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Final

Phase I Ground Water Monitoring Well Construction Plan Colbert Landfill Remedial Design/Remedial Action

1.2.1
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Prepared for

Spokane County
Utilities Department

Prepared by

Landau Associates, Inc.
P.O. Box 1029
Edmonds, WA 98020-1029

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1.0 INTRODUCTION

This document presents the Phase I Ground Water Monitoring Well Construction Plan for the Colbert Landfill Remedial Design/Remedial Action (RD/RA) Superfund project. The purposes of the Phase I monitoring wells are to provide the data needed to better define the site hydrogeology and contaminant distribution for design of the final RA (Phase II), to provide background data for long-term (Phase II) ground water monitoring, and (if appropriately located) to be incorporated into the Phase II ground water monitoring system; this plan is intended to establish the procedures for construction of these Phase I monitoring wells and includes a description of the site background and existing conditions, monitoring well construction and development procedures, procedures for equipment decontamination, and disposal practices for soil cuttings and excess ground water. Phase I ground water monitoring activities (subsequent to construction and development of monitoring wells) is described in Appendix QA-A of the project Quality Assurance Project Plan (Landau Associates, Inc. 1989).

This plan has been prepared by Landau Associates, Inc. (Landau), Spokane County's engineering consultant for the Colbert Landfill RD/RA. Landau will implement this work plan as part of the field activities required prior to design of the final RA (Phase II).

1.1 SITE BACKGROUND

The Colbert Landfill is an inactive 40-acre municipal solid waste landfill located approximately 15 miles north-northeast of the City of Spokane and 2.5 miles north of the Town of Colbert (Figure GM-1.1). The Colbert Landfill operated until 1986, when it became filled to capacity with municipal and commercial waste.

Ground water emanating from the Colbert Landfill has been shown to be contaminated with chlorinated organic solvents. This contamination has been traced to spent solvents that were disposed of at the landfill during the period from 1975 to 1980. Solvents were disposed of at an average rate of several hundred gallons per month, and primarily consisted of 1,1,1-trichloroethane (TCA) and methylene chloride (MC). Other organic solvents have also been detected in the ground water near the landfill, including trichloroethylene (TCE), tetrachloroethylene (PCE), 1,1-dichloroethylene (DCE), and 1,1-dichloroethane (DCA).

In 1980, nearby residents complained to the Eastern Regional Office of the Washington State Department of Ecology (Ecology) about disposal practices at the landfill. State and County officials, under the lead of the Spokane County Utilities Department, initiated an investigation into complaints of ground water contamination in the area by sampling nearby private wells. The results of this initial investigation indicated that some of these wells were contaminated with TCA and, in August 1983, the U.S. Environmental Protection Agency (EPA) placed the Colbert Landfill on its National Priorities List (NPL).

Source: U.S.G.S. Topograpic Map of Spokane, Washington; Idaho; Montana, 1980.

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Regional Location Map of Colbert Landfill Site

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Figure GM-1.1

Several studies of the Colbert Landfill have been conducted since 1980, including the 1987 Remedial Investigation/Feasibility Study (RI/FS; Golder and Envirosphere 1987). The purpose of the RI/FS was to determine the nature and extent of contamination caused by the release of chemicals from the landfill, and to evaluate proposed remedies. Data collection and site characterization were the primary elements of the RI. The data collected and evaluated in the RI formed the foundation of the FS, which presented and evaluated various remedial options. The remedial action for the Colbert Landfill was selected based on recommendations presented in the FS and is described in the EPA's Record of Decision (ROD), which was released for public comment in September 1987.

The ROD subdivides the remedial action into three systems designated the South, West, and East systems. The South and West systems are intended to intercept contaminated ground water to minimize degradation of downgradient resources. In contrast to the South and West systems, the East system is intended for source control.

Subsequent to implementation of the ROD, a Consent Decree for the Colbert Landfill (U.S. District Court 1989) was negotiated between the EPA and Ecology (Regulatory Agencies), Spokane County (County), and Key Tronic. By this action, the County agreed to implement the EPA-selected remedy in accordance with the Comprehensive Environmental Response Compensation and Liability Act (CERCLA) requirements and the State of Washington Hazardous Waste Cleanup Act, codified as Chapter 70.105B RCW.

A scope of work to address ground water contamination emanating from the Colbert Landfill (Scope of Work) is presented in Appendix B of the Consent Decree. The Scope of Work specifies the bases for design, the design criteria, and criteria for adjustment and modification of the RA if the performance criteria are exceeded during operation of the system(s).

1.2 SITE CONDITIONS

The remedial action site ("Site") was defined in the ROD as the area of potential impact surrounding and including the landfill. The Site extends north of the landfill about one-half mile, west about one mile to the Little Spokane River, east a similar distance, and south approximately five miles to Peone Creek (also known as Deadman Creek), as shown on Figure GM-1.1. The total remedial action area is approximately 6,800 acres and includes parts of Sections 2, 3, 10, 11, 14, 15, 16, 21, 22, 23, 26, 27, 28, 33, 34, and 35 in Township 27 North, Range 43 East.

The Colbert Landfill is located on a plateau which is bounded by steep bluffs and the Little Spokane River on the west, and low granite and basalt hills to the east. Surface drainage is to the west, towards the Little Spokane River. The climate is characteristic of eastern Washington, with temperatures ranging from typical average summer highs of about 83° F to average winter lows of around 23° F. The relatively low annual precipitation of approximately 17 inches falls mainly during the winter months of November through February (NOAA 1985).

The geology of the Colbert Landfill area consists of a series of glacially-derived materials deposited on an eroded landscape of

clays, basaltic lava flows, and granitic bedrock. The stratigraphic units (layers) as described in the RI, from youngest to oldest (i.e., from the top down), are:

Unit A. Glacial outwash/Missoula flood sand/gravel;

Unit B. Glacial Lake Columbia lacustrine silt/clay;

Unit C. Older glaciofluvial and/or alluvial sand/gravel;

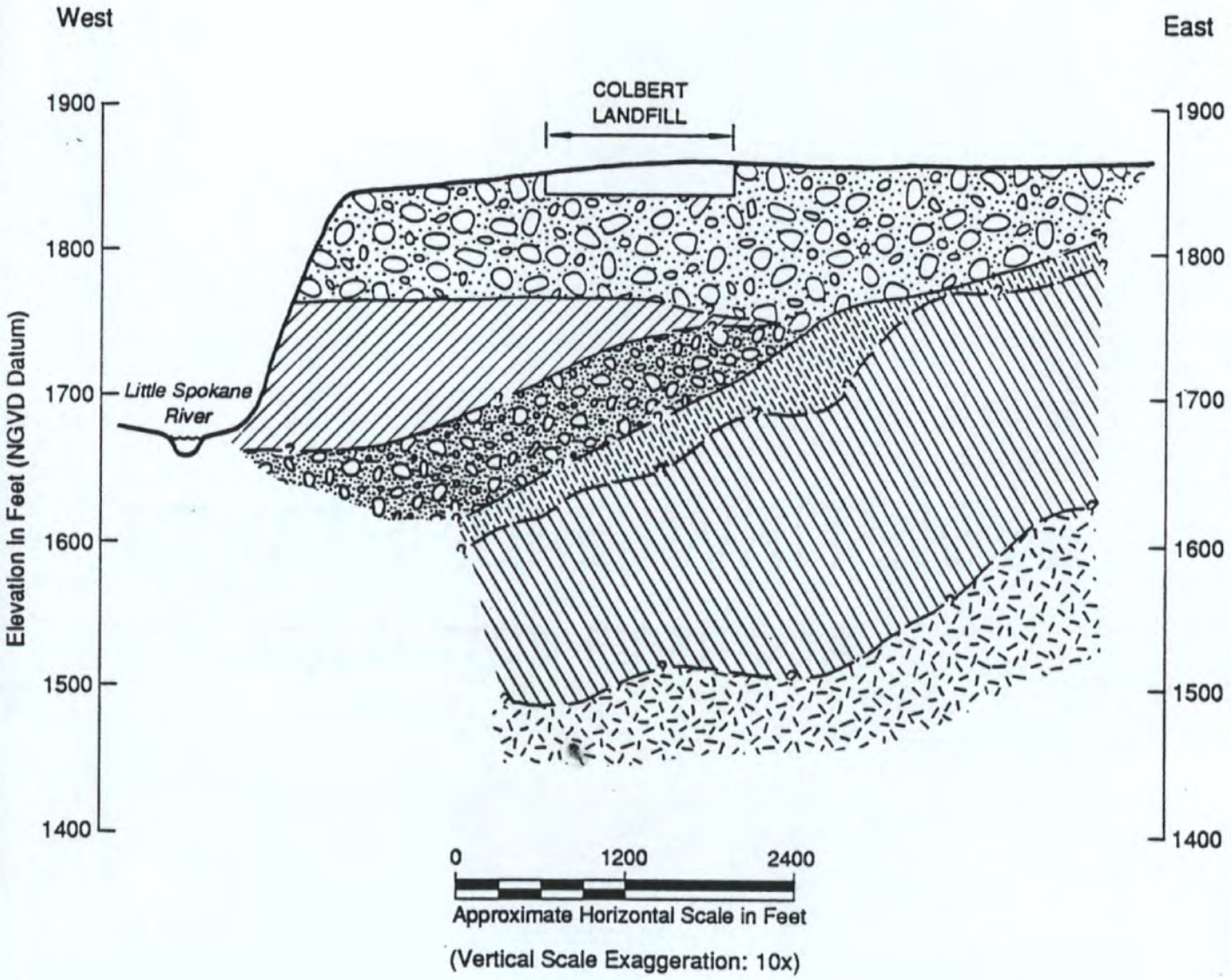
Unit D. Weathered basalts and Latah Formation (landslide deposits);

Unit E. Unweathered Latah Formation silt/clay; and

Unit F. Granite bedrock.

