ENGINEERING-SCIENCE, INC. a unit of
PARSONS ENVIRONMENTAL SERVICES, INC.

CCCO 36/19
3 5412

August 8, 1994
SP307:080894:01

Mr. Andy Ledford
EG&G Rocky Flats, Inc.
Rocky Flats Plant
P.O. Box 464, Building 080
Golden, Colorado 80402-0464

Subject: MTS 343756 GG
OU4 Solar Ponds IM/IRA
Roundtable Review draft of the Groundwater Control Methods Analysis

Dear Mr. Ledford:

On July 18, 1994 the working group (DOE, CDH, EPA) requested that an analysis be performed to determine if an upgradient vertical groundwater control system was a more appropriate system than the proposed lateral subsurface drainage layer. A two week period was provided for the analysis. Enclosed is the resulting report for review and comment. ES has structured the report as an Appendix to Part III of the IM/IRA-EA Decision Document. Therefore, this document is considered to be a round table review draft.

The Report recommends that design activities continue on the proposed subsurface drainage layer because the proposed system is considered to be a more reliable system for the 1000-year period of performance. In addition, the proposed system is anticipated to be a more cost effective alternative.

In keeping with the schedule established be the working group, please provide comments or concurrence by August 16, 1994.

Please call me at 764-8811 or pager 687-2551 if you have any questions.

Sincerely,

Philip A. Nixon
Project Manager: Solar Pond IM/IRA

cc:

R. Ogg, EG&G	W. Edmonson	A. Putinsky
M. Austin, EG&G	J. Giammona	C. Rosé
K. Ruger, EG&G	J. Hartfelder	R. Stegen
M. McKee, EG&G	H. Heidkamp	S. Stenseng
R. Popish (2), EG&G	R. Henry	R. Wilkinson
L. Balewick	N. Hilmar	T. Kuykendall
D. Creek	R. Lux	B. Glenn
B. Cropper	R.McConn	Central Files

PARSONS

DRAFT

APPENDIX III.I

EVALUATION OF SPECIFIC METHODS TO PREVENT GROUND WATER CONTAMINATION

APPENDIX III.I

EVALUATION OF SPECIFIC METHODS TO PREVENT GROUND WATER CONTAMINATION

1.0 INTRODUCTION

The purpose of this report is to evaluate specific alternatives to prevent ground water contamination from occurring if the water table in the vicinity of OU4 were to rise in the future to levels that saturated the contaminated materials consolidated beneath the proposed OU4 engineered cover. The specific ground water control alternatives under this evaluation include:

- Lateral subsurface drainage system and,

- Vertical upgradient ground water control system.

Ground water control methods are discussed generally in Part III, Section 3.2.1 of the IM/IRA-EA Decision Document in conjunction with the description of engineered cover alternatives. A detailed evaluation of ground water control alternatives is necessary due to the selection of the engineered cover alternative as the proposed IM/IRA for OU4 (Part III, Section 6). A system to prevent ground water contamination will be a component of the closure because the Solar Evaporation Ponds (SEPs) will be closed with contaminated materials consolidated beneath an engineered cover.

The design criteria for the ground water control system include:

- The system must prevent ground water from contacting the consolidated contaminated materials beneath the engineered cover for a 1,000-year period to be protective of human health and the environment.

- Ground water that is collected in the subsurface drain or that accumulates in front of a vertical ground water control system must be removed from the area so that increased hydraulic head does not cause a system failure.

- The ground water control and collection system should be designed for passive operation. Mechanical devices needed to remove ground water from the collection/drainage system will not be designed for 1000-year performance. It is assumed that the mechanical systems (ancillary to the ground water collection system) can be replaced by the DOE while the OU4 ground water is being remediated, and that the ground water at the Rocky Flats Environmental Technology Site (RFETS) will be remediated prior to final site closure.

- The proposed systems must be able to function adequately under the design-basis ground water rise of 2.2 feet.

- An upgradient vertical ground water control mechanism must be tied into competent low-permeable bedrock.

The ground water control alternatives presented in this report are conceptual and may not reflect the final design. The descriptions of the alternatives are adequate to perform a comparative analysis in order to select a ground water control method. This analysis is based on the following assumptions:

- SEP 207-C will be closed by excavating contaminated soils to the depth of the mean seasonal high water table elevation and consolidating these materials under an engineered cover that spans the area occupied by SEP 207-A and the B-series SEPs.

- The configuration of the engineered cover will be the same under both alternatives for ground water control. It should be noted that the assumed footprint of the engineered cover was not verified to be able to handle the volume of waste materials that would be consolidated under these alternatives. Therefore, the footprint or height of the engineered cover could change during detailed design.

It should be noted that this analysis focuses on the feasibility of the alternatives to be effective and whether the different systems can be constructed at the OU4 site. Detailed evaluations of performance and effectiveness can not be completed without additional geological/hydrogeological investigations, material testing, and engineering analysis.

The seven threshold and primary balancing evaluation criteria presented in Part III, Section 4 were considered in this alternative evaluation. With respect to the threshold criteria, both of the alternatives will be protective of human health and the environment. A subsurface drain will be designed to intercept rising ground water and prevent it from contacting the consolidated contaminated media. The vertical ground water control system will be designed to route ground water flow around the consolidated contaminated materials and dewater the upper hydrostratigraphic unit (UHSU) beneath the engineered cover. Therefore, both of the alternatives will be designed to meet the threshold criteria for overall protection of human health and the environment. Compliance with the ARARs threshold criteria is also met by both of the alternatives. In either instance, the system will be a component of the overall SEP closure system. Implementation of either of these ground water control alternatives will allow the overall closure system to comply with the ARARs identified in Part III, Section 5 of the IM/IRA-EA Decision Document. There are no specific ARARs associated with lateral subsurface drains and vertical ground water control systems.

With respect to the primary balancing criteria, this evaluation will focus on:

- long-term effectiveness and permanence,

- short-term effectiveness,
- implementability, and
- cost.

The reduction of toxicity, mobility, or volume through treatment criterion does not apply because the consolidated materials will not be treated. Both the subsurface drain and the vertical upgradient ground water control system will provide a method to prevent ground water from contacting the consolidated waste and prevent contaminant mobility.

2.0 BACKGROUND INFORMATION

2.1 Conceptual Model of Vadose Zone Flow

A conceptual model of variably saturated vadose zone flow was developed to provide an understanding of the proposed mechanisms for contaminant transport in the vadose zone and the natural flow limitations imposed by the existing hydraulic conditions in the vadose zone beneath the SEPs. This model provides a foundation to formulate decisions concerning closure and remedial actions at the site. It is also used in this evaluation to develop the design requirements for the ground water control alternatives. The model considers regional and local infiltration, variably saturated flow, and saturated flow. Estimates of infiltration at the site are provided along with a discussion of the processes governing infiltration, contaminant flow, and ground water recharge.

The central Rocky Mountain region, including the Front Range where the RFETS is located, is characterized by a mean annual precipitation of 15 inches. Approximately 40 percent of this precipitation falls during the spring. "Supercell" storm events during the summer account for an additional 30 percent of the annual precipitation. Autumn and winter are drier seasons, accounting for 19 and 11 percent of the annual precipitation, respectively. Snowfall averages 85 inches per year, occurring primarily between October and May. Negligible sources of recharge include infiltration of stream flow along drainages above the bedrock-alluvium contact, and mountain-front recharge along the foothills. Pan evaporation rates for the RFETS area exceed 60 inches per year. This evaporation rate results in a net annual water loss; however, evaporation and transpiration rates are less during the winter and spring months, so infiltration may occur during this period.

During operation of the SEPs, most of the recharge to the unconfined ground water system beneath the SEPs resulted from infiltrating precipitation, leakage from the SEPs, and possibly broken Original Process Waste Lines (OPWLs). Leakage from the SEPs was driven by the hydraulic head existing in the SEPS during their operation. Recharge through the vadose zone at OU4 is seasonal and occurs during late winter through spring months when precipitation exceeds bare soil evaporation and plant transpiration. Recharge most likely occurs when the frequency and duration of precipitation events, in conjunction with a lower rate of evaporation and transpiration, create an increase in the available moisture for infiltration and recharge.

The heterogeneous soils of the vadose zone suggest that significant variations in hydraulic properties occur laterally and vertically. Consequently, variably saturated flow through the vadose zone soils is not uniform and may be significantly changed by layers of varying hydraulic conductivity. The lack of wetting fronts in the neutron probe data collected during the Phase I RFI/RI suggests that areal interstitial infiltration does not occur. This apparent lack of areal interstitial infiltration in conjunction with the spring ground water rise suggests that ground water recharge occurs through localized areas of saturated flow, macropores, or other localized areas of higher hydraulic conductivity. This is suggested by the relatively rapid water table rise observed at some of the monitoring wells and piezometers at OU4. However, this trend was not seen throughout the OU4 area. When deep infiltration occurs, vadose zone flow generally is vertically downward from ground surface to the unconfined ground water table.

Areal infiltration by interstitial flow through the vadose zone soils was estimated by assuming that the hydraulic conductivity of the soils under a unit hydraulic gradient and a given matric potential is equivalent to the variably saturated flux. The geometric mean of the corrected unsaturated hydraulic conductivity is about 7×10^{-10} centimeters per day (cm/day). Therefore, assuming a unit hydraulic gradient, the flux through a unit area of the vadose zone is about 7×10^{-10} cm/day. Assuming that all of this flux reaches the saturated ground water system, ground water recharge at OU4 is estimated at 9×10^{-3} inches per year (in/yr).

This small amount of estimated areal interstitial infiltration cannot account for the water table fluctuations observed at the site (Part III, Appendix III.D in the OU4 IM/IRA-EA Decision Document), providing further evidence that the predominant infiltration mechanism at OU4 is macropore flow or local areas of high hydraulic conductivity. This apparent lack of areal interstitial infiltration through the alluvium as a source of ground water recharge may also suggest that the variations in the upper hydrostratigraphic unit (UHSU) ground water level observed at the site results from direct recharge from the bedrock strata (EG&G, 1993). Figure 2.1 presents a hydrograph of piezometer 41193 for the period between April 1993 and October 1993. Daily precipitation amounts are also shown on the hydrograph. This hydrograph does not show a definitive response to the precipitation events which suggests that other factors may be important in determining the ground water table elevation. Therefore, the lower bedrock strata may locally recharge the UHSU.

The saturated ground water zone immediately underlying the vadose zone at OU4 is termed the UHSU. This unit is composed of both the Rocky Flats Alluvium and associated soils, and weathered bedrock lithologies. Ground water flow within the UHSU at OU4 is generally controlled by the local topography. The SEPs are constructed on an east-west trending topographic ridge flanked to the north and south by tributaries of Walnut Creek. Ground water flow in the UHSU is generally toward North Walnut Creek north of the SEPs and toward South Walnut Creek south of the SEPs. An east-trending component of ground water flow is also present east of the SEPs, with flow occurring down the ridge crest toward the confluence of North and South Walnut Creeks. Ground water elevations range from approximately 5,965 ft above mean sea level (ft msl) beneath SEP 207-A and 5,080 ft msl along North Walnut Creek.

Several important characteristics of the OU4 site hydrogeology control ground water flow and contaminant movement in the saturated zone beneath OU4. Ground water elevation data obtained from both the Rocky Flats Alluvium and the bedrock lithologies indicate that in some areas the unconsolidated and weathered bedrock water-bearing strata are hydraulically connected. Due to the fluctuating ground water table beneath the site, this connection provides a mechanism to drain and potentially saturate the overlying alluvium. The drained alluvium areas are smallest during the high water period in the spring and largest during the dry period in the autumn and early winter. Some of these drained areas occur where the water table fluctuation is below the top of the bedrock and where the Rocky Flats Alluvium is directly underlain by bedrock sandstone. The latter mechanism is readily apparent along the northern edge of SEP 207-C where the Rocky Flats Alluvium underlain by the bedrock sandstone, remains dry throughout the year. Paleochannels on the bedrock paleosurface also appear to control ground water flow in the UHSU. Coarser-grained facies of the Rocky Flats Alluvium appear to be present in the paleochannels, providing a more permeable pathway for ground water flow.

2.2 Material Properties of the Vadose Zone

For this investigation, the vadose zone is defined as the subsurface interval between the ground surface and the water table. The vadose zone includes geologic materials consisting of the Rocky Flats Alluvium, colluvium, valley fill alluvium, disturbed materials, and artificial fill materials which are collectively referred to as the Rocky Flats Alluvium and associated soils. Bedrock strata of the Arapahoe and Laramie Formation may also be included in the vadose zone where the water table is below the top of bedrock. Because the ground water table fluctuates seasonally, the thickness of the vadose zone also varies seasonally. The thickness of the vadose zone is least in the spring when the ground water table is at its highest elevation. The greatest thickness of the vadose zone occurs during late summer and autumn when ground water levels are at their lowest elevation. The vadose zone varies in thickness from about zero at seep locations on the northern hill slope to about 20 feet in the area of the Interceptor Trench System (ITS).

Based upon the geological investigation conducted in the Phase I RFI/RI, the following tables summarize the physical properties of soils found beneath the SEPs. Table 2.1 provides summary data of the vadose zone particle type, particle density, dry bulk density, and saturated bulk density. Table 2.2 provides the porosity and saturated moisture contents of the vadose zone soils. Table 2.3 presents the saturated hydraulic conductivities of the vadose zone soils.

FIGURE 2.1
MONITORING LOCATION 41193
WATER TABLE ELEVATION AND PRECIPITATION

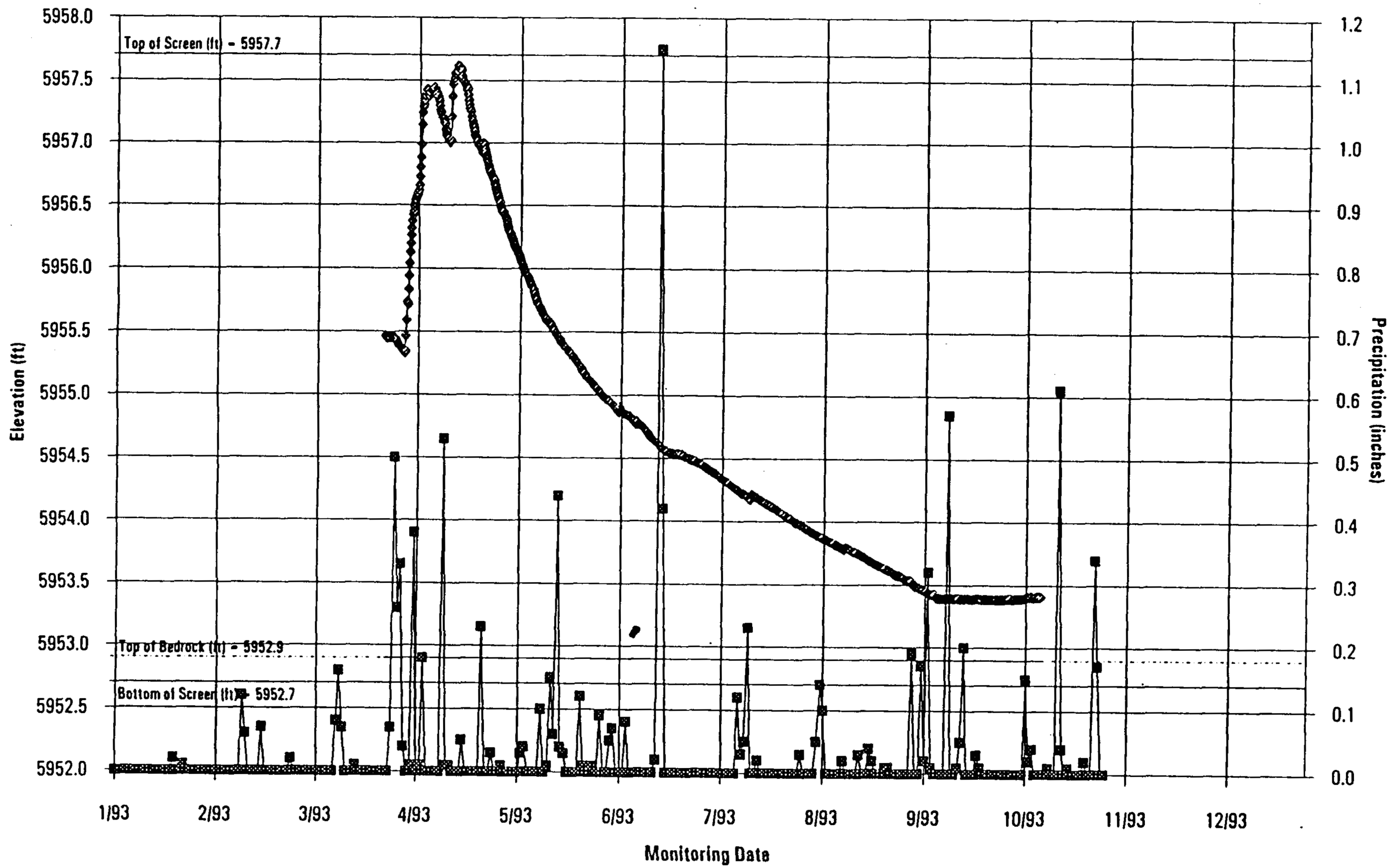


TABLE 2.1
PARTICLE, DRY BULK, AND SATURATED BULK DENSITY

SAMPLE	WELL	TOTAL SAMPLE (%) BY WEIGHT				Alluvium Properties (gm/cm^3)		
		Gl	Sd	Sl	Cl	$^d\rho_b$	ρ_s	$^w\rho_b$
BH40600AE	43193	37	25	20	18	1.94	2.71	2.19
BH40602AE	41793	31	31	26	12	1.79	2.70	2.10
BH40607AE	40793	30	21	26	23	1.61	2.64	1.97
BH40608AE	40993	59	23	0	9	1.95	2.64	2.22
BH40611AE*	42893	41	19	5	35	1.57	2.59	2.11
BH40612AE	43693	57	26	8	9	1.79	2.62	2.11
BH40613AE	41593	59	21	7	13	1.54	2.64	1.94
Average						1.77	2.65	2.08

