

Non-Radioactive Disposal Facility-Bioremediation Horizontal Well Installation Project

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A document prepared for SRS TECHNOLOGY DAY at Augusta, GA, USA from 2/25/98 - 2/25/98.

DOE Contract No. DE-AC09-96SR18500

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Introduction

The Sanitary Landfill Corrective Action Plan proposes a two pronged approach to remediation. The first part of the total remediation strategy is the placement of a RCRA style closure cap to provide source control of contaminants into the groundwater. The second part of the proposed remediation package is a phased approach primarily using an in situ bioremediation system for groundwater clean up of the Constituents of Concern (COCs) that exceed their proposed Alternate Concentration Limits (ACL). The phased in approach of groundwater clean up will involve operation of the in situ bioremediation system, followed by evaluation of the Phase I system and, if necessary, additional phased remediation strategies.

Purpose

With the success of an in situ bioremediation optimization test, an accelerated effort for remediation at the Sanitary Landfill is being proposed. This document presents pertinent information on operations, well locations, anticipated capture zones, monitoring strategies, observation wells and other information which will allow a decision on the acceptability of the remedial strategy as an interim corrective action prior to permit application approval.

The proposed interim phase of the remediation program will position two horizontal bioremediation wells such that the respective zones of influence will intersect the migration path for the highest concentrations of each plume. The entire contaminant plume will be addressed in subsequent phases of the remediation program. Monitoring of this interim phase will determine the appropriate approach for continued remediation strategies, including consideration of additional bioremediation wells and/or supplemental remedial systems.

The intent of the interim action is to effectively reduce the migration of contaminants out of the landfill area to the Points of Exposure (adjoining wetlands and Upper Three Runs Creek), as defined within the Sanitary Landfill - Postclosure RCRA Permit Application, March 1994, Revision 1. Refer to Figure 1 for Sanitary Landfill location. The interim action presented in this report is consistent with the full-scale corrective action plan for groundwater remediation, as presented in the permit application. Additional remediation strategies may be developed after analysis of the effectiveness of this interim action.

Description of the System

The proposed, interim remediation system is an in-situ bioremediation process which will stimulate aerobic biodegradation of the proposed ACL exceeded constituents (e.g., vinyl chloride and trichloroethylene). In addition, the system will remediate organic contaminants of concern and the daughter products associated with the breakdown of these contaminants. Lead and tritium will be addressed in future remediation strategies, if necessary. Table 1 presents optimization test results on the Sanitary Landfill groundwater contaminant concentrations.

Using horizontal wells placed in the saturated zone, atmospheric air and other nutrients will be gently blown into two injection zones to stimulate the native microbes within the groundwater matrix. This process will naturally biodegrade the constituents of concern. The interim action will consist of two horizontal wells drilled in the upper aquifer zone on the downgradient edge of the landfill. A shared, facility support system, to inject air and nutrients, will be located central to the well locations.

Figure 2 presents a plan view of the system which shows the relationship of the two well locations, the orientation of the screen zones, the locations of the vinyl chloride and trichloroethylene (TCE) plumes (4th Quarter 1996 data), and the shared, air/nutrient facility support location.

The facility support system will include, at a minimum, air injection/supply lines leading to the two horizontal wellheads, an air injection system consisting of a compressor and receiver tank, a check valve system, a methane blending system, nutrient addition system (to add nitrous oxide, triethyl-phosphate, and methane), pressure gauges, and flow meters. The facility support system will provide operating flows to each well independently of the other during specific operating periods. Once the detailed design for the facility support system is completed, additional details will be available and can be provided to SCDHEC, if requested.