A generalized east-west profile of these units is shown on Figure GM-1.2.

This geologic system can be hydrogeologically defined as containing three aquifers and three aquitards. There is a perched aquifer associated with Unit A, the glacial outwash/Missoula flood deposits (Upper Sand/Gravel Aquifer), when the underlying Unit B is present. Unit B, the lacustrine silt/clay stratum (Lacustrine Aquitard), is a relatively impermeable layer which acts as an aquitard. A second aquifer is associated with Unit C, the older glaciofluvial and/or alluvial deposits (Lower Sand/Gravel Aquifer). The weathered zone of the basalts and Latah Formation, Unit D, results in a zone of higher permeability than the unweathered units and may be considered an extension of the Lower Sand/Gravel Aquifer (Units C and D are collectively referred to as the "Lower Aquifer"). The unweathered Latah Formation silt/clay (Latah Formation), Unit E, serves as the second aquitard, although low yield wells have been installed in this unit at some locations. The upper fractured zone of the granite (Unit F) is capable of



KEY

Unit Designation and Description

- (A) Upper Sand/Gravel (Aquifer)
- (B) Lacustrine Silt/Clay (Aquitard)
- (C) Lower Sand/Gravel (Aquifer) } Lower Aquifer
- (D) Weathered Latah/Basalt (Aquifer) } Lower Aquifer
- (E) Latah Formation (includes interlayered basalt flows) (Aquifer/Aquitard)
- (F) Granitic Rock (Aquifer/Aquitard)

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Geologic Schematic
Colbert Landfill Vicinity

Figure GM-1.2

water transmission and, although a poor producer in most areas, it could be considered as an aquifer while the deeper, less fractured portions of the bedrock serves as the confining lower boundary or aquitard to the entire regional flow system.

The Upper Sand/Gravel Aquifer is unconfined with a water table at an approximate elevation of 1,770 feet (MSL), about 90 feet below ground surface in the area of the landfill. The thickness of the Upper Sand/Gravel Aquifer varies from about 8 to 15 feet along its north-south trending centerline, and decreases as it extends toward the western bluffs and eastern hills. Ground water flows predominantly towards the south with velocities ranging from 4 to 13 feet per day (ft/day) (Golder Associates, Inc. 1987).

The Lower Aquifer is generally a confined system to the west of the landfill and unconfined (or semi-confined) to the east. The potentiometric surface of the Lower Aquifer is at an approximate elevation of 1,680 feet (MSL), about 180 feet below ground surface in the area of the landfill. The thickness of the Lower Aquifer varies considerably from only a few feet thick east of the landfill, to over 150 feet thick as it approaches the Little Spokane River valley, where it appears to be hydraulically connected with the river. Ground water in the Lower Aquifer flows predominantly towards the west at velocities ranging from 2 to 12 ft/day (Golder Associates, Inc. 1987). East of the landfill, the Lacustrine Aquitard is not present (or is discontinuous) and the Lower Aquifer is closer to the surface, interconnecting with the Upper Sand/ Gravel Aquifer.

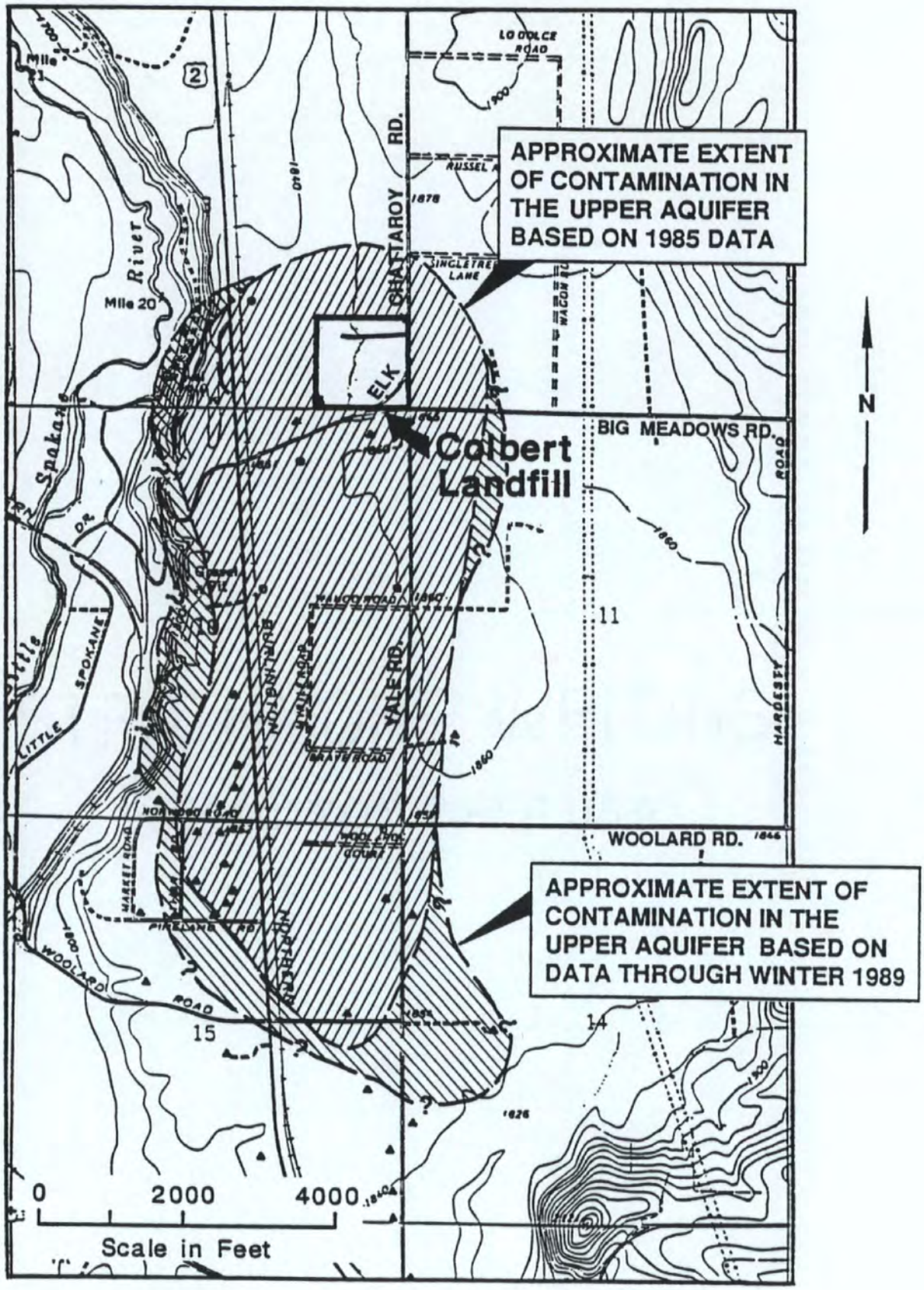
Both the Upper Sand/Gravel Aquifer and Lower Aquifer have been contaminated by chlorinated organic solvents. The extent of contamination was characterized in the RI, and has been re-evaluated using chemical data collected subsequent to the RI as part of the ongoing domestic well monitoring program. The approximate extent of contamination in upper and lower aquifers is shown on Figures GM-1.3 and GM-1.4 for the Upper Sand/Gravel Aquifer and Lower Aquifer, respectively.

1.3 SELECTED REMEDIAL ACTION

The remedial action selected by the EPA in the ROD, and further specified in the Scope of Work, includes the following components:

- In the South System, a series of extraction wells will be installed to intercept the contaminant plume in the upper aquifer;
- In the West System, a series of extraction wells will be installed to intercept contamination in the lower aquifer; and
- In the East System, where the plume originates, extraction wells will be installed for contaminant source control in the lower aquifer.

The ROD provides for a performance-based design, allowing flexibility in the remedial approach. Specific performance criteria were presented in the ROD (Performance Standards) and have been further refined in the Scope of Work (Tables IV-1 and V-1). The Scope of Work specifies the bases for design, the design criteria, and criteria for adjustment and modification of the remedial action if the performance criteria are exceeded during operation.



