STATE OF WASHINGTON
KING COUNTY SUPERIOR COURT

STATE OF WASHINGTON, DEPARTMENT OF ECOLOGY, Plaintiff, v. CITY OF SEATTLE, Defendant.	No. 90-2-13283-8 SEA **AMENDMENT NO. 1 TO CONSENT DECREE (MIDWAY LANDFILL SITE)**

This amendment to Consent Decree No. 90-2-13283-8 is issued pursuant to the authority of RCW 70.105D, the Model Toxics Control Act (MTCA).

STATEMENT OF CURRENT CONDITIONS

A. Consent Decree No. 90-2-13283-8 was signed by the Court and filed on June 29, 1990. The Decree was a negotiated settlement between the Washington State Department of Ecology ("Ecology") and the City of Seattle ("Seattle").

B. At the time the above Consent Decree was negotiated and filed, Seattle had already undertaken some actions intended to remedy the release of hazardous substances from the Midway Landfill Site ("Site"), which is the subject of the Consent Decree. The Consent Decree included provisions for the implementation of additional actions aimed at remedying the release of hazardous substances at the site. Based upon Ecology's determination that the remedial actions in the Consent Decree would provide immediate protection to the public health, welfare

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and environment, the Consent Decree was negotiated and filed before Ecology had completed a Cleanup Action Plan (CAP) under WAC 173-340-380 regarding a chosen cleanup alternative.

C. Since the time the Consent Decree was negotiated and filed, the United States Environmental Protection Agency (EPA) has issued a Record of Decision (ROD) for the Site. The ROD evaluates the status of work to be performed under the Consent Decree and identifies remedial actions and components that are not expressly described in the Consent Decree, including establishing groundwater cleanup levels, requiring Seattle to sample groundwater in order to monitor progress toward cleanup levels, and requiring Seattle to implement certain institutional controls to ensure the protection of human health until groundwater cleanup levels are achieved. Ecology reviewed and recommended approval of the ROD.

D. Ecology has chosen to utilize EPA's ROD for the Site as a CAP, pursuant to WAC 173-340-380(4).

E. This amendment to the Consent Decree is for the purpose of integrating the full remedies set forth in EPA's ROD for the Site into the existing Consent Decree, as well as for the purpose of making changes to clarify the intent of the existing Consent Decree.

AMENDMENT TO CONSENT DECREE

Based on the foregoing, the parties stipulate and agree that the Decree should be amended, pursuant to the provisions of Section XXI. AMENDMENT OF CONSENT DECREE, as follows:

A. All of the terms of the Consent Decree remain in effect unless expressly amended herein.

B. Section III. PARTIES BOUND, Heading A shall be amended to add a new Paragraph 3A (inserted between current Paragraphs 3 and 4) as follows:

3A. Implement the remedy selected in Section 11.2 of the Record of Decision (ROD) for the Midway Landfill, CERCLIS Identification Number WAD 980638910, issued by the United States Environmental Protection Agency (EPA) on September 6, 2000 (Exhibit B to this

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Amendment, incorporated herein by reference and enforceable under this Consent Decree), as utilized by Ecology as a cleanup action plan (CAP) pursuant to WAC 173-340-380(4), in accordance with the remedial action objectives and cleanup standards identified in that ROD. In summary, implementing the remedy selected in Section 11.2 of the ROD requires Seattle to:

a. Implement a Compliance Monitoring Plan approved by Ecology, as described in Section XI, Heading B, Paragraph 5 of the Consent Decree as amended herein;

b. Continue to operate and maintain all remedial elements required by the Consent Decree by implementing the Operations and Maintenance Manual described in Section XI, Heading B, Paragraph 4 of the Consent Decree as amended herein;

c. As described in Section XIX of the Consent Decree as modified herein, within six (6) months of the effective date of this Amendment, place a notice in the records of real property kept by the King County Recorder alerting any future purchaser of the landfill property, in perpetuity, that the property has been used as a landfill, is or was on EPA's National Priorities List, and is restricted in its future use in accordance with the terms of Washington's Criteria for Municipal Solid Waste Landfills (WAC 173-351-500(1)(i) and (2)(c)(iii)); and

d. As described in Section XI, Heading B, Paragraph 6 of the Consent Decree as modified herein, send an annual written notice to the Seattle-King County Department of Public Health (or its successor); local water districts; locally active well drillers; and the owner of Well #37 regarding groundwater conditions in affected areas downgradient of the landfill..

C. Section V. PURPOSE, Paragraph 1 shall be amended as follows:

1. To provide for an expeditious cleanup of the Midway Landfill facility by completing work on the final remedial action at the landfill, including capping the landfill, completing a surface water management system, completing a gas extraction system, and

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implementing the remedy selected in EPA's September 6, 2000 ROD, as utilized by Ecology as a CAP.

D. Section VI. COVENANT NOT TO SUE shall be amended as follows:

Subject to the Covenant Reopeners and Reservation of Rights herein, in consideration for Seattle's satisfactory performance and completion of the terms and conditions of this Consent Decree, Ecology covenants not to sue Seattle, or seek any administrative, legal, or equitable remedy against Seattle, for the performance, conduct, completion, or appropriateness of the remedial actions performed pursuant to this Decree, which include the surface water management system, the final cover, the landfill gas extraction systems, and implementation of the remedy selected in EPA's September 6, 2000 ROD, as utilized by Ecology as a CAP. This covenant not to sue is of a scope commensurate with this Decree and Amendment No. 1 thereto.

E. Section IX. DEFINITIONS shall be amended as follows:

P. "EPA" means the United States Environmental Protection Agency.

Q. "ROD" means a Record of Decision issued by EPA under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 42 U.S.C. §§ 9601 et seq., which can be utilized as a Cleanup Action Plan by Ecology pursuant to WAC 173-340-380(4).

F. Section X STATEMENT OF FACTS, Heading A, first paragraph, shall be amended to delete the reference to "Appendix A" and substitute a reference to "Exhibit A," attached hereto and incorporated herein by reference and enforceable under this Consent Decree.

G. Section XI. SCOPE OF WORK shall be amended to add a new Paragraph 3A (inserted between current Paragraphs 3 and 4), as well as amended to add language to Paragraph 4, as follows:

3A. Implementation of the remedy selected in Section 11.2 of the September 6, 2000 ROD, as utilized by Ecology as CAP.

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4. Preparation and implementation of an Operation and Maintenance Manual for all remedial action projects implemented at the landfill as part of this Decree.

H. Section XI. SCOPE OF WORK, Heading B, Paragraph 4 shall be amended, and new Paragraphs 5 and 6 shall be added, as follows:

4. Landfill Operation and Maintenance Manual. Seattle shall implement the comprehensive Operation and Maintenance Manual prepared by Seattle and approved by Ecology in December 1992 (Exhibit C to this Amendment, incorporated herein by reference and enforceable under this Consent Decree), which incorporates both short-term and long-term operation and maintenance requirements for all remedial action projects constructed at the Midway Landfill under the terms of this Decree. Changes to the requirements and provisions of the Operation and Maintenance Manual may be made without amending this Decree and shall be incorporated herein by reference.

5. Compliance Monitoring. Seattle shall monitor groundwater, surface water, and gas as described in Section 11.2 of the September 6, 2000 ROD and in accordance with the requirements and provisions of a Compliance Monitoring Plan (CMP) prepared by Seattle and approved by Ecology April 2000 (Exhibit D to this Amendment, incorporated herein by reference and enforceable under this Consent Decree). Additional monitoring under the CMP may be required by Ecology, if needed in accordance with Section 11.2 of the September 6, 2000 ROD, and reduced monitoring under the CMP may be requested by Seattle and approved by Ecology, based upon Site conditions. Changes to the requirements and provisions of the CMP may be made without amending this Decree and shall be incorporated herein by reference.

6. Institutional Controls. Until such time as compliance with applicable groundwater cleanup standards is met, and in addition to the notice and restrictions described in Section XIX, Seattle shall implement the institutional controls described in Section 11.2 of the September 6, 2000 ROD to notify well drillers of the groundwater contamination in the vicinity of the landfill for the purpose of discouraging wells from being drilled in the identified area.

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Seattle shall comply with this requirement by providing annual written notification to the following entities and persons concerning groundwater conditions in affected areas downgradient of the Midway Landfill:

a. Seattle-King County Department of Public Health, or its successor agency;

b. All local water districts potentially affected (currently the Kent and Highline Water Districts);

c. All "locally active well drillers," which are defined as those well drillers that have drilled wells within King County in the calendar year prior to the notice, as provided by Ecology to Seattle; and

d. The owner of record of the real property where Well #37 is located, as identified in figure 6-1 of the September 6, 2000 ROD, unless Seattle provides Ecology with adequate assurances that this well has been abandoned.

Seattle shall provide such annual notification on or before July 15 of each year, unless another notification date is approved by Ecology. With the exception of notice to the owner of record of the real property where Well #37 is located, the above annual notices shall include a map showing the location of the affected areas with indication of the affected aquifers and their elevations. Notice to the owner of Well #37 need only inform the owner of groundwater conditions in the area of that well. Notices to all of the above entities and persons should include reference to WAC 173-160-171 (or any succeeding regulation if recodified), which provides that a water well cannot be located within one thousand feet from the property boundary of a solid waste landfill, or within one hundred feet from all other sources or potential sources of contamination. The notice may be part of an annual groundwater monitoring report. The notice requirement may be removed or modified by Ecology in the future if compliance with cleanup standards in groundwater monitoring wells downgradient from the Midway Landfill is attained. Changes to these notice requirements approved by Ecology may be made without amending this Decree and shall be incorporated herein by reference.

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I. Section XIX. TRANSFER OF INTEREST IN PROPERTY shall be amended as follows:

No voluntary conveyance or relinquishment of title, easement, leasehold, or other interest in any portion of the landfill shall be consummated without provision for continued operation and maintenance of any containment system, treatment system, or monitoring system installed or implemented pursuant to this Decree, unless Ecology has approved of the retirement or abandonment of any such systems or part thereof.

Within six (6) months of the entry of this amendment to the Consent Decree, and to the extent Seattle is the owner of the real property described in Exhibit A to this Consent Decree, as amended, after review and approval by Ecology, Seattle shall place a notice in the records of real property kept by the county records office alerting any future purchaser of the landfill property, in perpetuity, that said property was on the National Priorities List. In addition, such notice shall contain the post-closure use restrictions and conform to the requirements of WAC 173-351-500(1)(i) and (2)(c)(iii), including providing notice that the property was used as a landfill. The notice shall further contain a restriction that no water supply wells may be installed on the property. Prior to transfer of any legal or equitable interest in all or any portion of the landfill real property, Seattle shall serve a copy of this Decree upon any prospective purchaser, lessee, transferee, assignee, or other successor in interest of the property; and, at least thirty (30) days prior to the transfer, Seattle shall notify Ecology of said contemplated transfer.

DEPARTMENT OF ECOLOGY

Jack A. Glatz

JACK GLATZ
Acting Program Manager
Toxics Cleanup Program

Date: 12/01/05

ROB MCKENNA
Attorney General

ANDREW A. FITZ, WSBA #22169
Assistant Attorney General
Attorneys for Plaintiff

Date: December 1, 2005

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CITY OF SEATTLE	THOMAS CARR City Attorney
Chuck Clarke	[signature]
CHUCK CLARKE, DIRECTOR SEATTLE PUBLIC UTILITIES	MARYA J. SILVERNALE, WSBA #14525 Assistant City Attorney Attorney for Defendant
Date: 07/12/05	Date: July 1, 2005

DATED this 3 day of February, 2006.

Dean S. Lum
JUDGE Dean S. Lum
King County Superior Court

ATTACHED EXHIBITS:

EXHIBIT A – Midway Landfill Legal Description [Revised]
EXHIBIT B – EPA Record of Decision (ROD) for Midway Landfill, September 6, 2000
EXHIBIT C – Operations & Maintenance Manual for Midway Landfill, December 1992
EXHIBIT D – Compliance Monitoring Plan (CMP) for Midway Landfill, April 2000

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Exhibit A

MIDWAY LANDFILL LEGAL DESCRIPTION [Revised]

PARCEL A: Tax lot # 222204-9168-03
That portion of the west half of the southwest quarter of the northwest quarter of Section 22, Township 22 North, Range 4 East, W.M., in King County, Washington, lying westerly of the Primary State Highway Number #1, (Interstate Highway No. 5) as condemned in King County Superior Court Cause No. 535009, and between the north and south lines of the south half of the north half of the southeast quarter of the northeast quarter of Section 21, Township 22 North, Range 4 East, W.M., in King County, Washington, extending easterly to the west margin of Primary Sate Highway #1.

PARCEL B: Tax lot # 212204-9025-07, and # 212204-9014-00, and a portion of # 212204-9033-07
The south half of the southeast quarter of the northeast quarter and the west half of the west half of the northeast quarter of the southeast quarter of Section 21, Township 22 North, Range 4 East, W.M., in King County, Washington, lying westerly of Primary State Highway Number 1 (Interstate Highway No. 5);
EXCEPT that portion described as follows:
Beginning at the southwest corner of the southeast quarter of the northeast quarter of said section;
thence north 01°07'09" east 363.64 feet along the west line of said subdivision;
thence south 87°53'39" east 602.44 feet ;
thence south 01°07'09" west 202.70 feet ;
thence south 81°19'39" west 447.99 feet ;
thence south 39°19'39" west 260.00 feet to the west line of the northeast quarter of the southeast quarter of said Section;
thence north 01°05'25" east 130.03 feet along said west line to the point of beginning;
AND EXCEPT that portion of the north half of the southwest quarter of the southeast quarter of the northeast quarter of said Section 21, lying north of the south 40 feet and west of the east 60 feet .
AND EXCEPT the north 100 feet of the south 130 feet of the west 95 feet of the west half of the west half of the northeast quarter of the southeast quarter, of said Section 21;
AND EXCEPT the south 30 feet thereof for South 252nd Street.

PARCEL C: Tax lot # 212204-9026-06
Those portions of the southeast quarter of the northeast quarter and the northeast quarter of the southeast quarter of Section 21, Township 22 North, Range 4 East, W.M., in King County, Washington, more particularly described as follows:
Beginning at the southwest corner of the southeast quarter of the northeast quarter of said section; thence north 01°07'09" east 363.64 feet along the west line of said subdivision;
thence south 87°53'39" east 602.44 feet;
thence south 01°07'09" west 202.70 feet;
thence south 81°19'39" west 447.99 feet;
thence south 39°19'39" west 260.00 feet to the west line of the northeast quarter of the southeast quarter of said section;
thence north 01°05'25" east 130.03 feet along said west line to the point of beginning;

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EXCEPT that portion, if any, lying north of the south 40 feet and west of the east 60 feet of the north half of the southwest quarter of the southeast quarter of the northeast quarter of said Section 21.

PARCEL D: Tax lot # 212204-9033-07 (portion)
The north 535.83 feet of the northeast quarter of the southeast quarter of Section 21, Township 22 North, Range 4 East, W.M., in King County, Washington, lying westerly of Primary State Highway Number 1 (Interstate Highway No. 5);
EXCEPT that portion within the west half of the northwest quarter of the northeast quarter of the southeast quarter of said Section 21.

SOUTHEAST PARCEL: Tax Lot #2122049137-02
That portion of the NE ¼ of the SE ¼ of Section 21, Township 22 North, Range 4 East, W. M., in King County, Washington, described as follows:
Beginning at the NE corner of the above described subdivision; thence South along the East section line of said Section 21, 535.83 feet to the True point of Beginning; thence West parallel with the South line of said subdivision 987.6 feet to the East line of the West ¼ of the NE ¼ of the SE ¼; thence South along said East line 780 feet to the South line of said subdivision; thence East along said South line 987.6 feet to the SE corner of said subdivision; thence North along said Section line 780 feet to the True Point of Beginning;
EXCEPT that portion lying within Primary State Highway Number #1 (Interstate Highway No. 5); and EXCEPT that portion lying within South 252nd Street.

