON	460	1 L/S	0	0	0	5600000	0	0	1704080	7304080
320005.0300006	ASTM CLASS F FLY ASH, 1112 LB/CY AND $48.60/TON	460	1 L/S	0	0	0	12159700	0	0	3700197	15859897
320005.0300008	NATURAL FINE AGGREGATE 1314 LB/CY AND $8.00/TON	460	1 L/S	0	0	0	2365200	0	0	719730	3084930
320005.0300010	SODIUM BENTONITE CLAY, 38 LB/CY AND $110.00/TON	460	1 L/S	0	0	0	940500	0	0	286194	1226694

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320005.0300012	HIGH-RANGE WATER REDUCING ADMIXTURE (DAXD19) AT 4.5 OZ/CY AND $5.00/GAL. (15,840 GAL.)	460	1 L/S	0	0	0	79200	0	0	24101	103301
320005.0300020	LABOR, ASSUME 8 MEN RUNNING OPERATION W/150 CY/HR OUTPUT FOR 6 HR/DAY (4500 CY/WK AND 320 MH/WK), 450,000 CY =	460	1 L/S	32128	1327208	0	0	0	0	403869	1731077
320005.0300022	100.4 WKS X 320 MH = 32128 MHS.	460	0	0	0	0	0	0	0	0	0
320005.0300032	***************************** GROUT FILL TKS- CONSTRUCTION ESCALATION *****************************	460	0	0	0	0	0	0	0	0	0
320005.0300034	ESCALATES PRICES FROM 1994 TO 1996 (5.88%) FOR CONSTR-UCTION PORTION OF ESTIMATE, LABOR ONLY, MATERIAL COSTS	460	1 L/S	0	0	0	0	78000	0	0	78000
320005.0300036	WERE CURRENT.	460	0	0	0	0	0	0	0	0	0
SUBTOTAL	CONCRETE			32,128	1,327,208	0	21,144,600	78,000	0	6,838,171	29,387,979
	SALES TAX 8.00 %						1691568		0		1691568
	OH&P (ON MARKUPS ONLY)									514744	514744
TOTAL	COST CODE 46003 WBS 320005 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			32,128	1,327,208	0	22,836,168	78,000	0	7,352,915	31,594,291
TOTAL WBS 320005 CONSTRUCTION - GROUT FILL TANKS				48,328	2,252,406	0	23,040,793	143,540	0	7,696,719	33,133,458

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320013	CONSTRUCTION - GROUT TUBES										
320013.15	MECHANICAL										
320013.1500000	**************************** CONSTRUCTION GROUT TUBE PLACEMENT ****************************	700	0	0	0	0	0	0	0	0	0
320013.1500002	PER GROUT ESTIMATE BY DON MOAK OF WATER DEVELOPEMENT HANFORD, DATED 7/19/96. INCLUDES MOBILIZATION TO	700	1 L/S	0	0	0	0	2500000	0	0	2500000
320013.1500004	FARM AND BETWEEN TANKS, 133 TANKS, 6 HOLES EACH - 50 FT DEEP.	700	0	0	0	0	0	0	0	0	0
SUBTOTAL	MECHANICAL			0	0	0	0	2,500,000	0	0	2,500,000
TOTAL	COST CODE 70015 WBS 320013 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			0	0	0	0	2,500,000	0	0	2,500,000
TOTAL WBS 320013 CONSTRUCTION - GROUT TUBES				0	0	0	0	2,500,000	0	0	2,500,000

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321001	SUBCONTRACT MPR - INFRASTRUCTURE										
321001.15	MECHANICAL										
321001.1500000	**************************** INFRASTRUCTURE - SUB. MPR ****************************	460	0	0	0	0	0	0	0	0	0
321001.1500001	BASED ON 3% OF WBS 110001, 320001 AND 322001.	460	1 L/S	0	0	0	0	437405	0	0	437405
SUBTOTAL	MECHANICAL			0	0	0	0	437,405	0	0	437,405
TOTAL	COST CODE 46015 WBS 321001 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			0	0	0	0	437,405	0	0	437,405
TOTAL WBS 321001 SUBCONTRACT MPR - INFRASTRUCTURE				0	0	0	0	437,405	0	0	437,405

ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
321002	SUBCONTRACT MPR - GRAVEL FILL										
321002.03	CONCRETE										
321002.0300000	**************************** GRAVEL FILL - SUBCONTR. MPR ****************************	460	0	0	0	0	0	0	0	0	0
321002.0300001	BASED ON 3% OF WBS 110002 AND 320002.	460	1 L/S	0	0	0	0	960212	0	0	960212
SUBTOTAL	CONCRETE			0	0	0	0	960,212	0	0	960,212
TOTAL	COST CODE 46003 WBS 321002 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			0	0	0	0	960,212	0	0	960,212
TOTAL WBS 321002 SUBCONTRACT MPR - GRAVEL FILL				0	0	0	0	960,212	0	0	960,212

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321003	SUBCONTRACT MPR - ANCILLARY GROUT										
321003.03	CONCRETE										
321003.0300000	**************************** ANCILLARY GROUT - SUB. MPR ****************************	460	0	0	0	0	0	0	0	0	0
321003.0300001	BASED ON 3% OF WBS 110003 AND 320003.	460	1 L/S	0	0	0	0	23450	0	0	23450
SUBTOTAL	CONCRETE			0	0	0	0	23,450	0	0	23,450
TOTAL	COST CODE 46003 WBS 321003 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			0	0	0	0	23,450	0	0	23,450
TOTAL WBS 321003 SUBCONTRACT MPR - ANCILLARY GROUT				0	0	0	0	23,450	0	0	23,450

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321004	SUBCONTRACT MPR - BARRIER CAP										
321004.02	SITEWORK										
321004.0200100	**************************** BARRIER - SUBCONTRACTOR MPR ****************************	460	0	0	0	0	0	0	0	0	0
321004.0200101	BASED ON 3% OF WBS 320004 AND 500004.	460	1 L/S	0	0	0	0	4105959	0	0	4105959
SUBTOTAL	SITEWORK			0	0	0	0	4,105,959	0	0	4,105,959
TOTAL	COST CODE 46002 WBS 321004 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			0	0	0	0	4,105,959	0	0	4,105,959
TOTAL WBS 321004 SUBCONTRACT MPR - BARRIER CAP				0	0	0	0	4,105,959	0	0	4,105,959

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321005	SUBCONTRACT MPR - GROUT FILL TANKS										
321005.03	CONCRETE										
321005.0300100	**************************** GROUT FILL TANKS SUBCONTRACTOR MPR ****************************	460	0	0	0	0	0	0	0	0	0
321005.0300101	BASED ON 3% OF WBS 320005	460	1 L/S	0	0	0	0	994000	0	0	994000
SUBTOTAL	CONCRETE			0	0	0	0	994,000	0	0	994,000
TOTAL	COST CODE 46003 WBS 321005 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			0	0	0	0	994,000	0	0	994,000
TOTAL WBS 321005 SUBCONTRACT MPR - GROUT FILL TANKS				0	0	0	0	994,000	0	0	994,000

ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
322001	PROJECT MANAGEMENT - INFRASTRUCTURE										
322001.19	PROJECT MANAGEMENT										
322001.1900000	*************************** CONSTRUCTION MANAGEMENT INFRASTRUCTURE ***************************	060	1 L/S	0	0	0	0	2160028	0	657297	2817325
322001.1900001	BASED ON 20% OF CONSTRUCTION	060	0	0	0	0	0	0	0	0	0
SUBTOTAL	PROJECT MANAGEMENT			0	0	0	0	2,160,028	0	657,297	2,817,325
TOTAL	COST CODE 06019 WBS 322001 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			0	0	0	0	2,160,028	0	657,297	2,817,325
TOTAL WBS 322001	PROJECT MANAGEMENT - INFRASTRUCTURE			0	0	0	0	2,160,028	0	657,297	2,817,325

ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
322004	PROJ/CONSTR MGMT - BARRIER CAP										
322004.19	PROJECT MANAGEMENT										
322004.1900000	**************************** PROJECT MGMT & CONSTRUCTION MANAGEMENT - BARRIER CAP ****************************	060	1 L/S	0	0	0	0	21145687	0	0	21145687
322004.1900001	BASED ON 15% OF WBS 320004, 321004 AND 500004.	060	0	0	0	0	0	0	0	0	0
SUBTOTAL	PROJECT MANAGEMENT			0		0		21,145,687		0	
					0		0		0		21,145,687
TOTAL	COST CODE 06019 WBS 322004 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			0		0		21,145,687		0	
					0		0		0		21,145,687
TOTAL WBS 322004	PROJ/CONSTR MGMT - BARRIER CAP			0		0		21,145,687		0	
					0		0		0		21,145,687

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500004	WHC PROJ MGMT - BARRIER CAP										
500004.9000000	*************************** WHC PROJECT MANAGEMENT BARRIER CAP ***************************	060	1 L/S	0	0	0	0	5912400	0	0	5912400
500004.9000001	APPLIED AT 4.5% OF WBS 320004.	060	0	0	0	0	0	0	0	0	0
TOTAL WBS 500004 WHC PROJ MGMT - BARRIER CAP				0	0	0	0	5,912,400	0	0	5,912,400

ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
500011	WHC PROJ MGMT - OVERFLOW LINE CRIMP										
500011.9000000	**************************** WHC PROJECT MANAGEMENT CRIMP OFF OVERFLOW LINES ****************************	060	0	0	0	0	0	0	0	0	0
500011.9000001	APPLIED AT 15% OF CONSTR.	060	1 L/S	0	0	0	0	726000	0	0	726000
TOTAL WBS 500011 WHC PROJ MGMT - OVERFLOW LINE CRIMP				0	0	0	0	726,000	0	0	726,000

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ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
500012	WHC PROJ MGMT - 42" RISER INSTALL										
500012.00	TECHNICAL SERVICES										
500012.0000005	WHC PROJECT MANAGEMENT 15% OF DIRECT CONSTR.	700	1 LS	0	0	0	0	997000	0	0	997000
SUBTOTAL	TECHNICAL SERVICES			0	0	0	0	997,000	0	0	997,000
TOTAL	COST CODE 70000 WBS 500012 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			0	0	0	0	997,000	0	0	997,000
TOTAL WBS 500012 WHC PROJ MGMT - 42" RISER INSTALL				0	0	0	0	997,000	0	0	997,000

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FILE NO. Z407SAA3

** IEST - INTERACTIVE ESTIMATING **
TWRS CLOSURE FILL ALTERNATIVES - OPTION 3
PREPLACED-AGGREGATE CONCRETE STUDY ESTIMATE
DOE_R08 - ESTIMATE DETAIL BY WBS / COST CODE

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BY R.OHRT

ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
500013	WHC PROJ MGMT - GROUT TUBES										
500013.9000000	***************************** WHC PROJECT MANAGEMENT GROUT TUBE PLACEMENT *****************************	060	0	0	0	0	0	0	0	0	0
500013.9000005	WHC PROJECT MANAGEMENT 15% OF DIRECT CONSTR. GROUT TUBE PLACEMENT	060	1 L/S	0	0	0	0	375000	0	0	375000
TOTAL WBS 500013 WHC PROJ MGMT - GROUT TUBES				0	0	0	0	375,000	0	0	375,000

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DOE_R08 - ESTIMATE DETAIL BY WBS / COST CODE

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ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
REPORT TOTAL				651,014	32,483,139	0	43,578,341	148,725,098	0	60,777,534	285,564,113

ALTERNATIVE 4: CONCRETE FILL

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** IEST - INTERACTIVE ESTIMATING **
TWRS CLOSURE FILL ALTERNATIVES - OPTION 4
CONCRETE FILL STUDY ESTIMATE
DOE_R01 - PROJECT COST SUMMARY

DATE 08/13/96 10:02:10
BY R.OHRT

COST CODE	DESCRIPTION	ESCALATED TOTAL COST	CONTINGENCY %	CONTINGENCY TOTAL	TOTAL DOLLARS
000	ENGINEERING	18,260,000	35	6,390,000	24,650,000
060	PROJECT MANAGEMENT	28,900,000	35	10,110,000	39,010,000
460	IMPROVEMENTS TO LAND	203,920,000	35	71,370,000	275,290,000
700	SPECIAL EQUIP/PROCESS SYSTEMS	4,840,000	35	1,690,000	6,530,000
	(ADJUSTED TO MEET DOE 5100.4)	<20,000>		40,000	20,000
	PROJECT TOTAL	255,900,000	35	89,600,000	345,500,000

TYPE OF ESTIMATE	STUDY ESTIMATE	AUGUST 13, 1996
ARCHITECT ENGINEER	[signature]	
OPERATING CONTRACTOR	[signature]	8/14/96

REMARKS:

(ROUNDED/ADJUSTED TO THE NEAREST " 10,000 / 100,000 " - PERCENTAGES NOT RECALCULATED TO REFLECT ROUNDING)

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** IEST - INTERACTIVE ESTIMATING **
TWRS CLOSURE FILL ALTERNATIVES - OPTION 4
CONCRETE FILL STUDY ESTIMATE
DOE_R02 - WORK BREAKDOWN STRUCTURE SUMMARY