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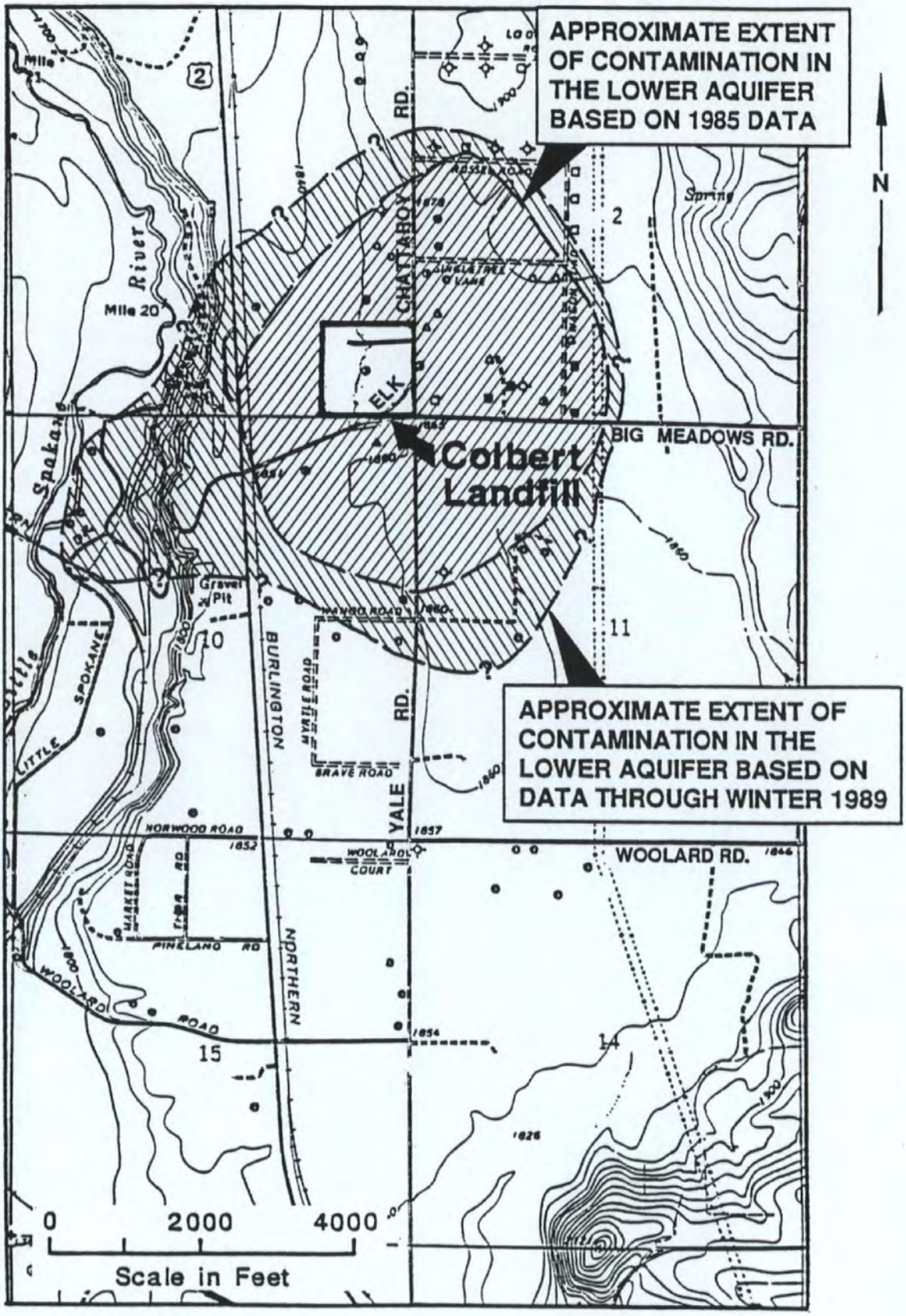
Extent of Contamination
Upper Aquifer

Figure GM-1.3



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Extent of Contamination
Lower Aquifer

Figure GM-1.4

As specified in the ROD, contaminated ground water will be removed using extraction wells. All three systems will be designed to treat extracted water to the ROD specified performance standards; air stripping has been tentatively identified as the method of treatment. Options for disposal of treated water include discharge to the Little Spokane River (all systems), subsurface recharge (South and East Systems), and discharge to Deep Creek (South System).

The RD/RA will be implemented in phases. Phase I is designed to provide initial RA, better characterize contaminant distribution and site hydrogeology, and provide the engineering parameters needed for design of the final RA. Following completion of the Phase I investigation, design, construction, and operation of the final RA will be accomplished during Phase II.

1.4 PERSONNEL POSITIONS AND RESPONSIBILITIES

A project the size of the Colbert Landfill RD/RA requires that personnel positions and responsibilities be clearly defined. The positions and responsibilities for Landau personnel involved with the Phase I ground water monitoring program are described below. Subcontractors performing site activities (such as well drilling) will be supervised by Landau personnel.

The Landau Project Manager will provide overall direction for Phase I ground water monitoring activities, will supervise the progress of these activities, and will coordinate the tasks required to accomplish the project objectives. The Landau Project Manager will report directly to the Landau Project Director and will be the point of contact for liaison with the County Project Manager.

The Landau Field Coordinator will provide guidance and internal oversight during monitoring well construction and hydrogeologic data collection activities, and will be responsible for effective utilization of technical and subcontractor personnel and equipment. The Landau Field Coordinator will also be responsible for addressing the day-to-day health and safety issues, and will report directly to the Landau Project Manager and the Site Safety Officer (the responsibilities of the Site Safety Officer are described in the project Health and Safety Plan [Landau Associates, Inc. 1989]).

The Landau Field Representative(s) will supervise various field activities, including monitoring well construction, and will be the field safety representative responsible for environmental monitoring at each well site. The Landau Field Representative(s) will report directly to the Landau Field Coordinator.

2.0 MONITORING WELL CONSTRUCTION

Phase I ground water monitoring wells will initially be installed at eleven locations (South System: three locations; West System: four locations; and East System: four locations). The purposes of these initial monitoring wells are to:

- Better characterize site hydrogeologic conditions and contaminant distribution;
- Provide the data required for properly locating the Phase I pilot extraction wells (construction and operation details for the Phase I pilot extraction wells will be presented in a separate work plan); and
- Provide hydrogeologic and chemical data during operation of the Phase I pilot studies.

The Scope of Work specifies that nested monitoring wells (more than one well in each boring) will be constructed for the Phase I-West and Phase I-East systems. However, because of the potential for cross aquifer contamination in multiple-completion (nested) wells, a separate boring will be drilled for each well resulting in groups of wells (well clusters) at locations where more than one monitoring well will be required.

It is anticipated that well clusters including two or three wells will be installed at the initial Phase I monitoring well locations in the East and West systems. Additional monitoring wells may be required in association with pilot extraction wells, primarily to provide hydrogeologic data during Phase I pilot study operation (pumping tests). It is anticipated that only one monitoring well will be needed at these additional locations. All ground water monitoring wells installed as part of Phase I activi-

ties will be constructed and developed in accordance with the practices and procedures described in this work plan.

The monitoring well construction program required to implement Phase I of the Scope of Work will be extensive, and the hydrogeologic conditions and goals are different for each system. Consequently, system-specific well construction methods and design details have been developed for the Phase I ground water monitoring wells, and are presented in subsequent sections of this work plan.

2.1 DRILLING PROCEDURES

In order to fulfill the purpose of the Phase I ground water monitoring program, and implement the program in a timely and cost-effective manner, a combination of cable tool and air rotary drilling techniques will be utilized. ODEX drilling, an air rotary method that utilizes an air percussion hammer, is the preferred drilling method for most wells. Cable tool drilling will be used at locations (and at depths) where complex hydrogeologic conditions are anticipated, and at locations where excessive water production makes air rotary drilling impractical. Cable tool will be the preferred method for well installation once drilling has been completed, although air rotary or other appropriate equipment may also be used.

A lithologic log of the soil and rock encountered in each boring will be maintained using a form similar to that shown on Figure GM-A-1, Appendix A. Additional information such as the presence of water-bearing zones, the depth and type of soil samples collected, and any unusual or notable conditions encountered during drilling will also be recorded on this form.

The Scope of Work specifies that monitoring wells will be constructed using 2-inch diameter Schedule 80 PVC pipe. However, difficulty is often encountered in maintaining acceptable monitoring well alignment when 2-inch diameter wells are installed in deep borings. Consequently, 2.5-inch diameter Schedule 80 PVC pipes will be used for wells deeper than about 220 feet.

The diameters of temporary steel casing employed during drilling will depend on the anticipated depth of the well. Temporary casing will be selected such that the borehole is at least 4 inches larger than the nominal diameter of the well pipe. Thus, at least a 6-inch diameter temporary casing will be used when installing 2-inch diameter monitoring wells, and 8-inch diameter temporary casing will be used when installing 2.5-inch diameter wells.