NORTH PARCEL: Tax Lot # 2122049021-01
Beginning at the southeast corner of the south half of the north half of the southeast quarter of the northeast quarter of Section 21, Township 22 North, Range 4 East, W.M., in King County, Washington;
Thence north 89°41'00" west along the south line of said south half of the north half of the southeast quarter of the northeast quarter 1318.90 feet to the southwest corner thereof;
Thence continuing north 89°41'00" west along the prolongation of said south line 79.98 feet, more or less, to an intersection with the easterly line of State Road Number 1 (Highway 99);
Thence north 08°54'00" east along said easterly line of State Road Number 1, 327.02 feet to a point where said easterly line of State Road Number 1 is intersected by the westerly prolongation of said north line of said south half of the north half of the southeast quarter of the northeast quarter;
Thence south 89°49'07" east along said westerly prolongation of said north line 25.91 feet, more or less, to the northwest corner of said south half of the north half of the southeast quarter of the northeast quarter;
Thence continuing south 89°49'07" east along the said north line 1319.25 feet to the northeast corner of said south half of the north half of the southeast quarter of the northeast quarter;
Thence south 00°28'18" east along the east line thereof 326.72 feet to the point of beginning;
EXCEPT the westerly 250 feet (as measured along the north line of said property), and parallel to the east line of State Road Number 1 (Highway 99).

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Exhibit B
to
Amendment No. 1 to Consent Decree
(Midway Landfill Site)

Midway Landfill EPA Record of Decision
September 6, 2000

EXHIBIT B

MIDWAY LANDFILL

EPA RECORD OF DECISION

SEPTEMBER 6, 2000

Declaration

SITE NAME AND LOCATION

Midway Landfill
Kent, Washington

CERCLIS Identification Number: WAD 980638910

STATEMENT OF BASIS AND PURPOSE

This Decision Document presents the selected remedy for the Midway Landfill site, located in the City of Kent, King County, Washington. This Record of Decision (ROD) has been developed in accordance with the requirements of Comprehensive Environmental, Response, Compensation, and Liability Act (CERCLA) of 1980, 42 USC §9601 *et seq.* (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), and, to the extent practicable, the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), 40 CFR Part 300. This decision is based on the Administrative Record for the Site.

The remedy was selected by the U.S. Environmental Protection Agency. The State of Washington concurs with the selected remedy.

ASSESSMENT OF THE SITE

The response action selected in this Record of Decision (ROD) is necessary to protect the public health or welfare or the environment from an actual or threatened release of hazardous substances into the environment. Such a release or threat of release may present an imminent and substantial endangerment to public health, welfare, or the environment.

DESCRIPTION OF THE SELECTED REMEDY

The selected remedy for the Midway Landfill site consists of:

1. Monitoring to:

   a) ensure the remedial systems are working as designed,

   b) ensure progress is being made towards meeting the groundwater cleanup standards,

   c) ensure adequate containment is maintained when and if major changes are approved by Ecology in the operation of the site, and

   d) demonstrate that the cleanup levels have been achieved.

Monitoring includes, but is not limited to, groundwater monitoring and landfill gas monitoring.

2. Continuing to operate and maintain all remedial project elements required in the Ecology/City of Seattle 1990 consent decree, including the gas collection system, the multilayered cap, and the storm water collection system.

3. Implementing institutional controls. Three types of institutional controls are included in the selected remedy: permanent notices in King County's real estate records, assurances in the 1990 consent decree that operation and maintenance of the containment and monitoring systems will continue if the ownership or control of the property should change; and annual notices to appropriate agencies, water districts and locally active well drillers so that no water supply wells are constructed or used in areas with groundwater contamination from the landfill.

This ROD also establishes cleanup levels for the groundwater down gradient from the landfill.

STATUTORY DETERMINATIONS

The selected remedy is protective of human health and the environment, complies with Federal and State requirements that are applicable or relevant and appropriate for the remedial action, is cost-effective, and utilizes permanent solutions and alternative treatment technologies to the maximum extent practicable.

The remedy selected in this ROD does satisfy the statutory preference for treatment as a principal element of the remedy. Extracted landfill gas is flared as part of the existing landfill gas collection system.

Because this remedy will result in hazardous substances remaining on-site above levels that allow for unlimited use and unrestricted exposure, a statutory review will be conducted under CERCLA within five years of this Record of Decision to ensure that the remedy continues to be protective of human health and the environment.

DATA CERTIFICATION CHECKLIST

The following information is included in the Decision Summary section of this ROD. Additional information can be found in the Administrative Record file for this site.

Chemicals of concern (COCs) and their respective concentrations. (See Section 5.)

A baseline risk assessment for current conditions at the landfill was not prepared because the contaminants of concern, migration routes, and the risks to human health and the environment were characterized in RI/FS reports completed in 1990. However, there is a need for action because groundwater downgradient from the landfill still contains contaminants of concern above federal drinking water standards (MCLs.) (See Section 7.)

Cleanup levels established for COCs and the basis for these levels. (See Section 8.)

How the source materials constituting principal threats are addressed. Source materials constituting principal threats have not been identified at Midway Landfill. (See Section 4.)

Current and reasonably anticipated future land and groundwater use assumptions used in the ROD. (See Section 6.)

Potential land uses that will be available at the site as a result of the selected remedy. (See Sections 6 and 11.3.)

Annual cost estimates for the selected remedy. (See Section 11.2.)

Key factors that led to selecting the remedy. (See Section 11.1)

Charles E. Findley
Acting Regional Administrator, Region 10
United States Environmental Protection Agency

9-6-00
Date

Decision Summary

Midway Landfill
Kent, Washington

1. Site Name, Location, and Description

The Midway Landfill is located between Interstate-5 (I-5) and Highway 99, and between S. 252nd Street and S. 246th Street in Kent, Washington, directly east of the city of Des Moines. (Figure 1-1.) The landfill is approximately 60 acres in size with refuse buried on about 40 acres and at depths over 100 feet. From 1966 to 1983, approximately three million cubic yards of solid waste were deposited at the Midway Landfill. The landfill is now owned by the City of Seattle.

Because of the remedial work performed by the City of Seattle since 1985, environmental conditions have greatly improved. The landfill is now covered with a multilayered engineered cap, with a top layer of grass. The landfill is fenced and access is limited. A gas extraction system is in place and operating throughout the landfill. Because of these actions, potentially explosive landfill gas does not leave the landfill property and the quality of the groundwater leaving the landfill has greatly improved. The city's estimate of closure costs amounted to about $56.5 million as of 1995.

Land use in the landfill vicinity consists primarily of commercial activities and residential areas. Commercial establishments and light industry and manufacturing border both sides of Highway 99 in the area. Two elementary schools, Sunnycrest Elementary School and Parkside Elementary School, and a city park, Linda Heights Park, are within a half-mile radius of the site. Most of the nearby residences are detached single-family dwellings, with some multi-unit residential developments to the south and west. Several mobile home parks are also in the vicinity. A six-acre wetland, the Parkside Wetland, located to the east of the Parkside Elementary School and west of the landfill is a naturally occurring detention basin for local surface water runoff, primarily from the west side of Highway 99.

There are no wetlands, flood plains, rare, threatened or endangered species, or sites on or eligible for the National Registry of Historic places at the site. Storm water from the site drains into McSorley Creek, which is a salmon-bearing stream containing coho and chum salmon, steelhead and cutthroat trout. Coho salmon is a candidate for listing under the Endangered Species Act.
The State of Washington Department of Ecology (Ecology) has been the lead regulatory agency for the cleanup work at Midway Landfill since the mid-1980's. While the U.S. Environmental Protection Agency (EPA) has prepared and released a proposed plan and this

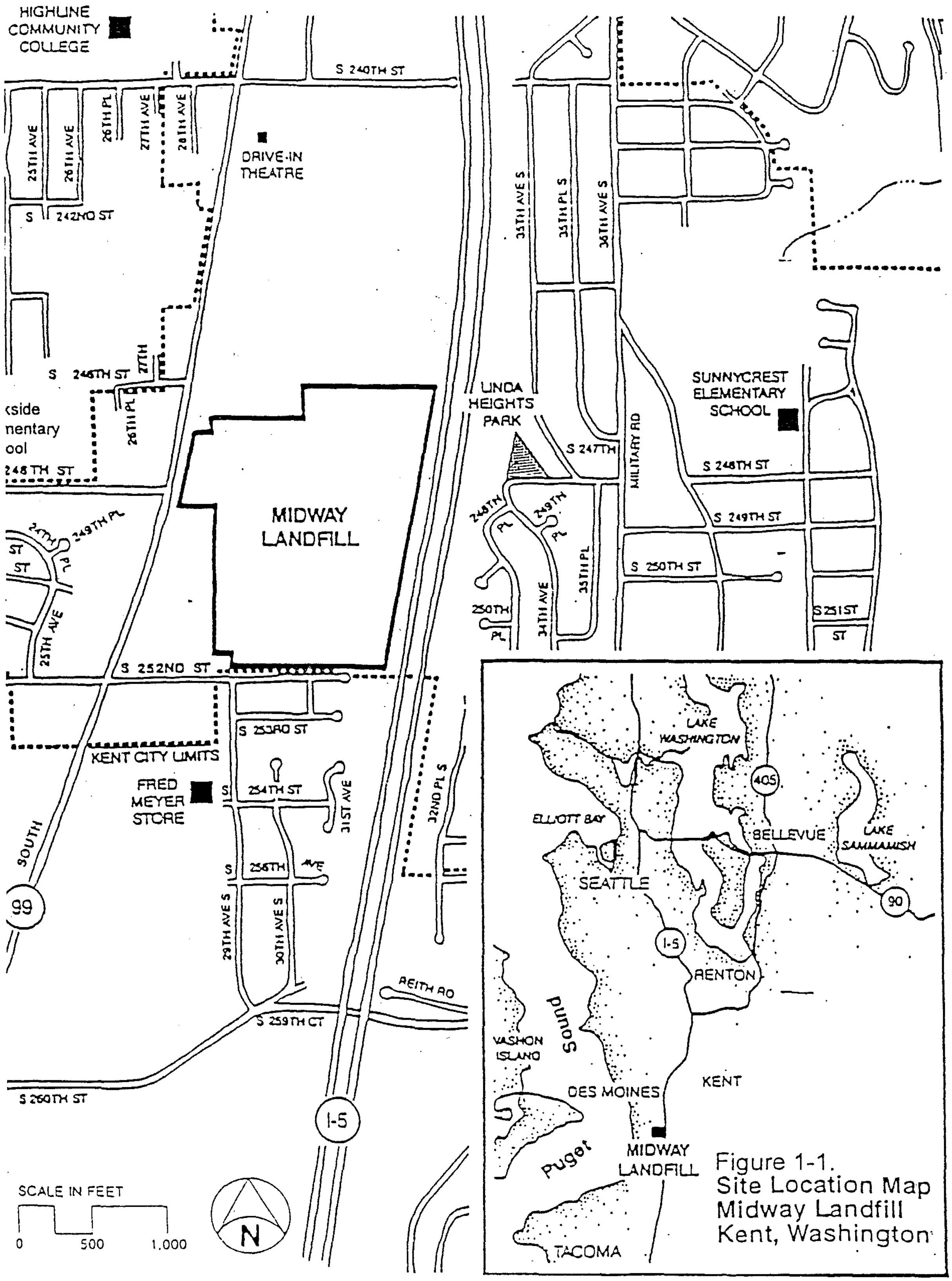


Figure 1-1.
Site Location Map
Midway Landfill
Kent, Washington

ROD, EPA expects Ecology to continue to be the lead cleanup regulatory agency overseeing this remedial action. The work has been, and will continue to be, conducted by the City of Seattle.

2. Site History and Enforcement Activities

2.1. Site History through the 1990 Consent Decree.

From 1945 to 1966, the site of the current Midway Landfill was operated as a gravel pit. Originally, the pit was adjacent to a natural drainage basin often used as a settling pond. This basin, known as Lake Meade, was located northeast from the center of the present landfill. As the pit was mined, water was drawn from Lake Meade to wash silt and clay from the gravel and sand, and then returned to the lake. This silt and clay settled on the lake bottom. Near the end of the gravel pit operation, the lake was drained into the southern end of the gravel pit, depositing a layer of clay and silt into the bottom of the pit. This layer of fine materials currently underlies much, but not all, of the present landfill.

In 1966, the City of Seattle leased the site and began using it as a landfill. From 1966 to 1983, approximately three million cubic yards of solid waste were deposited there. The exact dimensions of the bottom of the landfill are not known. However, existing boreholes indicate that the solid waste extends as deep as 130 feet in some places.

The Midway Landfill was created primarily to accept demolition materials, wood waste and other slowly decomposing materials. However, some hazardous wastes and industrial wastes, including approximately two million gallons of bulk industrial liquids from a single source, were also placed in the landfill. In 1980, a state-mandated screening process administered by the Seattle-King County Department of Public Health was initiated to eliminate the disposal of any hazardous waste into Midway Landfill.

When the City closed the landfill in the fall of 1983, it began extensive testing of water and gas in the landfill and its vicinity. Samples of groundwater from monitoring wells in and around the landfill, and gas samples from gas probes, indicated the presence of organic and inorganic contaminants outside the landfill boundary. In 1985, Ecology also began investigating the site and found methane gas in nearby residences. Beginning in September 1985, the City of Seattle constructed gas migration control wells within the landfill property and gas extraction wells beyond the landfill property to control the subsurface migration of gas. Gas was found to have migrated up to 2600 feet beyond the landfill prior to installation of the gas extraction system.

In October 1984, Midway Landfill was nominated for inclusion on the federal National Priorities List (NPL) based on potential groundwater contamination. Following that nomination, Ecology was designated as the lead agency for the Midway Landfill Superfund action, pursuant to a Cooperative Agreement with EPA. In May 1986, Midway Landfill was placed on the NPL. In September 1988, the City of Seattle, which owns and had operated Midway Landfill, entered a Response Order on Consent with Ecology. This Response Order governed the preparation of a Remedial Investigation and a Remedial Action Feasibility Study (RI/FS) for the landfill.

In May 1990, prior to completion of the remedial investigation and feasibility studies, the City and Ecology entered into a consent decree pursuant to State of Washington Model Toxics Control Act (MTCA.) This legal agreement set forth Ecology's determination that undertaking certain remedial actions at Midway Landfill, prior to a Cleanup Action Plan (a MTCA decision document, similar to a Superfund ROD) would provide immediate protection to public health and the environment. In this consent decree, the City of Seattle agreed to finance and perform specific cleanup work. This cleanup work, or remedial action, had four elements:

- Construction of a landfill cover. The multi-layered Landfill Cover System ("cap") was to be comprised of layers (from bottom to top) of low permeability clayey silt/silty clay, a 50-mil synthetic membrane, a geonet drainage layer, one foot of sand and one foot of topsoil planted with shallow rooted grasses. The landfill cover was designed to greatly reduce the amount of rain that would seep into the landfill and to control the post-closure escape of hazardous emissions from the landfill.

- Completion of a gas extraction system, including a Final Gas Manifold System to link onsite extraction wells to an enhanced motor blower and flare system. The purpose of the onsite extraction wells was to create a "vacuum curtain" around the closed landfill to prevent offsite migration of landfill gas, and to help draw previously migrated gas back to the landfill. The enhanced flares were installed to burn the extracted gas before discharge to the atmosphere. The gas extraction system also included approximately 127 offsite gas monitoring probes to provide data on the extent of landfill gas migration and the effectiveness of the extraction system.

- Completion of a surface water management system. This system consisted of site filling and grading to control surface water drainage to prevent surface water from infiltrating the landfill, construction of a 10 million gallon storm water detention pond with a permanent dewatering system, a controlled discharge structure, and rerouting of storm water from surrounding areas to prevent it from entering the landfill. This rerouting was done by diverting the Linda Heights Park drain and surface water runoff from I-5 to the detention pond.

- Preparation of a comprehensive operation and maintenance manual incorporating both short-term and long-term operation and maintenance requirements for all remedial actions implemented at the landfill as part of the consent decree.

The consent decree also required the City to place a notice in the records of real property kept by the county auditor stating that the landfill was on the NPL, and serve a copy of the consent decree upon any prospective purchaser, lessee, transferee, assignee, or other successor in interest to the property prior to the transfer of any legal or equitable interest in all or any portion of the landfill.

2.2. Status of the work required by the 1990 Consent Decree

The City of Seattle completed construction of the landfill cover, landfill gas extraction system, and surface water management system in November 1992. Some of the other requirements of the consent decree have not yet been completed. As discussed in the following section, Ecology and the City of Seattle anticipate amending the 1990 consent decree after this ROD is signed.

Construction elements required by the 1990 Consent Decree

Landfill Gas Control - An active gas control system was installed at the Midway Landfill. It originally included 87 gas extraction wells, 31 of which were located off the landfill in native soil. The off-landfill wells have since been abandoned or capped. In addition, approximately 70 off-landfill gas monitoring probes were installed to provide information on gas concentrations; about half of these probes have since been abandoned. The gas is extracted through the control wells at the landfill and routed to a permanent blower/flare system. Construction of the gas migration control system began in September 1985 and was completed in March 1991.