*Sample not used in alluvium property calculations Sd-Sand Sl-Silt Gl-Gravel Cl-Clay
ρ_s - Particle Density $^d\rho_b$-Dry Bulk Density $^w\rho_b$ - Wet Bulk Density

TABLE 2.2
POROSITY AND SATURATED MOISTURE CONTENTS

SAMPLE	WELL	Total Sample (%) by				Aquifer Parameters		
		Gl	Sd	Sl	Cl	Porosity	ωsat %	ωi %
BH40600AE	43193	37	25	20	18	28.3	24.4	3.3
BH40602AE	41793	31	31	26	12	33.8	31.6	10.2
BH40607AE	40793	30	21	26	23	38.8	35.7	14.1
BH40608AE	40993	59	23	0	9	26.1	27.0	6.5
BH40611AE*	42893	41	19	5	35	39.3	53.5	22.6
BH40612AE	43693	57	26	8	9	31.8	32.1	10.0
BH40613AE	41593	59	21	7	13	41.5	40.0	15.1
Average						33.4	31.8	9.9

* sample not used in aquifer parameter calculations ωsat - Saturated Moisture (% cm^3/cm^3)
Gl-Gravel Sd-Sand Sl-Silt Cl-Clay ϕ-Porosity ωi - Initial Moisture (% gm/gm)

TABLE 2.3
USCS AND LITHOFACIES CLASSIFICATION
WITH AQUIFER PARAMETERS

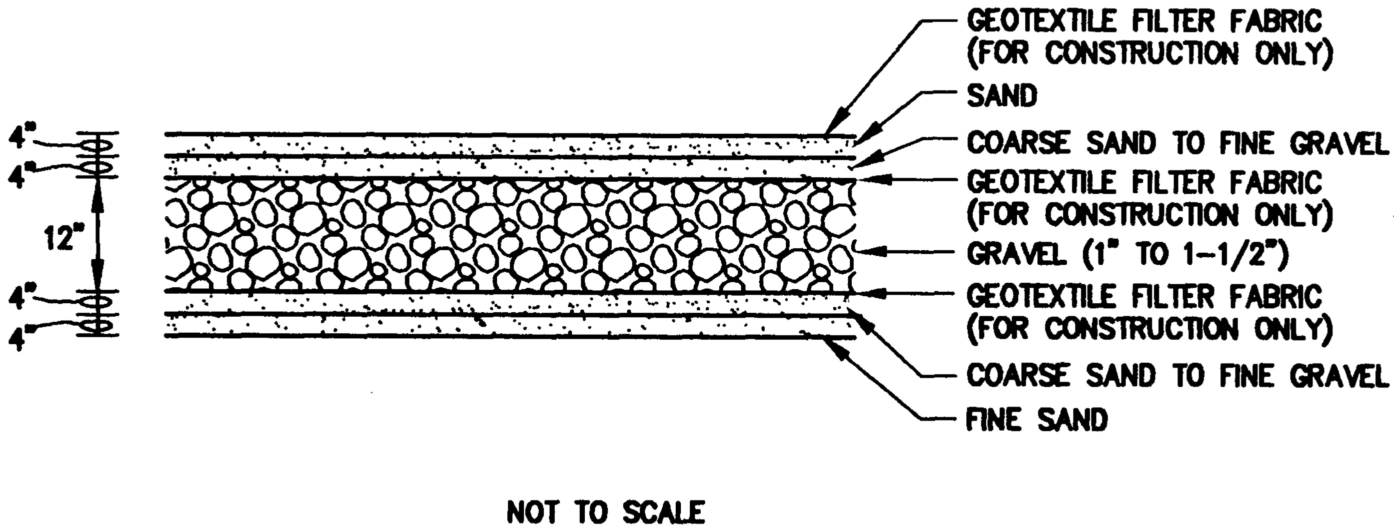
SAMPLE	WELL	Total Sample (%) by Weight				Lithofacies Type	Aquifer Parameters	
		Gl	Sd	Sl	Cl	USCS	ϕ %	κ (ft/s)
BH40600AE	43193	37	25	20	18	Clayey-Silty	28.3	6.56×10^{-5}
BH40602AE	41793	31	31	26	12	Clayey-Silty	33.8	1.87×10^{-7}
BH40607AE	40793	30	21	26	23	Clayey-Silty	38.8	5.90×10^{-7}
BH40608AE	40993	59	23	0	9	Sandy-Gravel	26.1	4.59×10^{-5}
BH40611AE*	42893	41	19	5	2	Clayey-Silty	39.3	3.28×10^{-11}
BH40612AE	43693	57	26	8	9	Sandy Gravel	31.8	4.59×10^{-8}
BH40613AE	41593	59	21	7	13	Sandy Gravel	41.5	3.61×10^{-6}
Geometric Mean and Average							32.9	1.95×10^{-6}

*Sample not used in aquifer parameter calculations
Gl-Gravel Sd-Sand Sl-Silt Cl-Clay
κ-Hydraulic Conductivity ϕ-Porosity

3.0 LATERAL SUBSURFACE DRAINAGE SYSTEM

3.1 System Description

A lateral subsurface drainage system could be implemented at OU4 by excavating to the appropriate elevation based on the depth of contamination and the elevation of the water table, and installing a horizontal subsurface drainage system. The conceptual design would require excavation to a depth of the mean seasonal high water table elevation, which is approximately 1 foot higher than the mean water table elevation. The lateral subsurface drainage system is a mitigative measure designed to function only in the event that the meteorological/hydrogeological conditions change in the future resulting in a rise in ground water above historically recorded levels. The slope of the drainage system would conduct intercepted ground water away from the engineered cover and discharge it to the north hillside. The system depicted in Figure 3.1 includes a primary drainage layer of washed gravel for intercepted ground water removal. A layer of sand above the gravel layer would act as a filter to prevent the consolidated soils above it from migrating into the gravel and cause clogging. A sand layer below the gravel would act as a filter for any solids carried by rising ground water to prevent clogging of the gravel drainage layer.



PREPARED FOR
U.S. DEPARTMENT OF ENERGY
ROCKY FLATS PLANT
GOLDEN, COLORADO

Figure 3.1

Lateral Subsurface Drainage Layer

94DN0841.DWG 8/8/94 AT 10:14

Analytical Solutions for the Lateral Subsurface Drain

This section presents the analytical ground water flow solutions for the lateral subsurface drain. Also presented is an estimation of the steady-state impingement rate of the rising ground water table and the hydraulic conductivity of the subsurface drain. These parameters are necessary to conceptually design an artificial drainage system to divert rising ground water from beneath the engineered cover.

Because of viscous resistance to horizontal flow, impinging fluids mound up in lateral drains composed of sand and gravel. This mounding could be great enough to cause overtopping of the lateral drain, resulting in leachate production from contaminated soils above the drain. It is important to determine the possible height of mounding to estimate the optimum lateral drain thickness to prevent leachate generation.

The height of the mound depends upon the configuration of the drainage layer and the steady-state impingement rate. The maximum height of rise (Hmax) for a horizontal lateral drain is related to the distance between locations where ground water can exit the subsurface drainage layer. For an inclined lateral drain, as shown in Figure 3.2, the maximum rise, Hmax, is related to the angle (α) of the phreatic aquifer, the porosity (ϕ) of the drainage layer, the hydraulic conductivity of the lateral drain (K_{drain}), the drain spacing (L) (the distance between ground water removal channels), and the impingement rate (I). The inclined lateral subsurface drain has two significant advantages over a horizontal lateral drain. The first advantage is the tendency to accelerate flow within the subsurface drainage layer, and the second is that liquid within the subsurface drainage layer will flow from beneath the cover.

The system will be designed with a slope of 1.0 degree ($\alpha = 1.0°$) and will be constructed with channels to collect and discharge ground water from the lateral subsurface drain. Figure 3.2 depicts a conceptual cross-section of the lateral subsurface drain beneath the engineered cover. The maximum rise due to ground water mounding is predicted by calculating one-half of the value of L using the EPA (1983) equation below:

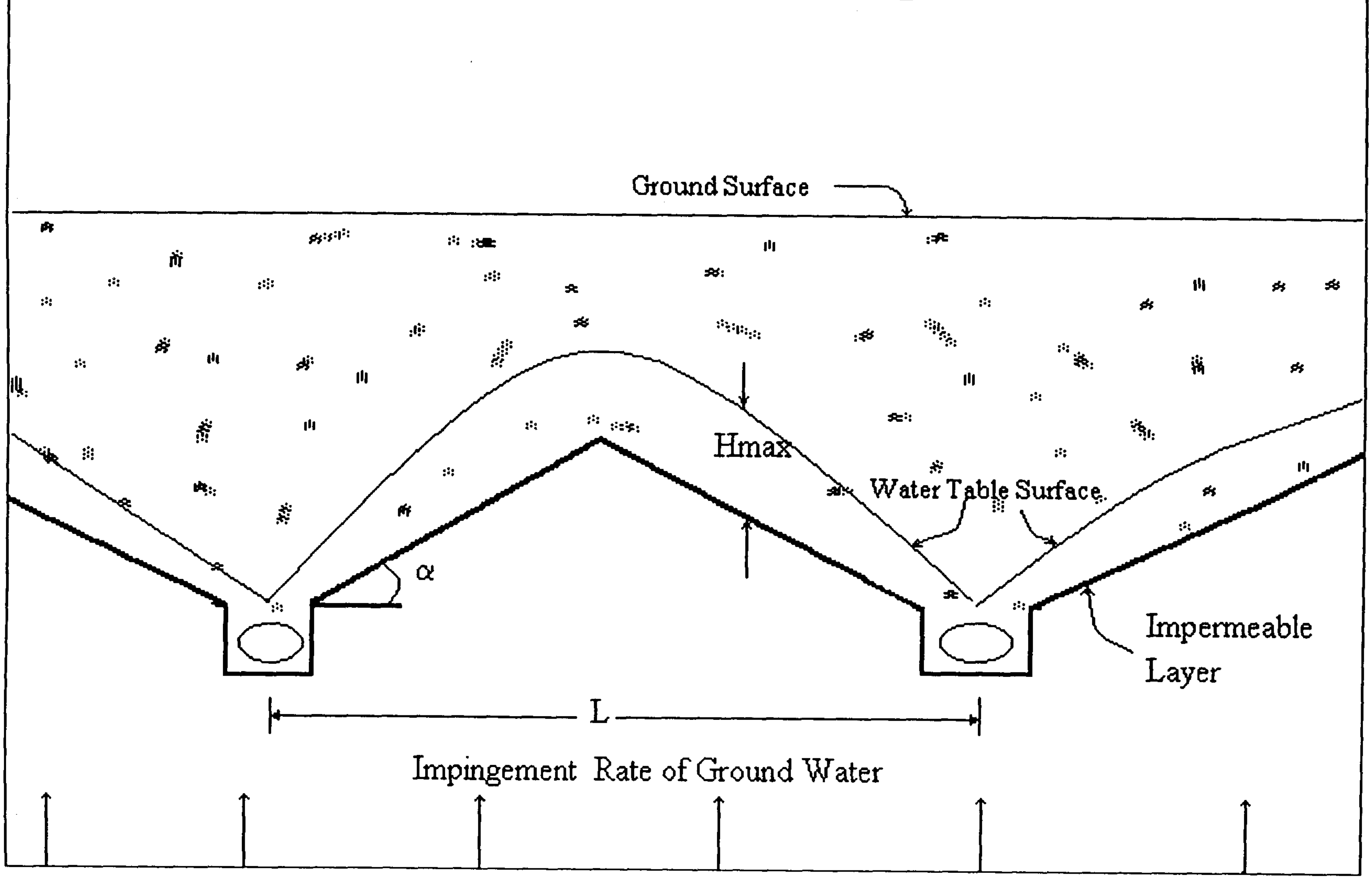
$$\text{Hmax} = (L \div (2 \times \phi)) \times (((I \div K_{drain}) + \tan^2\alpha)^{1/2} - \tan\alpha) .$$

To calculate the maximum height within the lateral drain, the hydraulic conductivity of the lateral drain (K_{drain}) needs to be considered.

Freeze and Cheery (1979) indicate that for unconsolidated gravels the hydraulic conductivity ranges between 1 and 100 cm/sec. No reference is given to indicate whether or not these gravels are naturally deposited. Additionally, the Naval Facilities Engineering Command (1986) report a hydraulic conductivity of approximately 37.4 cm/sec for clean, coarse-grained gravel drainage material. To verify the hydraulic conductivity values reported by Freeze and Cherry and the Naval Facilities Engineering Command, a numerical solution developed by Fair and Hatch was used. As reported by Freeze and Cherry (1979) and by Bear (1979), Fair and Hatch (1933) developed an analytical solution based upon dimensional considerations and verified the analytical results experimentally. Fair and Hatch's calculated hydraulic conductivity (K_{FH}) is

$$K_{FH} = (\rho \times g \div \mu) \times (\phi^3 \div (1-\phi)^2) \times \{1 \div (M \times ((\theta \div 100) \times \Sigma P_m \div d_m)^2)\}$$

Figure 3.2
Blanket Drain on Incline of Angle α



where ρ is the fluid density, g is the gravity constant, μ is the fluid viscosity, ϕ is the porosity, M is a unitless packing factor that was experimentally found to be about 5, θ is a roundness factor varying between 6.0 and 7.7, P_m is the percentage of sand held on adjacent sieves, and d_m is the geometric mean diameter of those particles. For the gravel lateral drain, the proposed geometric mean of sieved gravel is 3.11 cm (1.22 in) which represents sieved gravels ranging in size from 2.54 to 3.81 cm (1.0 to 1.5 in). To determine the sensitivity of Fair and Hatch's equation to porosity and the roundness factor several values were selected (Table 3.1.)

The lateral drain materials that are typically available have a roundness factor of 6.6 and a porosity of 20 percent. Using these data, a hydraulic conductivity of 54 cm/sec (1.8 ft/sec) is calculated using Fair and Hatch's method. A less conservative value may be calculated using a roundness factor of 6.6 and a 30 percent porosity which yields a hydraulic conductivity of 239 cm/sec (7.8 ft/sec).

Using a conservative hydraulic conductivity for the gravel lateral drain [54 cm/sec (1.77 ft/sec)], Freeze and Cherry, 1979, Naval Facilities Engineering Command, 1986, and Fair and Hatch as reported by Bear, 1979) and an aggressive impingement rate [1.36 x10^{-4} cm/sec (4.47 x 10^{-6} ft/sec)] the value of Hmax was determined.