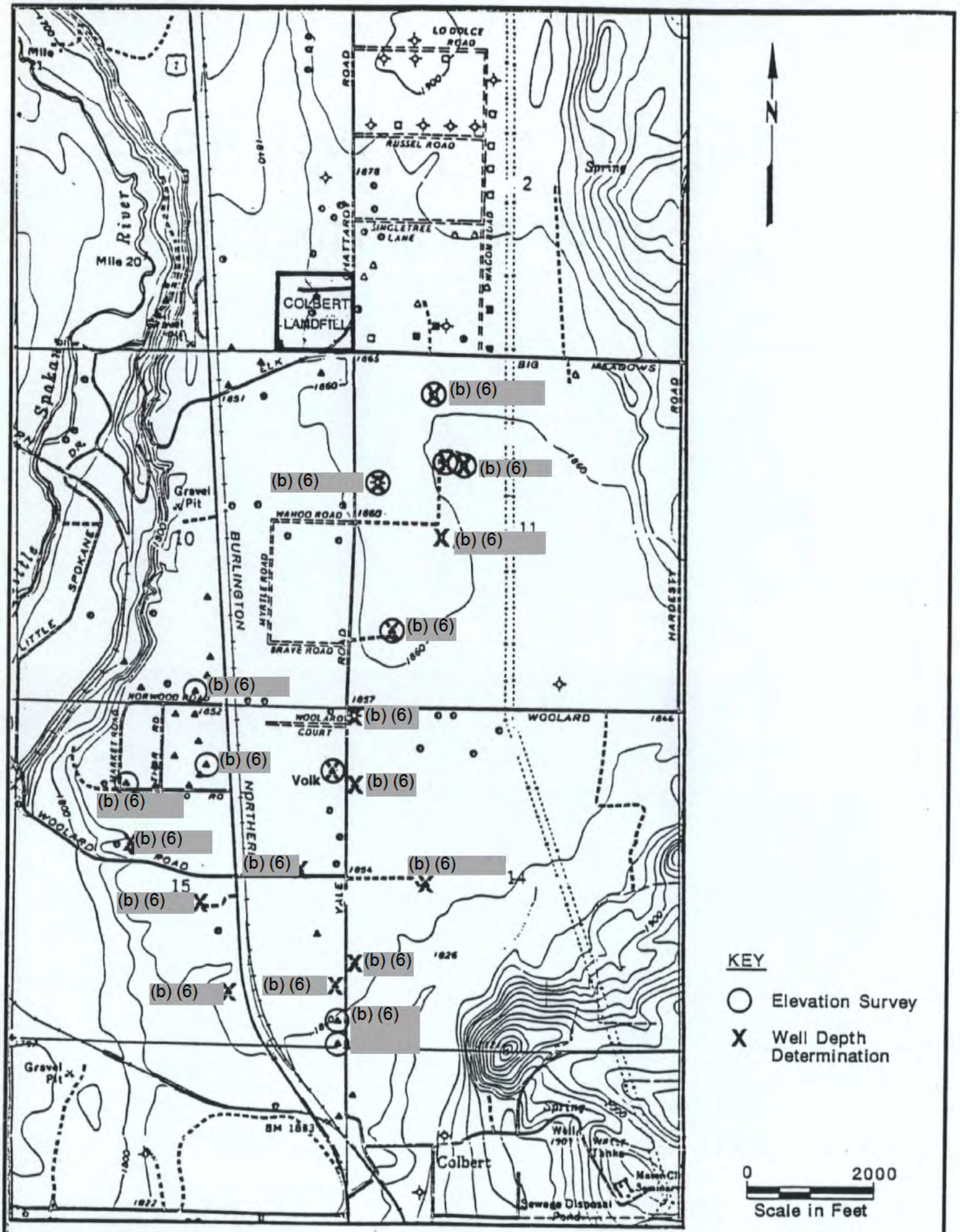
A form similar to that shown on Figure GM-A-2 (of Appendix A) will be used to record the well installation details subsequent to completion of the boring. The information recorded on this form will include materials used for installation of the well and the depths at which these materials are placed. Additional information such as the depth to water and any significant variations from standard well construction practices will also be recorded on this form.

All monitoring wells will be secured using a locking monument cover upon completion of construction. Where appropriate, steel posts will be installed adjacent to the monitoring well to prevent damage to the well from vehicles or equipment.

2.1.1 South System

Contaminants within the Upper Sand/Gravel Aquifer have not migrated as anticipated, based on the chemical and hydrogeologic parameters presented in the RI. Consequently, additional evaluation of existing wells will be accomplished to assist in the final selection of the initial Phase I-South monitoring well locations. First, well depths and static water levels will be verified ("field truthed") for selected existing domestic wells near the leading edge of the contaminant plume, and along the east margin of the Upper Sand/Gravel Aquifer. In conjunction with field truthing of these domestic wells, a ground water elevation survey will be accomplished to better define ground water flow direction and velocity near the leading edge of the contaminant plume in the upper aquifer; an elevation survey of some domestic wells will be required as part of this ground water elevation survey. Figure GM-2.1 shows the wells intended for evaluation as part of this characterization effort; however, evaluation of specific wells is dependent upon property access and well configuration.

If contamination migration in the Upper Sand/Gravel Aquifer cannot be adequately characterized for selection of initial Phase I monitoring well locations following this preliminary investigation, a soil/gas survey will be considered. However, the depth to ground water (approximately 80 feet) and the relatively low contaminant concentrations make a soil/gas survey only marginally



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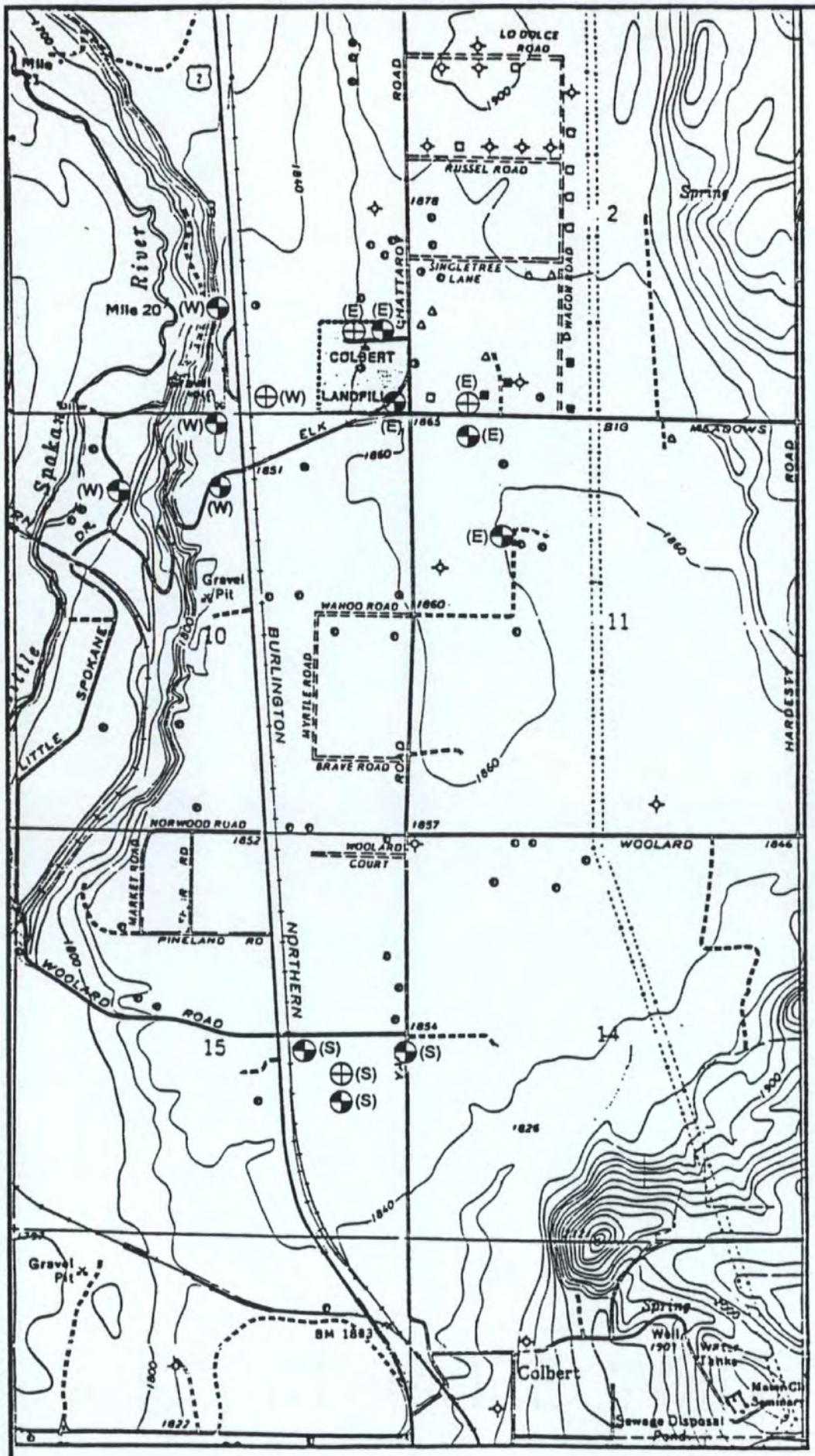
Field Verification Survey

Figure GM-2.1

feasible for the South area. To assist in evaluating the probability of obtaining useful information from a soil/gas survey, data and quality assurance/quality control (QA/QC) procedures from the RI soil/gas survey will be reviewed.

Following the preliminary evaluation described above (with or without a soil/gas survey), the Phase I-South monitoring wells will be installed. Initially, three monitoring wells will be installed in the Upper Sand/Gravel Aquifer; the tentative locations for these initial wells are shown on Figure GM-2.2. These wells are anticipated to be approximately 100 to 120 feet in depth and will be constructed using 2-inch diameter Schedule 80 PVC casing. The anticipated drilling technique is air rotary or ODEX. Soil samples will be collected during drilling activities for geologic logging purposes; grab samples of soil cuttings will be collected at about 5-foot depth intervals until the water table is encountered, and driven samples will be collected at about 5-foot intervals from the water table to the bottom of the boring. Drilling and sampling will extend into the Lacustrine Aquitard underlying the Upper Sand/Gravel Aquifer. If necessary, the casing shoe will be cut and casing separation will be verified prior to commencing monitoring well installation. After the casing shoe is cut, it will be isolated using bentonite chips or pellets. Post-drilling monitoring well installation is discussed in Section 2.2 of this work plan.