Landfill surface filling and grading - The landfill surface was regraded which increased the soil cover over the landfill by 2 to 14 feet. The engineered grades improved surface water runoff and decreased infiltration. The fill was also compacted to reduce permeability and prepare the surface for the cover system. The work began in August 1988 and was competed in June 1989.

Storm Water Detention Pond Construction and Associated Dewatering and Discharge System- A lined detention pond was constructed to the north of the landfill. Regrading of the landfill surface redirected surface water, which previously infiltrated into the landfill, to the new detention pond. The detention pond is a 3 acre structure, lined with a 60-millimeter high-density polyethylene membrane (HDPE) to eliminate infiltration. The bottom of the pond was constructed below localized groundwater; therefore, a permanent dewatering system was also installed. Construction of the storm water detention pond began in August 1988 and was completed in June 1989.

Landfill Cap Installation - Construction of the final landfill cover began in October 1989 and was completed in May 1991. It consists of the following layers from bottom to top: a 12-inch thick layer of low permeability (1 x 10-7 cm/sec) soil/clay material; a 50 millimeter HDPE flexible membrane; drainage net; filter fabric; 12-inch-thick drainage layer; and a 12-inch-thick topsoil layer.

Linda Heights Park Storm Water Diversion - The Linda Heights Park drain, a 30-inch culvert that drained directly into the landfill, was blocked. Storm water is now routed through a pump station and a pipeline to the detention pond. The old discharge line to the landfill is still in place and functions as an overflow in the event of a pump station failure. The construction of this rerouting began in August 1989 and was completed in 1991. The pump station and associated diversion of storm water was activated in January 1992.

Non-construction elements required by the 1990 consent decree

Operation and maintenance (O&M) plan - A comprehensive operation and maintenance manual for both short-term and long-term operation and maintenance for the systems constructed under the consent decree was prepared by the City of Seattle, and was approved by Ecology in April 1992.

Deed notice - The deed notice required by the consent decree has not yet been placed on the property.

Monitoring and monitoring plan - Monitoring and a monitoring plan are not specifically identified as required activities in the 1990 consent decree. An amendment to the consent decree will specify a requirement to implement a compliance monitoring plan approved by Ecology, as well as to implement an operations and maintenance plan already required to be prepared under the 1990 consent decree. The City of Seattle and Ecology are still in negotiations on the long-term monitoring plan. Starting in late 1989, the City initiated performance and compliance monitoring programs at the landfill. Performance monitoring (which did not include chemical analysis) was intended to track the response of landfill leachate levels and shallow groundwater levels to the implementation actions required by the consent decree. Quarterly water quality monitoring began in 1990 to develop a database for water quality in selected groundwater monitoring wells. This monitoring program, which became the compliance monitoring program, was modified in 1993 and again in 1998 with concurrence from Ecology. Compliance monitoring was intended to track the presence, concentrations and migration of groundwater contaminants both up gradient and downgradient of the landfill, and to assess the effectiveness of the remedial action. Both monitoring programs are ongoing and sampling is presently conducted on a twice yearly basis. Landfill gas monitoring is conducted frequently; it consists of checks for concentration, composition, temperature, flow and velocity of gases in and around the landfill.

3. Community Participation

Because of the high degree of public interest in the landfill, the City of Seattle and the Washington State Department of Ecology first developed a formal community involvement program in 1985 when residents near the landfill became concerned about landfill gas migration. Public meetings were held at critical points to keep residents informed about activities at the landfill. Also, for about two years, the City ran an information office in the Midway area to give citizens a convenient place to find out about cleanup activities, health information, and legal claims. As landfill gas migration was brought under control and residents' fears subsided, office hours were reduced and eventually the office closed. During the same period, a newsletter was sent to about 7000 area residents. The City and Ecology also worked with leaders from local active community groups to set up MAG (Midway Action Group) meetings, which were held monthly at first, and then less frequently. Through these meetings, community members could express their views and learn about the investigation and cleanup process.

The City created the Good Neighbor Program in 1986 to help the community when concern over landfill gas was at its peak. The program addressed fears about perceived drops in property values. The City guaranteed residents that their homes would sell for fair market value, as if the landfill was not there. The City continued the program until the real estate market returned to normal.

Very few formal community participation activities took place in the 1990's, though Ecology and City of Seattle staff continued to be available to respond to concerns and questions from the public.

EPA's proposed plan was issued in May 2000 and the original public comment period ran from May 18 to June 16, 2000. Over 2,000 fact sheets summarizing the proposed plan were sent to all addresses and residents in the three postal carrier routes around the landfill. Additionally, the fact sheets were mailed to 48 other potentially interested parties (such as the Cities of Kent and Des Moines) outside the carrier route. Approximately two to three dozen copies of the proposed plan were sent out, and additional copies were available from EPA's Seattle office and at the City of Kent Regional Library. The fact sheet and proposed plan were also available on the Region 10 web page. Display notices were published in the Seattle Times, Seattle Edition on May 16, in the Seattle Times, South County Edition, on May 23, and in the South County Journal on May 17. The City of Seattle asked for an extension of the comment period on June 15, and the end of the public comment period was extended until July 17, 2000. Notices of the extension were published in the Seattle Times, South County Edition and the South County Journal on June 21.

The fact sheets, newspaper notices and the proposed plan offered to hold a public meeting if sufficient interest was expressed by May 31, 2000. Only four requests for a meeting were received and thus a public meeting was not held. EPA staff called each person who requested a meeting to make sure he or she had all the information they wanted about the Midway Landfill and the proposed remedial decision.

Four comment letters on the proposed plan were received. EPA's response to these comments can be found in the attached Responsiveness Summary.

This decision is based on the administrative record. The Midway Landfill Administrative Record is located at the EPA Superfund Records Center, 1200 Sixth Avenue, Seattle, Washington, and in the Kent Regional Library, 212 2nd Avenue N, Kent, Washington.

4. Scope and Role of this Response Action

This ROD is the final CERCLA decision for the Midway Landfill site.
The City of Seattle's cleanup work, including the work done in response to the 1990 consent decree between the City and Ecology, has successfully reduced the environmental problems at the landfill. The selected remedy incorporates elements required in the 1990 consent decree between City and Ecology, and adds some elements to ensure long-term protectiveness of the remedy. The selected remedy also sets groundwater cleanup standards.

The Midway Landfill site has no "principal threat" wastes, as that phrase is defined in EPA guidance.

For the purposes of this ROD and potential future deletion of this site from EPA's National Priorities List, the Midway Landfill "site" is the landfill area containing waste, and all downgradient contaminated groundwater resulting from releases from the landfill. Several potential up gradient groundwater sources have been identified but are not included within the "site" and are not addressed by this ROD.

Ecology has separate responsibilities for decision-making at the Midway Landfill site under the State's Model Toxic Control Act (MTCA). Under MTCA, the decision document that selects the cleanup action and cleanup levels is called a Cleanup Action Plan. Ecology and the city had been working on a final Cleanup Action Plan for Midway Landfill for many years. When, in February 2000 it was determined that it was unlikely that such a Cleanup Action Plan could be completed in FY 2000, Ecology agreed that EPA could write a CERCLA ROD for the landfill so that a determination of CERCLA construction completion could be made. Ecology has decided to utilize the ROD as a Cleanup Action Plan for a final MTCA remedy, pursuant to WAC 173-340-360(13). This decision will be specified in an anticipated amendment to the 1990 consent decree.

Ecology has been the lead regulatory cleanup agency at the Midway Landfill site. EPA expects Ecology to continue in that capacity.

5. Site Characteristics and Nature and Extent of Contamination

5.1. Conceptual Site Model and Summary of Landfill Conditions

Because of the remedial work performed by the City of Seattle at Midway Landfill since 1985, the environmental conditions at the site have greatly improved.

- Potentially explosive methane gas does not leave the landfill property, and has not since 1990. The gas is collected within the landfill and then burned on the site. The gas collection system has also helped dry out the landfill contents and further reduce the contaminated groundwater leaving the landfill.
- Storm water no longer enters the landfill. The entire landfill is covered with an engineered cap. Clean storm water is collected from the entire surface of the landfill and the surrounding area and stored in a lined storm water detention pond north of the landfill before discharge to McSorley Creek.
- There are multiple layers of sand, or sand and gravel, under or around the landfill that allow subsurface movement of groundwater to and from the landfill. These layers, or aquifers are called, in order from the surface to the deepest layers studied: the Shallow Aquifer; Saturated Refuse and Landfill Leachate; the Upper Gravel Aquifer, the Sand Aquifer, and the Northern and Southern Gravel Aquifers.
- Water in the Shallow Aquifer, the Upper Gravel Aquifer and the Sand Aquifer moves from outside the landfill inward towards the south end of the Midway Landfill. This water, along with the leachate developed within the landfill itself, then joins the deeper Southern Gravel Aquifer. Water from the landfill does not appear to enter the Northern Gravel Aquifer.
- There is now significantly less water within the landfill because of the remedial actions described above. Many of the shallower monitoring wells in or near the landfill that used to contain contaminated groundwater are now dry. The water levels around the landfill in both the Upper Gravel Aquifer and the Sand Aquifer have also generally dropped. These results mean that much less water is entering the landfill and the containment systems constructed by the City of Seattle have been successful.
- The only downgradient monitoring wells where contamination has been detected over the past two or three years are in the Southern Gravel Aquifer. Two of these wells are located approximately 600 feet and 1200 feet east of the south-east corner of the landfill. Three chemicals, 1,2-dichloroethane, vinyl chloride, and manganese, have been detected at levels of concern. The two VOCs were detected at slightly above the federal drinking water standard. Manganese has also been detected at levels above background on the west side of the landfill in the Southern Gravel Aquifer.
- Another Southern Gravel Aquifer monitoring well that is closer to the landfill has met all federal drinking water standards for the past two years. Groundwater monitoring

conducted during the RI indicated that this same well had contaminants at levels greater than 10 times the federal drinking water standard. Again, these results indicate that the containment remedy appears to be successful.

- There is some groundwater contamination in the Sand Aquifer to the north, northwest and west of the landfill that did not come from Midway Landfill. Some of the groundwater samples in this area are above both federal and state drinking water standards and the MTCA cleanup standards. This contamination may be flowing towards and under the Midway Landfill. No one is using this groundwater and thus no one is currently exposed to this contamination.

The following sections provide more detailed summary information about the site characteristics, hydrogeology, and groundwater quality.

5.2. Geographic Description

The Midway Landfill is located near the crest of a narrow north-south trending glacier feature known as the Des Moines Drift Plain. This area, referred to as "upland" because of its location above adjacent valleys and sea level, is bordered by Puget Sound on the west and the Green River valley on the east. Maximum elevations along the crest of the upland generally range from 400 to 450 feet above mean sea level (MSL). Puget Sound is at sea level, and the Green River valley floor typically averages about 30 feet above MSL.

The Midway Landfill occupies a shallow, bowl-shaped depression near the crest of the upland. The surface of the landfill generally ranges from 360 to 400 feet above MSL and slopes upward to the south and east. West of the landfill, the land surface is nearly flat across Highway 99 and then drops steeply downward approximately 100 feet to the Parkside Wetland.

The upland area is cut with a number of steep-sided stream valleys. Midway Creek is located northeast of the landfill, and two other streams, the north and south forks of McSorley Creek, are located to the west and southwest, respectively.

There is no major surface water body in the immediate vicinity of the Midway Landfill. The closest are Lake Fenwick, located approximately one mile to the southeast, and Star Lake, located approximately 1.5 miles to the south.

5.3. Geology

Site geology and hydrogeology have had a major influence on the movement of contaminants in the vicinity of Midway Landfill, the impact of the completed remedial actions, and affect the selection of the cleanup remedy.

The Des Moines Drift Plain is part of the Puget Lowland that lies between the Olympic Mountains on the west and the Cascade Mountains on the east. The Puget Lowland is underlain by a thick sequence of Quaternary glacial, fluvial (riverine), and lacustrine (lake bed) deposits overlying Tertiary volcanic and sedimentary bedrock. Depth to bedrock is thought to exceed 1,000 feet near Midway Landfill. Deposits of at least four glaciations have been identified in the Puget Sound Lowland. The most recent glaciation, the Fraser, consisted of two stages: the Vashon (oldest) and Sumus (most recent).

Based on earlier studies of the area and analysis of geological samples collected during the installation of monitoring wells for the RI, nine stratigraphically distinct deposits were identified from the land surface down approximately 400 feet to sediments that are near current mean sea level. Because of the complex layering in all the sediments underlying the landfill, vertical and horizontal permeabilities are highly variable and produce a complex groundwater flow pattern.

5.4. Hydrogeology and Ground Water Quality

Groundwater movement within and below the landfill has been characterized to an approximate depth of 300 to 350 feet below ground surface (50 to 100 feet above mean sea level (MSL)). Several groundwater units have been identified within this interval. From shallowest to deepest these aquifers are: Shallow Groundwater; Saturated Refuse; Upper Gravel Aquifer (UGA); Sand Aquifer (SA); and Southern Gravel Aquifer (SGA) and Northern Gravel Aquifer (NGA) An east-west cross section is shown in Figure 5-1; the line of this cross-section is H-H' on Figure 5-2.

Between October 1986 and January 1990, a total of 56 groundwater monitoring wells were installed and sampled in 41 locations up gradient and downgradient of the Midway Landfill . (Many wells have multiple completions at the same location). Samples from these locations were analyzed for conventional water quality parameters and EPA's hazardous substance list, including metals, volatile organic compounds (VOCs), pesticides and other potentially hazardous substances. Hazardous substances detected in the groundwater included arsenic, manganese, benzene, 1,2-dichloroethane, vinyl chloride, and methylene chloride.

In addition, the extent of contaminant migration into the groundwater system beneath the landfill was estimated using specific chemicals as indicators of leachate movement within the aquifers. In particular, chloride concentrations in the landfill leachate were several hundred times greater than background groundwater concentrations. Therefore, elevated chloride was used to delineate the extent of the contaminant plume and as a conservative tracer of groundwater movement. The concentrations of manganese (a naturally-occurring metal that is often elevated downgradient of landfills) and certain chlorinated ethenes and ethanes in the groundwater were also used to confirm the extent of the plume.

A subset of the RI groundwater monitoring network has been used for monitoring the effects of the work required by the consent decree. Figure 5-3 shows the locations of the monitoring wells still used to monitor groundwater quality. Water levels are monitored in these and additional monitoring wells.

Of the hazardous substances identified during the RI, only manganese and two VOCs, 1,2-dichloroethane and vinyl chloride, are still considered groundwater contaminants of concern. None of the other hazardous substances have been detected in groundwater at levels approaching federal drinking water standards downgradient of the landfill for at least eight years.

The sections below summarize, by aquifer, the hydrogeology and groundwater quality information collected during the past 10 years as part of the groundwater monitoring program. For comparison, averaged contaminant concentration data (arithmetic mean) from the RI are also included. Nondetects were incorporated into these averages by using half the detection limit.

5.4.1. Shallow Groundwater

5.4.1.1. Shallow Groundwater Hydrogeology

This zone of saturation was described in the RI as shallow, discontinuous lenses of groundwater perched on low permeability deposits above the UGA. Field work and data analyses since completion of the RI indicate while the groundwater in this unit is shallow and discontinuous, it is not always perched above low permeability materials. The majority of these shallow zones are found north and south of the landfill. The general water elevation of the shallow groundwater zone adjacent to the landfill is generally at about 325 feet above MSL north and south of the landfill, and lower, and more discontinuous to the east and west (Figure 5-4).

The landfill's detention pond dewatering system affects shallow groundwater flow through areas along the northern periphery of the landfill. Shallow groundwater north of the landfill that exists at 320 feet or higher in elevation is captured by the pond's dewatering system and routed to North McSorley Creek. This system limits the capacity of the shallow groundwater to discharge into the landfill from the north; however, groundwater deeper than 320 feet in elevation can and does discharge into the landfill from the north. Shallow groundwater also occurs in disconnected zones south of the landfill at an elevation of approximately 325 feet, and discharges, at least seasonally, into the landfill.

5.4.1.1. Shallow Groundwater Water Quality

Shallow groundwater water quality has not been monitored as part of the performance and compliance monitoring system. Shallow groundwater flows into the landfill.