The maximum ground water rise due to mounding is calculated using EPA (1983):

$$Hmax = (L \div (2 \times \phi)) \times (((I \div K_{drain}) + \tan^2\alpha)^{1/2} - \tan\alpha) .$$

TABLE 3.1
HYDRAULIC CONDUCTIVITIES USING FAIR & HATCH'S EQUATION FOR THE LATERAL SUBSURFACE DRAINAGE SYSTEM GIVEN VARIOUS POROSITIES AND ROUNDNESS FACTORS

Roundness	Porosity	K (cm/sec)	K (ft/sec)
6.0	0.35	534	17.5
	0.30	290	9.5
	0.25	146	4.8
	0.20	65	2.1
6.6	0.35	442	14.5
	0.30	239	7.8
	0.25	120	3.9
	0.20	54	1.8

A sensitivity analysis was performed by varying the porosity and the hydraulic conductivity to determine the variation in mounding within the lateral drain. Table 3.2 presents the sensitivity analysis results for porosities of 25 percent and 30 percent. The calculated water level mounding ranges between 48.5 cm (1.59 ft) and 3.0 cm (0.10 ft) for hydraulic conductivities between 6.4 cm/sec (0.21 ft/sec) and 100 cm/sec (3.28 ft). Figure 3.3 is a graphical presentation of the results. These results suggest that hydraulic conductivity values greater than 40 cm/sec (1.3 ft/sec) provide little measurable decline in ground water mounding within the lateral drain. Using a 30.48 cm (1.0 ft) thick lateral drain comprised of similar size gravels will provide a safety factor of at least 5.

TABLE 3.2
MOUNDING OF WATER TABLE IN A 1° BLANKET DRAIN
FOR VARIOUS POROSITIES AND HYDRAULIC CONDUCTIVITIES

Porosity	Height (ft)	K (cm/sec)	K (ft/sec)
30%	1.59	6.4	0.21
	1.03	10.0	0.33
	0.27	38.1	1.25
	0.19	54.0	1.77
	0.16	64.0	2.10
	0.10	100.0	3.28
25%	1.92	6.4	0.21
	1.23	10.0	0.33
	0.33	38.1	1.25
	0.23	54.0	1.77
	0.19	64.0	2.10
	0.12	100.0	3.28

Advantages of the Lateral Subsurface Drainage System

1. The system would not operate continuously but would function only in the event of a future rise in the ground water table elevation above normal levels.

2. The system can be constructed with filters to prevent the drainage system from being clogged by fine grained materials.

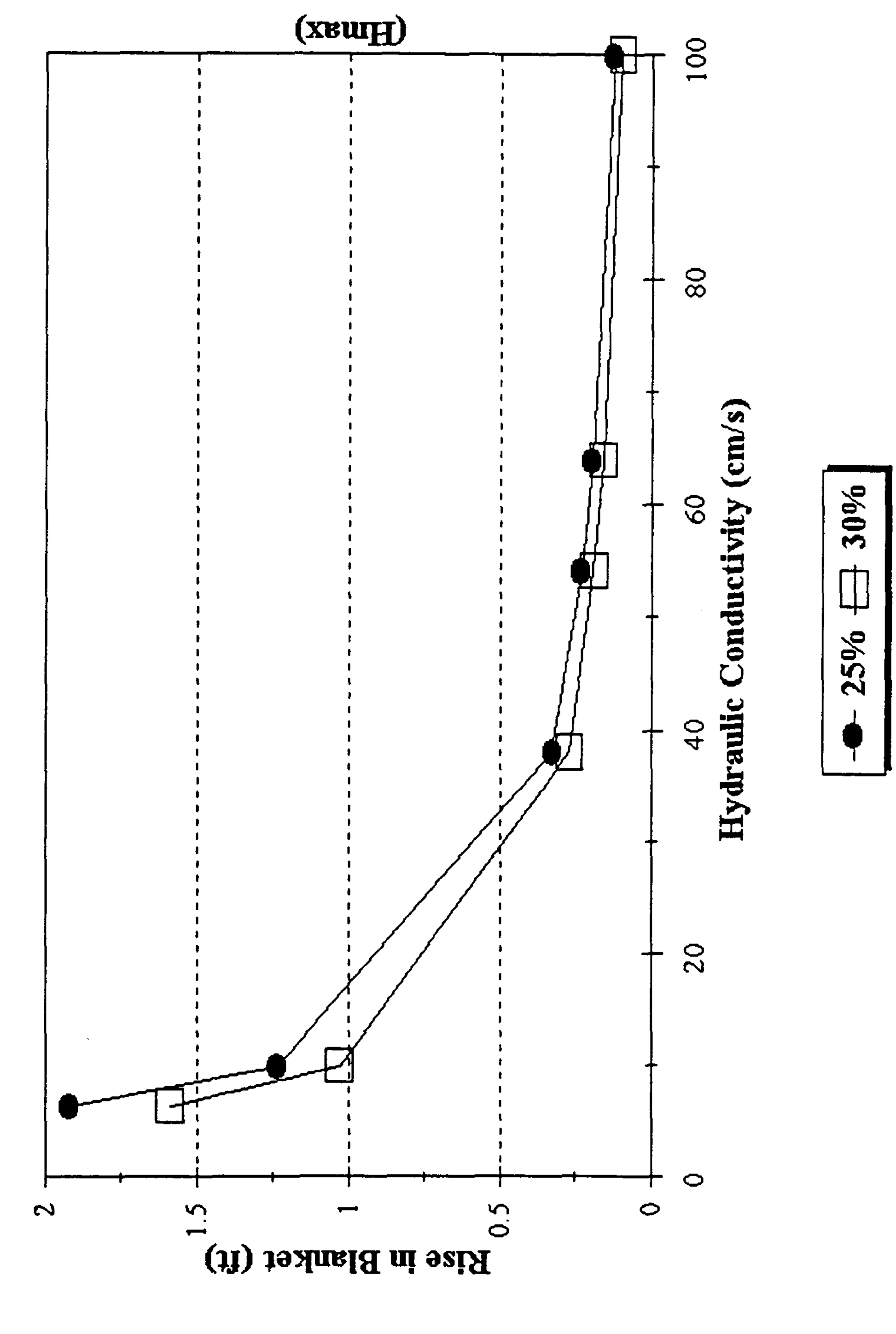
3. The system can be constructed so that disturbance of utilities and plant operations are minimized.

Disadvantages of the Lateral Subsurface Drainage System

1. Excavation of the contaminated subsurface soils beneath the SEPs is a risk to the construction and on-site workers.

Figure 3.3

Blanket Drain with 1 Degree Slope



2. A large volume of contaminated subsurface soils will be excavated, transferred, and staged in the SEP area during construction. The system will be partially installed while staging excavated materials within the SEP area. Excavated materials will be returned so that the remainder of the system can be constructed. This will result in double handling of the excavated materials.

3.2 System Evaluation

Long Term Effectiveness and Permanence

The subsurface drainage layer is anticipated to be effective for the 1000-year performance period based on the depth of its placement, the system design, and the natural materials used in construction. The base of the subsurface drainage layer would be positioned at the elevation of the mean seasonal high water table elevation. This elevation is approximately one foot above the mean water table elevation. Therefore, the system would function only during periods of ground water elevation that exceed the mean seasonal high water table elevation. Subsurface drainage is only anticipated during the spring months when snow melt and precipitation may cause the water table to rise higher than normal. It should be noted that the system would not operate during all spring seasons since the water table is not anticipated to intrude the system. The system should remain effective because the sand filter layers are designed to prevent fine-grained materials from migrating and clogging the porous gravels. The lateral subsurface drainage system is designed to remain effective for the 1000-year performance period because it is positioned at an elevation where it is generally expected to remain dry. The system would be permanent since the construction materials are natural sands and gravels.

The magnitude of residual risk to human health and the environment is anticipated to be low due to the fact that the system will prevent future rising ground water from contacting the consolidated contaminated materials. Therefore, the potential ground water exposure pathway would be protected by the lateral subsurface drainage system.

Short Term Effectiveness

The system would be effective over the short term for the same reasons that it would be effective over the long term. Construction of the system would not be expected to result in an unacceptable short term risk to onsite construction workers or members of the offsite public based on the results of the air dispersion and inhalation modeling presented in Part IV Section 10.3 of the IM/IRA-EA Decision Document for similar (but not identical) excavations. Dust suppression techniques would be employed during construction to minimize the release of dust and airborne particles.

The environmental impacts associated with the implementation of this system would be the same as those associated with the construction of the engineered cover (Section III, Part 5 of the IM/IRA-EA Decision Document).

The objectives of the lateral subsurface drainage system would be achieved as soon as the system was installed. The system would be installed prior to the installation of the engineered cover.

Implementability

The lateral subsurface drain is considered to be a reliable technology that can be engineered to be effective at the OU4 site. The subsurface drain would be constructed by common pit excavation techniques. The sides of the excavation would be cut back at a 2:1 slope. The subsurface drain would be installed via horizontal lifts of sands and gravel. The construction Quality Assurance/Quality Control (QA/QC) for placing horizontal lifts would be easy to implement by establishing appropriate slope elevations and layer thickness by surveying. The utilities that would be impacted are listed on Drawing 51045-440 in Appendix IV.B of the IM/IRA-EA Decision Document. A buried utility location identification field program would be required prior to the excavation. There would be a high level of inefficiency associated with the installation of the subsurface drain due to the fact that there is no area available for staging the excavated contaminated subsurface soils while the subsurface drain is being installed. Therefore, the subsurface drain would be installed in stages. The staged soils would be returned to the excavation above the subsurface drain.

The installation of the subsurface drainage system would be irreversible upon completion of the final engineered cover. However, the system would not interfere with any upgradient or downgradient corrective actions that may be taken for the future remediation of ground water.

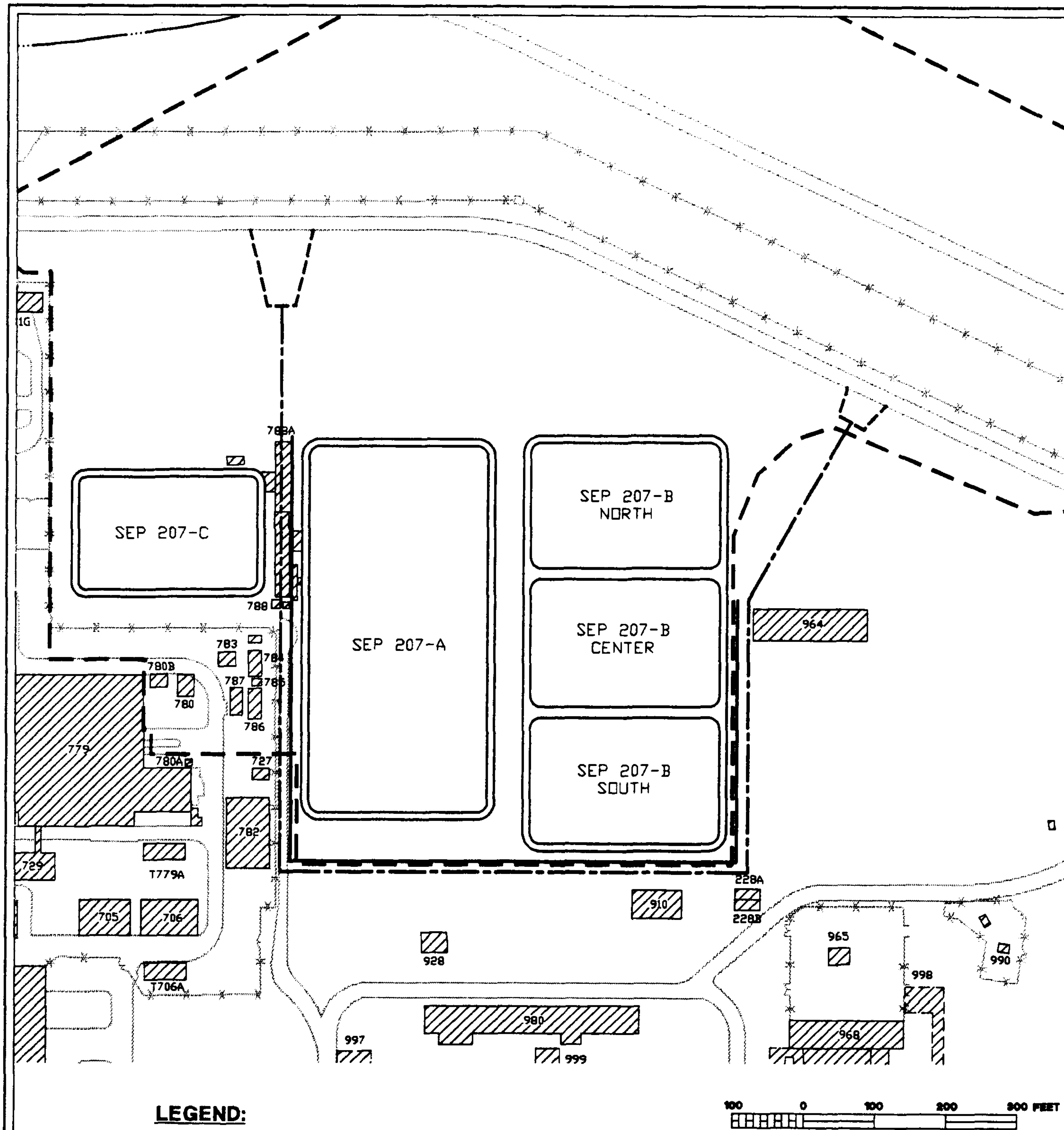
Cost

The estimated cost associated with installing the lateral subsurface drainage layer below the contaminated materials and engineered cover is $29,000,000. The direct cost associated with the installation of the system is approximately $400,000 including the excavation of the SEP area under the engineered cover to the mean seasonal high water table elevation, and the construction of the lateral subsurface drainage layer. The magnitude of cost estimate details are provided as Attachment 1.

4.0 VERTICAL GROUND WATER CONTROL SYSTEM

4.1 System Description

An upgradient vertical ground water control system could be implemented by excavating down to competent low-permeable bedrock and installing a slurry wall that would prevent ground water flow into the zone beneath the SEPs. A method of redirecting the ground water flow would be required to divert upgradient ground water away from the slurry wall. The conceptual design for this system (as depicted in Figure 4.1) would include a 2-feet thick slurry wall consisting of a natural bentonite material. A 3-feet thick collection trench would be installed upgradient of the slurry wall to collect the ground water. The collection trench would redirect ground water around the SEP closure area and tie into the downgradient ITS. The collection trench would be filled with gravel to provide a high permeability channel. This system would be required to function continuously for 1000 years since the system would be installed beneath the water table. The system would be installed along the west and south sides of the engineered cover to prevent upgradient ground water from contacting the contaminated media beneath the engineered cover. In addition, the system would be installed along one-half of the east side of



LEGEND:

- Streams
- Paved Roads
- Buildings
- Fence
- OU4 Boundary
- Bentonite Slurry Wall
- Drainage Trench
- Surface Flow

PREPARED FOR
U.S. DEPARTMENT OF ENERGY
ROCKY FLATS PLANT
GOLDEN, COLORADO

Figure 4.1

Solar Evaporation Ponds
Operable Unit No. 4, IM/IRA EA DD
Vertical Ground Water Control System
Plan

the engineered cover to prevent ground water from flowing around the slurry wall and contacting the contaminated media beneath the engineered cover. Figure 4.1 shows the layout of the upgradient vertical ground water control system. Figure 4.2 shows a cross section of the system. Water collected in the collection trench would need to be treated by an onsite wastewater treatment system.