Well drilling activities for the Phase I-South system are summarized in Table GM-2.1. Additional Phase I-South monitoring



KEY

- Approximate location of Proposed Monitoring Well or Monitoring Well Group
- Approximate location of Proposed Pilot Extraction Well
- (S) South System
- (W) West System
- (E) East System

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Phase I Monitoring Well and Extraction Well Locations

Figure GM-2.2

TABLE GM-2.1

SUMMARY OF ANTICIPATED MONITORING WELL CONSTRUCTION PRACTICES

Well System and Number of Initial Well Locations (a)	Number of Wells at each Location	Estimated Depth of Wells (Feet)	Estimated Depth to Water (Feet)	Antici-pated Screen Length (Feet)	Well and Screen Specifications	Temporary Steel Casing Diameter (Inches)	Anticipated Drilling Techniques(b)	Sampling Interval
South (3)	1	90 to 120	80	10	2 in. Sch. 80 PVC 0.010 in. slotted screen	6	AR/ODEX	5 ft. grab samples to water table at ~80 ft. depth. 5 ft. driven samples to aquitard. Terminate drilling in Lacustrine Aquitard.
West (4)	1 to 3	200 to >350	180	≥20	2 in. Sch. 80 PVC 0.010 in. slotted screen for wells less than ~250 ft.; 2-1/2 in. Sch. 80 PVC for wells deeper than ~250 ft.	10 and 8 or 8 and 6 (c)	AR/ODEX, CT (d)	First well in cluster: - grab samples every 5 ft. - driven samples every 20 ft. starting in lacustrine aquitard. Additional wells in each cluster: - grab samples every 5 feet. Terminate drilling in Latah Formation.
East (4)	1 to 3	100 to 250	≥90	5 to 20	Same as West System.	10 and 8 or 8 and 6(c)	AR/ODEX, CT (d)	First well in cluster: - grab samples every 5 ft. for first 70 ft. - driven samples every 5 ft. below 70 ft. Additional wells in each cluster: - grab samples every 5 ft. Terminate drilling in low permeability, Unweathered Latah Formation.

NOTES:

(a) Wells may be installed at additional locations in support of pilot study activities.

(b) AR = air rotary, ODEX = Air rotary using ODEX down hole hammer, CT = Cable tool.

(c) 10-inch stepped down to 8 inches in the Lacustrine Aquitard for 2.5-inch ID wells or 8 inch stepped down to 6 inch for 2-inch ID wells.

(d) Cable tool drilling will be employed when complex geohydrologic conditions are anticipated, or if air rotary drilling becomes impractical due to high volumes of water.

wells (if any) will be constructed using the drilling procedures described in this section.

2.1.2 West System

Initially, monitoring wells will be installed in the Lower Sand/Gravel Aquifer at the approximate locations shown on Figure GM-2.2, as part of the Phase I-West system. From one to three wells will be installed in clusters (a single well in each boring) at each location. Wells in each cluster will be screened at different depths within the Lower Sand/Gravel Aquifer to provide data concerning vertical variations in chemical and hydrogeologic conditions.

One well in each cluster will be installed at the base of the Lower Sand/Gravel Aquifer. The depth of the contact between the Lower Sand/Gravel Aquifer and the underlying Latah Formation (in the West area) is not known, but is expected to be at least 350 feet. The thickness of the Lower Sand/Gravel Aquifer will form the basis for determining the number of wells installed within a given well cluster. If the aquifer is less than about 50 feet thick, one monitoring well will be installed at the base of the aquifer. If the aquifer is greater than about 50 feet thick, but less than about 175 feet thick, two monitoring wells will be installed in the cluster; one well at the base and one well within the upper 90 feet of the aquifer. If the Lower Sand/Gravel Aquifer is greater than about 175 feet thick, three monitoring wells will be installed in the cluster; one at the base, one in the middle one-third, and one in the upper one-third of the aquifer.

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The temporary casing advanced during drilling will be downsized ("stepped down") in the Lacustrine Aquitard to create a seal and prevent downward migration of contamination from the Upper Sand/Gravel Aquifer. Consequently, each boring will have to be initiated with a temporary steel casing larger than that required to complete the well with the appropriate annular space. For 2-inch diameter monitoring wells, the boring will be initiated with an 8-inch (or larger) temporary casing and stepped down to a 6-inch casing. For 2.5-inch monitoring wells, the boring will be initiated with a 10-inch (or larger) temporary casing and stepped down to an 8-inch casing.

It is intended that the first well in each cluster be the deepest, and air rotary or ODEX equipment will be used to advance the boring. Since the anticipated depth of the deepest boring is greater than 250 feet, it will be assumed that a 2.5-inch well will be installed. Consequently, drilling will be initiated using a 10-inch diameter (or larger) temporary steel casing.

Drilling with 10-inch temporary casing will continue until the Lacustrine Aquitard is encountered; this aquitard is anticipated to be greater than 50 feet in thickness. After drilling into the aquitard about 5 feet, the casing will be driven about an additional 5 feet to create a seal. The casing size will then be stepped down to 8-inch diameter and drilling will continue through the Lacustrine Aquitard and the Lower Sand/Gravel Aquifer. Bentonite slurry will be placed in the annular space between steel casings. Drilling will terminate at the base of the Lower Sand/Gravel Aquifer, after advancing the boring approximately 10 feet

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into the Latah Formation. The casing shoe will be cut (if required) and isolated as previously described for Phase I-South monitoring wells.

It is expected that the volume of ground water encountered in the Lower Sand/Gravel Aquifer will be substantial. This condition may make air rotary drilling difficult or impractical, and require that borings started with rotary equipment be completed using cable tool methods.

Soil sampling for geologic identification purposes will be accomplished during drilling. Soil cuttings will be monitored frequently, and grab samples will be collected at about 5-foot intervals during drilling. Driven samples will be collected from the first boring in each monitoring well cluster at about 20-foot intervals when drilling in the Lacustrine Aquitard, the Lower Sand/Gravel Aquifer, and the underlying Latah Formation. A driven sample will be collected at the bottom of each boring (provided the boring is not terminated in bedrock).

Phase I-West monitoring well construction practices are summarized in Table GM-2.1. Phase I-West monitoring wells installed at additional locations (if any) will be constructed using the drilling procedures described in this section.

2.1.3 East System

Monitoring well clusters will be installed at the four approximate locations shown on Figure GM-2.2 for the East system. Up to three wells will be installed at each location in the following zones: a) the Upper Sand/Gravel Aquifer (if present), b) the Lower

Sand/Gravel Aquifer (if present), and c) the Weathered Basalt/Latah Formation or the Latah Formation.

Previous investigations (Golder Associates, Inc. 1987) indicate that, hydrogeologically, a zone of transition is present to the east and north of the Colbert Landfill between the simpler two-aquifer system observed to the west and south, and the more complex and heterogeneous, multiple-zone aquifer to the east and north. The Lacustrine Aquitard may be absent or discontinuous to the north and east of the Colbert Landfill, resulting in a combined Upper and Lower Sand/Gravel Aquifer. Additionally, the water table may be below the combined Sand/Gravel Unit in some areas to the east of the landfill. Therefore, the Weathered Basalt/Latah Formation and Latah Formation may be the only saturated units in the Lower Aquifer for portions of the East system.

Due to the complex hydrogeologic conditions anticipated for the East area, the first well at each location will be advanced using (primarily) cable tool drilling techniques. Air rotary equipment may be used to advance the boring for about the first 75 feet. However, cable tool equipment will then be used to complete the first boring in each cluster to facilitate accurate identification of hydrogeologic units and the collection of frequent driven soil samples; if basalt flows or large blocks are encountered, air rotary equipment may be required to complete the boring. Air rotary or ODEX equipment may be used for subsequent wells in each cluster.

Drilling for the first boring in each cluster will be initiated with 10-inch diameter (or larger) temporary steel casing

to allow for installation of a 2.5-inch diameter monitoring well. The 10-inch casing will be seated and grouted in the Lacustrine Aquitard, if it is encountered. The casing size will then be stepped down to 8 inches and drilling will continue through the subsequent units; bentonite slurry will be placed between the two steel casings. If the Lacustrine Aquitard is not encountered, the casing will be stepped down at a depth of about 120 feet. Temporary casing for subsequent borings in each cluster will be sized based on the anticipated depth of well completion, as described in Section 2.1. Drilling for the first boring at each cluster will be halted when granite bedrock, or a 20- to 30-foot thick section of low-permeability Latah Formation is encountered. Subsequent borings in each cluster (if any) will be terminated in the appropriate aquifer units, which will be identified during drilling of the first boring.

For the first boring at each location, grab samples of cuttings will be collected during air rotary drilling (the upper 75 feet). Driven samples will be collected during cable tool drilling at about 5-foot depth intervals to the bottom of the boring. At the discretion of the Landau Field Representative, driven samples may be collected at about 2.5-foot sampling intervals (such as when drilling through the Lacustrine Aquitard). Grab samples will be collected at about 5-foot intervals during drilling of subsequent borings in each well cluster, and a driven sample will be collected at the bottom of each boring (provided the boring is not terminated in bedrock).