5.4.2 Saturated Refuse and Landfill Leachate

5.4.2.1. Landfill Leachate Hydrogeology

Prior to the remediation required by the 1990 consent decree, the major sources of water to the landfill were: surface water infiltrating from the landfill surface and from areas north of the landfill that drained into the landfill; storm water discharge from the Linda Heights neighborhood, and I-5 drainage that was routed into the landfill as part of the construction of I-5; and shallow groundwater from north and south of the landfill. Refuse located below elevations of approximately 325 feet was generally saturated (Figure 5-5).

Flow in the refuse was generally from the north and west toward the south-central section of the landfill, where the pit excavations were deepest. Leachate may have discharged vertically throughout much of the landfill base, although the rate of discharge was affected by the fine-grained material deposited during gravel pit operations. Prior to remediation, the greatest volume of vertical flow was in the south-central area, where leachate discharged to the underlying Upper Gravel Aquifer.

Since construction of the engineered cap and storm water diversion systems, between 75 and 90 percent of the water that entered the landfill has been diverted and leachate levels have dropped by as much as 20 feet. This can be seen by comparing water elevations within the landfill in Figures 5-1 and 5-5, which corresponds to a 90 percent reduction in the amount of saturated refuse. The only remaining sources of water to the landfill are the shallow, discontinuous zones of groundwater north and south of the landfill. Water within the landfill now slowly evaporates into the gas system or leaks through the base of the landfill, approximately 100 to 150 feet below ground surface, into the underlying Upper Gravel Aquifer, described below.

5.4.2.2. Landfill Leachate Water Quality

Studies conducted during the RI established that most of the leachate from the landfill was aqueous. A small amount of floating light non-aqueous phase liquid (LNAPL) was also detected in the landfill. Dense non-aqueous phase liquid (DNAPL) has never been detected at the landfill.

Leachate samples were collected as part of the RI and analyzed for conventional water quality parameters and compounds on the EPA hazardous substance list. Results from these analyses and related monitoring indicated:

- The aqueous leachate contained aromatic and aliphatic hydrocarbons, dissolved salts, suspended particulates and low levels of VOCs and metals. Polynuclear aromatic hydrocarbons (PAHs) and polychlorinated biphenyls (PCBs) were only detected in groundwater samples in wells located adjacent to or in direct contact with NAPL pools.

- The LNAPL contained metals, VOCs including trans-1,2-dichloroethene and the BETX group (benzene, ethylbenzene, toluene and xylene), PAHs commonly detected in petroleum oil, and PCBs. PCB concentrations ranged from 107 ppm to 1,142 ppm.
- Some wells within the landfill had up to 20 feet of NAPL. Monitoring of wells outside the landfill did not detect any NAPL.
- A pumping program was tested as part of the 1990 FS to see if the LNAPL was extractable. Less than 100 gallons were extracted from the three wells with the greatest volume of NAPL; recharge into these wells was very slow.

Water quality in the landfill leachate has not been monitored as part of the performance monitoring system, though water depth and LNAPL have been. By 1998, of the approximately 18 wells monitored for oil thickness, approximately 13 had either no oil or only a trace of oil. The remaining 5 had oil measured between 0.27 feet and 3.96 feet.

5.4.3 The Upper Gravel Aquifer (UGA) and the Upper Silt Aquitard

5.4.3.1. Hydrogeology of the UGA and Upper Silt Aquitard

The Upper Gravel Aquifer consists of fifty to one hundred feet of outwash gravels that underlie the low permeability layer at the base of the landfill located 100 to 170 feet below ground surface. These gravels consist of interbedded zones of permeable gravels and less permeable mixtures of silt, sand, and gravels. Prior to construction of the actions required by the 1990 consent decree, discharge from the landfill resulted in significant areas of saturation within the UGA, especially in water-bearing strata at the base of the unit, where several monitoring wells were placed. (See, for example, Figure 5-5.)

Groundwater flow in the UGA is generally from both the north and south inward toward an area beneath the southern end of the landfill where the groundwater discharges downward into the underlying Sand Aquifer (SA). The UGA and SA are separated by the Upper Silt Aquitard, a discontinuous layer of fine-grained silt, clayey silt, and silty fine sand that is present throughout most of the study area. Vertical flow from the UGA into the SA is most pronounced in places where the aquitard is absent. One of these "windows" in the aquitard exists beneath the southern end of the landfill, where it allows the discharge from the UGA into the SA to occur. Discharge through this window was manifested as a distinct groundwater sink during the RI.

The construction of the remedial actions required by the 1990 consent decree and the subsequent dewatering of the refuse have greatly reduced the amount of recharge entering this unit. Groundwater continues to enter the UGA north and south of the landfill, and the groundwater and leachate continues to flow toward the sink beneath the southern part of the landfill.

However, the response of the UGA to changing conditions at the landfill was strong and rapid as indicated by the monitoring wells designed to monitor water quality conditions. Within the landfill footprint and around the perimeter, the UGA monitoring wells have been dry since 1992, even with rainfall that was significantly greater than average during the years from 1997 to 1999. Figure 5-6 shows the current potentiometric surface of the UGA. The sink still exists and appears to have "deepened" due to the loss of recharge from the landfill.

The UGA beneath the landfill is under vacuum from the landfill gas collection system. Any leachate leaking through the base of the landfill and infiltrating into this zone moves mostly by unsaturated flow and is directly exposed to the vacuum under conditions designed to strip volatile organics from the infiltrating water. This combination of predominately unsaturated conditions in the aquifer and the vacuum from the gas extraction system helps to contain volatile organics from being released to the underlying groundwater system.

5.4.3.2. Water Quality in the Upper Gravel Aquifer (UGA)

Prior to construction of the actions required by the 1990 consent decree, water quality in the water-bearing strata at the base of the unit, where several monitoring wells were placed, showed significant impacts from leachate. However, the RI concluded it was unlikely that contamination in the Upper Gravel Aquifer existed further than 100 to 200 feet from the landfill (in the south, west, and east direction) because of the strong component of downward flow in the aquifer into the underlying Sand Aquifer.

Following the remedial work required by the 1990 consent decree, the monitoring network in the UGA included two up gradient wells (MW-21A and MW-16) and two downgradient wells (MW-7A and MW-19B). The downgradient wells were located at points where the saturated refuse was believed to be discharging leachate downward into the UGA. However, the downgradient wells MW-7A and MW-19B have not been sampled since 1992 due to the declining groundwater levels in the UGA. In the two or so years prior to going dry, both wells had no detectable concentrations of any VOCs, except chlorobenzene at concentrations ranging from non-detected to 4 ppb (the federal drinking water standard or Maximum Contaminant Level (MCL) is 100 ppb); benzene at concentrations ranging from non-detect to 3 ppb (MCL is 5 ppb); chloroethane at concentrations from non-detected to 3 ppb and single hits of 1,2-dichloroethane at 1 ppb and acetone at 25 ppb. During the same years, manganese concentrations ranged from 3.5 to 5.2 mg/L.

5.4.4 The Sand Aquifer (SA) and the Lower Silt Aquitard

5.4.4.1. Hydrogeology of the Sand Aquifer and the Lower Silt Aquitard

The SA occurs as a widespread regional deposit of interbedded sands and silts 200 to 300 feet below the surface. Flow in this aquifer in the vicinity of the landfill is generally from the north and west to the southeast toward a hydraulic sink that occurs across a broad area beneath the southern part of the landfill and extending several hundred feet to the east (Figure 5-7). Groundwater to the south and east of this sink also flows towards the sink. Consequently, the sink limits the extent that the landfill impacts the SA, and impacts are not seen beyond the sink to the east. This sink is believed to be located from the southeastern section of the landfill and up to 800 feet further east. Groundwater entering this sink flows downward into the Southern Gravel Aquifer (SGA).

The deepening of the sink in the UGA as the landfill dewatered is also seen in the SA where the SA sink has also deepened over the last 5 years. The two SA groundwater flow monitoring wells within the footprint of the landfill are currently dry, and have been for several years; the down gradient SA groundwater chemistry monitoring wells, which are located further from the landfill, only sometimes contain sufficient water for sampling.

The SA and SGA are separated by the Lower Silt Aquitard. Like the Upper Silt Aquitard, the Lower Silt Aquitard is present as a significant unit throughout the site, but is discontinuous in places. These "windows" in the aquitard allow for the downward flow from the SA into the SGA. The largest such window identified in the study area exists below the sink in the SA.

5.4.4.2. Water Quality in the Sand Aquifer

The post-1990 monitoring network in the SA initially included four up gradient wells (MW-8B, MW-30B, MW-17B, and MW-21B) and three down gradient wells (MW-15A, MW-20A, and MW-23A). MW-30B was originally installed as a down gradient well, but the potentiometric surface showed that it was actually up gradient of the landfill on the far side of the groundwater sink formed by SA groundwater discharging into the SGA. The well has consistently been clean, and has been deleted from the groundwater monitoring network.

In this aquifer, the groundwater quality situation is complex because of up gradient contamination flowing towards the landfill. The up gradient wells MW-17B and MW-21B are contaminated with chlorinated solvents, as shown below:

Up Gradient Monitoring Wells In the Sand Aquifer - Recent Concentrations

	Recent concentrations	MCL
MW-17B		
1,1-dichloroethane	90 to 160 ppb	800 ppb*
1,1-dichloroethene	4.8 to 8.2 ppb	7 ppb
1,2-dichloroethane	8 to 12 ppb	5 ppb
MW-21B		
1,1-dichloroethane	11 to 14 ppb	800 ppb*
1,1-dichloroethene	1.6 to 2.6 ppb	7 ppb
tetrachloroethene	24 to 35 ppb	5 ppb
trichloroethene	2.4 to 3.1 ppb	5 ppb

* 1,1-dichloroethane has no MCL. 800 ppb is the MTCA Method B cleanup level in the 2/96 CLARC II table.

Contamination in MW-17B has remained fairly constant over the last decade, while contamination at MW-21B has been increasing slightly over the last several years. These two wells remain the most contaminated wells in the monitoring well network, in terms of number of contaminants found in the groundwater. Both Ecology and the City of Seattle have conducted studies to identify possible sources of this up gradient contamination.

MW-15A and MW-23A were selected to provide water quality information in the hydraulic sink area. MW-23A has not been sampled since 1993 due to declining groundwater levels in the Sand Aquifer. MW-15A was not sampled between 1993 and 1997, but has had sufficient water for sampling from 1997 to the present. Since 1997 all VOCs have been non-detected except 1,2-dichloroethane with concentrations from 1.1 to 2.1 ppb and manganese concentrations have ranged from 0.005 to 0.028 mg/L. In the two or so years prior to water levels getting low, MW-23A had similarly low concentrations of VOCs with 1,1-dichloroethene from non-detected to 2 ppb; 1,2-dichloroethane from 1.9 to 4 ppb; and trichloroethene from non-detected to 2 ppb. Manganese concentrations ranged from 1.7 to 4.1 mg/L.

One additional sand aquifer monitoring well (MW-20A) is located just west of the landfill. This well is hydraulically down gradient of the up gradient source area near MW-17. Monitoring well MW-20A is also located hydraulically up gradient of the western edge of the landfill because water from the Sand Aquifer flows underneath the landfill and down into the Upper Gravel Aquifer. Historically, the water quality in the zone monitored by MW-20A was impacted by both landfill and up gradient sources. MW-20A has been dry and thus not sampled since 1994. In the two or so years before going dry, the following concentrations were found in MW-20A:

MW-20A - 1992 to 1994 Concentrations

	1992 to 1994 Concentrations	MCLs
1,1,1-trichloroethane	non-detected to 2.4 ppb	200 ppb
1,1-dichloroethane	12 to 37 ppb	800 ppb*
1,2-dichloroethane	2 to 5.3 ppb	5 ppb
1,2-dichloroethene	non-detected to 2 ppb	70 ppb
benzene	non-detected to 1.1 ppb	5 ppb
chloroethane	15 to 20 ppb	***
manganese	0.735 to 1.28 mg/L.	2.2 mg/L**

* 1,1-dichloroethane has no MCL. 800 ppb is the MTCA Method B cleanup level in the 2/96 CLARC II table.

** manganese has no primary MCL. 2.2 mg/L is the MTCA Method B cleanup level in the 2/96 CLARC II table.

*** chloroethane, also known as ethyl chloride, has no MCL nor MTCA Method B cleanup level in the 2/96 CLARC II table.

5.4.5. The Southern and Northern Gravel Aquifers

5.4.5.1. Hydrogeology of the Southern and Northern Gravel Aquifers

The deepest stratigraphic units studied were the Northern and Southern Gravel Aquifers (NGA and SGA, respectively); they occur at about the same elevation (300 to 350 feet below the surface), but hydraulic heads in the NGA are typically 100 feet higher than heads in the SGA. During the RI, the NGA was found to be clean and unimpacted.

The SGA is found beneath the southern half of the landfill and extends to the east, south and west. It consists of permeable sands and gravel interbedded with silts and silty gravel. The SGA appears to be recharged by the SA and by lateral flow from the south. A groundwater mound in the SGA, below the hydraulic sink in the SA, is believed to be an expression of regional flow through the sink. Groundwater flow from the mound is to the east and west; flow to the north is blocked by higher potentiometric heads within the NGA. Groundwater in the SGA eventually discharges west to Puget Sound and east to the Green River Valley. The 1998 potentiometric surface of the SGA is shown in Figure 5-8. Although the groundwater mound is still present, water levels along the historical high point (MW-14B, for example) have dropped by as much as 10 feet from pre-remedial conditions.

Responses to changing recharge conditions have been fairly rapid between the base of the landfill and the SGA, with decreases in the SGA water levels occurring in less than 5 years from completion of the remedy required by the 1990 consent decree. Once groundwater enters the SGA, the primary direction of flow shifts from vertically downward to horizontal, with much lower potentiometric heads driving the flow indicating that water movement within the SGA horizontally away from the landfill will be much slower than vertical movement into the SGA.

5.4.5.2. Water Quality in the Southern Gravel Aquifer

Currently, the Southern Gravel Aquifer is the primary aquifer in which groundwater moves out and away from the landfill, and thus is the primary potential groundwater exposure pathway beyond the landfill property.

The post-1990 monitoring network in the SGA initially consisted of one up gradient well (MW-24B) and five downgradient wells (MW-14B, MW-20B, MW-23B, MW-29B, and MW-30C). Well 24B has since been removed from the water quality monitoring network because it has never shown any evidence of groundwater contamination.

Monitoring wells MW-14B, MW-23B, and MW- 29B form a line of monitoring wells to the east of the landfill, with MW-14B located at the edge of the landfill, and the other two wells approximately 600 and 1,500 feet further east, respectively.

The monitoring results for MW-14-B are interesting. (Table 5-1.) While the average 1,2-dichloroethane concentration during the RI was 50 ug/L, and were generally in the 10 to 20 ug/L range in the early 1990's, the 1,2-dichloroethane concentration has been non-detectable (with a detection limit of 1 ug/L) in this well in the four sampling rounds between May 1998 and November 1999. Similarly, while the average vinyl chloride concentration during the RI was 4 ug/L, and the concentrations were generally in the 2 to 4 ug/L range in the early 1990's, vinyl chloride concentration has been non-detected (with a detection limit of 1 or 2 ug/L) in this well in these four recent sampling rounds. Cis-1,2-dichloroethene is also found in the 5 to 7.7 ug/L range (the MCL is 70 ug/L) as has been 1,1-dichloroethane in the 1.6 to 3 ug/L range (no MCL, but the MTCA Method B cleanup level is 800 ug/L.) No other monitored VOCs have been detected in the past two years. Concentrations of chloride (a leachate marker) and manganese (from 4.8 mg/L average in the RI to approximately 1.5 mg/L in 1999) have shown similar reductions. Since MW-14B is located where SA groundwater discharges into the SGA, and the SA has been in compliance since 1994, this change is interpreted as the beginning of a "clean front" moving into the SGA.

Concentrations in MW-23B (Table 5-2) have also been declining, but at a slower rate. For example, average RI concentrations of 1,2, dichloroethane and vinyl chloride were 13 ug/L and 5 ug/L respectively; concentrations of these chemicals have been around 7 ug/L and 2 ug/L, respectively, in the four sampling rounds since May 1998. Manganese concentrations have always been low in this well, generally around 0.3 mg/L. Cis-1,2-dichloroethane is also detected in this well in the 4.5 to 6.4 ug/L range.