DATE 08/13/96 10:02:14
BY R.OHRT

WBS	DESCRIPTION	ESTIMATE SUBTOTAL	ONSITE INDIRECTS	SUB TOTAL	ESCALATION %	ESCALATION TOTAL	SUB TOTAL	CONTINGENCY %	CONTINGENCY TOTAL	TOTAL DOLLARS
110001	DEFINITIVE DESIGN - INFRASTRUCTURE	1066500	0	1066500	0.00	0	1066500	35	373275	1439775
110002	DEFINITIVE DESIGN - GROUT TANKS	15360300	0	15360300	0.00	0	15360300	35	5376105	20736405
110003	DEFINITIVE DESIGN - ANCILLARY GROUT	138729	0	138729	0.00	0	138729	35	48555	187284
110011	DEFIN DESIGN - OVERFLOW LINE CRIMP	1210000	0	1210000	0.00	0	1210000	35	423500	1633500
SUBTOTAL 11	DEFINITIVE DESIGN	17775529	0	17775529	0.00	0	17775529	35	6221435	23996964
120011	ENGRG/INSPECT - OVERFLOW LINE CRIMP	484000	0	484000	0.00	0	484000	35	169400	653400
SUBTOTAL 12	ENGINEERING/INSPECTION	484000	0	484000	0.00	0	484000	35	169400	653400
SUBTOTAL 1	ENGINEERING	18259529	0	18259529	0.00	0	18259529	35	6390835	24650364
310011	CONSTRUCTION - OVERFLOW LINE CRIMP	4840587	0	4840587	0.00	0	4840587	35	1694205	6534792
SUBTOTAL 31	FA CONST-ONSITE E/C	4840587	0	4840587	0.00	0	4840587	35	1694205	6534792
320001	CONSTRUCTION - INFRASTRUCTURE	4266172	0	4266172	0.00	0	4266172	35	1493160	5759332
320002	CONSTRUCTION - CONCRETE FILL TANKS	61441058	0	61441058	0.00	0	61441058	35	21504370	82945428
320003	CONSTRUCTION - ANCILLARY GROUT	557814	0	557814	0.00	0	557814	35	195234	753048
320004	CONSTRUCTION - BARRIER CAP	130950526	0	130950526	0.00	0	130950526	35	45832684	176783210
321001	SUBCONTRACT MPR - INFRASTRUCTURE	267000	0	267000	0.00	0	267000	35	93450	360450
321002	SUBCONTR. MPR - CONCRETE FILL TANKS	2304000	0	2304000	0.00	0	2304000	35	806400	3110400
321003	SUBCONTRACT MPR - ANCILLARY GROUT	23450	0	23450	0.00	0	23450	35	8208	31658
321004	SUBCONTRACT MPR - BARRIER CAP	4105959	0	4105959	0.00	0	4105959	35	1437086	5543045
322001	PROJECT MANAGEMENT - INFRASTRUCTURE	1112873	0	1112873	0.00	0	1112873	35	389506	1502379
322004	PROJ/CONSTR MGMT - BARRIER CAP	21145687	0	21145687	0.00	0	21145687	35	7400990	28546677
SUBTOTAL 32	CONSTRUCTION-FIXED PRICE	226174539	0	226174539	0.00	0	226174539	35	79161088	305335627
SUBTOTAL 3	CONSTRUCTION	231015126	0	231015126	0.00	0	231015126	35	80855293	311870419
500004	WHC PROJ MGMT - BARRIER CAP	5912400	0	5912400	0.00	0	5912400	35	2069340	7981740
500011	WHC PROJ MGMT - OVERFLOW LINE CRIMP	726000	0	726000	0.00	0	726000	35	254100	980100
SUBTOTAL 5	OTHER PROJECT COST	6638400	0	6638400	0.00	0	6638400	35	2323440	8961840

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** IEST - INTERACTIVE ESTIMATING **
TWRS CLOSURE FILL ALTERNATIVES - OPTION 4
CONCRETE FILL STUDY ESTIMATE
DOE_R02 - WORK BREAKDOWN STRUCTURE SUMMARY

DATE 08/13/96 10:02:15
BY R.OHRT

WBS	DESCRIPTION	ESTIMATE SUBTOTAL	ONSITE INDIRECTS	SUB TOTAL	ESCALATION %	ESCALATION TOTAL	SUB TOTAL	CONTINGENCY %	CONTINGENCY TOTAL	TOTAL DOLLARS
PROJECT TOTAL		255,913,055	0	255,913,055	0.00	0	255,913,055	35	89,569,568	345,482,623

1. DOCUMENTS AND DRAWINGS

DOCUMENTS: PROJECT TIME AND COSTS SPREAD SHEET ESTIMATE, DATED 5/24/96, ICF KAISER HANFORD STUDY ESTIMATE #W340SAA1, DATED 01/12/94, STATEMENT OF WORK DRAFT.

DRAWINGS: NONE

2. MATERIAL PRICES

UNIT COSTS REPRESENT CURRENT PRICES FOR SPECIFIED MATERIAL.

3. LABOR RATES

A.) ICF-KH HOURLY RATES ARE BASED ON THE 1996 FISCAL YEAR BUDGET LIQUIDATION RATES AS ISSUED BY KEH FINANCE (EFFECTIVE 10-17-95). SEE ALSO THE FY 1996 PLANNING RATES * (REPORT BGHB2000 & BGHB2005).
B.) WHC HOURLY RATES ARE BASED UPON THE FY 1996 PLANNING RATES * (REPORT BGHB2001).
C.) IRM HOURLY RATES ARE BASED UPON THE FY 1996 PLANNING RATES * (REPORT BGHB7008).
D.) BASE CRAFT RATES ARE AS ISSUED BY KEH FINANCE (EFFECTIVE 10-17-95). RATES INCLUDE FRINGE BENEFITS, LABOR INSURANCE, TAXES DEPARTMENT OVERHEADS, G&A AND SWS, AND TRAVEL WHERE APPLICABLE, PER HANFORD SITE STABILIZATION AGREEMENT, APPENDIX "A".
* SEE HANFORD SOFT REPORTING, FDS BUDGET GUIDELINE HANDBOOK, SECTION 2 - COMPANY INFORMATION, FY 1996 PLANNING RATES.

4. GENERAL REQUIREMENTS/TECHNICAL SERVICES/OVERHEADS

A.) ONSITE CONSTRUCTION FORCES GENERAL REQUIREMENTS, TECHNICAL SERVICES AND CRAFT OVERHEAD COSTS ARE INCLUDED AS A COMPOSITE PERCENTAGE BASED ON THE ICF-KH ESTIMATING FACTOR, REVISION 1, FY96, DATED 1-/-1/95 THE TOTAL COMPOSITE PERCENTAGE APPLIED TO ONSITE CONSTRUCTION FORCES LABOR, FOR THIS PROJECT, IS 52% FOR ALL WORK, WHICH IS REFLECTED IN THE "OH&P/B&I" COLUMN OF THE ESTIMATE DETAIL.

B.) ONSITE CONTRACT ADMINISTRATION AND CONSTRUCTION MANAGEMENT COSTS, ASSOCIATED WITH THE OVERALL MANAGEMENT OF THE FIXED PRICE CONTRACTS, ARE INCLUDED AS A COMPOSITE PERCENTAGE AND LUMP SUM ALLOWANCE (FOR BID PACKAGE PREP) BASED ON THE ESTIMATING FACTOR/BILLING SCHEDULE. THE TOTAL COMPOSITE PERCENTAGE AND LUMP SUM ALLOWANCE ARE APPLIED AGAINST THE TOTAL FIXED PRICE CONTRACT AMOUNT WHICH IS REFLECTED ON THE KEH SUMMARY REPORT DOE_R07, INCLUDED WITH THIS ESTIMATE. (FINAL ESTIMATES MAY BE PARTIALLY MANLOADED AND INCLUDED WITHIN THE ESTIMATE DETAIL)

C.) FIXED PRICE CONTRACTOR OVERHEAD, PROFIT, BOND AND INSURANCE COSTS HAVE BEEN APPLIED AT THE FOLLOWING PERCENTAGES AND ARE REFLECTED IN THE "OH&P/B&I" COLUMN OF THE ESTIMATE DETAIL:
LABOR - 30.4%, MATERIAL - 30.4%, EQUIPMENT USAGE - 30.4%, EQUIPMENT - 30.4%, SUBCONTRACTS - 38.47%.

5. ESCALATION

ESCALATION WAS NOT APPLIED TO THE DOLLAR AMOUNTS FOR FUTURE PROJECTIONS, ALL COSTS HAVE BEEN CONVERTED TO 1996 DOLLARS.

6. ROUNDING

U.S. DEPARTMENT OF ENERGY - DOE ORDER 5100.4 PAGE I-32 SUBPARAGRAPH (M), REQUIRES ROUNDING OF ALL GENERAL PLANT PROJECTS (GPP'S) AND LINE ITEM (LI) COST ESTIMATES. REFERENCE: DOE 5100.4, FIGURE I-11, DATED 10-31-84.

7. REMARKS
=======

A.) IT WAS ASSUMED THAT BURN-OUT WILL NOT BE EXPERIENCED DURING ANY ACTIVITIES.