Phase I-East monitoring well construction procedures are described in Table GM-2.1. Phase I-East monitoring wells installed at additional locations (if any) will be constructed using the drilling procedures described in this section; except, air rotary drilling may be used for the first boring, provided sufficient hydrogeologic data is available to determine the depth of the appropriate target aquifer zone.

2.2 INSTALLATION OF MONITORING WELLS

Well installation will be accomplished in general accordance with the Washington State Minimum Standards for Construction and Maintenance of Wells (WAC 173-160). It is anticipated that cable tool equipment will be used for most monitoring well installations, once the boring has been completed. All permanent well casing, centralizers, and equipment used downhole (such as tremie pipe) will be cleaned using a hot water pressure wash prior to installation, as described in Section 5.0.

As described in Section 2.1, monitoring wells that are less than about 220 feet in depth will be constructed using 2-inch nominal inside diameter (ID) Schedule 80 PVC pipe as permanent casing. Monitoring wells greater than about 220 feet in depth will be constructed using 2.5-inch ID Schedule 80 PVC pipe. The permanent casing will be installed with stainless steel centralizing devices located above and below the screen section to provide a filterpack of consistent dimension in the vicinity of the well screen. If conditions at individual wells warrant installation of a blank section below the screen, the filterpack will be extended 2 to 3 feet below the screened section.

It is important that permanent well casing be installed (and backfilled) without sharp bends so that ground water sampling equipment can be lowered down the well. A bailer, or other appropriate equipment (such as a pump blank), will be lowered to the bottom of the well periodically during well installation to evaluate permanent casing alignment. Additionally, tension will be maintained on the well pipe to maintain proper alignment during backfilling of the annular space.

In general, monitoring well screen lengths will be 20 feet or less. However, the Scope of Work provides for screen lengths up to 20 percent of the aquifer thickness in the West system, which may result in longer screened sections if the aquifer is greater than 100 feet thick.

The target zones for all monitoring wells are anticipated to consist of fairly course materials (sand and gravel). However, all monitoring wells will be constructed using 0.010-inch slotted screens, and No. 10-20 Colorado silica sand (or equivalent) for the filterpack. This relatively fine slot size and filterpack material will be used to help minimize ground water sample turbidity.

Filterpack material will be installed in the annulus between the temporary steel casing and the permanent well casing. The sand will be tremied, or poured slowly from the surface. Filterpack material will be maintained approximately 3 feet above the bottom (inside) of the temporary casing to maintain formation stability. During installation of filterpack material, frequent measurements will be made to determine the depth to the top of the filterpack

material, relative position with respect to the bottom of the steel casing, and the planned position of the bentonite seal. The filterpack will be extended approximately 3 to 5 feet above the top of the well screen.

One of the most difficult and time-consuming tasks during well construction is the installation of a bentonite pellet seal above the filterpack, particularly when the seal is placed through a thick water column. The primary purpose of this pellet seal is to prevent the intrusion of the annular sealant (typically bentonite slurry) into the filterpack. With the advent of "high-solids" bentonite grout such as Volclay* (20 percent solids versus 8 to 10 percent solids for standard bentonite grout), and the more recently developed PureGold* grout (35 percent solids), the required bentonite plug seal may be able to be satisfactorily constructed using the high solids bentonite grout. Recent discussions with Ecology representatives indicate that this approach is acceptable (Landau communication 1989).

Both methods of creating a bentonite plug (high-solids grout and bentonite pellets) are expected to be used for installation of Phase I monitoring wells. The high-solids bentonite grout method is intended for use for most wells installed in the Lower Aquifer (West and East areas). A pellet seal may be installed in some East Area wells if the well is to be installed within about 10 feet of the static water level elevation (unconfined conditions). It is

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* American Colloid brand name.

anticipated that a bentonite pellet seal will be installed for monitoring wells completed within the Upper Sand/Gravel Aquifer (South Area and possibly some East Area wells); however, if the aquifer is thicker than anticipated, high-solids bentonite may be used instead of a pellet seal at these locations.

If high-solids bentonite grout is used to create the bentonite plug, at least 2 feet of fine sand (20-40 Colorado silica sand, or equivalent) will be placed above the filterpack to minimize the possibility of the grout entering the filterpack. Following placement of the fine sand layer, at least 10 feet of PureGold grout (or equivalent) will be tremied into the annular space, near the top of the existing backfill. The bentonite plug will be allowed to "set up" for at least two hours (from the time grout mixing is initiated) prior to installing additional annular sealant. The bottom of the temporary steel casing will be maintained at a lower elevation than the grout material to maintain formation stability during grouting activities.

If the bentonite plug is created using bentonite pellets, at least a 2-foot thick seal will be installed. The pellets will be added slowly. The temporary steel casing will be withdrawn slowly as the pellets are added, maintaining the bottom of the temporary casing about 1 foot below the top of the pellets to provide formation stability. The bentonite pellet seal will be allowed to hydrate for at least one-half hour prior to adding additional annular sealant material.

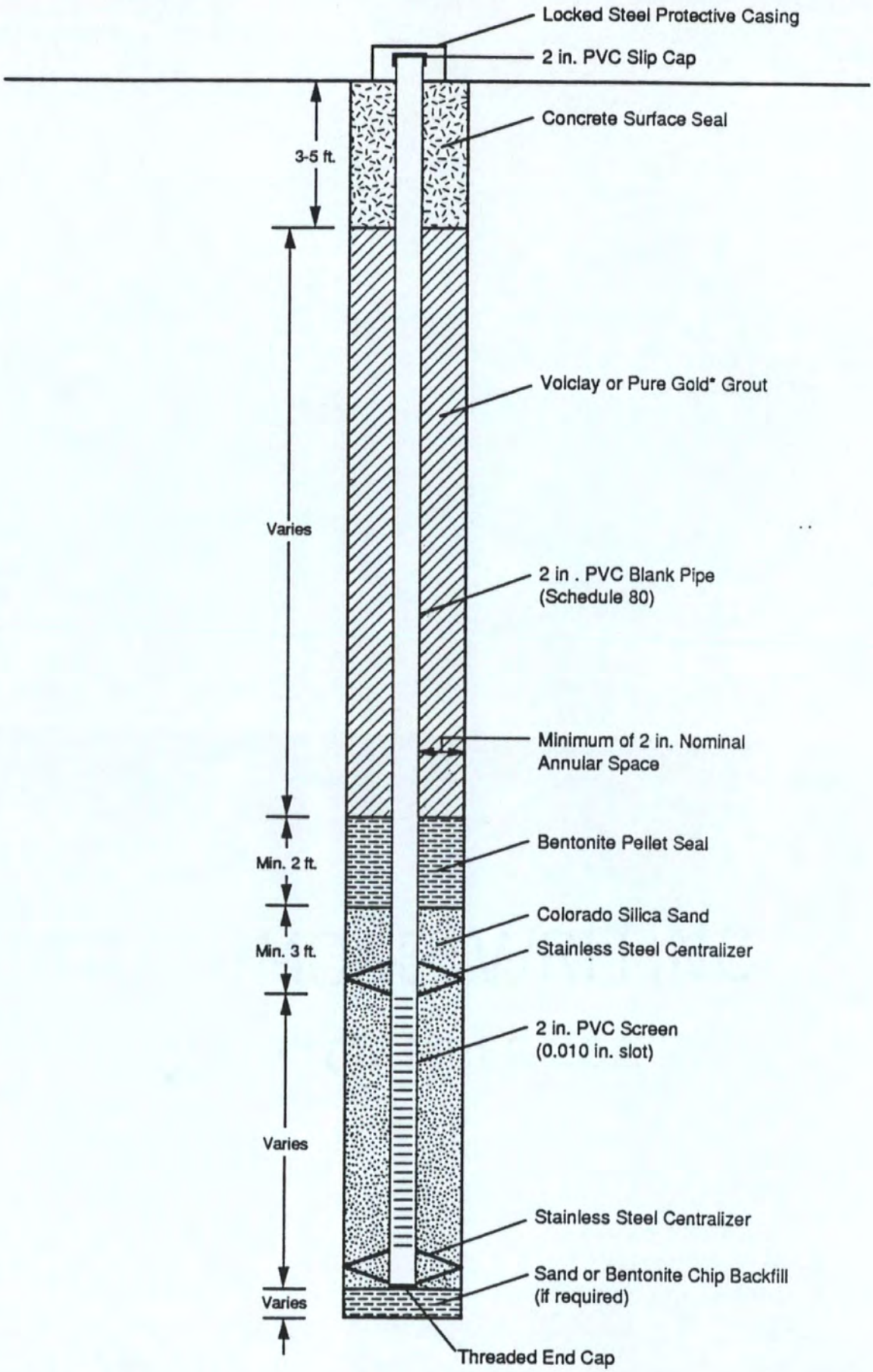
Following installation of the bentonite plug, Volclay grout (or equivalent) will be used as an annular sealant. If conditions

warrant (such as anticipated excessive grout loss to the formation), bentonite chips may be used instead of Volclay grout as an annular sealant above the bentonite plug. If grout is used, the annular sealant will be installed using a tremie pipe lowered near the top of backfill material, so that water and sediment within the well casing are displaced upward when grout is pumped into the annulus; bentonite chips, if used, will be placed from the surface. Care will be taken to pump the first portion of grout into the annulus at a rate low enough to avoid disturbing the bentonite plug. If a bentonite pellet seal is installed (and if practicable), at least one batch of Volclay grout (or equivalent) will be installed, and the casing withdrawn to above the pellet seal on the same day as the pellet seal is installed. Same-day withdrawal will help prevent bridging between the pellets, well pipe, and temporary steel casing. Volclay grout will be placed to within about 5 feet of the surface and will be allowed to set up for at least 12 hours prior to installing the surface seal.