Analytical Solution for Collection of Ground Water

Although additional data is necessary, the amount of ground water flow from the collection trench can be estimated using the Dupuit-Forchheimer discharge formula for a trench (Bear, 1979). The discharge, Q, is calculated as:

$$Q = A \times K \times (H^2 - h^2) \div (2 \times L)$$

where A is the area, K is the hydraulic conductivity, H is the height of the unaffected water table, h is the height of water in the trench, and L is the length of influence (radius of influence). For the alluvium it can be assumed that the trench is 1600 ft long and 4.0 ft deep,$K=5.0 \times 10^{-5}$ ft/sec (maximum rounded value of 4.59 x 10-5 from Table 2.3), H = 4.0 ft, h =0.0 ft (based upon selection of coordinates), and L is large enough to cover the ponds or about 1000 ft. Thus, the above equation yields:

$$Q = 80{,}700 \text{ ft}^3/\text{yr} \text{ or about } 600{,}000 \text{ gal/yr.}$$

For the bedrock, it can be assumed that the trench length is 1600 ft and depth is 30 ft, K= 3.0 x 10^{-8} ft/sec (estimated from available hydrogeological data in the vicinity of OU4), H = 30 ft, h =0.0 ft (based upon selection of coordinates), and L is large enough to cover the ponds and is greater than the alluvium or about 2000 ft. Thus, the above equation yields

$$Q = 10{,}200 \text{ ft}^3/\text{yr} \text{ or about } 76{,}000 \text{ gal/yr.}$$

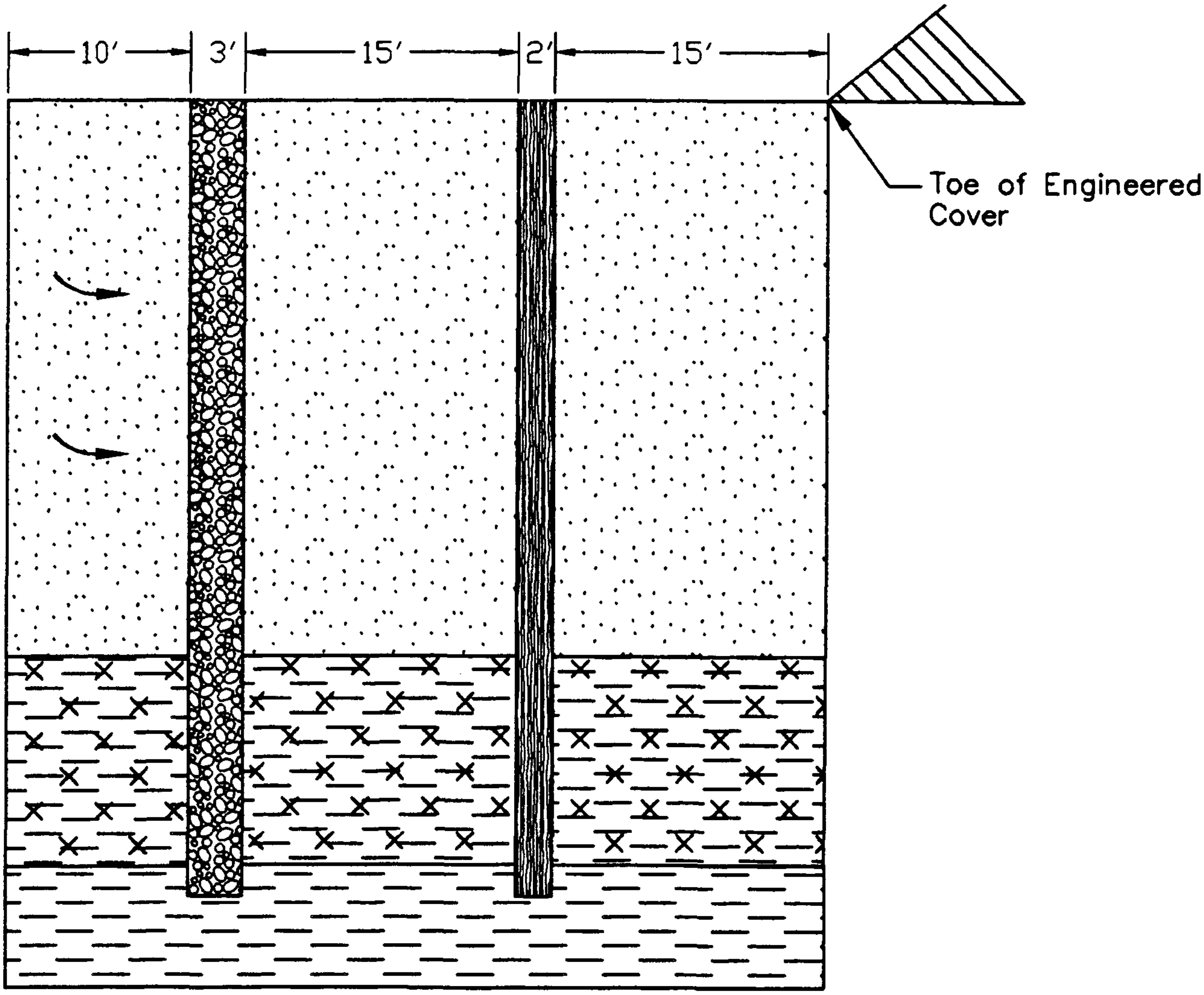
Although these flow rates are estimated they give an approximate ground water flow rate that may be derived from the vertical control system, and would be collected for treatment at the ITS system.

Advantages of the Vertical Ground Water Control System

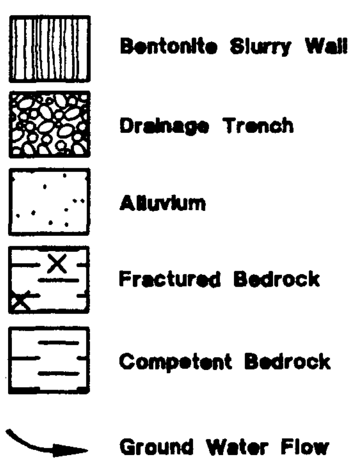
1. Lesser volumes of contaminated soils beneath the SEPs would have to be excavated and handled by construction workers.

2. The volume of contaminated soils requiring excavation would be less than for the construction of the lateral subsurface drain. Therefore, the side slope of the engineered cover may be reduced which would make the engineered cover more stable with respect to erosion, and more effective with respect to evaporation and transpiration.

3. The upgradient vertical ground water control system would aid in dewatering the hillside in the OU4 remediation area which would increase the slope stability.



LEGEND



PREPARED FOR
U.S. DEPARTMENT OF ENERGY
ROCKY FLATS PLANT
GOLDEN, COLORADO

Figure 4.2

Solar Evaporation Ponds
Operable Unit No. 4, IM/IRA EA DD
Cross Section of Vertical
Ground Water Control System

4. The upgradient vertical ground water control system may expedite the collection and treatment of contaminated ground water from the RFETS upgradient industrial areas.

Disadvantages

1. The system would have to operate continuously over the 1,000 year-period of performance since the system would extend below the top of the water table.

2. There are numerous RFETS buried utility lines that run along the south and west sides of the SEPs that may be impacted by the installation of the upgradient system but would not be impacted by the lateral subsurface drainage layer.

3. The depth to competent bedrock may limit the methods of construction.

4. The vertical ground water collection trench would not have sand filter layers to prevent fine grain materials from clogging the system.

5. The construction activities could be complicated due to the need to dewater the phreatic zone in the construction area.

6. Demonstrating that the system is effective for the 1,000-year period would be dependent upon ground water flow modeling. There is not enough existing hydrogeological information in the vicinity of the OU4 SEPs to construct an appropriate ground water flow model since the Phase II RFI/RI field work has not been completed. Therefore, the OU4 closure would be delayed until the hydrogeological data could be collected, analyzed, and used to create and calibrate a ground water flow model to demonstrate the system's effectiveness.

7. Construction QA/QC could be difficult to ensure if slurry trenching techniques were used because these techniques are essentially *in situ* construction methods.

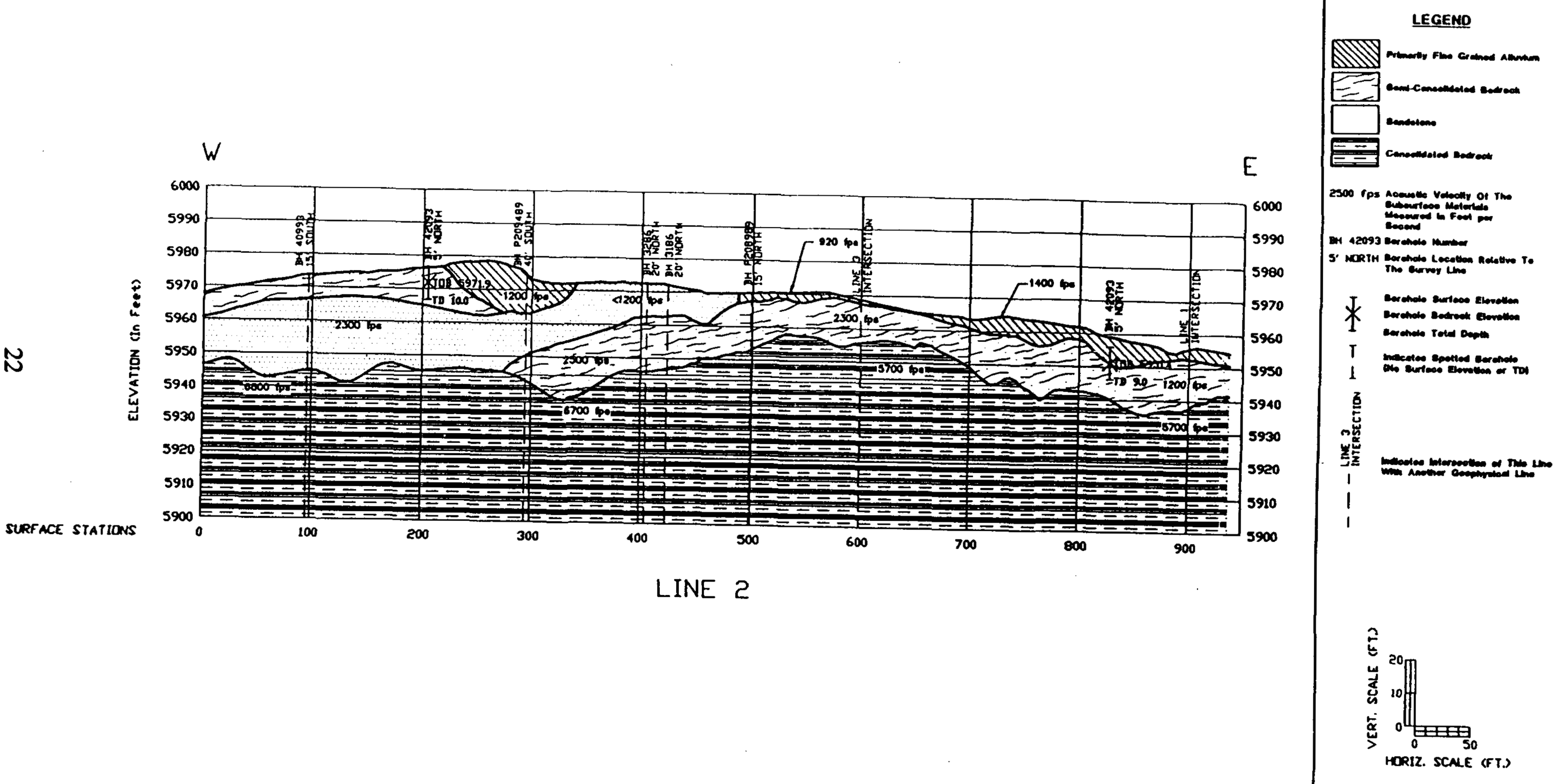
8. If the UHSU and the LHSU are not demonstrated to be hydraulically connected, then the construction of a vertical ground water collection trench would connect the distinct aquifer systems and provide a pathway for contaminants in the UHSU to migrate into the LHSU. It is noted that the aquifers are thought to be connected. This should be verified by the Phase II RFI/RI.

9. The construction of the system could potentially interfer with future upgradient or downgradient ground water corrective action programs.

4.2 System Evaluation

Long Term Effectiveness and Permanence

An evaluation of the ground water flow system must be considered for the long term effectiveness of a vertical drain and slurry wall. The ground water flow system for OU4



PREPARED FOR
U.S. DEPARTMENT OF ENERGY
ROCKY FLATS PLANT
GOLDEN, COLORADO

Figure 4.3

Solar Evaporation Ponds
Operable Unit No. 4, IM/IRA EA DD
Geophysical Line 2

consists of the UHSU and the lower hydrostratigraphic unit (LHSU). These two hydrostratigraphic units are designated as independent water-bearing strata, however, they are hydraulically connected. The predominance of flow is from the UHSU to the LHSU, beneath the SEPs, except possibly in the spring months. Section 2.1, Conceptual Model of the Vadose Zone Flow, envisions macropore ground water flow recharging the alluvium and weathered bedrock zones of the UHSU. It is unclear from the data currently available, the extent and depth of these macropores and the quantity of ground water flow between the two hydrostratigraphic units. During the spring, the LHSU may have sufficient hydrostratigraphic head to locally recharge the UHSU, which is likely to account for some of the ground water rise observed in the UHSU.

The success of a bentonite slurry wall and drainage system to effectively stop ground water flow and lower the water table beneath the engineered cover appears to be dependent upon "keying" the slurry wall into unweathered (and unfractured) impermeable bedrock. Currently available subsurface geologic and geophysical data obtained from within OU4 suggests that the "weathered bedrock" horizon is highly variable in thickness. If portions of the slurry wall are keyed only into weathered bedrock, effective communication will exist between ground water outside the wall and areas inside the wall.

On the pediment slopes, the weathered bedrock zone is approximately 20 to 40 feet thick, as measured from the alluvial/colluvial contact downward. Figure 4.3 is Line 2 from the refraction survey for the Phase I RFI/RI for OU4. Line 2 is located along the upper edge of the pediment slope adjacent and parallel to the northern edges of the SEPs. Based on velocity contrasts the weathered bedrock is interpreted to extend down to an elevation of 5935 msl or about 35 feet below ground surface. On the pediment, the weathered bedrock interval is more variable in thickness and composition, and not completely discernable using refraction survey techniques.

Since the weathered horizon is of variable thickness, extent, and depth, keying the slurry wall into unweathered bedrock will be extremely difficult without a detailed geotechnical study of the slurry wall footprint area. Both geological and geophysical information may be necessary to effectively design the slurry wall.

The collection trench upgradient of the slurry wall is designed to act as an interceptor system for the slurry wall so that increased hydraulic head is minimized along the slurry wall. The collection trench will have to be engineered to allow for a 1000-year accumulation of silt deposition within the drain system. Engineered drains typically use graded filter layers. Because of the assumed depth and limited width of the vertical drain, filter packing would be difficult to implement during construction. Without a filter pack for the gravel fraction of the drain, the system would begin to clog due to accumulation of silt and clay particles. The rate of clogging is dependent upon the composition of the adjoining soil materials and the velocity of ground water flow. Additional investigation may be necessary to estimate this rate.

The system would be permanent since that materials of construction are natural sands and gravels. The magnitude of residual risk is anticipated to be low due to the fact that the system will be designed to prevent ground water from contacting the consolidated contaminated materials (assuming that the system is successfully keyed into competent low permeable bedrock). Therefore, the potential ground water exposure pathway would be blocked by the upgradient vertical ground water control system.

Short Term Effectiveness

The short term effectiveness for the ground water collection trench and the slurry wall will be dependent upon keying the slurry wall to competent bedrock. Depending upon which season the collection trench is installed, the collection trench may divert an additional quantity of ground water above the estimated steady-state flow quantity until an equilibrium is reached. The water table downgradient from the vertical ground water control system should gradually be lowered to the effective drainage height of the trench. Since the hydraulic conductivities of the bedrock are on the order of 10^{-8} ft/sec, the re-equilibration of the water table may take several years. Dust suppression techniques would be employed during construction to minimize the release of dust and airborne particles.

The environmental impacts associated with the implementation of this system would be the same as those associated with the construction of the engineered cover (Section III, Part 5 of the IM/IRA-EA Decision Document).

The objectives of the upgradient vertical ground water control system would be achieved as soon as the system was installed. The system would be installed prior to the installation of the engineered cover.

Implementability

The upgradient vertical ground water control system would be a reliable technology for the OU4 site if the slurry wall was effectively keyed into competent low permeability bedrock. Additional geophysical and/or boring investigations would be required to establish the depths required to key the system into competent low permeability bedrock. Hydrogeological investigations upgradient and downgradient of the system would be required to construct and calibrate a ground water flow model. This model would need to be developed to demonstrate that the system would be an effective solution for the site. It is estimated that the detailed design for the OU4 SEP closure IM/IRA would be delayed for one year while these studies were planned, implemented, and analyzed. A buried utility identification field program would be required prior to excavation.

Two methods of constructing the upgradient vertical ground water control system were considered. The first method is opening a trench excavation to the required depth with the appropriate cut back slope (ratio of 2 horizontal feet to 1 vertical foot of excavation). The second method is to utilize slurry trenching techniques..

A cut back distance of 90 feet would be required for a trench excavation of 45 feet. Figure 4.4 provides a plot plan which identifies the southern edge of the ground water collection trench and shows the location of the edge of the required cut back. It is obvious that the trench excavation construction method is not practical due to interferences with the utilities and operating facilities.