B.) ALL SOILS DISTURBED BY CONSTRUCTION ACTIVITIES WILL BE ASSUMED TO GO BACK INTO ORIGINAL PLACE WITHOUT DISPOSAL COSTS INCURRED.

C.) EXCAVATION ACTIVITIES TO UNCOVER UNDERGROUND OVERFLOW LINES WILL BE SEQUENCED IN ORDER TO PREVENT THE NEED TO HAUL MATERIALS OUT OF FARM FOR STOCKPILING.

D.) THE COSTS AS REFLECTED IN THE ESTIMATE WBS'110001, 110002, 110003, 110102, 110103, 320001 THRU 320004, 320102, 320103, 321001 THRU 321004, 322001, 322004 AND 500004 COME FROM PROJECT TIME AND COST ESTIMATE DATED 5/24/96 DONE BY LEE SMITH.

E.) WBS 110012, 120012, 200012, 310012 AND 500012 WERE EXTRACTED FROM ICF KAISER HANFORD STUDY ESTIMATE W340SAA1 DATED 1/12/94 WITH ADJUSTMENTS MADE TO REFLECT FY96 LABOR RATES AND ADDERS.

F.) ALL MATERIAL COSTS FROM P.T.& C. ESTIMATE INCLUDE SALES TAX.

REFERENCE: ESTIMATE BASIS SHEET PAGE 4 & 5 OF 6

THE U.S. DEPARTMENT OF ENERGY - RICHLAND ORDER 5700.3 "COST ESTIMATING, ANALYSIS AND STANDARDIZATION" DATED 3-27-85, PROVIDES GUIDELINES FOR ESTIMATE CONTINGENCIES. THE GUIDELINE FOR A STUDY ESTIMATE SHOULD HAVE AN OVERALL RANGE OF 20 TO 50%.

CONTINGENCY IS EVALUATED AT THE THIRD COST CODE LEVEL AND SUMMARIZED AT THE PRIMARY AND SECONDARY COST CODE LEVEL OF THE DETAILED COST ESTIMATE.

ENGINEERING

ALL ENGINEERING WAS GIVEN A 35% CONTINGENCY REFLECTIVE OF EITHER THE EARLIER ESTIMATE THAT WAS USED FOR THIS STUDY OR THE AMOUNT OF UNCERTAINTIES SURROUNDING THE NEWLY ADJUSTED WORK SCOPE.

AVERAGE ENGINEERING CONTINGENCY 35%

CONSTRUCTION

CONSTRUCTION COSTS WERE ALL GIVEN A 35% BUFFER BECAUSE OF THE LACK OF DESIGN AND DETAILS AT THIS STAGE OF DEVELOPEMENT. MOST OF THE ENVISIONED WORK WILL BE DONE IN CONDITIONS REMAINING AFTER W340 WORK HAS BEEN COMPLETED, UNTIL THAT TIME MANY UNKNOWNS WILL REMAIN.

AVERAGE CONSTRUCTION CONTINGENCY 35%

AVERAGE PROJECT CONTINGENCY 35%

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TWRS CLOSURE FILL ALTERNATIVES - OPTION 4
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DOE_R08 - ESTIMATE DETAIL BY WBS / COST CODE

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BY R.OHRT

ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
110001	DEFINITIVE DESIGN - INFRASTRUCTURE										
110001.00	TECHNICAL SERVICES										
110001.0000001	*************************** INFRASTRUCTURE - DEF.DESIGN ***************************	000	1 L/S	0	0	0	0	1066500	0	0	1066500
110001.0000002	AT 25% OF CONSTRUCTION (WBS 320001)	000	0	0	0	0	0	0	0	0	0
SUBTOTAL	TECHNICAL SERVICES			0	0	0	0	1,066,500	0	0	1,066,500
TOTAL	COST CODE 00000 WBS 110001 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			0	0	0	0	1,066,500	0	0	1,066,500
TOTAL WBS 110001	DEFINITIVE DESIGN - INFRASTRUCTURE			0	0	0	0	1,066,500	0	0	1,066,500

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ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
110002	DEFINITIVE DESIGN - GROUT TANKS										
110002.00	TECHNICAL SERVICES										
110002.0000001	**************************** GROUT FILL TANKS DEFINITIVE DESIGN ****************************	000	1 L/S	0	0	0	0	15360300	0	0	15360300
110002.0000002	AT 25% OF CONSTRUCTION (WBS 320002)	000	0	0	0	0	0	0	0	0	0
SUBTOTAL	TECHNICAL SERVICES			0	0	0	0	15,360,300	0	0	15,360,300
TOTAL	COST CODE 00000 WBS 110002 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			0	0	0	0	15,360,300	0	0	15,360,300
TOTAL WBS 110002 DEFINITIVE DESIGN - GROUT TANKS				0	0	0	0	15,360,300	0	0	15,360,300

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ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
110003	DEFINITIVE DESIGN - ANCILLARY GROUT										
110003.00	TECHNICAL SERVICES										
110003.0000001	**************************** ANCILLARY GROUT FILL DEFINITIVE DESIGN ****************************	000	1 L/S	1782	101770	0	0	0	0	30969	132739
110003.0000002	PER P.T.& C ESTIMATE	000	0	0	0	0	0	0	0	0	0
110003.0000004	**************************** ANCILLARY GROUT - DEF.DESIGN ESCALATION ****************************	000	1 L/S	0	0	0	0	5990	0	0	5990
110003.0000005	ESCALATES PRICES FROM 1994 TO 1996 (5.88%) FOR DEFINITIVE DESIGN. PER P.T. & C. ESTIMATE	000	0	0	0	0	0	0	0	0	0
SUBTOTAL	TECHNICAL SERVICES			1,782	101,770	0	0	5,990	0	30,969	138,729
TOTAL	COST CODE 00000 WBS 110003 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			1,782	101,770	0	0	5,990	0	30,969	138,729
TOTAL WBS 110003 DEFINITIVE DESIGN - ANCILLARY GROUT				1,782	101,770	0	0	5,990	0	30,969	138,729

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ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
110011	DEFIN DESIGN - OVERFLOW LINE CRIMP										
110011.00	TECHNICAL SERVICES										
110011.0000000	*************************** DEFIN. DES. - OVERFLOW CRIMP ***************************	000	1 L/S	0	0	0	0	1210000	0	0	1210000
110011.0000001	AT 25% OF CONSTRUCTION (WBS 310011)	000	0	0	0	0	0	0	0	0	0
SUBTOTAL	TECHNICAL SERVICES			0	0	0	0	1,210,000	0	0	1,210,000
TOTAL	COST CODE 00000 WBS 110011 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			0	0	0	0	1,210,000	0	0	1,210,000
TOTAL WBS 110011 DEFIN DESIGN - OVERFLOW LINE CRIMP				0	0	0	0	1,210,000	0	0	1,210,000

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ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
120011	ENGRG/INSPECT - OVERFLOW LINE CRIMP										
120011.00	TECHNICAL SERVICES										
120011.0000000	*************************** ENGIN./INSP - OVERFLOW CRIMP ***************************	000	1 L/S	0	0	0	0	484000	0	0	484000
120011.0000001	AT 10% OF CONSTRUCTION (WBS 310011)	000	0	0	0	0	0	0	0	0	0
SUBTOTAL	TECHNICAL SERVICES			0	0	0	0	484,000	0	0	484,000
TOTAL	COST CODE 00000 WBS 120011 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			0	0	0	0	484,000	0	0	484,000
TOTAL WBS 120011	ENGRG/INSPECT - OVERFLOW LINE CRIMP			0	0	0	0	484,000	0	0	484,000