A concrete surface seal will be installed above the Volclay grout seal. Bentonite chips may be used to stiffen the top of the grout material prior to installing the surface seal. A locking steel monument cover will be installed to protect the monitoring well at the surface. A concrete pad or metal posts will be constructed around the steel casing in accordance with WAC 173-160-510.

An elevation survey will be conducted following monitoring well installation to establish elevations (National Geodetic Vertical Datum) for the PVC casing, monument cover, and ground

surface. The PVC casing and monument cover will be surveyed to the nearest 0.01 foot, and the ground surface will be surveyed to the nearest 0.1 foot. Figures GM-2.3 and GM-2.4 show typical monitoring well construction details for the Upper Sand/Gravel Aquifer and Lower Aquifer, respectively.



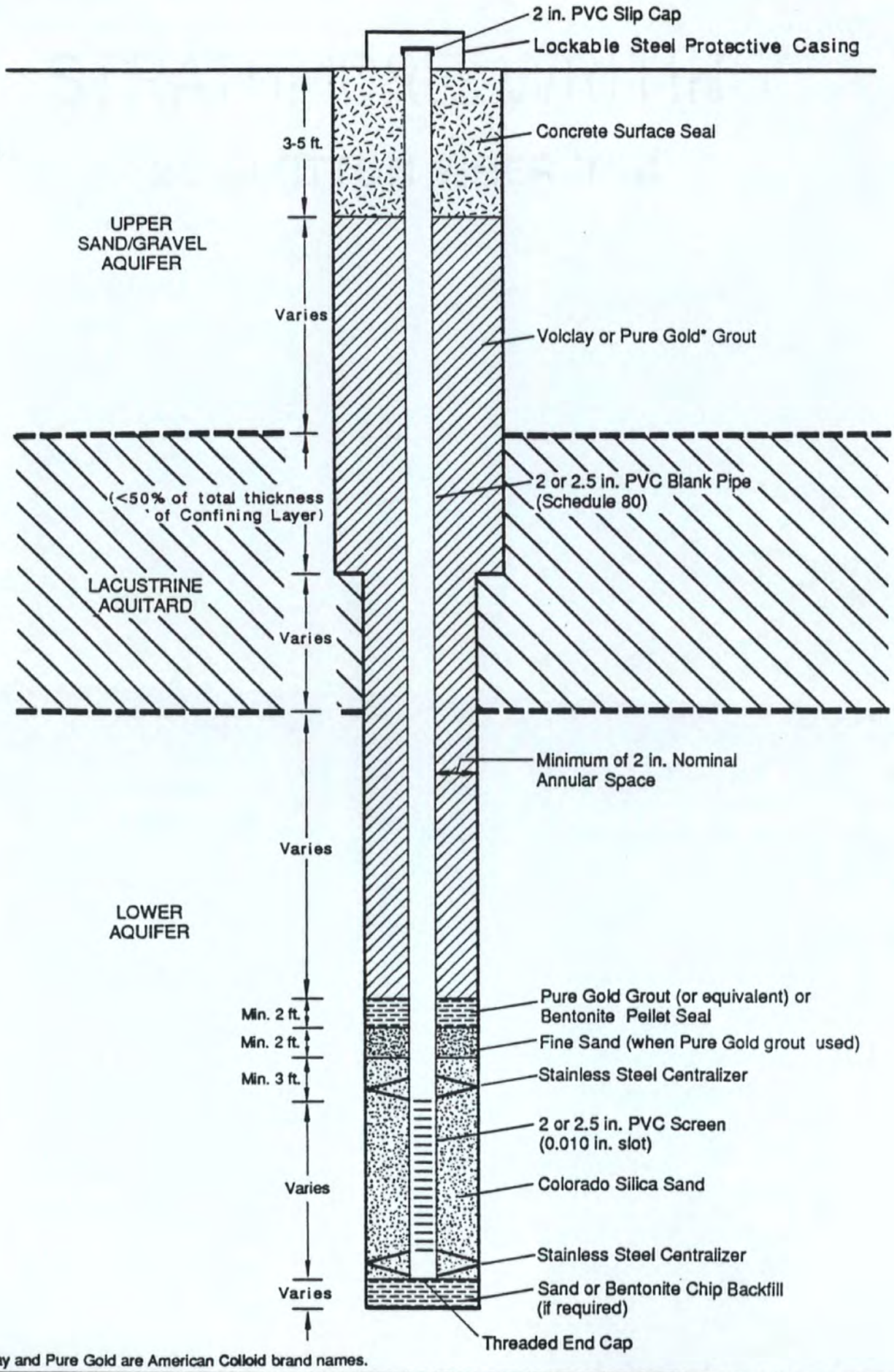
*Volclay and Pure Gold are American Colloid brand names.

LANDAU ASSOCIATES, INC.

Typical Monitoring Well Design
Upper Sand/Gravel Aquifer

124-01.20 Colbert Landfill/Phase I Ground Water Monitoring Well Construction Plan 8-14-89

Figure GM-2.3



* Volclay and Pure Gold are American Colloid brand names.

LANDAU ASSOCIATES, INC.

Typical Monitoring Well Design
Lower Aquifer

124-01-20 Colbert Landfill/Phase I Ground Water Monitoring Well Construction Plan 8-14-89

Figure GM-2.4

3.0 MONITORING WELL DEVELOPMENT

Monitoring wells are developed to remove suspended formation materials introduced into the borehole and filterpack during drilling and well installation activities, and to remove fine-grained material (if present) from the native soil adjacent to the filterpack. Proper well development results in lower turbidity water samples.

The effectiveness of different development methods varies depending on the type of aquifer materials, depth to water, height of the water column, and other factors. It is anticipated that air-lift techniques, mechanical surging, pumping, or a combination of these methods will be utilized for development of Phase I monitoring wells.

Air lift can be used for both surging and pumping wells, and is most appropriate for coarse aquifers such as the Upper and Lower Sand/Gravel Aquifers. However, air lift efficiency decreases as the pumping submergence decreases (pumping submergence is the length of air line below the pumping water level divided by the total length of air line in the casing, and is expressed as a percentage); a pumping submergence of at least 10 to 30 percent is usually needed for effective air lift development. Consequently, it may not be possible to develop some of the wells in the Upper Sand/Gravel Aquifer (if the saturated thickness is less than about 10 feet), some of the East system wells in the Lower Sand/Gravel Aquifer to the east of the landfill site (where the aquifer is deep and may have a limited saturated thickness), and possibly some of

the West system wells that are installed near the top of the Lower Sand/Gravel Aquifer.

For wells where air lift is not effective, development will be accomplished by pumping the well using a gas- or air-driven pump, possibly in combination with surging. Surging will either be accomplished mechanically (using a surge block, or by rapidly raising and lowering the pump), or hydraulically (by rapidly reintroducing purge water into the well).

Surging can result in increased residual turbidity when performed on wells screened in (or immediately adjacent to) fine-grained soils (Palmer, et al. 1988). Although installation of monitoring wells in fine-grained formations is not anticipated for this project, East system wells installed in the Weathered Latah/ Basalt or Latah Formations may be screened in close proximity to fine-grained confining layers; in these instances, wells will be pumped but not surged.

Well development will be considered complete when at least ten casing volumes have been purged and the discharge water appears to be low in turbidity. If the turbidity does not decline sufficiently during initial development, the well will be allowed to "rest" for at least 24 hours, and then development procedures will be reinitiated. If turbidity cannot be reduced to an acceptable level, either the well will be reconstructed, or chemical analysis will be restricted to parameters not significantly impacted by suspended sediments.

4.0 DISPOSAL PROCEDURES FOR SOIL CUTTINGS AND EXCESS GROUND WATER

Disposal procedures for soil and excess ground water generated during well drilling, development, and sampling activities are described in the project Health and Safety Plan (Landau Associates, Inc. 1989), and are summarized in this section. Soil and ground water will be considered non-hazardous for borings/monitoring wells located at least 75 feet outside of the landfill refuse disposal area, provided residual volatile organic compounds are not detected at levels above background in vapors emitted from these materials. Soil cuttings and ground water from borings/monitoring wells located within the refuse disposal area (and a 75-foot wide buffer zone) will be considered potentially hazardous. Non-hazardous materials may be disposed of at the work station. Hazardous or potentially hazardous materials will be disposed of within the refuse disposal area.

Vapors emitted from soil cuttings and excess ground water will be screened in the field for volatile organic compounds using a photoionization meter. If concentrations above background are not detected, the materials will be considered non-hazardous. If concentrations of volatile organic compounds are present above background levels in excess ground water, air will be bubbled through the water to remove residual volatile organics prior to disposal at the work station. Soil cuttings will be disposed of in the refuse disposal area if concentrations of volatile organic compounds are detected above background, or if desired for aesthetic reasons. At the discretion of the Landau Field Coordinator, soil

and excess ground water may be disposed of within the refuse disposal area in lieu of screening for organic vapors.