TABLE 1 - OPTIMIZATION TEST RESULTS

Constituent	Primary GWPS ug/L	Requested ACL ug/L	Highest 1Q97 Concentration at POC Well ug/L	In Situ Bio Minimum Achieved ug/L
Lead	15	33.7	18.1	Reduced ^b
1, 1, 1 Trichloroethane	200	249	22.5	< 2
1, 4 Dichlorobenzene	75	99	94	< 5
Benzene	5	21.2	9.6	< 5
Chlorobenzene ^a	100	NA	20.1	< 5
Chloroethene (Vinyl Chloride)	2	2	36.7	< 5
Dichloromethane	5	757	24.3	< 5
Dichlorodifluoromethane	NA	94	20.4	< 5
Tetrachloroethylene	5	2028	34.2	< 5
Trans-1, 2 Dichloroethylene	100	560	< 2	< 2
Trichloroethylene	5	28.5	72.2	< 2
Trichlorofluoromethane	NA	625	68.7	< 2
Tritium (pCi/mL)	20	92	< -3.2	Unknown

a = Not an ACL Constituent of Concern

b = If redox increased to positive, metals leaching reduced significantly

Location of the Wells

Two horizontal wells have been placed at a downgradient location to effectively reduce further downgradient migration of the contaminant plumes into the points of exposure. See Figure 3 for the groundwater flow path. With the descriptions of the contaminant plumes the wells are to be placed in a horizontal plane with the zone of influence to directly cut the migration path of the highest concentrations of each respective plume. The contaminant plumes, downgradient of the in-situ bioremediation system, will be influenced by the attenuation effects of bioremediation spreading downgradient into that portion of the plume over time.

As presented in Figure 2, horizontal well SLH 1 is located south of the landfill oriented nearly parallel to the edge of the waste trenches. The proposed screen location for this well has been estimated to start at approximately N82836.78 and E45808.98 (plant coordinates).

The effective screen zone for SLH 1 is approximately 800 feet at an elevation of 120 feet mean sea level (msl). The screen zone end point is at plant coordinates N82989.45 and E46594.27.

Horizontal well SLH 2 is proposed to run tangentially along the west side of the landfill. The screen zone starts at plant coordinates N83006.63 and E45770.26, the screen zone(s) stretch 900 feet starting at 120 feet msl. The screen zone will be at approximately 125 feet msl by the time it reaches the terminus point, located approximately at plant coordinates N83748.00 and E45260.

The depth levels (120 ft msl and 120 to 125 ft msl) for the screen zones for each well are placed so that they are approximately ten feet below the observed contaminant plume (either vinyl chloride or trichloroethylene). This placement is necessary because the diffusion of oxygen and nutrients will predominantly be in an upward expanding plume.

Two important factors of horizontal well placement at this site will be the geology and the length of the screen zone. Horizontal wells can be drilled at lengths of 800 to 900 feet and can be placed in interbedded sands, clayey sands, and silty sands (as in this case). The combination of these two factors may preclude the installation of just one well. A series of two to three wells in sequence may be necessary to provide the necessary screen length at each site location. Changes of this nature will be reported in full, for approval, prior to initiation of any work.

Anticipated Zone of Influence

The optimization test indicated a radius of influence of at least 54 feet about the injection point from the vertical wells. See Figure 4 for plan view of anticipated zone of influence. Use of horizontal wells will not affect the radius of influence, but will change the three dimensional shape of the zone of influence down the entire length of horizontal screen.

As reported in the optimization test report and presented in Acomb, et al., 1995, the zone of influence for this application will resemble an inverted tear drop - with the narrowest zone of influence at the lowest elevation of injection. The upper limit of the zone of influence will be a burgeoning zone reaching its maximum effectiveness symmetrically above the horizontal screen zone. See Figure 5 for a cross-sectional view of the expected zone of influence across the contaminant/groundwater flow path. This symmetry requires that the well screen be placed below the contaminant plume flow to insure the zone of influence crosses the contaminant plume flow path.

Local influences from groundwater flow patterns are expected. These influences should be more pronounced downgradient from the injection screens with decreasing influence further downgradient. Consideration of retardation factors of the contaminant plumes with the normal groundwater flow, implies a zone of influence which will encompass the portions of the plumes south of the injection screen zone.