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TWRS CLOSURE FILL ALTERNATIVES - OPTION 4
CONCRETE FILL STUDY ESTIMATE
DOE_R08 - ESTIMATE DETAIL BY WBS / COST CODE

ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
310011	CONSTRUCTION - OVERFLOW LINE CRIMP										
310011.01	GENERAL REQUIRMENTS										
310011.0100000	****************************** STEP OFF PAD ******************************	700	0	0	0	0	0	0	0	0	0
310011.0100002	ASSUME ONE MAN REQUIRED AT ALL TIMES FOR STEP OFF PAD, AND 4 MAN WORK CREW EXCEPT AS NOTED.	700	1 L/S	15970	600632	0	0	0	0	0	600632
SUBTOTAL	GENERAL REQUIRMENTS			15,970	600,632	0	0	0	0	0	600,632
TOTAL	COST CODE 70001 WBS 310011 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			15,970	600,632	0	0	0	0	0	600,632
310011.02	SITEWORK										
310011.0200000	****************************** CRIMP OFF OVERFLOW LINES ******************************	700 W	0	0	0	0	0	0	0	0	0
310011.0200002	MACHINE DIG 25' @1/1 SLOPE WITH 10'SQ BOTTOM EXPOSURE, 1325 CY EA X 87 LOCATIONS.	700 W	115275 CY	19597	851098	0	0	0	0	0	851098
310011.0200004	BREAK OUT ENCASEMENT TO EXPOSE PIPE LINE, CRIMP SHUT, ALLOW 8 MAN CREW ONE DAY EACH.	700 W	87 EA	5568	252286	0	0	0	0	0	252286
310011.0200006	BACKFILL AND COMPACT PLUS 20% SWELL.	700 W	138330 CY	41499	1802302	0	0	0	0	0	1802302
310011.0200008	ALLOWANCE FOR SPECIAL EQUIPMENT FOR CRIMPING OPERATION.	700 W	1 L/S	0	0	0	150000	0	0	0	150000
SUBTOTAL	SITEWORK		(SWP)	66,664	2,905,686	0	150,000	0	0	0	3,055,686
	SWP 30.00%			19999	871705						871705
	GENERAL FOREMAN 7.00 %			6066	264417						264417
	CONSUMABLES 6.00 %						9000				9000
	SALES TAX 8.00 %						12720		0		12720
	WAREHOUSING 16.62 %						26425				26425

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ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
TOTAL	COST CODE 70002			92,729		0		0		0	
	WBS 310011				4,041,809		198,145		0		4,239,955
	(ESCALATION 0.00% - CONTINGENCY 35.00 %)										
TOTAL WBS 310011 CONSTRUCTION - OVERFLOW LINE CRIMP				108,699		0		0		0	
					4,642,441		198,145		0		4,840,587

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ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
320001	CONSTRUCTION - INFRASTRUCTURE										
320001.01	GENERAL REQUIRMENTS										
320001.0100000	**************************** INFRASTRUCTURE - INDIRECTS ****************************	460	0	0	0	0	0	0	0	0	0
320001.0100002	TRAILER OFFICES, PURCHASED AND INSTALED IN 200 EAST AND 200 WEST.	460	4 EA	240	9914	0	40000	0	0	15189	65103
320001.0100004	TEMPORARY POWER.	460	1 L/S	2000	82620	0	40000	0	0	37313	159933
320001.0100006	SMALL TOOLS - ALLOWED AT $1.25/MH	460	1 L/S	0	0	0	104250	0	0	31723	135973
320001.0100008	FUELS (ALLOW)	460	1 L/S	0	0	0	25000	0	0	7608	32608
320001.0100010	SUPERVISION OF CONSTRUCTION, BASED ON 17,000 HOURS AT $57.11/HR.	460	1 L/S	17000	970870	0	0	0	0	295436	1266306
SUBTOTAL	GENERAL REQUIRMENTS			19,240	1,063,404	0	209,250	0	0	387,269	1,659,923
TOTAL	COST CODE 46001 WBS 320001 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			19,240	1,063,404	0	209,250	0	0	387,269	1,659,923
320001.10	SPECIALTIES										
320001.1000100	**************************** CONCRETE BATCH PLANT ****************************	460	0	0	0	0	0	0	0	0	0
320001.1000102	INSTALL ONE BATCH PLANT FACILITY WITH 150 CY/HR CAPACITY, W/COMPUTERIZED BATCH CONTROLS, SCALES, A	460	1 EA	0	0	0	0	415000	0	126285	541285
320001.1000103	DUST CONTROL SYSTEM, SILOS FOR CEMENT AND FLY ASH, AN AGGREGATE BIN, WATER HEATER, 10 CY MIXER AND HOPPER.	460	0	0	0	0	0	0	0	0	0
320001.1000104	CONCRETE PUMP W/150 CY/HR CAPACITY.	460	1 EA	0	0	0	0	250000	0	76075	326075
320001.1000106	PUMPLINE COST AT $15,000 WITH REPLACEMENTS EACH 150,000 CY (ASSUME 7 TIMES) = $105000	460	1 EA	0	0	0	0	105000	0	31952	136952

ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
SUBTOTAL	SPECIALTIES			0	0	0	0	770,000	0	234,312	1,004,312
TOTAL	COST CODE 46010 WBS 320001 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			0	0	0	0	770,000	0	234,312	1,004,312
320001.15	MECHANICAL										
320001.1500000	**************************** FILTRATION UNITS ****************************	460	0	0	0	0	0	0	0	0	0
320001.1500002	ASSUMED ONE HEPA FILTER UNIT LOCATED IN EACH TANK FARM, ALLOWANCE.	460	18 EA	0	0	0	0	270000	0	82161	352161
320001.1500004	HEPA FILTERS, ALLOWANCE.	460	1 L/S	0	0	0	66000	0	0	20084	86084
320001.1500010	CYCLONE SEPARATORS, 2 FOR EAST AND 2 FOR WEST, ALLOWANCE.	460	4 EA	4000	165240	0	80000	0	0	74627	319867
320001.1500100	**************************** INSTRUMENTATION ****************************	460	0	0	0	0	0	0	0	0	0
320001.1500102	MONITOR PANEL, ALLOWANCE	460	18 EA	720	29743	0	90000	0	0	36438	156181
320001.1500104	INSTRUMENTS, ASSUMED 5 PER TANK TO MEASURE COMPACTION, DENSITY, LEVEL, VISUAL AND MAPPING, ALLOWANCE.	460	885 EA	8850	365594	0	88500	0	0	138181	592275
320001.1500106	WIRING AND CONNECTIONS	460	885 EA	1770	73119	0	0	0	0	22250	95369
SUBTOTAL	MECHANICAL			15,340	633,696	0	324,500	270,000	0	373,741	1,601,937
TOTAL	COST CODE 46015 WBS 320001 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			15,340	633,696	0	324,500	270,000	0	373,741	1,601,937
TOTAL WBS 320001 CONSTRUCTION - INFRASTRUCTURE				34,580	1,697,100	0	533,750	1,040,000	0	995,322	4,266,172

ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
320002	CONSTRUCTION - CONCRETE FILL TANKS										
320002.01	GENERAL REQUIRMENTS										
320002.0100000	*************************** CONCRETE FILL TKS - INDIRECT ***************************	460	0	0	0	0	0	0	0	0	0
320002.0100002	WATER, 9,000,000 GALLONS AT $.02/GAL.	460	1 L/S	0	0	0	180000	0	0	54774	234774
320002.0100004	GASOLINE, FOR PICKUPS	460	107380 GAL	0	0	0	123487	0	0	37577	161064
320002.0100006	SMALL TOOLS AND CONSUMABLES AT $1.25 PER MANHOUR	460	1 L/S	0	0	0	117500	0	0	35755	153255
320002.0100010	SUPERVISION	460	1 L/S	36000	2055960	0	0	0	0	625629	2681589
320002.0100020	*************************** CONCRETE FILL TKS - INDIRECT ESCALATION ***************************	460	1 L/S	0	0	0	0	145644	0	0	145644
320002.0100022	ESCALATES PRICES FROM 1994 TO 1996 (5.88%) FOR INDIRECT PORTION OF ESTIMATE.	460	0	0	0	0	0	0	0	0	0
SUBTOTAL	GENERAL REQUIRMENTS			36,000	2,055,960	0	420,987	145,644	0	753,735	3,376,326
TOTAL	COST CODE 46001 WBS 320002 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			36,000	2,055,960	0	420,987	145,644	0	753,735	3,376,326
320002.03	CONCRETE										
320002.0300000	*************************** CONCRETE FILL TKS - CONSTR. ***************************	460	0	0	0	0	0	0	0	0	0
320002.0300002	MATERIAL COSTS FOR 1 MILLION CY OF GROUT:	460	0	0	0	0	0	0	0	0	0
320002.0300004	TYPE II PORTLAND CEMENT @ 557 LB/CY AND $55/TON.	460	278500 TON	0	0	0	15317500	0	0	4661115	19978615
320002.0300006	ASTM CLASS F FLY ASH, 363 LB/CY AND $48.60/TON	460	181500 TON	0	0	0	8820900	0	0	2684200	11505100
320002.0300008	NATURAL FINE AGGREGATE 1194 LB/CY AND $8.00/TON	460	597000 TON	0	0	0	4776000	0	0	1453337	6229337
320002.0300010	COARSE AGGREGATE, 1472 LB/CY AND $10.00/TON	460	736000 TON	0	0	0	7360000	0	0	2239648	9599648
320002.0300012	HIGH-RANGE WATER-REDUCING ADMIXTURE (DAXAD19) AT	460	144550 GAL	0	0	0	722750	0	0	219933	942683

ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
	18.5 OZ/CY AND $5.00/GAL (144,550 GAL.)										
320002.0300018	RHEOLOGICAL MODIFIER, 0.6 LB/CY AND $7.40/LB.	460	600000 LB	0	0	0	4440000	0	0	1351092	5791092
320002.0300020	LABOR - ASSUME 8 MEN RUNNING OPERATION W/150 CY/HR OUTPUT FOR 6 HR/DAY (4500 CY/WK AND 320 MH/WK), 1 MILLION CY=	460	1 L/S	71360	2947882	0	0	0	0	897040	3844922
320002.0300022	223 WKS X 320 MH = 71360 MHS	460	0	0	0	0	0	0	0	0	0
320002.0300030	*************************** GROUT FILL TKS- CONSTRUCTION ESCALATION ***************************	460	1 L/S	0	0	0	0	173335	0	0	173335
320002.0300032	ESCALATES PRICES FROM 1994 TO 1996 (5.88%) FOR CONSTR-UCTION PORTION OF ESTIMATE, LABOR ONLY, MATERIAL COSTS	460	0	0	0	0	0	0	0	0	0
320002.0300033	WERE CURRENT.	460	0	0	0	0	0	0	0	0	0
SUBTOTAL	CONCRETE			71,360	2,947,882	0	41,437,150	173,335	0	13,506,365	58,064,732
TOTAL	COST CODE 46003 WBS 320002 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			71,360	2,947,882	0	41,437,150	173,335	0	13,506,365	58,064,732
TOTAL WBS 320002 CONSTRUCTION - CONCRETE FILL TANKS				107,360	5,003,842	0	41,858,137	318,979	0	14,260,100	61,441,058

ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
320003	CONSTRUCTION - ANCILLARY GROUT										
320003.01	GENERAL REQUIRMENTS										
320003.0100000	**************************** ANCILLARY GROUT - INDIRECTS **************************** PER P.T. & C. ESTIMATE	460	0	0	0	0	0	0	0	0	0
320003.0100002	SUPERVISION	460	1 L/S	630	35979	0	0	0	0	10948	46927
320003.0100004	**************************** ANCILLARY GROUT - INDIRECTS ESCALATION ****************************	460	1 L/S	0	0	0	0	1580	0	0	1580
320003.0100006	ESCALATES PRICES FROM 1994 TO 1996 (5.88%) FOR INDIRECT PORTION OF ESTIMATE. PER P.T. & C. ESTIMATE.	460	0	0	0	0	0	0	0	0	0
SUBTOTAL	GENERAL REQUIRMENTS			630	35,979	0	0	1,580	0	10,948	48,507
TOTAL	COST CODE 46001 WBS 320003 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			630	35,979	0	0	1,580	0	10,948	48,507
320003.03	CONCRETE										
320003.0300000	**************************** ANCILLARY GROUT - CONSTR. **************************** PER P.T.& C ESTIMATE	460	0	0	0	0	0	0	0	0	0
320003.0300002	ANCILLARY EQUIPMENT STABILIZATION, SINGLE SHELL TANKS, 10,500 CM OF GROUT FILL.	460	0	0	0	0	0	0	0	0	0
320003.0300004	CEMENT	460	94500 KG	0	0	0	13230	0	0	4026	17256
320003.0300006	SAND	460	4900 CM	0	0	0	90650	0	0	27585	118235
320003.0300008	FLY ASH	460	850500 KG	0	0	0	34020	0	0	10352	44372
320003.0300012	ANCILLARY EQUIPMENT STABILIZATION, DOUBLE SHELL TANKS, 7,900 CM OF GROUT FILL.	460	0	0	0	0	0	0	0	0	0
320003.0300014	CEMENT	460	86000 KG	0	0	0	12040	0	0	3664	15704
320003.0300016	SAND	460	4450 CM	0	0	0	82325	0	0	25051	107376
320003.0300018	FLY ASH	460	771850 KG	0	0	0	30874	0	0	9395	40269
320003.0300020	LABOR, RADIATION WORKER	460	1 L/S	1260	52051	0	0	0	0	15839	67890

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320003.0300022	LABOR, NON-RADIATION WORKER	460	1 L/S	1300	53703	0	0	0	0	16342	70045
320003.0300030	*************************** ANCILLARY GROUT - CONSTR. ESCALATION ***************************	460	1 L/S	0	0	0	0	28160	0	0	28160
320003.0300032	ESCALATES PRICES FROM 1994 TO 1996 (5.88%) FOR CONSTRUCTION PORTION OF ESTIMATE. PER P.T. & C. ESTIMATE	460	0	0	0	0	0	0	0	0	0
SUBTOTAL	CONCRETE			2,560	105,754	0	263,139	28,160	0	112,254	509,307
TOTAL	COST CODE 46003 WBS 320003 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			2,560	105,754	0	263,139	28,160	0	112,254	509,307
TOTAL WBS 320003 CONSTRUCTION - ANCILLARY GROUT				3,190	141,733	0	263,139	29,740	0	123,202	557,814