Based on a 45 foot deep excavation with a 2:1 slope, the impacted areas would extend approximately 125 feet from the toe of the cover (includes the 90 foot required cutback, the three feet thick drainage layer, 15 feet of soil, two feet thick slurry wall, and 15 feet of soil as shown on Figure 4.2) assuming the slurry wall will be constructed immediately outside the berms of the SEPs. For this scenario, numerous buildings and utilities would be impacted as shown on Figure 4.4. The buildings, tanks, and utilities that would be impacted but would not be affected by the construction of the lateral drainage system include the following:

Buildings/Tanks

- Building 782
- Building 727
- Building 964
- Building 910
- Building 783
- Storage tank 215-C
- Storage tank 215-D
- Cooling towers

Utilities

(identified as items on Drawing 51045-440 in Appendix IV.B of the IM/IRA-EA Decision Document)

- Item No. 11 - Overhead power south of C Ponds and west of SEP 207-A.
- Item No. 13 - 10" domestic cold water west of SEP 207-A.
- Item No. 24 - Underground power line west of SEP 207-A.
- Item No. 30 - Reverse osmosis product water south of B-Series SEPS.
- Item No. 40 - Reverse osmosis lines south of B-Series SEPs.
- Item No. 41 - Reverse osmosis feed south of B-Series SEPs.

Based on the construction impact analysis it was determined that the open trench construction method was not implementable at the OU4 site. This method is therefore not carried forward with respect to preparing a cost analysis.

The second method for constructing a vertical ground water control system would be the construction of a collection trench followed by the construction of a downgradient slurry wall utilizing straight-wall trenching techniques. The collection trench would be constructed prior to the slurry wall in order to avoid the ponding of ground water, which can adversely affect future construction efforts. Construction equipment would consist of excavators, mixing trucks, pumping units, and general small support equipment. The required overhead operating space during construction operation would be 90 feet.

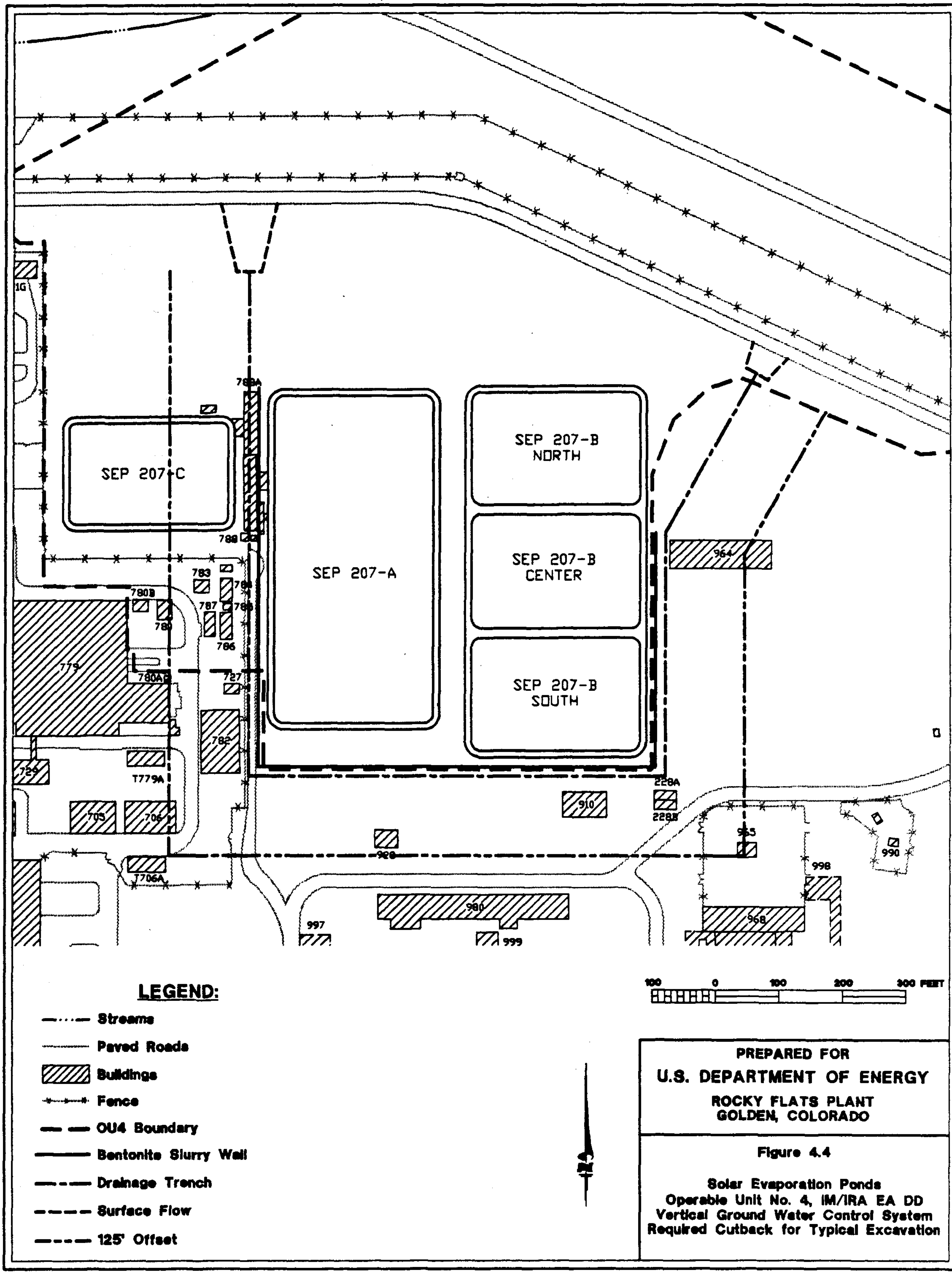


Figure 4.4

Solar Evaporation Ponds
Operable Unit No. 4, IM/IRA EA DD
Vertical Ground Water Control System
Required Cutback for Typical Excavation

The slurry wall would be constructed utilizing general slurry trenching techniques. The construction sequence of the slurry wall would include the excavation of the trench while maintaining a bentonite-water slurry at the top of the excavation. The bentonite-water slurry generally allows for the excavation to continue without the use of other lateral support within, or surrounding, the trench. As trenching operations progress, the area that was previously keyed into competent low-permeability bedrock would be backfilled with a soil-bentonite mixture, which would act as the final low permeability barrier material. Excavation and backfilling operations would be conducted concurrently so that displaced excess slurry or the need for new slurry would be minimized. The soil-bentonite mixture is usually blended adjacent to the backfilling operations. As the backfill mixture is placed within the trench, any displaced bentonite-water slurry would be pumped from the trench into a holding area. The suitability of the onsite soil (from the trenching) for use in the soil-bentonite backfill mixture is uncertain and would need to be tested. It should be noted that this construction method is very difficult to ensure that the QA/QC requirements are met during installation because it is an insitu type placement of materials.

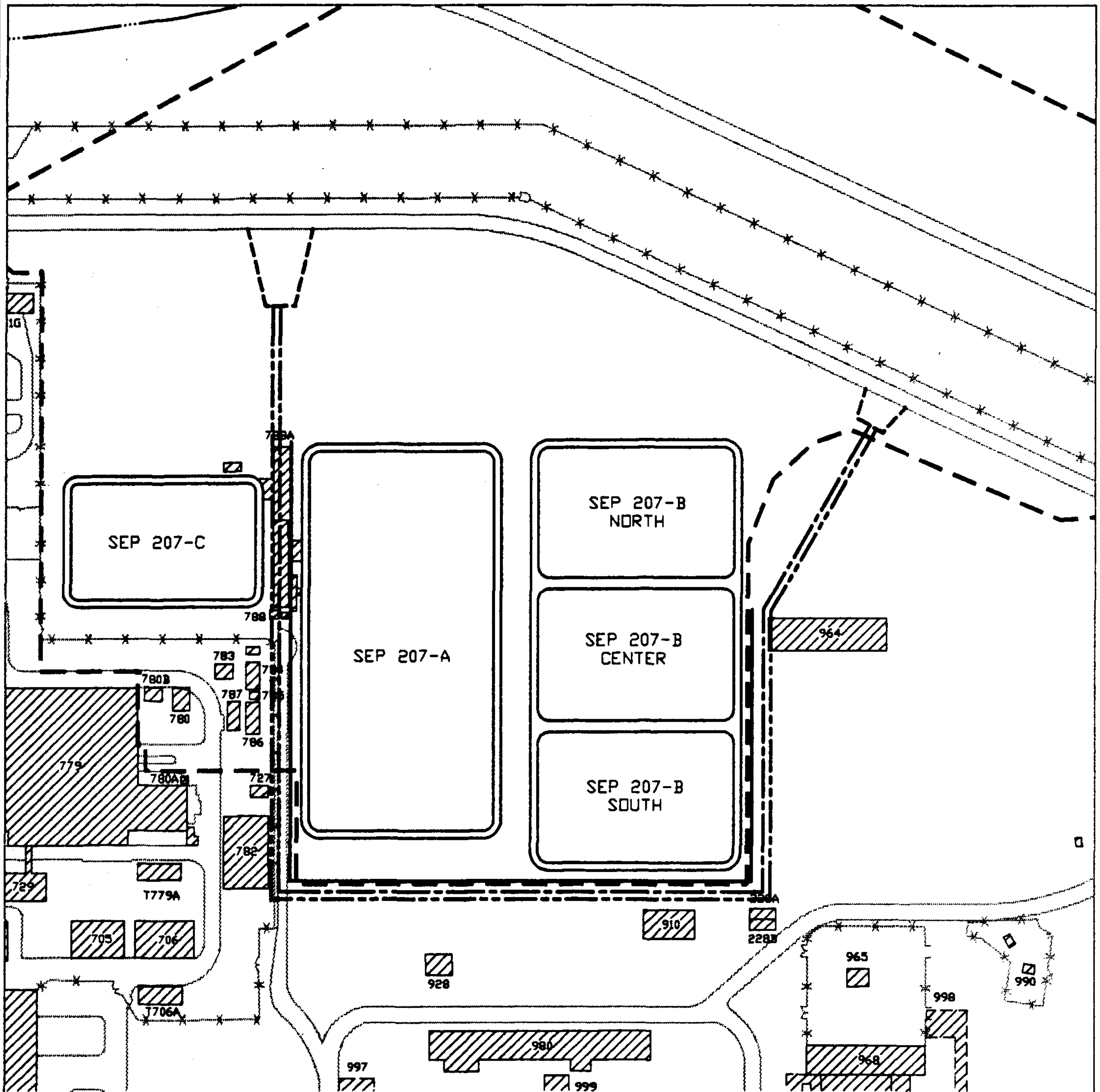
The ground water collection trench would be constructed utilizing the same construction methods as in the slurry wall. However, a bio-polymer slurry would be used instead of a bentonite-water slurry to sustain the integrity of the trench. The bio-polymer slurry would also be mixed adjacent to the trenching operations. The bio-polymer slurry would consist of a biodegradable carbohydrate in which any remaining slurry would naturally degrade to allow for a permeable collection trench. Any displaced bio-polymer slurry would also be pumped from the trench into a controlled holding area as the drainage media (gravel) is backfilled into the trench.

Difficulties that can be experienced while using straight-wall trenching techniques include excessive sloughing, or fall-in, of soils into the excavation, or the existence of significant obstructions (e.g., underground utilities or boulders). The possibility of excessive sloughing in the upper 10 feet of alluvium material may require the use of a trench box, geofabric, or tremie system during the construction of the collection trench and slurry wall. Finally, quality control/quality assurance methods and procedures would be critical in the construction of the vertical ground water control system as no visual inspection of system placement would be possible.

Based on a trenching scenario the impacted area would extend approximately 45 feet from the toe of the cover (includes the 10 feet constructability area, three feet drainage layer, 15 feet of soil, two feet slurry wall, and 15 feet of soil as shown on Figure 4.2) assuming the slurry wall would be constructed immediately outside the berms of the SEPs. For this scenario, buildings and utilities would also be impacted as shown on Figure 4.5. The buildings and utilities that would be impacted by the upgradient vertical ground water control system installed by this second construction technique include the following:

<u>Buildings/Tanks</u>

- None



LEGEND:

- Streams
- Paved Roads
- Buildings
- Fence
- OU4 Boundary
- Bentonite Slurry Wall
- Drainage Trench
- Surface Flow
- 10' Offset

PREPARED FOR
U.S. DEPARTMENT OF ENERGY
ROCKY FLATS PLANT
GOLDEN, COLORADO

Figure 4.5

**Solar Evaporation Ponds
Operable Unit No. 4, IM/IRA EA DD
Vertical Ground Water Control System
Required Cutback for Trenching**

Utilities

(identified as items on Drawing 51045-440 in Appendix IV.B of the IM/IRA-EA Decision Document)

- Item No. 11 - Overhead power south of SEP 207-C and west of SEP 207-A.
- Item No. 13 - 10" domestic cold water west of SEP 207-A.
- Item No. 24 - Underground power line west of SEP 207-A.
- Item No. 30 - Reverse osmosis product water south of B-Series SEPs.
- Item No. 40 - Reverse Osmosis Lines South of B-Series Ponds.
- Item No. 41 - Reverse Osmosis Feed South of B-Series Ponds.

It should be noted that these utilities would not be impacted by the construction of the lateral subsurface drainage system. The installation of the upgradient vertical ground water control system is a permanent system that could be modified without impacting the final engineered cover. The system could interfere with future upgradient or downgradient ground water corrective action programs.

Cost

The estimated cost to construct a vertical ground water control system along with the engineered cover over the existing contaminated materials would be $31,000,000 based on the slurry trenching excavation method. The direct cost associated with installing the upgradient vertical ground water control system is approximately $1,116,000. The cost of installing the upgradient vertical ground water control system is approximately 36 percent higher than the cost of installing the lateral subsurface drainage system (based on the direct cost for the installation of the two systems). The excavation of soils beneath the engineered cover is not required under this alternative. This estimated cost, however, can not be directly compared with the cost of the lateral subsurface drainage system. No additional costs were added for supplementary geologic investigations, ground water modeling activities, or for the demolition costs of additional facilities or utility obstructions that may require removal prior to the installation of the upgradient vertical ground water control system. These additional costs are likely to be significant because many of the utilities that would be impacted may currently be active and require relocation. The magnitude of cost estimate details are enclosed as Attachment 2.

5.0 CONCLUSIONS REACHED FROM THE EVALUATION OF SPECIFIC METHODS TO PREVENT GROUND WATER CONTAMINATION

Based on the analysis of these methods to prevent ground water from contacting the contaminated materials consolidated beneath the engineered cover, it is recommended that the lateral subsurface drainage layer be installed. The lateral subsurface drainage layer is considered to be a more reliable system that can be engineered with a higher level of confidence so that it will remain effective for the 1000-year period of performance. The rationale for this decision are as follows:

1. The lateral subsurface drainage system will function only during periods when the ground water elevation is higher than the mean elevation, and is therefore predicted to

be reliable for the 1000-year period of performance. The upgradient vertical ground water control system will be required to function continuously for the 1,000 year period of performance. The potential for either system to fail increases with the amount of time that the system must function.

2. The lateral subsurface drain can be constructed with filter layers to prevent clogging over time. The upgradient vertical drain system cannot be constructed with filter layers. Therefore, the vertically installed system has a higher potential for clogging due to the lack of filters and the fact that it must operate continuously.

3. The depth to competent bedrock and the uncertainties associated with keying the entire slurry wall into competent low-permeable bedrock make the effectiveness of the upgradient ground water control system difficult to verify and demonstrate.

4. The project schedule would be impacted to engineer the upgradient vertical ground water control system due to the need to perform geologic/hydrogeologic investigations and develop a ground water flow model to demonstrate that the system would be effective.

5. Suitable soil materials may need to be imported so that the soil-bentonite mixture meets design specifications, and so that contaminated soils are not incorporated into the slurry wall. A method of disposing displaced (potentially contaminated) bentonite-water slurry or bio-polymer slurry would need to be determined.

6. The cost of the lateral subsurface drainage system is expected to be less than the cost of the upgradient vertical ground water control system.

7. The lateral subsurface drainage system will not interfere with any future upgradient or downgradient corrective actions that may be taken for the remediation of ground water. The installation of localized upgradient ground water control for the OU4 site may interfere with future sitewide ground water corrective action alternatives.

6.0 REFERENCES

1. Bear, Jacob, 1979, Hydraulics of Groundwater. McGraw-Hill, Inc. Publishers, New York, New York.

2. Doty & Associates, May, 1993, OU4 Phase I RFI/RI Report, "Previous SEP Investigations."

3. EG&G Rocky Flats, Inc. 1993. "Final Palynology of the Uppermost Laramie and Arapahoe Formations at the Rocky Flats Plant near Golden, Colorado," December, 1993.

4. Freeze, R. A. and J. A. Cherry. 1979. Groundwater. Prentice-Hall, Inc. Publishers, Englewood Cliffs, New Jersey.

5. Rockwell International. 1988. "Solar Evaporation Ponds Hydrogeologic Characterization Report." Prepared by Roy F. Weston Inc., July, 1988.