Description of the Operation

During operation of the optimization test, it became apparent that the two areas where remediation is to be focused will differ significantly in operational requirements. The plume on the west side of the landfill showed significant declines in vinyl chloride concentrations with an air injection campaign. In addition, the concentrations of the vinyl chloride did not reappear in the groundwater matrix until after a 5 to 6 week recovery period. The significance of this is that it appears that the vinyl chloride site can be operated by a once a month air injection campaign combined with effectiveness monitoring.

The south side of the landfill (TCE site) exhibits lower concentrations of organic carbon, higher dissolved oxygen, less reduced contaminants, produces less methane intrinsically, and has lower microbial activity than the vinyl chloride site. Therefore, the TCE site will require more nutrients to stimulate the same level of biological activity as the vinyl chloride site. The operating campaign will require an air injection campaign every 2 to 3 weeks with nutrient injections. This strategy would be closely monitored for system requirements to meet optimum destruction capabilities.

Both sites will mimic the operation of the optimization test results. The injection pressures are expected to be between 6 to 8 psig across the screen zone for each location. Table 2 lists the expected operational parameters as described in the Optimization Test Report.

TABLE 2 - EXPECTED OPERATIONAL CONDITIONS

COC Plume	Injectant(s)	Injection Duration*	Injection Pressure*	Injectant Concentrations*	Recovery Period*
Vinyl Chloride	Atmospheric Air	40 hours	6 - 8 psig		5 - 6 weeks
Trichloro-ethylene	Atmospheric Air	40 hours	6 - 8 psig		2 - 3 weeks
	Methane	8 hours	6 - 8 psig	4% by volume	2 - 3 weeks
	Nitrous Oxide	8 hours	6 - 8 psig	0.07% by volume	2 - 3 weeks
	Triethyl-phosphate	8 hours	6 - 8 psig	0.007% by volume	2 - 3 weeks

* All values are estimates based on the optimization test.

Results Summary of the Optimization Test

The optimization test objectives were to determine the optimum design parameters for full-scale operations. A detailed conclusion section is reported in the In Situ Bioremediation Optimization Test Report, they are summarized here:

- 1.) Lithology and hydrology on both the southern and western sides of the landfill will support air and gaseous nutrient injection for in situ bioremediation. The pressure needed to biosparge were much lower than originally expected (6-10 psig).
- 2.) The two test sites and their associated sides of the landfill exhibited significant differences in terms of ambient dissolved oxygen concentrations, total organics, anaerobic vs. aerobic activity, total community bioactivity, and types of contaminants of concern. This necessitates a different remedial operation for each site.
- 3.) Stripping of the COCs from the water to air phase was found to be insignificant.
- 4.) In situ biostimulation with injection of air and gaseous nutrients was effective at both sites and could reduce the concentrations of COCs to undetectable levels in the groundwater and vadose zone, i.e., < 2 ppb.
- 5.) Complete mineralization of the COCs in the groundwater by indigenous microbes was demonstrated, thereby effecting the complete destruction of these compounds in situ.
- 6.) The west side of the landfill can be biostimulated with air injection and trace nutrients alone. Oxygen was the single most limiting element for microbes in this part of the landfill.
- 7.) The southern side of the landfill can be biostimulated with air, nitrous oxide, triethyl-phosphate and methane. Addition of the methane as a co-metabolic carbon/energy source was necessary to obtain reduction of COCs to undetectable levels.
- 8.) Biostimulation at both sites remediated both the groundwater and adjacent unsaturated zone of the COCs, but also a large variety of other organic compounds.

References Cited

Sanitary Landfill In Situ Bioremediation Optimization Test, Final Report - Draft, WSRC-TR-96-0065, Rev. 0, March 1, 1996.

1992 RCRA Part B Permit Renewal Application, Savannah River Site, Volume XXIII, Sanitary Landfill Postclosure, Rev. 1, March 1994.

Acomb, L.J., McKay, D., Currier, P., Berglund, S.T., Sherhart, T.V., and Benediktsson, C.V., *Neutron Probe Measurements of Air Saturation Near an Air Sparging Well*, presented in In Situ Aeration: Air Sparging, Bioventing, and Related Remediation Processes, proceedings from the Third International In-Situ and On-Site Bioremediation Symposium, Hincee, R.E., Miller, R.N., and Johnson, P.C., editors, Battelle Press, 1995.