5.0 EQUIPMENT DECONTAMINATION PROCEDURES

All materials and equipment that enters (or comes in close contact with) the borehole will be thoroughly cleaned prior to use for each monitoring well as required by WAC 173-160-530. Drill rigs, temporary and permanent casing, drill rods and bits, and bailers will be washed with a hot water pressure wash; non-dedicated (soil and water) sampling equipment and sounding devices (water level indicators and measuring tapes) will be cleaned using a detergent wash and distilled water rinse.

The Project Health and Safety Plan (Landau Associates, Inc. 1989) should be referred to for a more detailed description of decontamination procedures.

6.0 HEALTH AND SAFETY

Detailed health and safety procedures for Phase I of the Colbert Landfill RD/RA project are presented in the Project Health and Safety Plan (Landau Associates, Inc. 1989). As discussed in the Health and Safety Plan, Level D and modified Level D* personal protection is anticipated to be appropriate during most monitoring well construction activities. Monitoring of chemical exposure (via inhalation) in the vicinity of drilling operations will be conducted by the Landau Field Representative, using a photoionization meter. If appropriate, the Landau Field Representative will temporarily suspend activities and upgrade the level of protection to Level C*; Level C protection will also be used for any drilling accomplished within the refuse disposal area, and for the first well at each location in the 75-foot buffer zone.

A safe-work policy for technical field personnel and subcontractors will apply at all times. Observance of standard industrial safety is an important consideration in the vicinity of drilling rigs, and a factor limiting personnel access in the vicinity of drilling operations. Drilling contractors will be required to operate drill rigs and associated equipment in a safe and appropriate manner during all well construction activities.

Heat stress is another important consideration when working during hot weather, particularly when wearing protective clothing. Water will be available at each work site. If weather and working conditions warrant, a reduced work/rest cycle will be adopted.

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* Refer to the Project Health and Safety Plan for a description of the clothing and equipment required for the different levels of personnel protection.

To limit site access, the area surrounding monitoring well installation activities will be clearly marked with yellow or red caution tape. This tape will be displayed prominently along site perimeters of the work zone to present a visual barrier to entry.

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Griggs, A.B. (1976). The Columbia Basalt River Group in the Spokane Quadrangle, Washington, Idaho, and Montana USGS Bulletin 1413.

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State of Washington Department of Ecology (1988). Minimum Standards for the Construction and Maintenance of Water Wells (WAC 173-160).

APPENDIX A

MONITORING WELL CONSTRUCTION FORMS

Landau Associates, Inc.
Edmonds, WA (206) 778-0907

Log of Exploration

Exploration No. _____
Sheet _____ of _____

Client/Owner _____
Project No. _____
Exploration No. _____
Start Date _____ Hour _____
Ground Surface Conditions _____
Weather Conditions _____
Landau Representative _____
Contractor/Operator _____
Drill Type/Method _____
Hammer Weight & Stroke _____

LOCATION SKETCH
(show dimensions to mapped features)

North Arrow

Surface Elevation _____ Datum _____

WATER LEVEL INFORMATION			
Date			
Time			
Depth to Water			
Hole Depth			
Casing Depth			

Sample No.	Sampler Type	Penetration Resistance/6"	Length Driven	Sample Length Recovered	Sample Depth (ft.)	Graphic Recovery	Depth Scale	Unified Symbol	SOIL DESCRIPTION	COMMENTS
							0			
							1			
							2			
							3			
							4			
							5			
							6			
							7			
							8			
							9			
							0			
							1			
							2			
							3			
							4			
							5			
							6			
							7			
							8			
							9			
							0			

☐ No Recovery
☒ Disturbed Sample
■ Undisturbed Sample

Sampler: D/M, SPT, Thinwall (TW), Shelby Tube (S), Bulk (B), etc.
(Add 'C' to sampler type if a catcher is used)

Finish Date _____ Hour _____ Cont. ☐

LANDAU ASSOCIATES, INC. | Log of Exploration

124-01-20 Colbert Landfill Phase I GWM/Well Construction Plan 8-14-89

Figure GM-A-1

FIELD WELL COMPLETION FORM

JOB NAME:

JOB NUMBER: | PROJECT MANAGER:

LOGGED BY: | EDITED BY:

WELL NAME: | DATE:

DRILLING COMPANY:

EQUIPMENT: ☐ _____ INCH HOLLOW STEM AUGER | DRILLER:

☐ _____ INCH ROTARY WASH | HOURS DRILLED:

GALLONS OF WATER USED DURING DRILLING: GALLONS

METHOD OF DECONTAMINATION PRIOR TO DRILLING:

DEVELOPMENT

METHOD OF DEVELOPMENT:

DEVELOPMENT BEGAN DATE: TIME:

YIELD: GPM	TIME: FROM TO	DATE:
YIELD: GPM	TIME: FROM TO	DATE:
YIELD: GPM	TIME: FROM TO	DATE:
YIELD: GPM	TIME: FROM TO	DATE:

TOTAL WATER REMOVED DURING DEVELOPMENT: GALLONS

DESCRIPTION OF TURBIDITY AT END OF DEVELOPMENT: ☐ CLEAR ☐ SLIGHTLY CLOUDY ☐ MOD. TURBID ☐ VERY MUDDY

ODOR OF WATER:

WATER DISCHARGED TO: ☐ GROUND SURFACE ☐ TANK TRUCK ☐ STORM SEWERS ☐ STORAGE TANK ☐ DRUMS ☐ OTHER _____

DEPTH TO WATER AFTER DEVELOPMENT: FEET

MATERIALS USED

_____ SACKS OF _____ SAND

_____ SACKS OF _____ CEMENT

_____ GALLONS OF GROUT USED

_____ SACKS OF POWDERED BENTONITE

_____ POUNDS OF BENTONITE PELLETS

_____ FEET OF _____ INCH PVC BLANK CASING

_____ FEET OF _____ INCH PVC SLOTTED SCREEN

_____ FEET OF _____ INCH STEEL CONDUCTOR CASING

_____ YARD^3 CEMENT-SAND (REDI-MIX) ORDERED

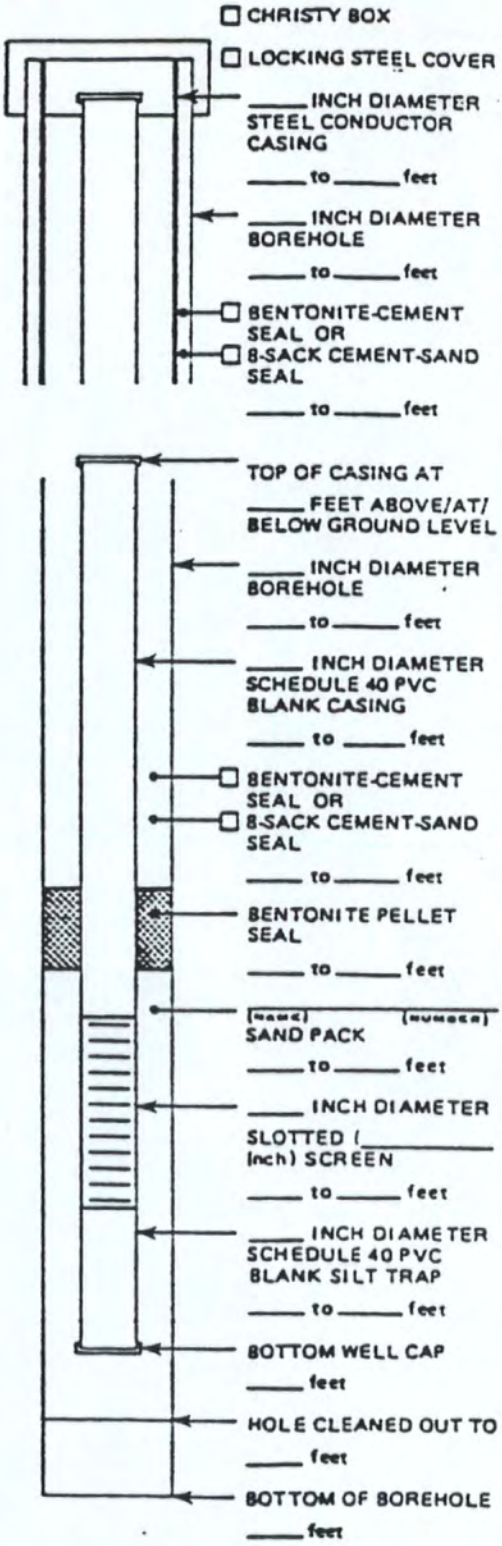
_____ YARD^3 CEMENT-SAND (REDI-MIX) USED

CONCRETE PUMPER USED? ☐ NO ☐ YES

NAME _____

WELL COVER USED: ☐ LOCKING STEEL COVER ☐ CHRISTY BOX ☐ OTHER _____

SILT TRAP USED? ☐ NO ☐ YES



NOT TO SCALE

ADDITIONAL INFORMATION: _____

LANDAU ASSOCIATES, INC.	Field Well Completion Form

124-01.20 Colbert Landfill Phase I GWM/Well Construction Plan 8-14-89

Figure GM-A-2