6. U.S. Environmental Protection Agency (EPA). 1983. Publication SW-869, Landfill and Surface Impoundment Performance Evaluation. U.S. Government Printing Office. 69 pages.

ATTACHMENT 1

CLIENT: EG&G
ADDRESS: Rocky Flats Plant
ESTIMATOR: Edmonson/Montes/Lux

OU4 IM/IRA PROJECT COST ESTIMATE
CONSTRUCTION SCHEDULE: JUNE 1995 THROUGH NOVEMBER 1997
1000 YEAR COVER WITH LATERAL SUBSURFACE DRAIN

DATE: 03-Aug-94
TIME: 09:29:21 AM

COST CODE	DESCRIPTION	QTY	UNIT	MATERIAL UNIT COST	MATERIAL TOTAL COST	LABOR UNIT COST	LABOR TOTAL COST	CONSTR. EQUIP UNIT COST	CONSTR. EQUIP TOTAL COST	TOTAL
0100	Baseline radiological/hazardous survey				0		523,900		0	523,900
	Initial survey									
	Set up material staging area	80	MH		0	65.00	5,200		0	5,200
	Set up exclusion zone	160	MH		0	65.00	10,400		0	10,400
	Set up step-off/survey area	80	MH		0	65.00	5,200		0	5,200
	Develop radiation worker permit for zone entry	80	MH		0	65.00	5,200		0	5,200
	Baseline survey by HPT	80	MH		0	65.00	5,200		0	5,200
	Obtain excavation permit	40	MH		0	65.00	2,600		0	2,600
	Conduct pre-job training on sampling grid	60	MH		0	65.00	3,900		0	3,900
	Phase II activities									
	Modify radiation worker permit for excavation	40	MH		0	65.00	2,600		0	2,600
	Write health and safety plan	640	MH		0	65.00	41,600		0	41,600
	Phase III activities				0					
	Daily initial surveys, surveys of equipment leaving exclusion zone and daily end of day surveys of ground and equipment	4000	MH		0	65.00	260,000		0	260,000
	Covering any "surface contamination" during operations and overnight if discovered in end-of-day survey	2800	MH		0	65.00	182,000		0	182,000
0200	Monitor job site remediation/entry security				0		705,828		0	705,828
	Rad technicians - 4 for 9 months of project	4,536	MH		0	34.53	156,628		0	156,628
	Construction personnel enter/exit job site	13,730	MH		0	40.00	549,200		0	549,200

CLIENT: EG&G
ADDRESS: Rocky Flats Plant
ESTIMATOR: Edmonson/Montes/Lux

OU4 IM/IRA PROJECT COST ESTIMATE
CONSTRUCTION SCHEDULE: JUNE 1995 THROUGH NOVEMBER 1997
1000 YEAR COVER WITH LATERAL SUBSURFACE DRAIN

DATE: 03-Aug-94
TIME: 09:29:21 AM

COST CODE	DESCRIPTION	QTY	UNIT	MATERIAL UNIT COST	MATERIAL TOTAL COST	LABOR UNIT COST	LABOR TOTAL COST	CONSTR. EQUIP UNIT COST	CONSTR. EQUIP TOTAL COST	TOTAL
5000	Indirect field costs				54,616		1,561,236		2,276,014	3,891,866
5010	Obtain building permits	80	MH		0	40.00	3,200		0	3,200
	Cost of Permit	1	LS	500.00	500					500
5020	Mobilization - set up construction staging area and perform decon and smear tests on equipment entering the job site	1,000	MH		0	40.00	40,000		0	40,000
5040	Sanitary (portable toilets) - 8	24	MONTH		0		0	584.00	14,016	14,016
5045	Handwash unit - 4	24	MONTH					340.00	8,160	8,160
	Eyewash Unit - 4	24	MONTH					116.62	2,799	2,799
5050	Temporary utils (phone, water, 220V elec)	24	MONTH	500.00	12,000		0		0	12,000
	Temporary security fence and lighting installation									
5060	Security fence	2,090	LF	4.00	8,360	6.00	12,540		0	20,900
	Terminal posts	8	EA	70.00	560	105.00	840		0	1,400
	Security gates	4	EA	404.00	1,616	606.00	2,424		0	4,040
	Lights north of seepline	24	MONTH					4100	98,400	98,400
	Lights south of seepline	24	MONTH					4100	98,400	98,400
5100	Trucks									
	Water tanker (631ww) and operator	24	MONTH		0	7,040.00	168,960	13,680.00	328,320	497,280
	Off highway truck (777C) and operator	24	MONTH		0	7,040.00	168,960	10,465.00	251,160	420,120
	Wheel loader (992C) and operator	24	MONTH		0	7,040.00	168,960	33,240.00	797,760	966,720
5110	Mobile lab for geotechnical soil testing	24	MONTH		0		0	700.00	16,800	16,800
	Geotechnical Technician	1500	MH			80.00	120,000		0	120,000
	Field Technician	3000	MH			80.00	240,000		0	240,000
5120	Mobile analytical lab for environmental testing				0					
	Staffed lab	120	DAY		0	3,000.00	360,000		0	360,000
	Standby lab	120	DAY		0	800.00	96,000		0	96,000
5121	Site prep. trailer area									
	Road base (6") and grading	740	SY	7.54	5,580	0.06	44	0.04	30	5,654
5125	Office trailer	24	MONTH					375.00	9,000	9,000
5126	Break trailer	24	MONTH					260.00	6,240	6,240
5130	Trailer with lockers	24	MONTH		0		0	375.00	9,000	9,000

CLIENT: EG&G
ADDRESS: Rocky Flats Plant
ESTIMATOR: Edmonson/Montes/Lux

OU4 IM/IRA PROJECT COST ESTIMATE
CONSTRUCTION SCHEDULE: JUNE 1995 THROUGH NOVEMBER 1997
1000 YEAR COVER WITH LATERAL SUBSURFACE DRAIN

DATE: 03-Aug-94
TIME: 09:29:21 AM

COST CODE	DESCRIPTION	QTY	UNIT	MATERIAL UNIT COST	MATERIAL TOTAL COST	LABOR UNIT COST	LABOR TOTAL COST	CONSTR. EQUIP UNIT COST	CONSTR. EQUIP TOTAL COST	TOTAL
5150	Personnel decon trailer with showers	24	MONTH		0		0	550.00	13,200	13,200
5155	Lab/trailer:set-up/remove	6	LS		0		0	505	3,030	3,030
5170	Prepare backfill stockpile area	200,000	SY		0	0.10	20,000	0.07	14,000	34,000
5200	Health and Safety equipment	1	LS		0		0	605,700.00	605,700	605,700
5210	Demobilization/project site final clean up	1	LS		0	120,000.00	120,000		0	120,000
	Decontamination of equipment inside the PA	800	MH			17.84	14,272			14,272
	Decontamination of equipment - buffer zone	400	MH			17.84	7,136			7,136
	Waste crates									
5220	Purchase waste crates	100	EA	260.00	26,000		0		0	26,000
	Install lids on waste crates	100	EA		0	12.00	1,200		0	1,200
	Offload waste crates	100	EA		0	7.00	700		0	700
5230	Assay waste crates	200	MH		0	80.00	16,000		0	16,000
6000	**Relocate power lines from between Ponds 207A and 207B-series**				17,846		67,068		0	84,914
6001	Lock out/tag out	64	MH			81.8	5,235			5,235
6010	Install power poles	563	MH		12,386	33.17	18,675		0	31,061
6020	Install conductors	2,600	LF	2.10	5,460	3.14	8,164		0	13,624
6030	Tie in relocated power lines	121	MH		0	33.17	4,014		0	4,014
6040	Perform hi-pot test on new power lines	241	MH		0	33.17	7,994		0	7,994
6050	Remove obsolete power lines and poles	392	MH		0	33.17	13,003		0	13,003
6060	Transport and Store Power Lines	181	MH		0	33.17	6,004		0	6,004
6070	Shred obsolete poles & dispose in 207A	120	MH		0	33.17	3,980		0	3,980
7000	**Vegetation removal**				22,500		4,756		1,891	29,147
	Zones E and F									
7030	Lie Down Liner (double thickness)	24	MH		0	40.00	960		0	960

CLIENT: EG&G
ADDRESS: Rocky Flats Plant
ESTIMATOR: Edmonson/Montes/Lux

OU4 IM/IRA PROJECT COST ESTIMATE
CONSTRUCTION SCHEDULE: JUNE 1995 THROUGH NOVEMBER 1997
1000 YEAR COVER WITH LATERAL SUBSURFACE DRAIN

DATE: 03-Aug-94
TIME: 09:29:21 AM

COST CODE	DESCRIPTION	QTY	UNIT	MATERIAL UNIT COST	MATERIAL TOTAL COST	LABOR UNIT COST	LABOR TOTAL COST	CONSTR. EQUIP UNIT COST	CONSTR. EQUIP TOTAL COST	TOTAL
	Bottom Liner	9,000	SF	1.50	13,500		0		0	13,500
7040	Excavate veg. and soils from remediation areas	2,251	CY		0	1.26	2,836	0.84	1,891	4,727
7050	Cover Piles W/Heavy Tarp	24	MH			40.00	960		0	960
	Top Liner	9,000	SF	1.00	9,000		0		0	9,000
8000	Pond preparation for cover				273,058		232,494		219,639	725,190
8110	Grind 207A, 207C and 207B-series liners (grinder, 3000 SY/day)	11,800	SY		0	0.24	2,832	0.08	944	3,776
8115	Move and stockpile liners	5900	CY			1.51	8,909	1.01	5,959	14,868
8120	Excavate berms and Zones B, C, D & G	21,737	CY		0	1.26	27,389	0.84	18,259	45,648
8121	Move & place backfill for Zones B,C,D & E	20,200	CY	6.27	126,654	1.51	30,502	1.01	20,402	177,558
8130	Dispose berms and Zones B, C, D & G into B pond (Vadose Zone) (scraper, 500 CY/day)	21,737	CY		0	1.51	32,823	1.01	21,954	54,777
8140	Subsurface drain									
	Delivery of Gravel (drain trench)	3667	CY	15.07	55,262		0		0	55,262
	Move gravel	3667	CY		0	1.51	5,537	1.01	3,704	9,241
	Grade gravel	3667	CY		0	0.06	220	0.04	147	367
					0					
	Delivery of sand	3519	CY	8.28	29,137		0		0	29,137
	Move sand	3519	CY		0	1.51	5,314	1.01	3,554	8,868
	Grade sand	3519	CY		0	0.06	211	0.04	141	352
8150	Excavate C Pond Soils	27,796	CY		0	1.26	35,023	0.84	23,349	58,372
8160	Move C Pond Soils on top of Drainage	27,796	CY		0	1.51	41,972	1.01	28,074	70,046
8170	Move balance of berms on top of drainage	1,238	CY		0	1.51	1,869	1.01	1,250	3,120
8180	Spread liner material	11,800	CY		0	1.51	17,818	1.01	11,918	29,736
8190	Grade soil, liner and berm material in 207-A	37,024	CY		0	0.06	2,221	0.04	1,481	3,702

CLIENT: EG&G
ADDRESS: Rocky Flats Plant
ESTIMATOR: Edmonson/Montes/Lux

OU4 IM/IRA PROJECT COST ESTIMATE
CONSTRUCTION SCHEDULE: JUNE 1995 THROUGH NOVEMBER 1997
1000 YEAR COVER WITH LATERAL SUBSURFACE DRAIN

DATE: 03-Aug-94
TIME: 09:29:21 AM

COST CODE	DESCRIPTION	QTY	UNIT	MATERIAL UNIT COST	MATERIAL TOTAL COST	LABOR UNIT COST	LABOR TOTAL COST	CONSTR. EQUIP UNIT COST	CONSTR. EQUIP TOTAL COST	TOTAL
8200	Compact 207-A, and B-series ponds (Vibratory sheepsfoot, 5-ton roller, 4 passes)	128,000	SY		0	0.04	5,120	0.03	3,840	8,960
8260	Construct Equipment decon wash area	1	LS		0		0	60,000.00	60,000	60,000
8280	Move and distribute soils & veg. from the hillside north of the seepline in SEP 207-C	2,251	CY		0	1.51	3,399	1.01	2,274	5,673
8290	Grade soils in SEP 207-C	9225	SY		0	0.06	554	0.04	369	923
8300	Compact 207-C pond (Vibratory sheepsfoot, 5-ton roller, 2 passes)	18450	SY		0	0.04	738	0.03	554	1,292
8400	Reclaim Pond C area									
	Delivery of general backfill	4613	CY	6.27	28,924					28,924
	Move general backfill	4613	CY			1.51	6,966	1.01	4,659	11,625
	Grade general backfill	4613	CY			0.06	277	0.04	185	461
	Delivery of topsoil	1538	CY	19.03	29,268					29,268
	Move topsoil	1538	CY			1.51	2,322	1.01	1,553	3,876
	Grade topsoil	1538	CY			0.06	92	0.04	62	154
	Delivery of pea gravel	246	CY	15.5	3,813	0	0	0	0	3,813
	Move pea gravel	246	CY			1.51	371	1.01	248	620
	Grade pea gravel	246	CY			0.06	15	0.04	10	25
	Seed Pond C	1.9	AC					2500	4,750	4,750
9000	Stabilize hillside				223,464		20,620		47,537	291,621
9060	Deliver topsoil	10,389	CY	19.03	197,703		0		0	197,703
9070	Move topsoil	10,389	CY		0	1.51	15,687	1.01	10,493	26,180
9080	Grade topsoil	10,389	SY		0	0.06	623	0.04	416	1,039
9085	Hydroseed	13.5	AC		0		0	2,500.00	33,750	33,750
9090	Deliver pea gravel	1,662	CY	15.5	25,761		0		0	25,761
9100	Move pea gravel	1,662	CY		0	1.51	2,510	1.01	1,679	4,188
9110	Grade pea gravel	30,000	SY		0	0.06	1,800	0.04	1,200	3,000

CLIENT: EG&G
ADDRESS: Rocky Flats Plant
ESTIMATOR: Edmonson/Montes/Lux

OU4 IM/IRA PROJECT COST ESTIMATE
CONSTRUCTION SCHEDULE: JUNE 1995 THROUGH NOVEMBER 1997
1000 YEAR COVER WITH LATERAL SUBSURFACE DRAIN

DATE: 03-Aug-94
TIME: 09:29:21 AM

COST CODE	DESCRIPTION	QTY	UNIT	MATERIAL UNIT COST	MATERIAL TOTAL COST	LABOR UNIT COST	LABOR TOTAL COST	CONSTR. EQUIP UNIT COST	CONSTR. EQUIP TOTAL COST	TOTAL
10000	Utilities				0		465,676		25,817	491,493
10001	Design/review shoring activities	200	MH			90.00	18,000			18,000
10005	Shoring (excavation/removal)	5580	LF			40.40	225,432			225,432
10006	Shoring (excavation/grouting)	1150	LF			8.08	9,292			9,292
10020	Remove 3"-LD-STL	60	LF		0	27.24	1,634	1.33	80	1,714
10030	Remove 3"-LD-STL	60	LF		0	27.24	1,634	1.33	80	1,714
10040	Remove 3"-PW-STL	60	LF		0	27.24	1,634	1.33	80	1,714
10090	Remove and grout 3"-PW-SST, Remove and grout 3"-PW-STL	570	LF		0	27.24	15,527	1.33	758	16,285
10100	Remove & Relocate 6"-RW-CI	550	LF		0	27.24	14,982	1.33	732	15,714
10110	Remove 3"SROB-CAP	310	LF		0	27.24	8,444	1.33	412	8,857
10120	Remove 8"PWF-CI	40	LF		0	27.24	1,090	1.33	53	1,143
10130	Remove 8"PW-CI	30	LF		0	27.24	817	1.33	40	857
10140	Remove 440V-E	130	LF A/G		0	27.24	3,541	1.33	173	3,714
		50	LF U/G		0	27.24	1,362	1.33	67	1,429
10150	Remove 440-V-E	620	LF		0	27.24	16,889	1.33	825	17,713
10160	Remove 15"-SD-CMP	520	LF		0	27.24	14,165	1.33	692	14,856
10200	Remove/relocate 440V-E	320	LF		0	27.24	8,717	1.33	426	9,142
10210	Remove/relocate telephone	350	LF		0	27.24	9,534	1.33	466	10,000
10220	Remove @ 10"PW-PVC (VCP) 6"-PW-VCP	290	LF		0	27.24	7,900	1.33	386	8,285
10260	Remove 3"-SROB-CAP	90	LF		0	27.24	2,452	1.33	120	2,571
10270	Remove 3/4" E-PVC	90	LF		0	27.24	2,452	1.33	120	2,571