Concentrations are remaining constant in MW-29B. For example, over the past three years, 1,2-dichloroethane has consistently been detected in the 5 to 10 ppb range (as compared to the RI average concentration of 5 ppb) with 1,1-dichloroethane detected a single time at 1.2 ppb and vinyl chloride detected a single time at 1.1 ppb. Manganese concentrations are low and have ranged from 1.06 to 1.24 mg/L over the past four years.

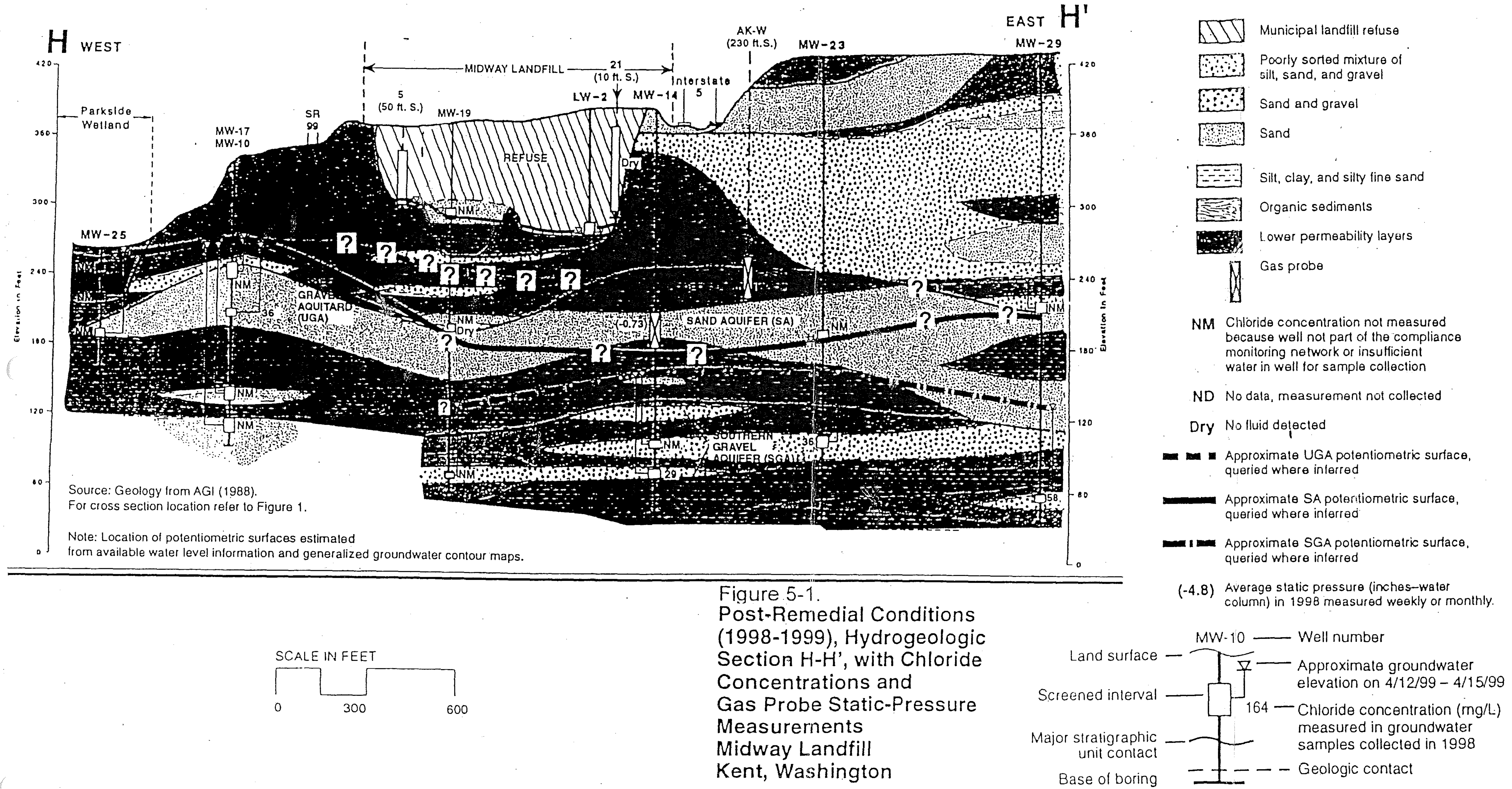
The volatile COCs historically have rarely been detected in downgradient wells MW-20B (to the west of the landfill) or MW-30C (to the far southeast of the landfill).

Background manganese concentrations are high in the SGA and the related Northern Gravel Aquifer, with the regional background concentration considered to be 1.1 mg/L. MW-24B, MW-23B, MW-29B, and MW-30C all have manganese concentrations at or below background; and manganese concentrations in MW-14B have been decreasing rapidly over the last few years as a "clean front" of less contaminated groundwater enters the SGA. However, manganese concentrations in MW-20B are above background and increasing, with concentrations in the 4.5 to 5.87 mg/L range over the past 3 years, as compared to an average of 1.84 mg/L during the RI. Since this well also has elevated levels of chloride, which is a marker of landfill leachate, the cause is likely an indirect result of Midway Landfill leachate. Manganese is a natural mineral that likely is dissolving into the groundwater because of the chemistry of the landfill leachate.

In summary, two volatile COCs are detected above MCLs to the east of the landfill in MW-23B and MW-29B, but have not been detected in recent rounds in MW-14B near the landfill boundary. Manganese concentrations exceed background in MW-14B and MW-20B, but are decreasing rapidly toward background in MW-14B.

5.5. Nature and Extent of Gas Migration

The Upper Gravel Aquifer beneath the landfill is under vacuum from the landfill gas collection system. The vacuum extends to the Sand Aquifer is some locations. Sixty-three gas probes throughout the neighborhood are regularly monitored for landfill gas. Figure 5-9 shows the extent of the vacuum system beneath the landfill. As of 1997, none of the off-landfill property gas extraction wells were still in use because of the significant decreases in off-property methane gas concentrations. All gas probes and gas monitoring locations surrounding the landfill are under the state's landfill gas regulatory limits and all such monitoring locations where the limit may be approached are under the influence of the gas collection system. During the RI, numerous hazardous substances were found in the extracted landfill gas including vinyl chloride, xylenes, toluene, benzene and other solvents.



Source: Geology from AGI (1988).
For cross section location refer to Figure 1.

Note: Location of potentiometric surfaces estimated from available water level information and generalized groundwater contour maps.

Figure 5-1.
Post-Remedial Conditions (1998-1999), Hydrogeologic Section H-H', with Chloride Concentrations and Gas Probe Static-Pressure Measurements
Midway Landfill
Kent, Washington

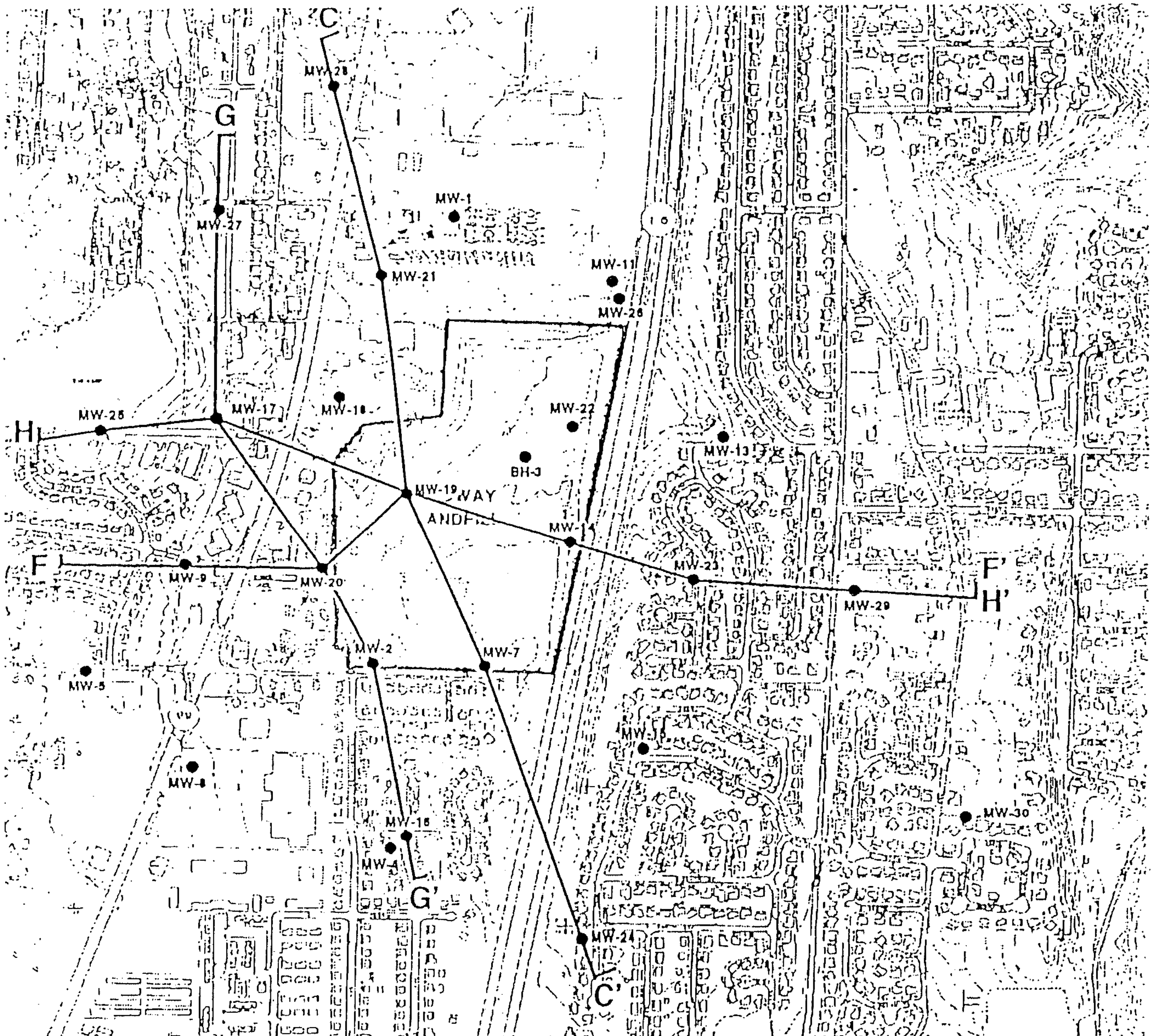
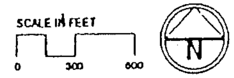


Figure 5-2.
Line of Geologic Section Map
Midway Landfill
Kent, Washington

Base Map Source: AGI (1990)



Midway Cap/S55-1550-03

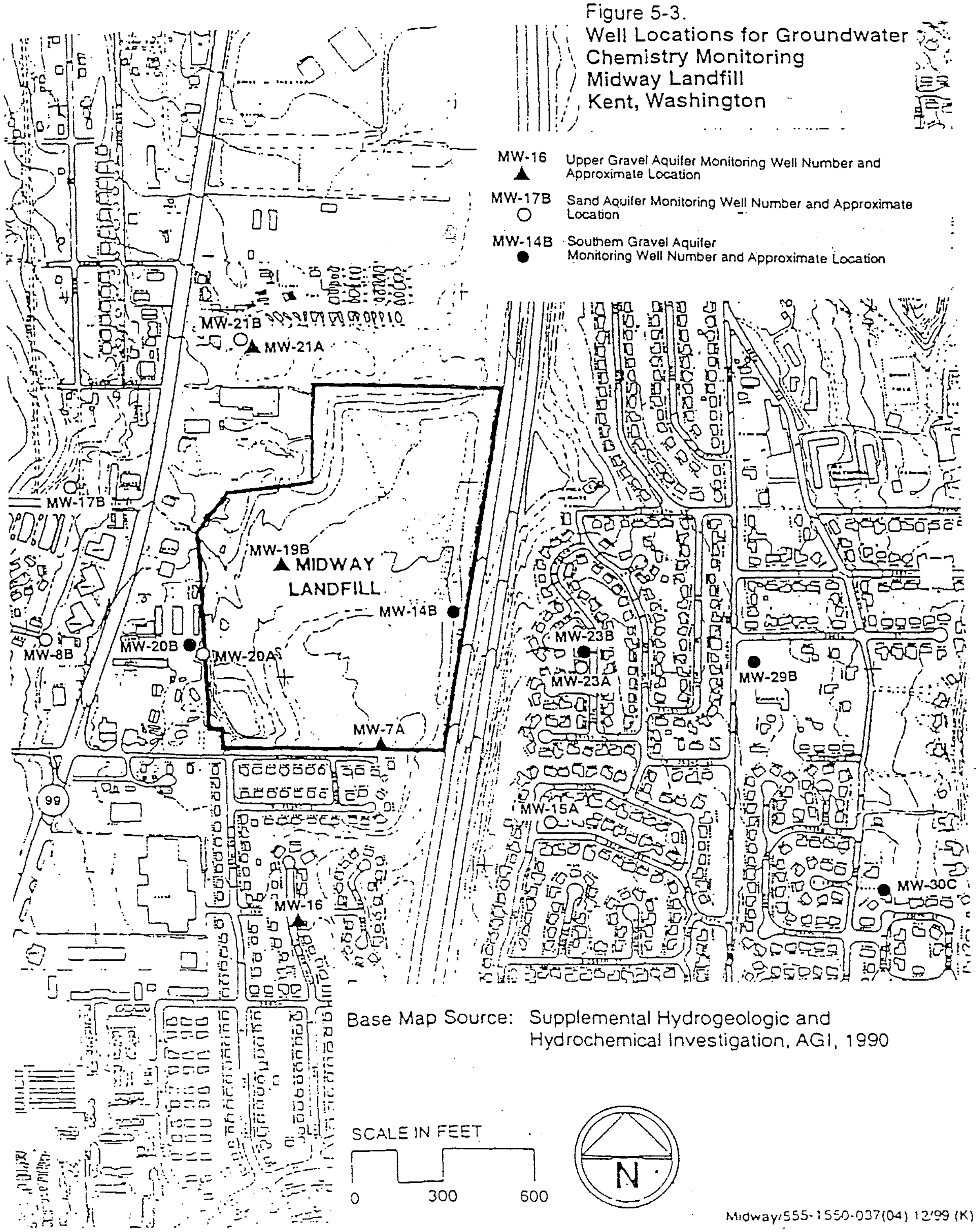
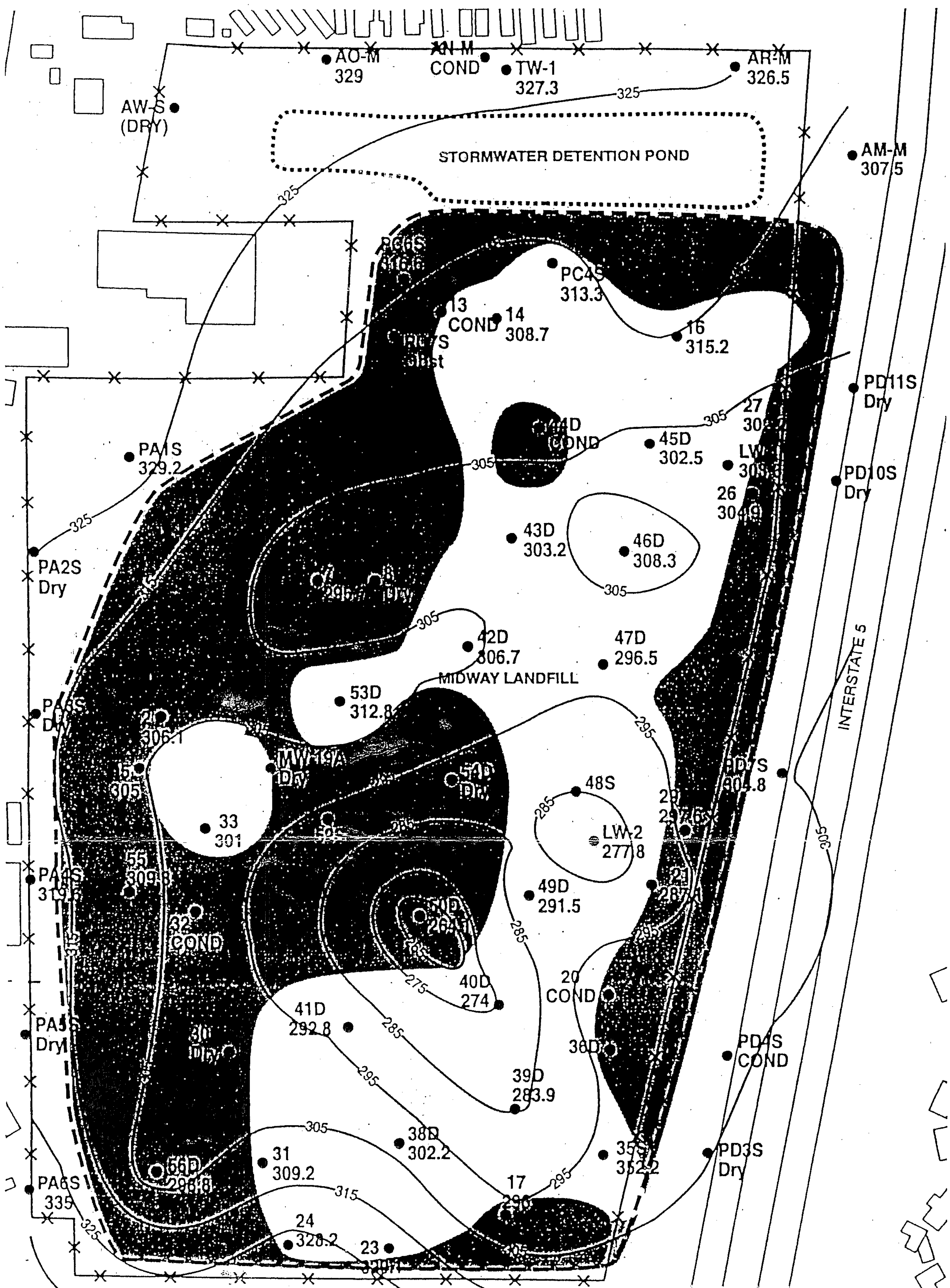


Figure 5-3.
Well Locations for Groundwater Chemistry Monitoring
Midway Landfill
Kent, Washington

Base Map Source: Supplemental Hydrogeologic and Hydrochemical Investigation, AGI, 1990

Midway/555-1550-037(04) 12/99 (K)



Fenced Area Boundary

320.00 Fluid Level Contour. Interval equals 10 feet. Contour placement is approximate.

40D 275.8 — Well number and approximate location, showing leachate or groundwater elevation. Fluid elevations measured November 1998.