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320004	CONSTRUCTION - BARRIER CAP										
320004.02	SITEWORK										
320004.0200000	**************************** BARRIER CAPS - CONSTRUCTION ****************************	460	0	0	0	0	0	0	0	0	0
320004.0200002	TX FARM	460	1 L/S	0	0	0	0	7414000	0	2852166	10266166
320004.0200004	U FARM	460	1 L/S	0	0	0	0	5565800	0	2141163	7706963
320004.0200006	C FARM	460	1 L/S	0	0	0	0	5807300	0	2234068	8041368
320004.0200008	SX FARM	460	1 L/S	0	0	0	0	5836100	0	2245148	8081248
320004.0200010	BY FARM	460	1 L/S	0	0	0	0	4840900	0	1862294	6703194
320004.0200012	B FARM	460	1 L/S	0	0	0	0	5688500	0	2188366	7876866
320004.0200014	BX FARM	460	1 L/S	0	0	0	0	4784500	0	1840597	6625097
320004.0200016	A FARM	460	1 L/S	0	0	0	0	2858200	0	1099550	3957750
320004.0200018	TY FARM	460	1 L/S	0	0	0	0	2885600	0	1110090	3995690
320004.0200020	AX FARM	460	1 L/S	0	0	0	0	2181000	0	839031	3020031
320004.0200022	T FARM	460	1 L/S	0	0	0	0	5688500	0	2188366	7876866
320004.0200024	S FARM	460	1 L/S	0	0	0	0	4891600	0	1881799	6773399
320004.0200026	AN FARM	460	1 L/S	0	0	0	0	4045000	0	1556112	5601112
320004.0200028	AZ FARM	460	1 L/S	0	0	0	0	1410600	0	542658	1953258
320004.0200030	AY FARM	460	1 L/S	0	0	0	0	1410600	0	542658	1953258
320004.0200032	AP FARM	460	1 L/S	0	0	0	0	3742200	0	1439624	5181824
320004.0200034	AW FARM	460	1 L/S	0	0	0	0	3007100	0	1156831	4163931
320004.0200036	SY FARM	460	1 L/S	0	0	0	0	2239600	0	861574	3101174
320004.0200038	LLW VAULTS	460	1 L/S	0	0	0	0	20272500	0	7798831	28071331
SUBTOTAL	SITEWORK			0	0	0	0	94,569,600	0	36,380,926	130,950,526
TOTAL	COST CODE 46002 WBS 320004 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			0	0	0	0	94,569,600	0	36,380,926	130,950,526
TOTAL WBS 320004 CONSTRUCTION - BARRIER CAP				0	0	0	0	94,569,600	0	36,380,926	130,950,526

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321001	SUBCONTRACT MPR - INFRASTRUCTURE										
321001.15	MECHANICAL										
321001.1500000	**************************** INFRASTRUCTURE - SUB. MPR ****************************	460	0	0	0	0	0	0	0	0	0
321001.1500001	BASED ON 3% OF WBS 110001, 320001 AND 322001.	460	1 L/S	0	0	0	0	267000	0	0	267000
SUBTOTAL	MECHANICAL			0	0	0	0	267,000	0	0	267,000
TOTAL	COST CODE 46015 WBS 321001 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			0	0	0	0	267,000	0	0	267,000
TOTAL WBS 321001 SUBCONTRACT MPR - INFRASTRUCTURE				0	0	0	0	267,000	0	0	267,000

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321002	SUBCONTR. MPR - CONCRETE FILL TANKS										
321002.03	CONCRETE										
321002.0300000	**************************** CONCRETE FILL TANKS SUBCONTRACTOR MPR ****************************	460	0	0	0	0	0	0	0	0	0
321002.0300001	BASED ON 3% OF WBS 110002 AND 320002.	460	1 L/S	0	0	0	0	2304000	0	0	2304000
SUBTOTAL	CONCRETE			0	0	0	0	2,304,000	0	0	2,304,000
TOTAL	COST CODE 46003 WBS 321002 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			0	0	0	0	2,304,000	0	0	2,304,000
TOTAL WBS 321002	SUBCONTR. MPR - CONCRETE FILL TANKS			0	0	0	0	2,304,000	0	0	2,304,000

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321003	SUBCONTRACT MPR - ANCILLARY GROUT										
321003.03	CONCRETE										
321003.0300000	**************************** ANCILLARY GROUT SUBCONTRACTOR MPR ****************************	460	0	0	0	0	0	0	0	0	0
321003.0300001	BASED ON 3% OF WBS 110003 AND 320003.	460	1 L/S	0	0	0	0	23450	0	0	23450
SUBTOTAL	CONCRETE			0	0	0	0	23,450	0	0	23,450
TOTAL	COST CODE 46003 WBS 321003 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			0	0	0	0	23,450	0	0	23,450
TOTAL WBS 321003 SUBCONTRACT MPR - ANCILLARY GROUT				0	0	0	0	23,450	0	0	23,450

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321004	SUBCONTRACT MPR - BARRIER CAP										
321004.02	SITEWORK										
321004.0200100	**************************** BARRIER - SUBCONTRACTOR MPR ****************************	460	0	0	0	0	0	0	0	0	0
321004.0200101	BASED ON 3% OF WBS 320004 AND 500004. PER P.T.& C. ESTIMATE.	460	1 L/S	0	0	0	0	4105959	0	0	4105959
SUBTOTAL	SITEWORK			0	0	0	0	4,105,959	0	0	4,105,959
TOTAL	COST CODE 46002 WBS 321004 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			0	0	0	0	4,105,959	0	0	4,105,959
TOTAL WBS 321004 SUBCONTRACT MPR - BARRIER CAP				0	0	0	0	4,105,959	0	0	4,105,959

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322001	PROJECT MANAGEMENT - INFRASTRUCTURE										
322001.19	PROJECT MANAGEMENT										
322001.1900000	**************************** CONSTRUCTION MANAGEMENT INFRASTRUCTURE ****************************	060	1 L/S	0	0	0	0	853234	0	259639	1112873
322001.1900001	BASED ON 20% OF CONSTRUCTION (WBS 320001)	060	0	0	0	0	0	0	0	0	0
SUBTOTAL	PROJECT MANAGEMENT			0	0	0	0	853,234	0	259,639	1,112,873
TOTAL	COST CODE 06019 WBS 322001 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			0	0	0	0	853,234	0	259,639	1,112,873
TOTAL WBS 322001	PROJECT MANAGEMENT - INFRASTRUCTURE			0	0	0	0	853,234	0	259,639	1,112,873

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** IEST - INTERACTIVE ESTIMATING **
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ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
322004	PROJ/CONSTR MGMT - BARRIER CAP										
322004.19	PROJECT MANAGEMENT										
322004.1900000	**************************** PROJECT MGMT & CONSTRUCTION MANAGEMENT - BARRIER CAP ****************************	060	1 L/S	0	0	0	0	21145687	0	0	21145687
322004.1900001	BASED ON 15% OF WBS 320004, 321004 AND 500004. PER P.T.& C. ESTIMATE	060	0	0	0	0	0	0	0	0	0
SUBTOTAL	PROJECT MANAGEMENT			0	0	0	0	21,145,687	0	0	21,145,687
TOTAL	COST CODE 06019 WBS 322004 (ESCALATION 0.00% - CONTINGENCY 35.00 %)			0	0	0	0	21,145,687	0	0	21,145,687
TOTAL WBS 322004 PROJ/CONSTR MGMT - BARRIER CAP				0	0	0	0	21,145,687	0	0	21,145,687

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ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
500004	WHC PROJ MGMT - BARRIER CAP										
500004.9000000	**************************** WHC PROJECT MANAGEMENT BARRIER CAP ****************************	060	1 L/S	0	0	0	0	5912400	0	0	5912400
500004.9000001	APPLIED AT 4.5% OF WBS 320004. PER P.T.& E ESTIMATE	060	0	0	0	0	0	0	0	0	0
TOTAL WBS 500004 WHC PROJ MGMT - BARRIER CAP				0	0	0	0	5,912,400	0	0	5,912,400