Sanitary Landfill Groundwater Quality Assessment Plan - Amendment, WSRC-RP-95-1538, September 1995.

FIGURE 1 - SITE VICINITY MAP, SANITARY LANDFILL

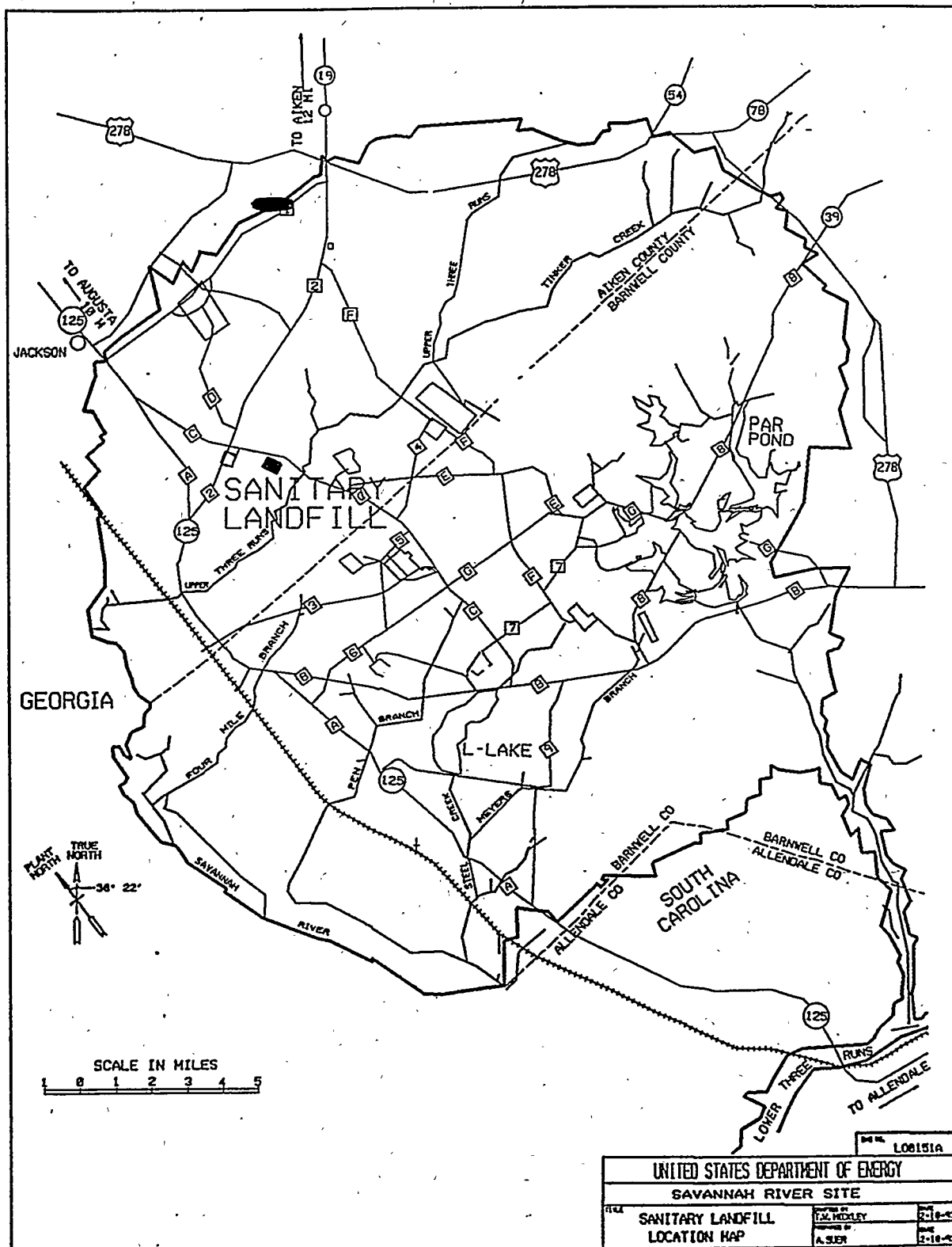
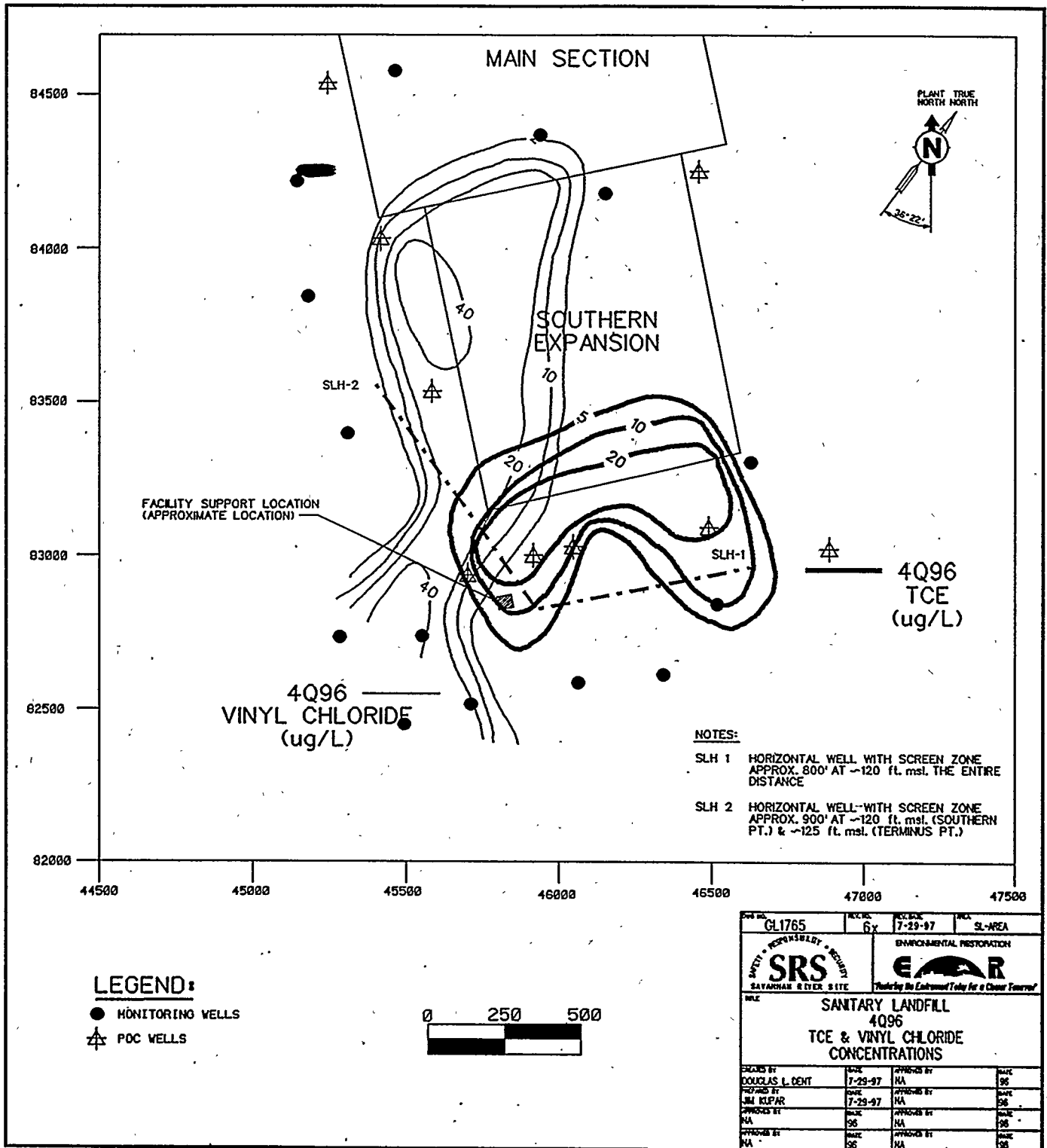