48S COND — Condensate is present in well. Data point not used for potentiometric surface calculations.

54D DRY — Well is dry. Data point not used for potentiometric surface calculations.

Approximate Area Where Potentiometric Surface is Below Refuse Based on Intersection of November 1998 Potentiometric Surface with Base of Refuse

Figure 5-4.
Shallow Groundwater/ Saturated Refuse Potentiometric Surface Map - November 1998
Midway Landfill
Kent, Washington

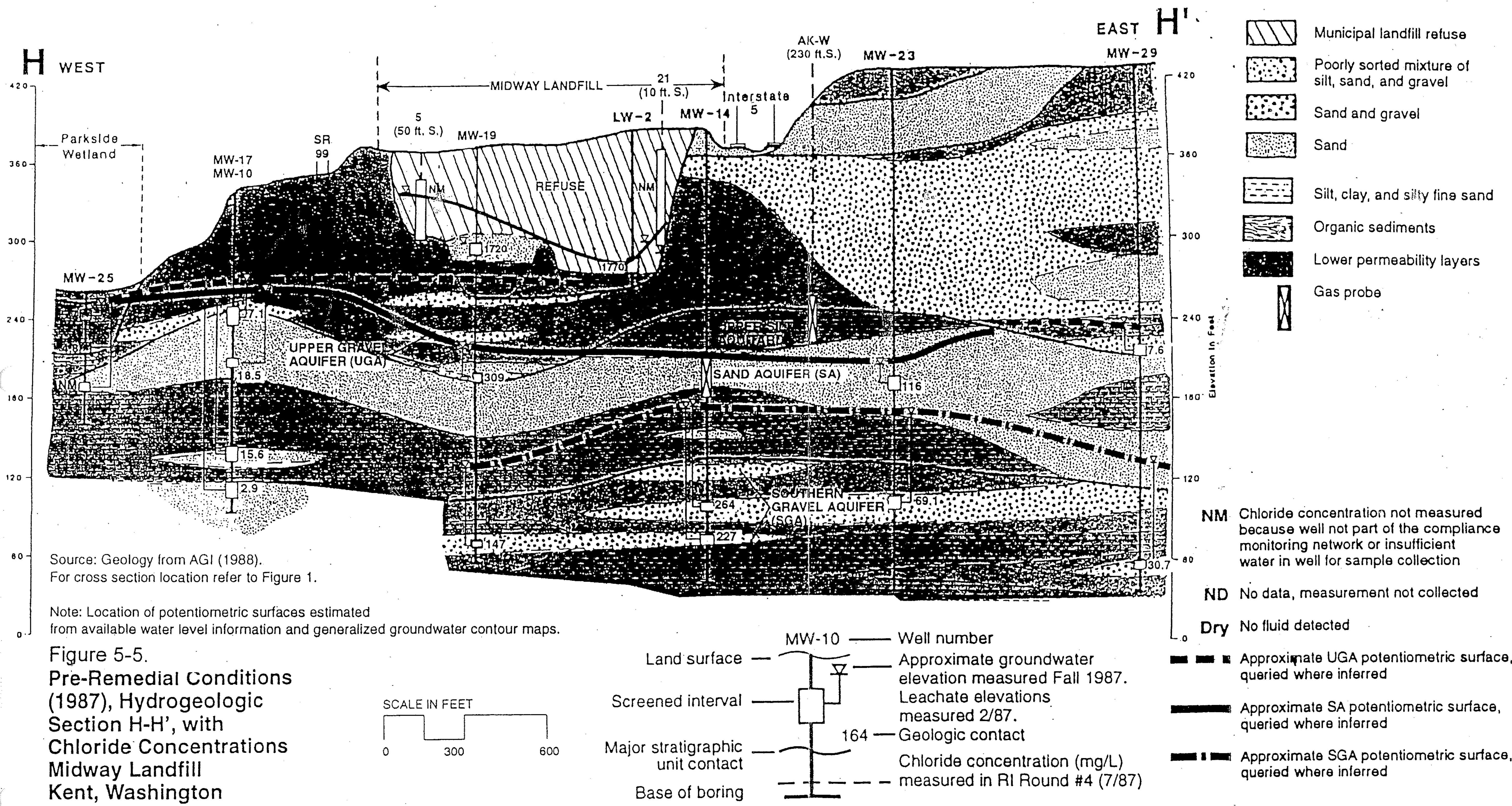


Figure 5-5.
Pre-Remedial Conditions (1987), Hydrogeologic Section H-H', with Chloride Concentrations Midway Landfill Kent, Washington

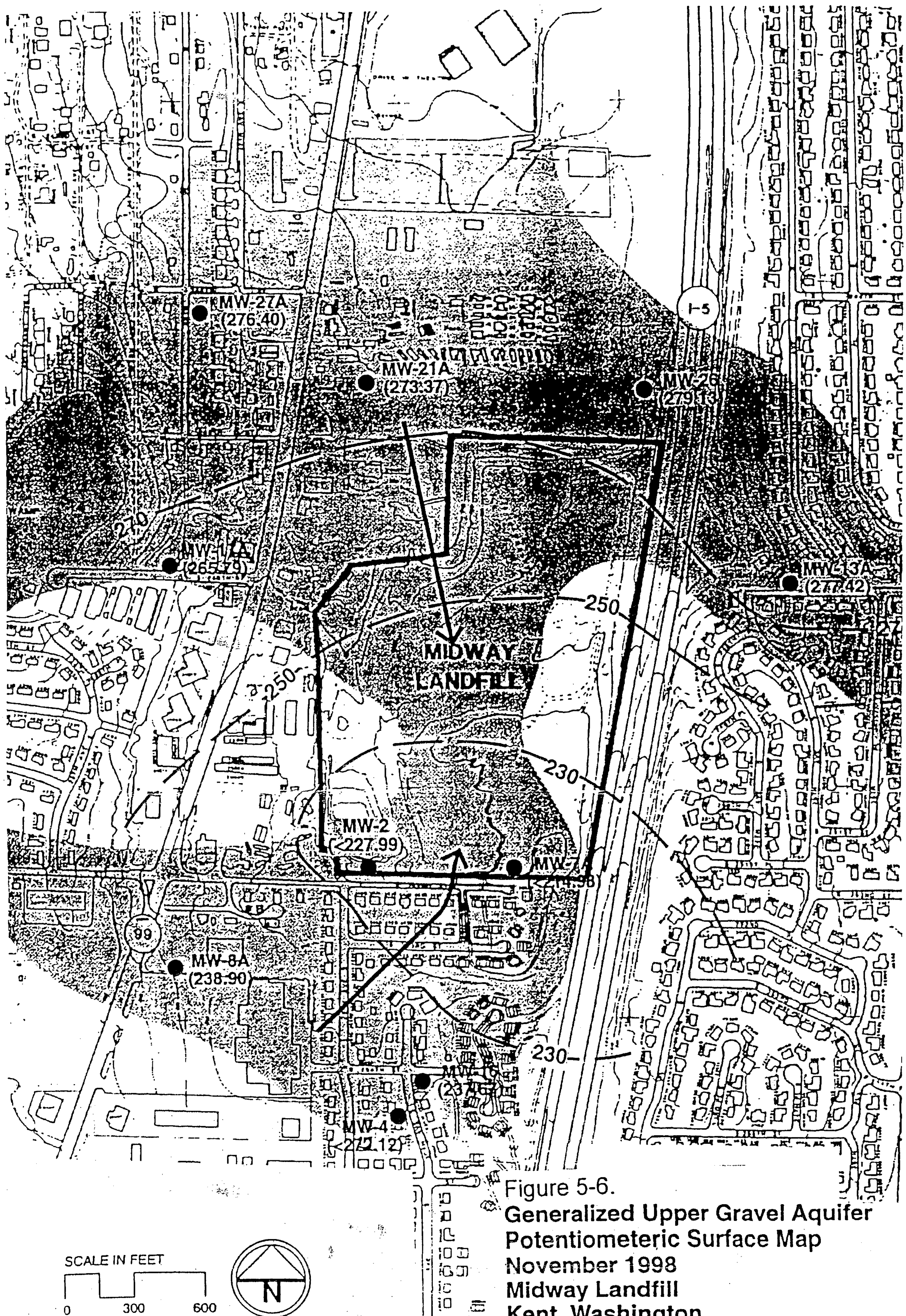
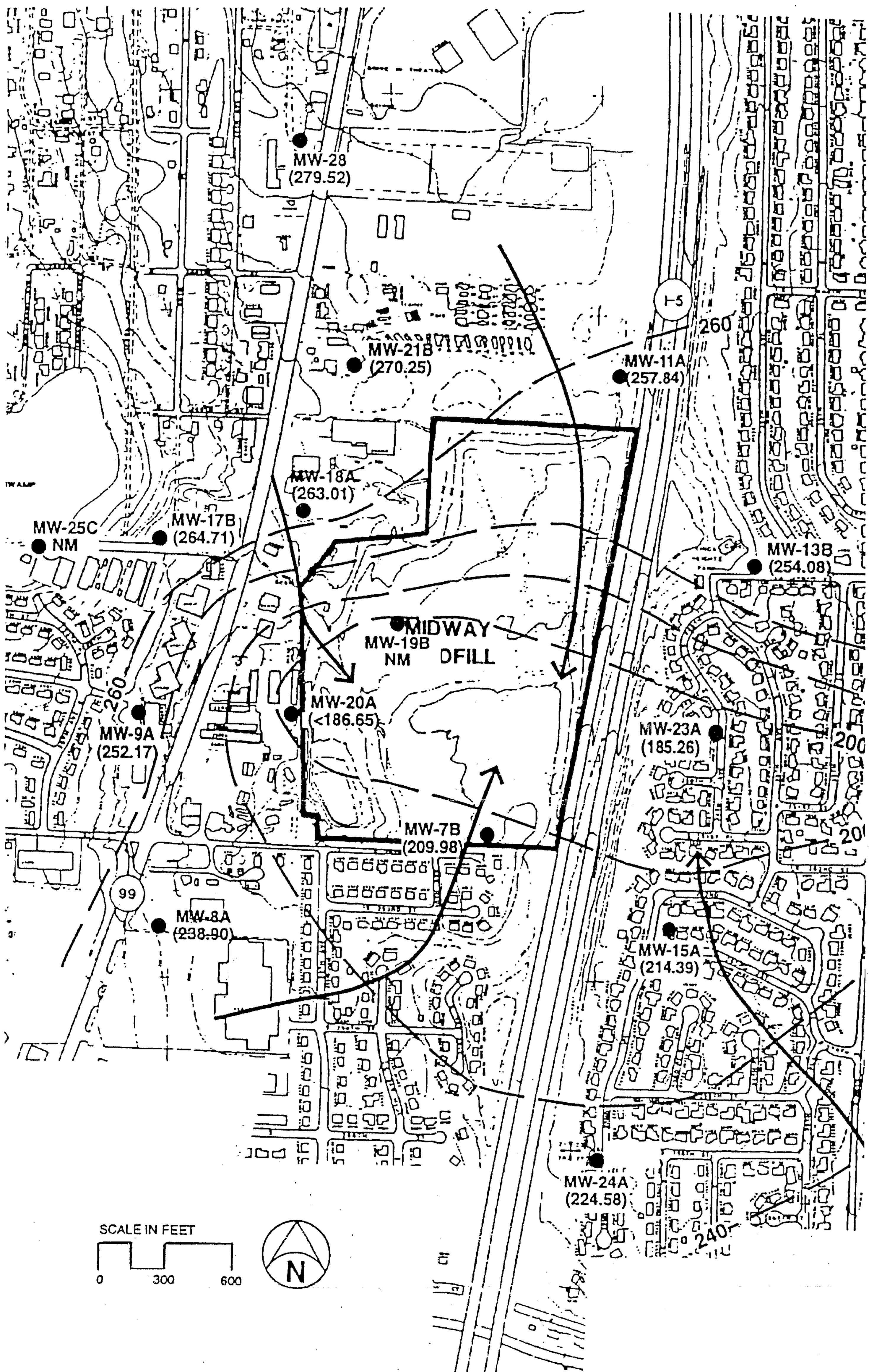


Figure 5-6.
Generalized Upper Gravel Aquifer Potentiometeric Surface Map
November 1998
Midway Landfill
Kent, Washington

MW-7A ●	Upper Gravel Aquifer Monitoring Well Number and Approximate Location
—260—	Approximate Potentiometric Surface Contour (in feet)
(195.03)	Measured Groundwater Elevation in Feet (November 9-13, 1998)
⟵	General Direction of Groundwater Flow
NM	Water Level Not Measured
(<188.7)	Well was Dry, Elevation is Elevation of Bottom of Well
(pattern)	Inferred Extent of Upper Gravel Aquifer