COST CODE	DESCRIPTION	QTY	UNIT	MATERIAL UNIT COST	MATERIAL TOTAL COST	LABOR UNIT COST	LABOR TOTAL COST	CONSTR. EQUIP UNIT COST	CONSTR. EQUIP TOTAL COST	TOTAL
10280	Grout 8"-RW-CAP	760	LF		0	46.98	35,705	11.08	8,421	44,126
10290	Grout 8"-RW-CAP	390	LF		0	46.98	18,322	11.08	4,321	22,643
10300	Remove 12"-OS-CMP	50	LF		0	27.24	1,362	1.33	67	1,429
10310	Remove 1-1/2"DCW-STL	320	LF		0	27.24	8,717	1.33	426	9,142
10320	Remove 3"-SROB-CAP, Remove 3"-ROPW-CAP, Remove 3"-SROP-CAP, Remove 6"-SE-CAP	140	LF		0	27.24	3,814	1.33	186	4,000
10350	Remove 8"-PW-CI	20	LF		0	27.24	545	1.33	27	571
10360	Remove 8"-PW-CI (8"-PCWF-CI)	50	LF		0	27.24	1,362	1.33	67	1,429
10390	Dispose of utilities in 207-A	6,730	LF		0	1.51	10,162	1.01	6,797	16,960
10410	Cut, Transport and store piping (Includes PPE)	6,730	LF		0	3.00	20,190		0	20,190
11000	**Install Final Engineered cover over Pond 207-A and western portion of B-series ponds**				2,213,289		398,104		227,544	2,838,937
11001	Geotextile material (construction purpose only)	143,500	SY	0.45	64,575	0.75	107,625			172,200
11005	Delivery of Gravel Base	6,000	CY	15.07	90,420					90,420
11006	Move gravel base course to Pond 207-A	6,000	CY		0	1.51	9,060	1.01	6,060	15,120
11007	Grade gravel base course in Pond 207-A	6,000	CY		0	0.06	360	0.04	240	600
11008	Compact lower base course (1 pass)	36,000	SY		0	0.04	1,440	0.03	1,080	2,520
11109	Delivery of asphalt concrete and asphalt layer	36,000	SY	12.02	432,720		0		0	432,720
11120	Unload & distribute asphalt concrete and asphalt layer	36,000	SY		0	1.51	54,360	1.01	36,360	90,720
11200	Delivery of Sand (drainage)	12,000	CY	8.28	99,360		0		0	99,360
11205	Move sand for lower sand layer	12,000	CY		0	1.51	18,120	1.01	12,120	30,240
11210	Grade lower sand layer	36,000	SY		0	0.06	2,160	0.04	1,440	3,600
11220	Compact lower sand layer (2 passes)	72,000	SY		0	0.04	2,880	0.03	2,160	5,040

OU4 IM/IRA PROJECT COST ESTIMATE
CONSTRUCTION SCHEDULE: JUNE 1995 THROUGH NOVEMBER 1997
1000 YEAR COVER WITH LATERAL SUBSURFACE DRAIN

DATE: 03-Aug-94
TIME: 09:29:21 AM

COST CODE	DESCRIPTION	QTY	UNIT	MATERIAL UNIT COST	MATERIAL TOTAL COST	LABOR UNIT COST	LABOR TOTAL COST	CONSTR. EQUIP UNIT COST	CONSTR. EQUIP TOTAL COST	TOTAL
11300	Delivery of angular riprap	30,000	CY	18.28	548,400		0		0	548,400
11305	Move angular riprap	30,000	CY		0	1.51	45,300	1.01	30,300	75,600
11310	Grade angular riprap layer	36,000	SY		0	0.06	2,160	0.04	1,440	3,600
11320	Compact angular riprap layer (4 passes)	144,000	SY		0	0.04	5,760	0.03	4,320	10,080
11400	Delivery of gravel (filter)	12,000	CY	15.07	180,840					180,840
11405	Move gravel	12,000	CY		0	1.51	18,120	1.01	12,120	30,240
11410	Grade gravel layer	36,000	SY		0	0.06	2,160	0.04	1,440	3,600
11420	Compact gravel layer (2 passes)	72,000	SY		0	0.04	2,880	0.03	2,160	5,040
11500	Delivery of sand (filter)	12,000	CY	8.28	99,360		0		0	99,360
11505	Move sand for upper sand layer	12,000	CY		0	1.51	18,120	1.01	12,120	30,240
11510	Grade upper sand layer	36,000	SY		0	0.06	2,160	0.04	1,440	3,600
11520	Compact upper sand layer (2 passes)	72,000	SY		0	0.04	2,880	0.03	2,160	5,040
11600	Delivery of general backfill	35,000	CY	6.27	219,450		0		0	219,450
11605	Move general backfill	35,000	CY		0	1.51	52,850	1.01	35,350	88,200
11620	Grade general backfill	36,000	SY		0	0.06	2,160	0.04	1,440	3,600
11700	Delivery of topsoil/gravel admix (20%)	21,000	CY	19.03	399,630		0		0	399,630
11705	Move topsoil	21,000	CY		0	1.51	31,710	1.01	21,210	52,920
11710	Grade topsoil	36,000	SY		0	0.06	2,160	0.04	1,440	3,600
11800	Delivery of pea gravel	2,400	CY	15.5	37,200		0		0	37,200
11805	Move pea gravel	2,400	CY		0	1.51	3,624	1.01	2,424	6,048
11810	Grade pea gravel	36,000	SY		0	0.06	2,160	0.04	1,440	3,600
11820	Perimeter runoff swales									
	Delivery of Topsoil	74	CY	19.03	1,408		0		0	1,408
	Move Topsoil	74	CY			1.51	112	1.01	75	186
	Grade Topsoil	74	CY			0.06	4	0.04	3	7
	Delivery of Pea gravel	25	CY	15.5	388	0	0		0	388
	Move Pea Gravel	25	CY			1.51	38	1.01	25	63
	Grade Pea Gravel	25	CY			0.06	2	0.04	1	3

CLIENT: EG&G
ADDRESS: Rocky Flats Plant
ESTIMATOR: Edmonson/Montes/Lux

OU4 IM/IRA PROJECT COST ESTIMATE
CONSTRUCTION SCHEDULE: JUNE 1995 THROUGH NOVEMBER 1997
1000 YEAR COVER WITH LATERAL SUBSURFACE DRAIN

DATE: 03-Aug-94
TIME: 09:29:21 AM

COST CODE	DESCRIPTION	QTY	UNIT	MATERIAL UNIT COST	MATERIAL TOTAL COST	LABOR UNIT COST	LABOR TOTAL COST	CONSTR. EQUIP UNIT COST	CONSTR. EQUIP TOTAL COST	TOTAL
11830	Delivery of Gravel (Toe Drain)	296	CY	15.07	4,461		0		0	4,461
	Move Gravel	296	CY			1.51	447	1.01	299	746
11840	Clean fill wedge									
	Delivery of general Backfill	4,000	CY	6.27	25,080		0		0	25,080
	Move general Backfill	4,000	CY			1.51	6,040	1.01	4,040	10,080
	Grade general Backfill	4,000	CY			0.06	240	0.04	160	400
11850	Reclaim Traffic areas and Misc.									
	Delivery of Pea Gravel	645	CY	15.50	9,998		0		0	9,998
	Move Pea Gravel	645	CY			1.51	974	1.01	651	1,625
	Grade Pea Gravel	645	CY			0.06	39	0.04	26	65
11855	Seed Traffic Area	5	AC		0		0	2,500.00	12,500	12,500
11860	Seed Cover	7.8	AC					2,500.00	19,500	19,500
13000	Remove Equipment Decon Wash Area	1	LS		0	15,000.00	15,000		0	15,000
14000	Off-site disposal				0		0		183,620	183,620
	Transportation by railcar	2	EA		0		0	2,210.00	4,420	4,420
	Envirocare	100	EA		0		0	1,792.00	179,200	179,200
15000	Final site survey by HPT	160	MH		0	80.00	12,800		0	12,800
18000	Training	2,400	HR		0	50.00	120,000		0	120,000
19000	Postclosure (monitoring system)	1	LS		0	254,296.00	254,296	341,040.00	341,040	595,336
20000	Construction subtotal				2,804,772		4,381,780		3,323,102	10,509,653
21000	Building Factor (33.5%)									1,467,896
22000	Construction subtotal									11,977,550
23000	Engineering Costs									2,500,000
24000	Purchase small tools and consumables (5%)									219,089
25000	Project Management (6%)									630,579
26000	Contractor Construction Management									3,000,000
27000	Construction Management (15%)									1,796,632
28000	Contractor G&A (10.75% Total Const. Cost)									1,287,587
29000	Subtotal									21,411,437
30000	Escalation (9.73% Const. Cost)									1,165,416
31000	Escalated Subtotal									22,576,852
32000	Contingency (30%)									6,773,056
33000	Total Estimated Cost									29,349,908

ATTACHMENT 2

CLIENT: EG&G
ADDRESS: Rocky Flats Plant
ESTIMATOR: Edmonson/Montes/Glade

OU4 IM/IRA PROJECT COST ESTIMATE
CONSTRUCTION SCHEDULE: JUNE 1995 THROUGH NOVEMBER 1997
1000 YEAR COVER & VERTICAL GW CONTROL SYSTEM

DATE: 05-Aug-94
TIME: 11:06:35 AM

COST CODE	DESCRIPTION	QTY	UNIT	MATERIAL UNIT COST	MATERIAL TOTAL COST	LABOR UNIT COST	LABOR TOTAL COST	CONSTR. EQUIP UNIT COST	CONSTR. EQUIP TOTAL COST	TOTAL
0100	Baseline radiological/hazardous survey				0		523,900		0	523,900
	Initial survey									
	Set up material staging area	80	MH		0	65.00	5,200		0	5,200
	Set up exclusion zone	160	MH		0	65.00	10,400		0	10,400
	Set up step-off/survey area	80	MH		0	65.00	5,200		0	5,200
	Develop radiation worker permit for zone entry	80	MH		0	65.00	5,200		0	5,200
	Baseline survey by HPT	80	MH		0	65.00	5,200		0	5,200
	Obtain excavation permit	40	MH		0	65.00	2,600		0	2,600
	Conduct pre-job training on sampling grid	60	MH		0	65.00	3,900		0	3,900
	Phase II activities									
	Modify radiation worker permit for excavation	40	MH		0	65.00	2,600		0	2,600
	Write health and safety plan	640	MH		0	65.00	41,600		0	41,600
	Phase III activities				0					
	Daily initial surveys, surveys of equipment leaving exclusion zone and daily end of day surveys of ground and equipment	4000	MH		0	65.00	260,000		0	260,000
	Covering any "surface contamination" during operations and overnight if discovered in end-of-day survey	2800	MH		0	65.00	182,000		0	182,000
0200	Monitor job site remediation/entry security				0		705,828		0	705,828
	Rad technicians - 4 for 9 months of project	4,536	MH		0	34.53	156,628		0	156,628
	Construction personnel enter/exit job site	13,730	MH		0	40.00	549,200		0	549,200

CLIENT: EG&G
ADDRESS: Rocky Flats Plant
ESTIMATOR: Edmonson/Montes/Glade

OU4 IM/IRA PROJECT COST ESTIMATE
CONSTRUCTION SCHEDULE: JUNE 1995 THROUGH NOVEMBER 1997
1000 YEAR COVER & VERTICAL GW CONTROL SYSTEM

DATE: 05-Aug-94
TIME: 11:06:35 AM

COST CODE	DESCRIPTION	QTY	UNIT	MATERIAL UNIT COST	MATERIAL TOTAL COST	LABOR UNIT COST	LABOR TOTAL COST	CONSTR. EQUIP UNIT COST	CONSTR. EQUIP TOTAL COST	TOTAL
5000	Indirect field costs				54,616		1,561,236		2,276,014	3,891,866
5010	Obtain building permits	80	MH		0	40.00	3,200		0	3,200
	Cost of Permit	1	LS	500.00	500					500
5020	Mobilization - set up construction staging area and perform decon and smear tests on equipment entering the job site	1,000	MH		0	40.00	40,000		0	40,000
5040	Sanitary (portable toilets) - 8	24	MONTH		0		0	584.00	14,016	14,016
5045	Handwash unit - 4	24	MONTH					340.00	8,160	8,160
	Eyewash Unit - 4	24	MONTH					116.62	2,799	2,799
5050	Temporary utils (phone, water, 220V elec)	24	MONTH	500.00	12,000		0		0	12,000
	Temporary security fence and lighting installation									
5060	Security fence	2,090	LF	4.00	8,360	6.00	12,540		0	20,900
	Terminal posts	8	EA	70.00	560	105.00	840		0	1,400
	Security gates	4	EA	404.00	1,616	606.00	2,424		0	4,040
	Lights north of seepline	24	MONTH					4100	98,400	98,400
	Lights south of seepline	24	MONTH					4100	98,400	98,400
5100	Trucks									
	Water tanker (631ww) and operator	24	MONTH		0	7,040.00	168,960	13,680.00	328,320	497,280
	Off highway truck (777C) and operator	24	MONTH		0	7,040.00	168,960	10,465.00	251,160	420,120
	Wheel loader (992C) and operator	24	MONTH		0	7,040.00	168,960	33,240.00	797,760	966,720
5110	Mobile lab for geotechnical soil testing	24	MONTH		0		0	700.00	16,800	16,800
	Geotechnical Technician	1500	MH			80.00	120,000		0	120,000
	Field Technician	3000	MH			80.00	240,000		0	240,000
5120	Mobile analytical lab for environmental testing				0					
	Staffed lab	120	DAY		0	3,000.00	360,000		0	360,000
	Standby lab	120	DAY		0	800.00	96,000		0	96,000
5121	Site prep. trailer area									
	Road base (6") and grading	740	SY	7.54	5,580	0.06	44	0.04	30	5,654
5125	Office trailer	24	MONTH					375.00	9,000	9,000
5126	Break trailer	24	MONTH					260.00	6,240	6,240
5130	Trailer with lockers	24	MONTH		0		0	375.00	9,000	9,000

CLIENT: EG&G
ADDRESS: Rocky Flats Plant
ESTIMATOR: Edmonson/Montes/Glade

OU4 IM/IRA PROJECT COST ESTIMATE
CONSTRUCTION SCHEDULE: JUNE 1995 THROUGH NOVEMBER 1997
1000 YEAR COVER & VERTICAL GW CONTROL SYSTEM

DATE: 05-Aug-94
TIME: 11:06:35 AM

COST CODE	DESCRIPTION	QTY	UNIT	MATERIAL UNIT COST	MATERIAL TOTAL COST	LABOR UNIT COST	LABOR TOTAL COST	CONSTR. EQUIP UNIT COST	CONSTR. EQUIP TOTAL COST	TOTAL
5150	Personnel decon trailer with showers	24	MONTH		0		0	550.00	13,200	13,200
5155	Lab/trailer:set-up/remove	6	LS		0		0	505	3,030	3,030
5170	Prepare backfill stockpile area	200,000	SY		0	0.10	20,000	0.07	14,000	34,000
5200	Health and Safety equipment	1	LS		0		0	605,700.00	605,700	605,700
5210	Demobilization/project site final clean up	1	LS		0	120,000.00	120,000		0	120,000
	Decontamination of equipment inside the PA	800	MH			17.84	14,272			14,272
	Decontamination of equipment - buffer zone	400	MH			17.84	7,136			7,136
	Waste crates									
5220	Purchase waste crates	100	EA	260.00	26,000		0		0	26,000
	Install lids on waste crates	100	EA		0	12.00	1,200		0	1,200
	Offload waste crates	100	EA		0	7.00	700		0	700
5230	Assay waste crates	200	MH		0	80.00	16,000		0	16,000
6000	**Relocate power lines from between Ponds 207A and 207B-series**				17,846		67,068		0	84,914
6001	Lock out/tag out	64	MH			81.8	5,235			5,235
6010	Install power poles	563	MH		12,386	33.17	18,675		0	31,061
6020	Install conductors	2,600	LF	2.10	5,460	3.14	8,164		0	13,624
6030	Tie in relocated power lines	121	MH		0	33.17	4,014		0	4,014
6040	Perform hi-pot test on new power lines	241	MH		0	33.17	7,994		0	7,994
6050	Remove obsolete power lines and poles	392	MH		0	33.17	13,003		0	13,003
6060	Transport and Store Power Lines	181	MH		0	33.17	6,004		0	6,004
6070	Shred obsolete poles & dispose in 207A	120	MH		0	33.17	3,980		0	3,980