FIGURE 2 - PLAN VIEW OF PROPOSED INTERIM CORRECTIVE ACTION SYSTEM



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Interim Groundwater Corrective Action Proposal

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FIGURE 3 - GROUNDWATER ELEVATION AND FLOW AT SANITARY LANDFILL

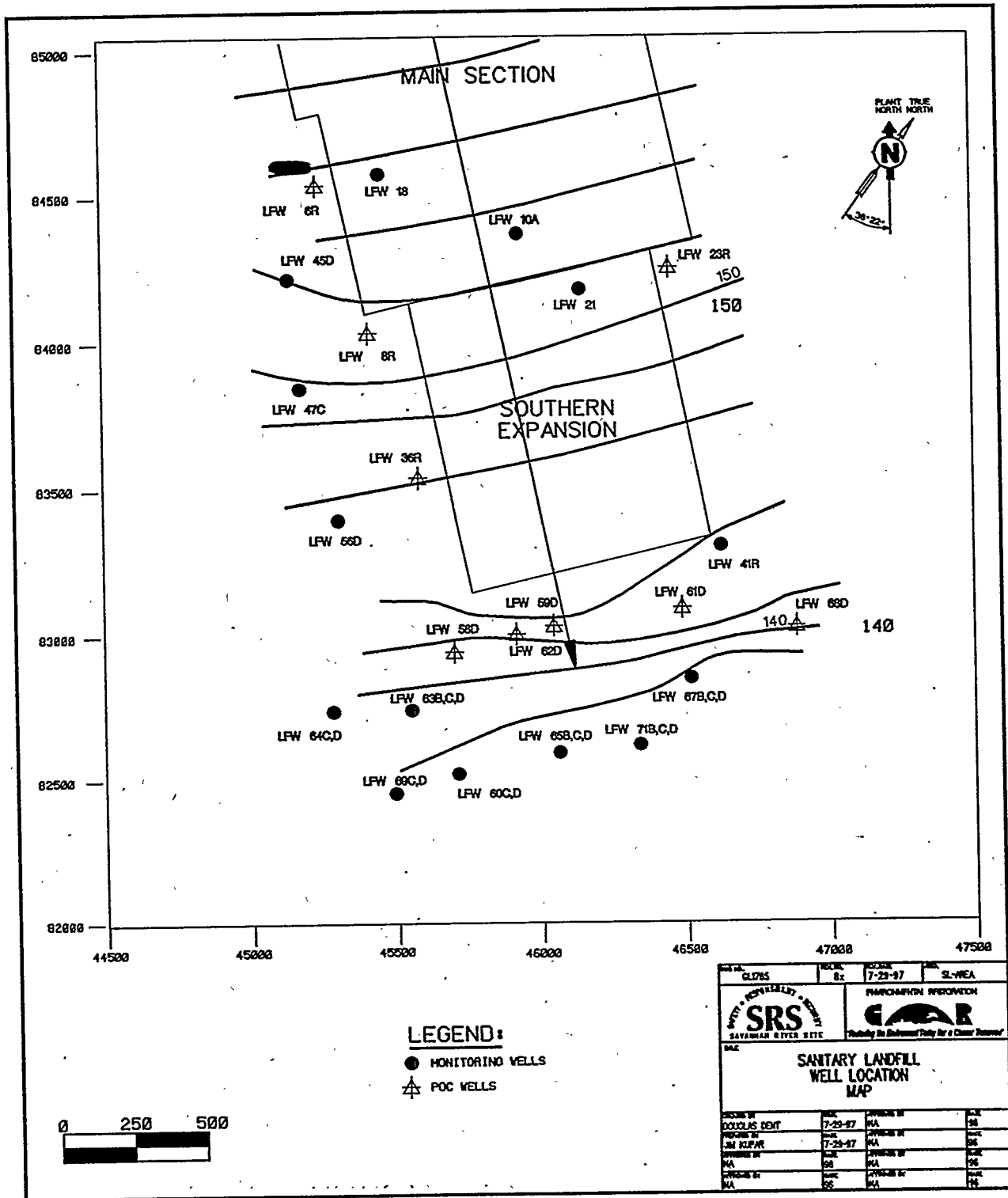