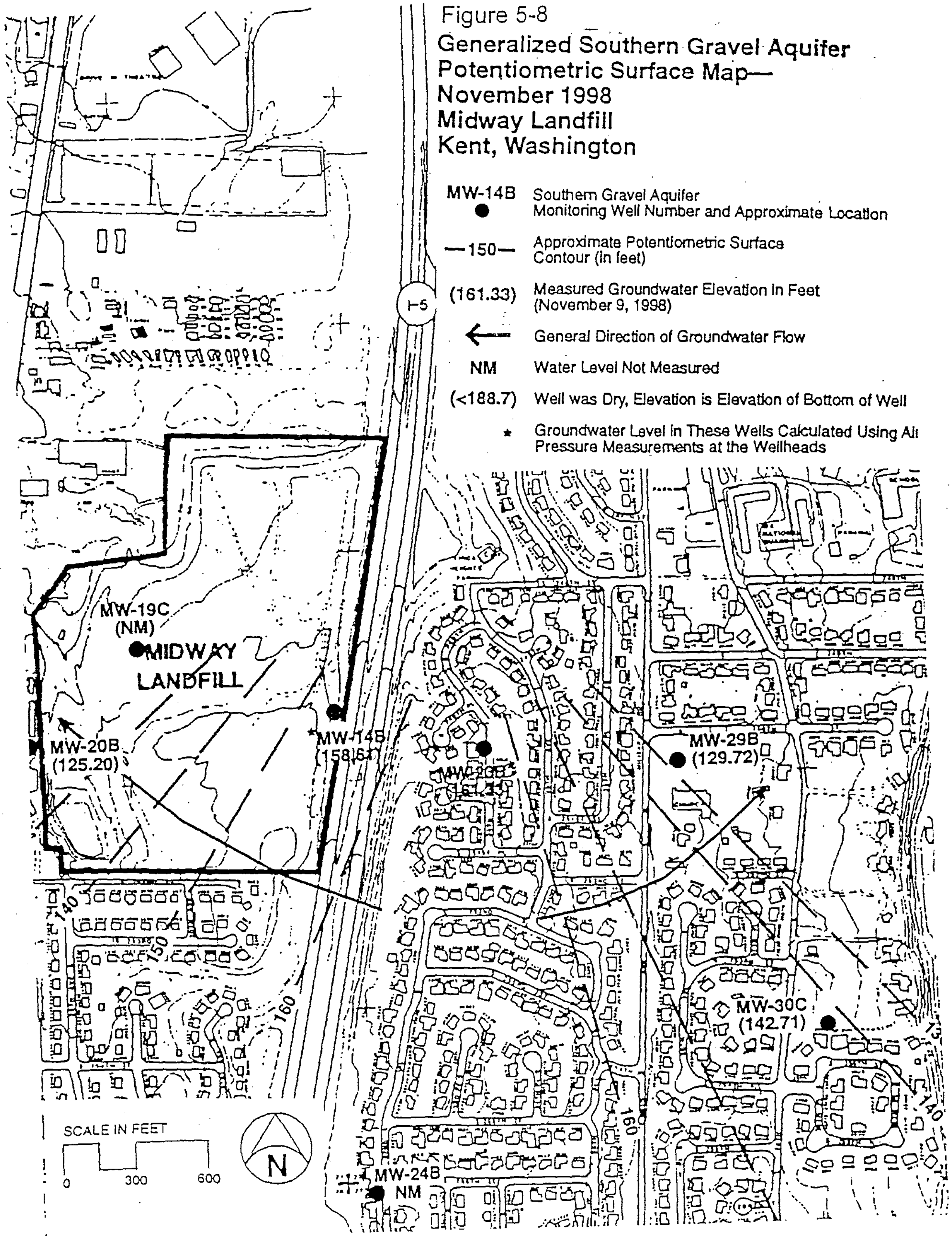
MW-11A ●	Sand Aquifer Monitoring Well Number and Approximate Location
—220—	Approximate Potentiometric Surface Contour (in feet)
(195.03)	Measured Groundwater Elevation in Feet (November 9, 1998)
←	General Direction of Groundwater Flow
NM	Water Level Not Measured
(<188.7)	Well was Dry, Elevation is Elevation of Bottom of Well

Figure 5-7.
Generalized Sand Aquifer Potentiometeric Surface Map November 1998 Midway Landfill Kent, Washington

Figure 5-8

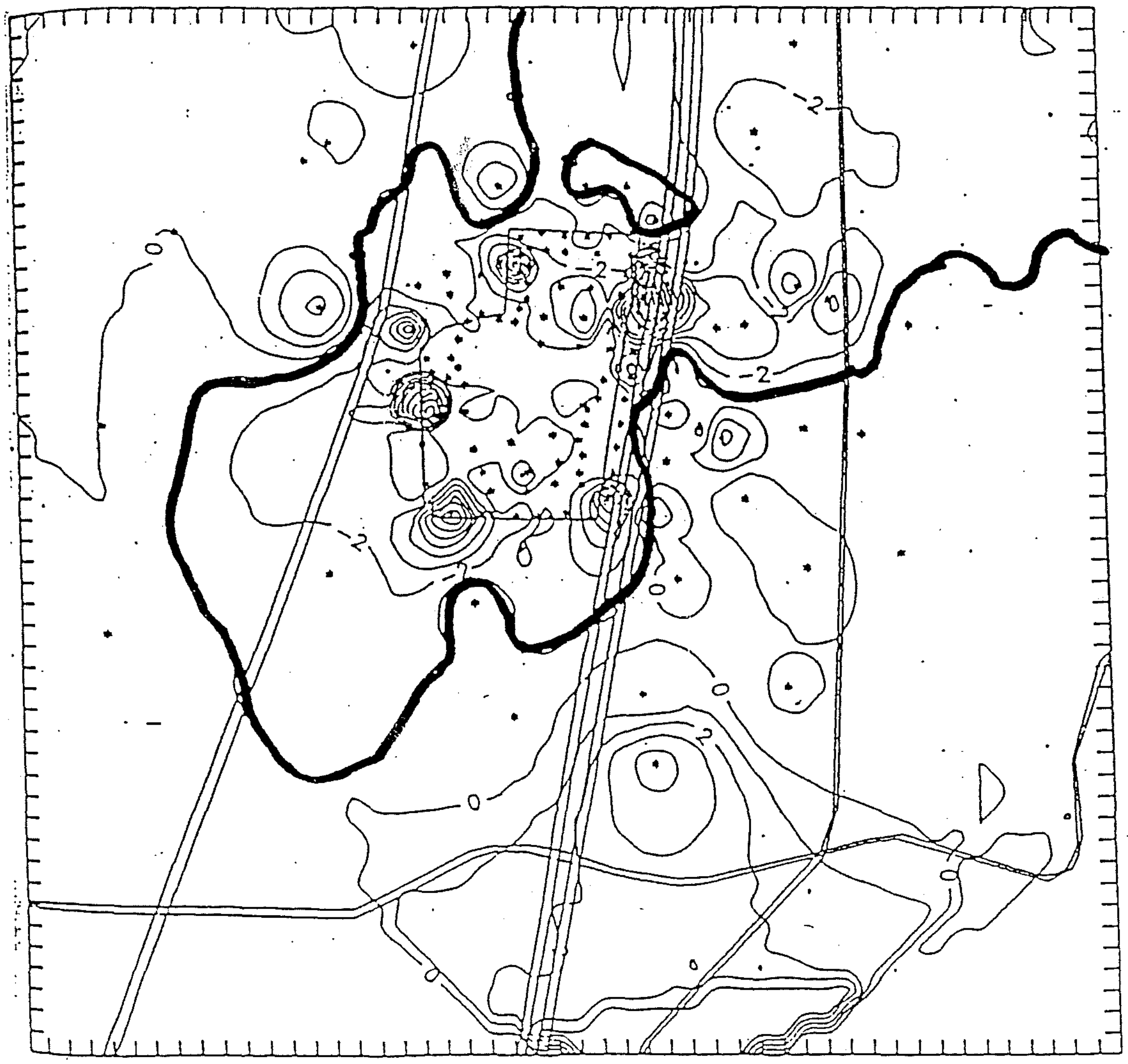
Generalized Southern Gravel Aquifer Potentiometric Surface Map—November 1998
Midway Landfill
Kent, Washington

MW-14B ●	Southern Gravel Aquifer Monitoring Well Number and Approximate Location
—150—	Approximate Potentiometric Surface Contour (in feet)
(161.33)	Measured Groundwater Elevation in Feet (November 9, 1998)
⟵	General Direction of Groundwater Flow
NM	Water Level Not Measured
(<188.7)	Well was Dry, Elevation is Elevation of Bottom of Well
*	Groundwater Level in These Wells Calculated Using Air Pressure Measurements at the Wellheads



Landfill Gas System Gas Contours

PRESSURE GRADIENTS 1QT, 1997



SCALE 1:1000

The heavy contour line depicts the lateral extent of the vacuum in the Upper Gravel Aquifer beneath the landfill, which results from operation of the gas extraction system.

5.6 Surface Water, Seeps and Soil Contamination

Surface water, seeps and soils in areas around the landfill were sampled in the late 1980's as part of the RI and no contamination from the Midway Landfill was found.

6. Current and Potential Future Land and Resource Uses

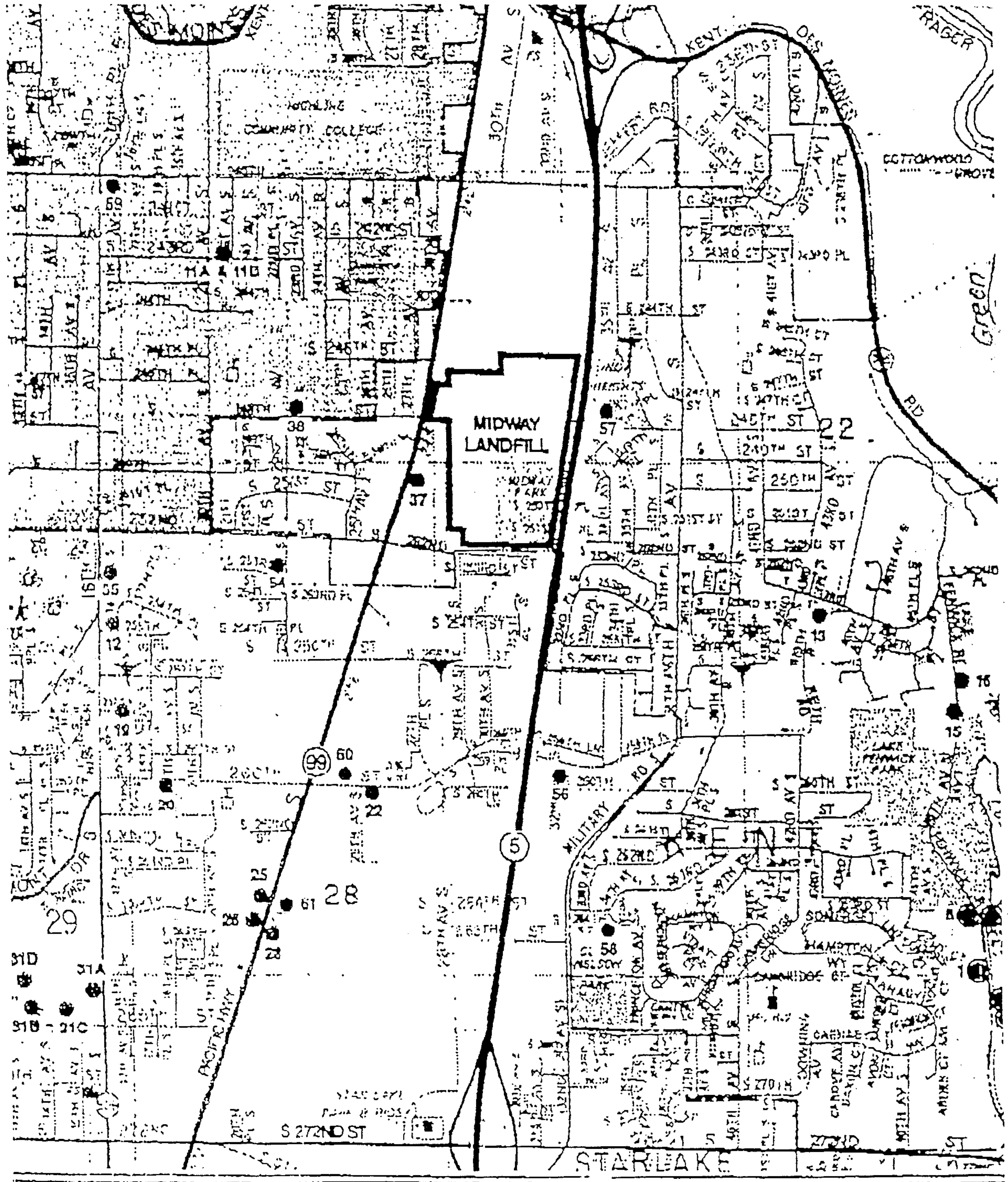
Land Use: Currently, the landfill is capped and fenced. No public access is allowed. Future land use has been the subject of an extensive but preliminary 1992 study by community representatives, the City of Kent, and the City of Seattle. Some possible uses considered desirable by the Midway Citizens Advisory Committee include open space uses such as a passive park, a sports complex with ball fields, or garden center. Less desirable but potentially possible future uses would be a golf driving range or a park and ride facility. All uses would be designed to protect the integrity of the cap and other containment systems.

Groundwater uses: To the best of Ecology's and the City's knowledge, no one is drinking the groundwater from any aquifer within almost a mile of the landfill, and there are no current plans to use the groundwater near the landfill for drinking water. The closest wells currently in use for drinking water are the Lake Fenwick wells almost 1 mile southeast of the Midway Landfill.

As part of the Midway Landfill Environmental Impact Survey (EIS) in 1985, the City's contractor located private wells within a one-mile radius of the landfill, and public wells within five miles of the landfill by reviewing numerous agency files. Based on this inventory, the contractor sent questionnaires to approximately 90 households near the landfill in order to verify the existence and use of private wells. The list of households was updated during the RI, and several key downgradient wells were re-verified in 1999. Citizens were also questioned at several public meetings and at meetings of the Midway Action Group regarding their knowledge of any wells in neighborhoods surrounding the landfill.

From this information, 31 private wells were identified within a one-mile radius of the landfill. (See Figure 6-1.) Of the 31 wells, nine are in use, 12 are unused, and 10 are inoperable. Of the nine wells, five are used for drinking water, including the Lake Fenwick supply, which services nine homes, and the other four wells are used for irrigation. The five drinking-water wells are all located over 4,600 feet from the landfill, in the Lake Fenwick area. Three of the four irrigation wells are located over 2,000 feet southwest of the landfill (out of the plume path). The fourth irrigation well is located between the groundwater plume and the Lake Fenwick wells.

Monitoring Well MW-30 in the Southern Gravel Aquifer was added in 1988 to act as an early warning location should any measurable contamination from the landfill move toward the irrigation well or toward the Lake Fenwick wells. MW-30 is still monitored, and has



Wells Presently Being Used for Human Drinking Supplies

Wells Not Currently in Use for Human Drinking Supplies

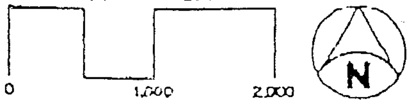


Figure 6-1.
Private and Public Wells Within One Mile of the Midway Landfill

generally remained clean and unimpacted throughout the groundwater monitoring program.

Two other wells were identified within 1,000 feet of the landfill (Well Nos. 37 and 57). Well No. 57 is dry and owned by the City of Kent. Well No. 37, on privately owned property, is unused and covered.

There are three public wells in the Midway Landfill area. Two are operated by the Highline Water District near the two intersections of South 209th Street and 31st Avenue South, and South 208th Street and 12th Avenue South, respectively. These two wells are screened in the second confined aquifer, at over 120 feet below sea level. Both are over two miles north and northwest from the landfill in an area that is up gradient of the landfill, and are completed in aquifers that are not connected to the affected aquifers. The third well is operated by the Kent Water District at South 212th Street and Valley Freeway and is used to satisfy peak summer demands. None of these municipal wells draw water from affected aquifers, and all are more distant from the landfill than are the Lake Fenwick wells.

Finally, neither water district has future plans to develop groundwater supplies from any aquifers within a one-mile radius of the Midway Landfill. The wellhead protection areas delineated by these utilities do not include the Midway Landfill site.

State regulations (WAC 173-160 -171) do not allow any new private drinking water wells within 1000 feet of a solid waste landfill or 100 feet of all other sources or potential sources of contamination, and notice is required to be given to Ecology prior to the construction of any well. However, the NCP is more stringent and requires EPA to consider all groundwater as drinking water except directly under a waste management area. The landfill area with refuse is a waste management area and thus is not considered a future drinking water source by EPA. All other areas downgradient of the landfill are considered to be potential future drinking water sources. However, it is likely that all future developments lie within water district service areas and, therefore, are not likely to rely on private wells for their potable water supply.

7. Summary of Site Risks

7.1 Human Health Risks - Prior to the Work Required by the 1990 Consent Decree.

Before the cleanup work began at the Midway Landfill site in 1985, there were many ways in which humans could have potentially been exposed to unacceptable levels of contaminants. These exposures could have posed acute hazards to residents due to the high levels of methane gas reaching residential basements, and long-term potential risks from solvents in the groundwater if anyone had been drinking the groundwater. The risks from these possible exposures were greater than EPA's and the State of Washington's acceptable risk levels. For example, if a person had been using the groundwater in MW-14B, one of the most contaminated down gradient wells, as their source of domestic water for 30 years, the estimated excess cancer risk from vinyl chloride and 1,2-dichloroethane alone would have been approximately 6 x 10-4. Other possible exposures could have occurred through air emissions or through direct contact with the landfill contents.