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ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
500011	WHC PROJ MGMT - OVERFLOW LINE CRIMP										
500011.9000000	**************************** WHC PROJECT MANAGEMENT CRIMP OFF OVERFLOW LINES ****************************	060	0	0	0	0	0	0	0	0	0
500011.9000001	APPLIED AT 15% OF CONSTR. (WBS 310011)	060	1 L/S	0	0	0	0	726000	0	0	726000
TOTAL WBS 500011 WHC PROJ MGMT - OVERFLOW LINE CRIMP				0	0	0	0	726,000	0	0	726,000

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ACCOUNT NUMBER	DESCRIPTION	COST CODE	QUANTITY	MANHOURS	LABOR	EQUIP USAGE	MATERIAL	SUB-CONTRACT	EQUIP-MENT	OH&P / B & I	TOTAL DOLLARS
REPORT TOTAL				255,611	11,586,886	0	42,853,171	149,422,839	0	52,050,158	255,913,055

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APPENDIX F

DECISION PLAN: FILLING OF HANFORD SITE SINGLE-SHELL WASTE TANKS

CONTENTS

F1.0 STATEMENT OF DECISION

The draft *Tank Waste Remediation System (TWRS) Environmental Impact Statement* (DOE/EIS 1996) addresses the question of what to do with the waste in Hanford Site SSTs and DSTs. The preferred alternative is to remove 99% of the tank waste, which would be vitrified for onsite or offsite disposal. The question of tank farm closure is not addressed, although for purposes of impact assessment, it is assumed that the farms would be closed as landfills.

The *Decision Document For Function 4.2.4, Dispose Waste* (WHC 1996a) addresses what is to be done with the immobilized waste, and more importantly, how the tank farms will be closed. Closure options include clean closure, landfill closure, and modified closure. The document eliminates all options except landfill closure, because the other options are not consistent with the current planning basis or the EIS. The closure options will be addressed in a supplement to the TWRS EIS.

This document assumes that the tank farms will be closed as landfills; thereby, the tanks will remain in place and must be filled with inert material to eliminate voids and prevent subsidence. The question addressed by this document is: **With what material should Hanford Site waste tanks be filled?** The purpose of this document is to describe exactly how a decision will be made regarding the fill material.

Fill materials that might be adequate for tank closure have already been identified (WHC 1995) and will be evaluated in an Alternatives Generation Analysis (AGA) in 1996. These materials include gravel, grout, concrete and hybrid (a concrete which is a combination of gravel and grout).

F2.0 DECISION STRATEGY

The decision regarding what fill will be used for the tanks under the landfill closure option will be addressed by the closure supplement to the TWRS EIS.

F3.0 DECISION CRITERIA

The following criteria for evaluating fill material will be used in the EIS supplement:

- Material properties of fill. That is, which fill material best prevents future voids and subsidence?
- Public risk mitigation for each type of fill. That is, which fill material results in the least offsite dose from disposal system leakage?
- Occupational risk from each fill alternative. That is, in filling the tanks, which fill results in the least occupational dose and risk from accidents?

- Dollar cost of each fill alternative.
- Regulatory acceptability of each fill alternative.

Each of these criteria are discussed below, relative to their feasibility and adequacy for use in the decision-making process. Performance measures in each of these categories will be developed to provide a basis for decision making.

F3.1 MATERIAL PROPERTIES

Material properties of gravel, grout and hybrid are discussed by Baxter (WHC 1996b). Models will be developed to evaluate deformations and stresses in tanks, soils, and the engineered barrier for the types of fill.

F3.2 PUBLIC RISK MITIGATION

Assuming that an engineered barrier is constructed over the waste tanks to prevent surface contamination and spread, the most significant long-term risk to the public from tank disposal systems is through the groundwater pathway (DOE/EIS 1996). A study will be made to determine if groundwater concentrations are sensitive to the use of different fill materials.

F3.3 OCCUPATIONAL RISK

The doses incurred by workers for three types of filling operations (gravel, grout, and hybrid) have been estimated and will be discussed in the AGA. The differences in the doses are primarily due to the need to install or modify risers for gravel slinging.

In the case of filling operations, the doses incurred by workers are roughly proportional to other, nonradiological risks, such as accident frequency. This is because the doses are proportional to the man-hours required and the complexity of the work. Therefore, the doses and the performance measures derived from them should be good indices of the overall occupational risk.

F3.4 COSTS

The estimated costs for gravel, grout, and hybrid operations; including design costs, material costs, equipment costs, and labor will be developed in the AGA.

F3.5 REGULATORY ACCEPTABILITY

Irrespective of an objective evaluation of the risks and costs of the various fill alternatives, there may be objections to a given fill material based on regulatory issues or concerns. For example, grout or hybrid materials may be viewed as non-retrievable, and therefore not amenable to future retrieval action should it prove warranted from the results of performance monitoring. On the other hand, gravel may be viewed as providing insufficient immobilization of the residual waste. Regulatory acceptability of fill options will be dealt with in the negotiations with the State regarding the approval of the final closure plan for tank farms. For now, it is assumed that all identified fill options are acceptable. Performance measures for regulatory acceptability are not appropriate.

F4.0 REQUIRED INFORMATION

The following information is required to finalize the performance measures relative to the types of fill material:

- The differences in structural properties of fill materials regarding the ability to prevent voids and future subsidence
- The differences in performance of gravel, grout, hybrid with respect to migration of contaminants and potential public risk
- The occupational doses (person/rem) incurred by performing each alternative
- The cost of performing each alternative
- Resolution of regulatory acceptability issue.

F5.0 DECISION TIME FRAME

Although closure of tank farms will not occur until after the retrieval project, there may be a need to decide on what type of fill will be used before retrieval begins. This is because the decision on fill may have an impact on the scope of the retrieval project. If gravel (or possibly hybrid) is used as fill, some of the ancillary equipment in the tanks must be removed because it would inhibit the uniform dispersal of gravel. It is assumed here that removal of such equipment would be within the scope of retrieval. If grout or concrete is used as fill, all instrument trees and other ancillary equipment could be left in the tanks, since grout or concrete would flow around such equipment.

F6.0 CONSTRAINTS

As mentioned previously, the subject decision is constrained by a TWRS EIS supplement for tank farm closure. It is assumed here that closure as landfill will be the selected alternative.

F7.0 CURRENT PLANNING BASIS AND ASSUMPTIONS

As already stated, the planning basis for the subject decision is that tank farms will be closed as landfills, under the provisions of WAC 173-303-610(2)(a), WAC 173-303-640(8), and DOE orders.

F8.0 REFERENCES

DOE/EIS, 1996, *Tank Waste Remediation System Environmental Impact Statement*, DOE/EIS-0189D, prepared by the U.S. Department of Energy and the Washington State Department of Ecology, Richland, Washington.

WHC, 1995, *Closure Technical Data Package for the Tank Waste Remediation System Environmental Impact Statement,* WHC-SD-WM-EV-107, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

WHC, 1996a, *Decision Document for Function 4.2.4 Dispose Waste,* WHC-SD-WM-ES-381, Westinghouse Hanford Company, Richland, Washington.

WHC, 1996b, *Structural Models for Closure of Single-Shell Tanks*, WHC-SD-WM-ES-372, Westinghouse Hanford Company, Richland, Washington.