FIGURE 4 - PLAN VIEW OF EXPECTED ZONE OF INFLUENCE

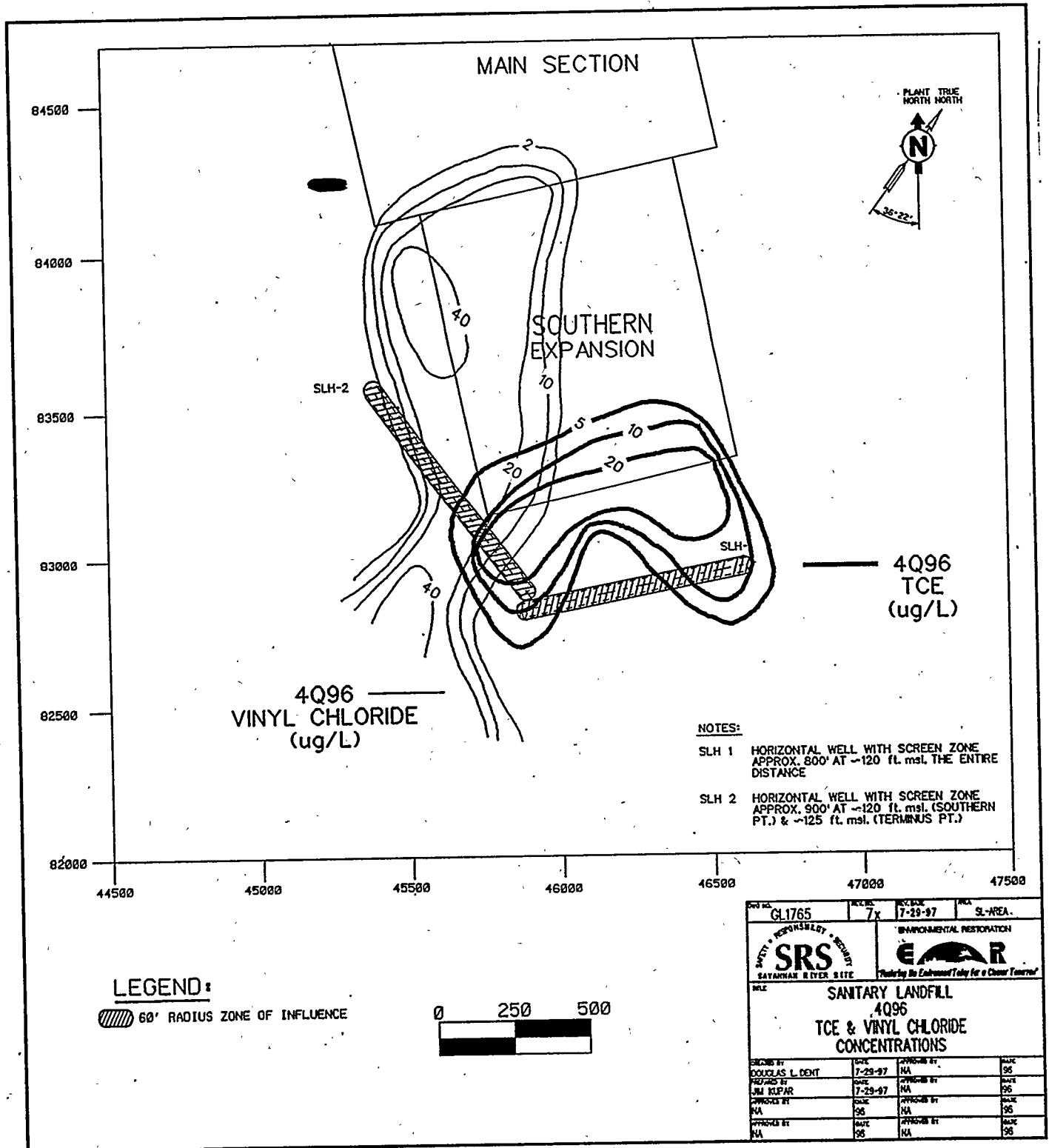
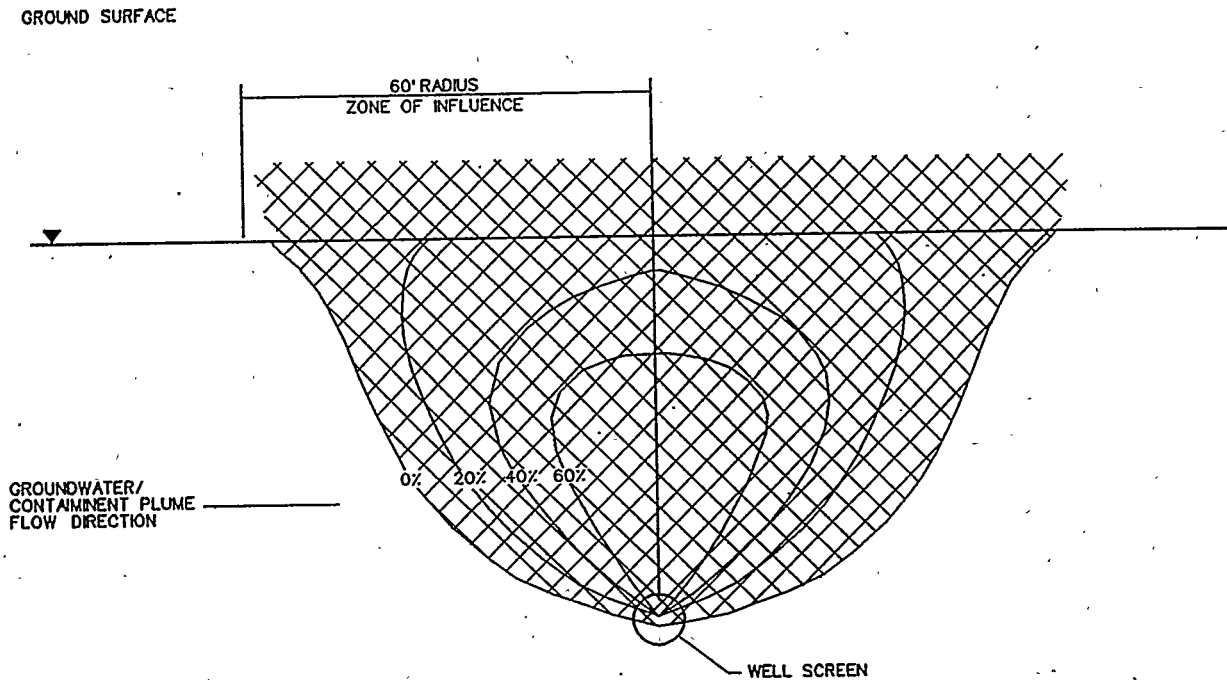




FIGURE 5 - CROSS SECTIONAL VIEW EXPECTED ZONE OF INFLUENCE
As Adopted from Acomb, et al., 1995



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<p>SAVANNAH RIVER SITE</p> <p><i>Protecting the Environment Today for a Cleaner Tomorrow</i></p>			
<p>TITLE</p> <p>SANITARY LANDFILL EXPECTED ZONE OF INFLUENCE CROSS SECTION</p>			
CREATED BY DOUGLAS L. DENT	DATE 4-25-96	APPROVED BY NA	DATE 97
DRAWN BY JIM KUPAR	DATE 4-25-96	APPROVED BY NA	DATE 96
CHECKED BY NA	DATE 96	APPROVED BY NA	DATE 96
APPROVED BY NA	DATE 96	APPROVED BY NA	DATE 96

7.4 In Situ Bioremediation Process