CLIENT: EG&G
ADDRESS: Rocky Flats Plant
ESTIMATOR: Edmonson/Montes/Glade

OU4 IM/IRA PROJECT COST ESTIMATE
CONSTRUCTION SCHEDULE: JUNE 1995 THROUGH NOVEMBER 1997
1000 YEAR COVER & VERTICAL GW CONTROL SYSTEM

DATE: 05-Aug-94
TIME: 11:06:35 AM

COST CODE	DESCRIPTION	QTY	UNIT	MATERIAL UNIT COST	MATERIAL TOTAL COST	LABOR UNIT COST	LABOR TOTAL COST	CONSTR. EQUIP UNIT COST	CONSTR. EQUIP TOTAL COST	TOTAL
7000	**Vegetation removal**				22,500		4,756		1,891	29,147
	Zones E and F									
7030	Lie Down Liner (double thickness)	24	MH		0	40.00	960		0	960
	Bottom Liner	9,000	SF	1.50	13,500		0		0	13,500
7040	Excavate veg. and soils from remediation areas	2,251	CY		0	1.26	2,836	0.84	1,891	4,727
7050	Cover Piles W/Heavy Tarp	24	MH			40.00	960		0	960
	Top Liner	9,000	SF	1.00	9,000		0		0	9,000
7500	**Vertical GW Control System (Subcontractor)**				0		1,115,750		0	1,115,750
7505	Mobilization/Demobilization	1	LS		0	65,000.00	65,000		0	65,000
7510	Bio-Polyner Drainage Trench	94,500	SF		0	9.50	897,750		0	897,750
7520	Slurry Cutoff Wall	76,500	SF		0	2.00	153,000		0	153,000
8000	**Pond preparation for cover**				62,005		119,720		144,268	325,993
8110	Grind 207A, 207C and 207B-series liners (grinder, 3000 SY/day)	11,800	CY		0	0.24	2,832	0.08	944	3,776
8150	Excavate C Pond Soils	27,796	CY		0	1.26	35,023	0.84	23,349	58,372
8160	Move C Pond Soils on top of Drainage	27,796	CY		0	1.51	41,972	1.01	28,074	70,046
8180	Spread liner material	11,800	CY		0	1.51	17,818	1.01	11,918	29,736
8190	Grade soil, liner and berm material in 207-A	37,024	CY		0	0.06	2,221	0.04	1,481	3,702
8200	Compact 207-A, and B-series ponds (Vibratory sheepsfoot, 5-ton roller, 4 passes)	128,000	SY		0	0.04	5,120	0.03	3,840	8,960
8260	Construct Equipment decon wash area	1	LS		0		0	60,000.00	60,000	60,000
8280	Move and distribute soils & veg. from the hillside north of the seepline in SEP 207-C	2,251	CY		0	1.51	3,399	1.01	2,274	5,673

COST CODE	DESCRIPTION	QTY	UNIT	MATERIAL UNIT COST	MATERIAL TOTAL COST	LABOR UNIT COST	LABOR TOTAL COST	CONSTR. EQUIP UNIT COST	CONSTR. EQUIP TOTAL COST	TOTAL
8290	Grade soils in SEP 207-C	9225	SY		0	0.06	554	0.04	369	923
8300	Compact 207-C pond (Vibratory sheepsfoot, 5-ton roller, 2 passes)	18450	SY		0	0.04	738	0.03	554	1,292
8400	Reclaim Pond C area									
	Delivery of general backfill	4613	CY	6.27	28,924					28,924
	Move general backfill	4613	CY			1.51	6,966	1.01	4,659	11,625
	Grade general backfill	4613	CY			0.06	277	0.04	185	461
	Delivery of topsoil	1538	CY	19.03	29,268					29,268
	Move topsoil	1538	CY			1.51	2,322	1.01	1,553	3,876
	Grade topsoil	1538	CY			0.06	92	0.04	62	154
	Delivery of pea gravel	246	CY	15.5	3,813	0	0	0	0	3,813
	Move pea gravel	246	CY			1.51	371	1.01	248	620
	Grade pea gravel	246	CY			0.06	15	0.04	10	25
	Seed Pond C	1.9	AC					2500	4,750	4,750
9000	Stabilize hillside				223,464		20,620		47,537	291,621
9060	Deliver topsoil	10,389	CY	19.03	197,703		0		0	197,703
9070	Move topsoil	10,389	CY		0	1.51	15,687	1.01	10,493	26,180
9080	Grade topsoil	10,389	SY		0	0.06	623	0.04	416	1,039
9085	Hydroseed	13.5	AC		0		0	2,500.00	33,750	33,750
9090	Deliver pea gravel	1,662	CY	15.5	25,761		0		0	25,761
9100	Move pea gravel	1,662	CY		0	1.51	2,510	1.01	1,679	4,188
9110	Grade pea gravel	30,000	SY		0	0.06	1,800	0.04	1,200	3,000
10000	Utilities				0		465,676		25,817	491,493
10001	Design/review shoring activities	200	MH			90.00	18,000			18,000
10005	Shoring (excavation/removal)	5580	LF			40.40	225,432			225,432
10006	Shoring (excavation/grouting)	1150	LF			8.08	9,292			9,292
10020	Remove 3"-LD-STL	60	LF		0	27.24	1,634	1.33	80	1,714

OU4 IM/IRA PROJECT COST ESTIMATE
CONSTRUCTION SCHEDULE: JUNE 1995 THROUGH NOVEMBER 1997
1000 YEAR COVER & VERTICAL GW CONTROL SYSTEM

DATE: 05-Aug-94
TIME: 11:06:35 AM

COST CODE	DESCRIPTION	QTY	UNIT	MATERIAL		LABOR		CONSTR. EQUIP		TOTAL
				UNIT COST	TOTAL COST	UNIT COST	TOTAL COST	UNIT COST	TOTAL COST	
10030	Remove 3"-LD-STL	60	LF		0	27.24	1,634	1.33	80	1,714
10040	Remove 3"-PW-STL	60	LF		0	27.24	1,634	1.33	80	1,714
10090	Remove and grout 3"-PW-SST, Remove and grout 3"-PW-STL	570	LF		0	27.24	15,527	1.33	758	16,285
10100	Remove & Relocate 6"-RW-CI	550	LF		0	27.24	14,982	1.33	732	15,714
10110	Remove 3"SROB-CAP	310	LF		0	27.24	8,444	1.33	412	8,857
10120	Remove 8"PWF-CI	40	LF		0	27.24	1,090	1.33	53	1,143
10130	Remove 8"PW-CI	30	LF		0	27.24	817	1.33	40	857
10140	Remove 440V-E	130	LF A/G		0	27.24	3,541	1.33	173	3,714
		50	LF U/G		0	27.24	1,362	1.33	67	1,429
10150	Remove 440-V-E	620	LF		0	27.24	16,889	1.33	825	17,713
10160	Remove 15"-SD-CMP	520	LF		0	27.24	14,165	1.33	692	14,856
10200	Remove/relocate 440V-E	320	LF		0	27.24	8,717	1.33	426	9,142
10210	Remove/relocate telephone	350	LF		0	27.24	9,534	1.33	466	10,000
10220	Remove @ 10"PW-PVC (VCP) 6"-PW-VCP	290	LF		0	27.24	7,900	1.33	386	8,285
10260	Remove 3"-SROB-CAP	90	LF		0	27.24	2,452	1.33	120	2,571
10270	Remove 3/4" E-PVC	90	LF		0	27.24	2,452	1.33	120	2,571
10280	Grout 8"-RW-CAP	760	LF		0	46.98	35,705	11.08	8,421	44,126
10290	Grout 8"-RW-CAP	390	LF		0	46.98	18,322	11.08	4,321	22,643
10300	Remove 12"-OS-CMP	50	LF		0	27.24	1,362	1.33	67	1,429
10310	Remove 1-1/2"DCW-STL	320	LF		0	27.24	8,717	1.33	426	9,142

COST CODE	DESCRIPTION	QTY	UNIT	MATERIAL UNIT COST	MATERIAL TOTAL COST	LABOR UNIT COST	LABOR TOTAL COST	CONSTR. EQUIP UNIT COST	CONSTR. EQUIP TOTAL COST	TOTAL
10320	Remove 3"-SROB-CAP, Remove 3"-ROPW-CAP, Remove 3"-SROP-CAP, Remove 6"-SE-CAP	140	LF		0	27.24	3,814	1.33	186	4,000
10350	Remove 8"-PW-CI	20	LF		0	27.24	545	1.33	27	571
10360	Remove 8"-PW-CI (8"-PCWF-CI)	50	LF		0	27.24	1,362	1.33	67	1,429
10390	Dispose of utilities in 207-A	6,730	LF		0	1.51	10,162	1.01	6,797	16,960
10410	Cut, Transport and store piping (Includes PPE)	6,730	LF		0	3.00	20,190		0	20,190
11000	**Install Final Engineered cover over Pond 207-A and western portion of B-series ponds**				2,213,289		398,104		227,544	2,838,937
11001	Geotextile material (construction purpose only)	143,500	SY	0.45	64,575	0.75	107,625			172,200
11005	Delivery of Gravel Base	6,000	CY	15.07	90,420					90,420
11006	Move gravel base course to Pond 207-A	6,000	CY		0	1.51	9,060	1.01	6,060	15,120
11007	Grade gravel base course in Pond 207-A	6,000	CY		0	0.06	360	0.04	240	600
11008	Compact lower base course (1 pass)	36,000	SY		0	0.04	1,440	0.03	1,080	2,520
11109	Delivery of asphalt concrete and asphalt layer	36,000	SY	12.02	432,720		0		0	432,720
11120	Unload & distribute asphalt concrete and asphalt layer	36,000	SY		0	1.51	54,360	1.01	36,360	90,720
11200	Delivery of Sand (drainage)	12,000	CY	8.28	99,360		0		0	99,360
11205	Move sand for lower sand layer	12,000	CY		0	1.51	18,120	1.01	12,120	30,240
11210	Grade lower sand layer	36,000	SY		0	0.06	2,160	0.04	1,440	3,600
11220	Compact lower sand layer (2 passes)	72,000	SY		0	0.04	2,880	0.03	2,160	5,040
11300	Delivery of angular riprap	30,000	CY	18.28	548,400		0		0	548,400
11305	Move angular riprap	30,000	CY		0	1.51	45,300	1.01	30,300	75,600
11310	Grade angular riprap layer	36,000	SY		0	0.06	2,160	0.04	1,440	3,600
11320	Compact angular riprap layer (4 passes)	144,000	SY		0	0.04	5,760	0.03	4,320	10,080
11400	Delivery of gravel (filter)	12,000	CY	15.07	180,840					180,840
11405	Move gravel	12,000	CY		0	1.51	18,120	1.01	12,120	30,240
11410	Grade gravel layer	36,000	SY		0	0.06	2,160	0.04	1,440	3,600
11420	Compact gravel layer (2 passes)	72,000	SY		0	0.04	2,880	0.03	2,160	5,040

CLIENT: EG&G
ADDRESS: Rocky Flats Plant
ESTIMATOR: Edmonson/Montes/Glade

OU4 IM/IRA PROJECT COST ESTIMATE
CONSTRUCTION SCHEDULE: JUNE 1995 THROUGH NOVEMBER 1997
1000 YEAR COVER & VERTICAL GW CONTROL SYSTEM

DATE: 05-Aug-94
TIME: 11:06:35 AM

COST CODE	DESCRIPTION	QTY	UNIT	MATERIAL UNIT COST	MATERIAL TOTAL COST	LABOR UNIT COST	LABOR TOTAL COST	CONSTR. EQUIP UNIT COST	CONSTR. EQUIP TOTAL COST	TOTAL
11500	Delivery of sand (filter)	12,000	CY	8.28	99,360		0		0	99,360
11505	Move sand for upper sand layer	12,000	CY		0	1.51	18,120	1.01	12,120	30,240
11510	Grade upper sand layer	36,000	SY		0	0.06	2,160	0.04	1,440	3,600
11520	Compact upper sand layer (2 passes)	72,000	SY		0	0.04	2,880	0.03	2,160	5,040
11600	Delivery of general backfill	35,000	CY	6.27	219,450		0		0	219,450
11605	Move general backfill	35,000	CY		0	1.51	52,850	1.01	35,350	88,200
11620	Grade general backfill	36,000	SY		0	0.06	2,160	0.04	1,440	3,600
11700	Delivery of topsoil/gravel admix (20%)	21,000	CY	19.03	399,630		0		0	399,630
11705	Move topsoil	21,000	CY		0	1.51	31,710	1.01	21,210	52,920
11710	Grade topsoil	36,000	SY		0	0.06	2,160	0.04	1,440	3,600
11800	Delivery of pea gravel	2,400	CY	15.5	37,200		0		0	37,200
11805	Move pea gravel	2,400	CY		0	1.51	3,624	1.01	2,424	6,048
11810	Grade pea gravel	36,000	SY		0	0.06	2,160	0.04	1,440	3,600
11820	Perimeter runoff swales									
	Delivery of Topsoil	74	CY	19.03	1,408		0		0	1,408
	Move Topsoil	74	CY			1.51	112	1.01	75	186
	Grade Topsoil	74	CY			0.06	4	0.04	3	7
	Delivery of Pea gravel	25	CY	15.5	388	0	0		0	388
	Move Pea Gravel	25	CY			1.51	38	1.01	25	63
	Grade Pea Gravel	25	CY			0.06	2	0.04	1	3
11830	Delivery of Gravel (Toe Drain)	296	CY	15.07	4,461		0		0	4,461
	Move Gravel	296	CY			1.51	447	1.01	299	746
11840	Clean fill wedge									
	Delivery of general Backfill	4,000	CY	6.27	25,080		0		0	25,080
	Move general Backfill	4,000	CY			1.51	6,040	1.01	4,040	10,080
	Grade general Backfill	4,000	CY			0.06	240	0.04	160	400

CLIENT: EG&G
ADDRESS: Rocky Flats Plant
ESTIMATOR: Edmonson/Montes/Glade

OU4 IM/IRA PROJECT COST ESTIMATE
CONSTRUCTION SCHEDULE: JUNE 1995 THROUGH NOVEMBER 1997
1000 YEAR COVER & VERTICAL GW CONTROL SYSTEM

DATE: 05-Aug-94
TIME: 11:06:35 AM

COST CODE	DESCRIPTION	QTY	UNIT	MATERIAL UNIT COST	MATERIAL TOTAL COST	LABOR UNIT COST	LABOR TOTAL COST	CONSTR. EQUIP UNIT COST	CONSTR. EQUIP TOTAL COST	TOTAL
11850	Reclaim Traffic areas and Misc.									
	Delivery of Pea Gravel	645	CY	15.50	9,998		0		0	9,998
	Move Pea Gravel	645	CY			1.51	974	1.01	651	1,625
	Grade Pea Gravel	645	CY			0.06	39	0.04	26	65
11855	Seed Traffic Area	5	AC		0		0	2,500.00	12,500	12,500
11860	Seed Cover	7.8	AC					2,500.00	19,500	19,500
13000	Remove Equipment Decon Wash Area	1	LS		0	15,000.00	15,000		0	15,000
14000	Off-site disposal				0		0		183,620	183,620
	Transportation by railcar	2	EA		0		0	2,210.00	4,420	4,420
	Envirocare	100	EA		0		0	1,792.00	179,200	179,200
15000	Final site survey by HPT	160	MH		0	80.00	12,800		0	12,800
18000	Training	2,400	HR		0	50.00	120,000		0	120,000
19000	Postclosure (monitoring system)	1	LS		0	254,296.00	254,296	341,040.00	341,040	595,336
20000	Construction subtotal				2,593,719		5,384,756		3,247,732	11,226,206
21000	Building Factor (33.5%)									1,803,893
22000	Construction subtotal									13,030,100
23000	Engineering Costs									2,500,000
24000	Purchase small tools and consumables (5%)									269,238
25000	Project Management (6%)									673,572
26000	Contractor Construction Management									3,000,000
27000	Construction Management (15%)									1,954,515
28000	Contractor G&A (10.75% Total Const. Cost)									1,400,736
29000	Subtotal									22,828,160
30000	Escalation (9.73% Const. Cost)									1,267,829
31000	Escalated Subtotal									24,095,989
32000	Contingency (30%)									7,228,797
33000	Total Estimated Cost									
										31,324,786