The City's contractors prepared an Endangerment Assessment (EA) as part of the 1990 RI/FS for Midway Landfill. Because the RI found little contamination in the surface water, seeps or soil, the EA concluded that the contaminants detected in these environmental media had not migrated from the landfill. The EA also found that there was no direct exposure pathway connecting leachate to either human or ecological receptors. The only potential exposure pathways existed through cross-media pathways: volatilization of contaminants from leachate into landfill gas or discharge of leachate into the groundwater system. The contaminants in landfill gas were found to pose a negligible risk leaving leachate to groundwater as the only migration pathway of concern.

7.2 Current and Future Human Health Risks

A baseline risk assessment that follows current EPA Superfund guidance on risk assessment and that reflects current conditions at the landfill has not been performed on Midway Landfill because the contaminants of concern, migration routes, and the risks to human health and the environment were characterized in the 1990 EA. Based on the success of the containment actions required by the 1990 consent decree, there are likely to be no current unacceptable risks to human health from the landfill because the gas migration has been stopped and no one is currently drinking the groundwater. VOC contamination in the groundwater downgradient of the landfill also appears to be decreasing, at least in the well closest to the landfill. The only remaining contaminants of concern appear to be vinyl chloride, 1,2-dichloroethane, and manganese.

Even though no baseline risk assessment has been done, the potential future risk was estimated. Vinyl chloride is a known human carcinogen and 1,2-dichloroethane is a probable human carcinogen. Manganese is an essential nutrient but is toxic in high quantities. The estimated risk was calculated considering only the maximum 1999 concentrations in Well MW-23B, currently the monitoring well with the highest concentrations of VOCs downgradient of the landfill. This estimate was calculated assuming domestic use of the groundwater for drinking and showering, EPA's reasonable maximum exposure assumptions for 30 years, IRIS or Region 9 PRG table toxicity values, and a conservative assumption that the contaminant concentrations will not change in the future. The excess cancer risk is estimated to be approximately 1 x 10-4 (with vinyl chloride being the primary risk driver) and the HI is estimated to be approximately .3 (with manganese being the primary risk driver), both of which are within EPA's acceptable risk range. This cancer risk level is, however, not within the acceptable risk level under Washington's Model Toxics Control Act, which requires that cumulative excess cancer risk be no greater than 1 x 10-5.

The estimated risk was also calculated for MW-20B, again considering only the maximum 1999 concentrations and using the same assumptions. Well MW-20B is currently the monitoring well with the highest concentration of manganese downgradient of the landfill. The Hazard Quotient for manganese in this well is approximately 6.

These estimated risks are potential future risks only, because there are no drinking water wells within the down gradient plume of the landfill, nor are there any plans to place any drinking wells in this area in the future. (See Section 6.)

7.3 Ecological Risks

No ecological risks to plants or animals are expected now or in the future because there will be no exposure to the contaminants at or from the site. The site is covered and capped with clean material, and the groundwater from the site does not impact any surface water bodies or seeps. Surface water discharging from the site is monitored for conventional pollutants such as pH, dissolved oxygen and turbidity. No hazardous substances are expected to be in the surface water discharge from the landfill because the remedial actions under the 1990 consent decree have eliminated surface water contact with the refuse..

7.4. Basis for Action

While the estimated future risk from drinking groundwater downgradient from Midway Landfill is within the NCP acceptable risk range, there is groundwater contamination above federal drinking water standards, or MCLs, in two monitoring wells east of the landfill and I-5. According to EPA policy, when MCLs are exceeded, action is generally warranted. In addition, state groundwater cleanup levels under MTCA are exceeded. Because drinking this groundwater could result in an imminent and substantial endangerment to human health, remedial action is needed at Midway Landfill.

8. Remedial Action Objectives

Midway Landfill is an example of a site where containment has been successful and has reduced the risks posed by the site. However, the containment measures already in place must be maintained and institutional controls are necessary to ensure continued long-term protection of human health and the environment.

The remedial action objectives of this response action are:

- To ensure containment is effective and working
- To ensure containment will be maintained
- To return groundwater to drinking water standards and state cleanup standards

downgradient of the landfill boundary

- To ensure no residential exposure to groundwater until groundwater cleanup standards have been met

Cleanup Standards

For groundwater that is a potential future source of drinking water, the more stringent of federal drinking water standards (also known as Maximum Contaminant Levels or MCLs) and State of Washington cleanup standards under the Model Toxics Control Act (MTCA) are the cleanup levels. For the groundwater contaminants at this site, the cleanup levels and their basis are shown in Table 1.

Table 8-1. Groundwater Cleanup Standards

Contaminant	Cleanup Level	Basis of the Cleanup Level
1,2-dichloroethane	5 ug/L	Federal Drinking Water Standard (MCL)
vinyl chloride	.02 ug/L*	MTCA Method B.
manganese	2.2 mg/L	MTCA Method B

* Pursuant to WAC 173-340-707(2), Ecology will utilize the practical quantitation limit (PQL) of 0.2 ug/L to determine compliance with this cleanup standard because the cleanup standard is lower than the PQL.

1,2-Dichloroethane and vinyl chloride are solvents. Vinyl chloride can also be formed in groundwater during the natural breakdown of other solvents. Manganese is a natural mineral in soil that dissolves into the groundwater because of the chemistry of the water leaving the landfill.

If other contaminants resulting from releases from the landfill are found in any downgradient monitoring well, cleanup levels, if necessary, will be established for these additional contaminants using the federal drinking water standards and MTCA.

The point of compliance for the groundwater will be at the edge of the landfill waste as specified in a Compliance Monitoring Plan to be approved by Ecology. Under MTCA, this location is considered a "conditional point of compliance." All groundwater downgradient of this point of compliance will need to meet these cleanup levels for contaminants resulting from releases from the landfill before the Midway Landfill is removed from the Superfund National Priorities List.

9. Summary of Remedial Alternatives

Two remedial alternatives were considered for the Midway Landfill site.

No Action Alternative:

Under the No Action alternative, EPA would not require any additional action at the Midway Landfill site. The City of Seattle would still have to fulfill its responsibilities under its 1990 consent decree with Ecology, as well as any other requirements established under state or local regulations for closed landfills. Monitoring could be required under this alternative. EPA would not set cleanup levels nor points of compliance under this alternative.

Limited Action Alternative:

This alternative does not require any significant additional remedial construction because the actions taken by the City of Seattle since 1985 have eliminated or greatly reduced the contaminants leaving the landfill. Instead, this alternative focuses on maintaining and monitoring the constructed containment remedy to ensure it is and will continue to be effective and protective. This alternative would also set groundwater cleanup levels and points of compliance. This approach is consistent with EPA's presumptive remedy for municipal landfills.

The main elements of the limited action alternative are:

1. Monitoring to :

    a) ensure the remedial systems are working as designed,

    b) ensure progress is being made towards meeting the groundwater cleanup standards,

    c) ensure adequate containment is maintained when and if major changes are approved by Ecology in the operation of the site, such as turning off or scaling down the gas collection system, and

    d) demonstrate that the cleanup levels have been achieved.

2. Continuing to operate and maintain all remedial elements required in the 1990 Ecology/City of Seattle consent decree.

3. Implementing institutional controls. Institutional controls are legal or administrative actions that help ensure the long-term protectiveness of the remedy. At this site, the limited action alternative includes three types of institutional controls. The first type of institutional control would be a legal notice the City would place in King County's records, alerting any

future purchaser of the property, in perpetuity, that this property had been used as a landfill and was on EPA's National Priorities List, and that future use of the property is restricted. The second type of institutional control is a requirement that the City ensures continued operation and maintenance of the containment and monitoring systems if ownership of the property should change. Both of these institutional controls are required as part of the 1990 consent decree between Ecology and the City of Seattle, though the legal notice has not yet been placed in the County's records. The third type of institutional control is an annual written notice about the groundwater quality down gradient from the landfill. The City of Seattle would be required to notify the Seattle-King County Department of Public Health, nearby water districts, locally active licensed well drillers and Ecology. As an additional protection, state regulations forbid any private drinking water wells within 1,000 feet of a municipal landfill or within 100 feet from all other sources of potential contamination.

The remedy would also be reviewed no less often than every five years to ensure that the remedial action remains protective of human health and the environment.

10. Comparative Evaluation of Alternatives

EPA evaluated the two alternatives using the nine criteria established in EPA's National Oil and Hazardous Substances Pollution Contingency Plan. The nine criteria are divided into three categories: threshold, balancing, and modifying criteria. To be eligible for selection, an alternative must meet the first two threshold criteria. The next five criteria are the balancing criteria which weigh trade-offs among the alternatives. The last two modifying criteria are considered after the public comment period during the final selection of the remedy.

Overall Protection of Human Health and the Environment

Both alternatives are protective, because the City of Seattle would continue to operate and maintain the cap, and the gas and storm water systems under both alternatives.

Compliance with Applicable or Relevant and Appropriate Requirements

Federal and state drinking water standards and MTCA groundwater cleanup standards are the primary applicable or relevant and appropriate requirements under the Limited Action Alternative. The cleanup standards listed above would need to be met in the downgradient monitoring wells before the remedial action at the Midway Landfill could be considered complete. No cleanup standards would be set by EPA under the No Action Alternative, though Ecology could decide to set cleanup standards separately under MTCA at a later time.

Long-term Effectiveness and Permanence

The Limited Action Alternative has greater long-term effectiveness and permanence than the No Action Alternative because it would require annual notice to water districts and well permit regulators, which would provide slightly greater assurance that no one would drink the groundwater leaving the landfill. It would also clarify the need to adjust monitoring requirements as site conditions change.

Reduction of Toxicity, Mobility and Volume of Contaminants through Treatment
Neither alternative includes any additional treatment. Extracted landfill gas is flared as part of the existing landfill gas collection system.

Short-term Effectiveness
Both alternatives have the same short-term effectiveness. Neither alternative includes construction nor will either alternative affect the time needed for all groundwater leaving the site to meet cleanup standards.

Implementability
Both alternatives are equally implementable.

Cost
The costs for the two alternatives are expected to be very similar. The monitoring costs for the Limited Action Alternative may be slightly higher than the monitoring costs for the No Action Alternative.

State Acceptance
Ecology was consulted on the proposed plan and reviewed this ROD. Ecology concurs with the selected limited action remedy.

Community Acceptance

Four comment letters have been received. Two letters, from the Seattle-King County Department of Public Health and from a local resident, supported the Limited Action Alternative. The second letter, from the City of Des Moines, does not express any opinion about the alternatives, but is concerned about turbidity that may be leaving the landfill cap and discharging into North McSorley Creek. The City of Des Moines asked the City of Kent and the City of Seattle to prepare a storm water pollution plan for turbidity from this outfall, and asked for specific monitoring. The City of Seattle supported the Limited Action Alternative, but requested certain changes and clarifications. A longer summary of these comments and EPA's responses can be found in the attached Responsiveness Summary.

EPA staff also received informal comments through phone calls. In these calls, five members of the public supported the limited action alternative.

11. The Selected Remedy

11.1 Summary of the Rationale for the Selected Remedy

EPA's selected remedy is the Limited Action Alternative. Of the alternatives considered, this alternative will provide the best long-term protectiveness at the Midway Landfill site. It sets groundwater cleanup standards and it ensures long-term operation, maintenance, and monitoring of the containment systems at the Midway Landfill site. It would also clarify the need for, and types of, institutional controls that are necessary to ensure long-term protectiveness of the remedy.

Additionally, this alternative will best ensure long-term protectiveness of the containment remedy currently in place. While EPA believes no new remedial construction (as EPA guidance defines the term) is needed, it is important that the City of Seattle continue to operate and maintain the gas collection system, the cap that was constructed over the landfill, and the storm water collection system. The City also needs to continue to monitor the effectiveness of these actions, and to regularly sample the groundwater until groundwater cleanup standards have been met. The City needs to establish permanent, legally binding, controls on the landfill property to ensure that the cap and containment systems are not damaged as long as the cap and gas and storm water systems are required. The less formal institutional control requirements, in the form of notices to agencies, water districts, and active well drillers, for the off-property groundwater contamination are appropriate for this site considering that the area is fully served by community water systems, no private wells are known to be in use, and the relatively low levels of remaining contamination in the downgradient monitoring wells. Also, groundwater cleanup levels for the groundwater downgradient of the landfill need to be established.

In order for Ecology to utilize this ROD as a Cleanup Action Plan, the cleanup action established through the ROD must meet the MTCA remedy selection requirements of WAC 173-340-360(2) (threshold requirements) and (3) (requirement to utilize permanent solutions to the maximum extent practicable; requirement to provide for a reasonable restoration time frame; requirement to consider concerns raised during public comment.) WAC 173-340-360(13). The threshold requirements for remedy selection are that the remedy shall protect human health and the environment, comply with cleanup standards, comply with applicable state and federal laws, and provide for compliance monitoring. Ecology has determined that the selected remedy, as described in the ROD, satisfies those threshold requirements.

With respect to MTCA's preference for permanent solutions, Ecology has determined that the following remedies for individual components, taken together, are permanent to the maximum extent practicable in that they prevent or minimize the migration of hazardous substances into the environment and provide for a net reduction in the amount of hazardous substances released from the source area. First, with respect to the Midway Landfill refuse itself, Ecology has determined that the isolation and containment remedy of the 1990 consent decree and this ROD is the preferred available cleanup technology. See WAC 173-340-360(9)(c) (describing Ecology's expectations of sites with large volumes of materials with relatively low levels of hazardous substances where treatment is impracticable.) With respect to landfill gas generated by the refuse, Ecology has determined that the treatment of such gas, as specified under the 1990 consent decree and this ROD, constitutes "destruction or detoxification" which is the highest preference cleanup technology under MTCA. With respect to groundwater contaminated by landfill leachate, Ecology has determined that the incremental benefit to be realized from implementing additional remedial engineering measures (e.g. treatment) is substantially and disproportionately outweighed by the cost of such measures. This determination is based upon the facts that: 1) the actions taken by the City of Seattle since 1985 have eliminated or greatly reduced the contaminants leaving the landfill; 2) the levels of contamination that remain in the groundwater are low and trending towards compliance with cleanup standards; and 3) the groundwater does not have any current human or environmental receptors. Therefore, Ecology has determined that institutional controls and monitoring, as required under this ROD, constitute an appropriate remedy for groundwater until cleanup levels are achieved.

With respect to a reasonable restoration time frame, EPA and Ecology agree that the remedial actions implemented have created conditions under which groundwater will achieve compliance with the cleanup standards over time. Based on the results of the groundwater monitoring to date, it is apparent that groundwater down gradient of the landfill is very near compliance with the cleanup standards. Ecology concludes that based on present trends, it is likely that groundwater down gradient of the landfill will reach compliance with cleanup standards in approximately five years. Based upon the facts that institutional controls aimed at preventing the use of contaminated groundwater as a drinking water source are a component of this ROD, that the contaminant levels are already low; and that a documented trend towards compliance exists. Ecology has concluded that this constitutes a reasonable restoration time frame.

Finally, Ecology has determined that the ROD has considered concerns raised during public comment. (See ROD Section 13 and EPA Responsiveness Summary.)

11.2. Detailed Description of the Selected Remedy

The selected remedy consists of:

1. Monitoring to :

    a) ensure the remedial systems are working as designed,

    b) ensure progress is being made towards meeting the groundwater cleanup standards,

    c) ensure adequate containment is maintained when and if major changes are approved by Ecology in the operation of the site, such as turning off or scaling down the gas collection system, and

d) demonstrate that the cleanup levels have been achieved.

The monitoring will be done by the City of Seattle, while Ecology will continue to be the lead cleanup regulatory agency at the site. The details of the monitoring requirements have been set out by the City of Seattle in an Ecology-approved compliance monitoring plan.

Monitoring, including installation of new monitoring wells, are among the activities EPA expects at sites even after EPA determines that construction has been "completed" at a site. Through the procedures outlined in the agreements between Ecology and the City of Seattle, Ecology may require the City of Seattle to install and monitor new monitoring wells if needed.

If necessary, the monitoring program may also address the issue of the source of turbidity in North McSorley Creek raised by the City of Des Moines in their comment letter on the proposed plan. The City of Des Moines requested that the City of Seattle continue to monitor the S. 250th Street outfall for turbidity during storm events (on a periodic basis) and provide the results to the City of Des Moines Engineering Department.

2. Continuing to operate and maintain all remedial elements required in the 1990 consent decree. Ecology will continue to oversee the City's operation and maintenance activities. Operational changes can be approved by Ecology when such changes ensure that the site and remedy will remain protective. The Seattle King County Public Health Department should be given the opportunity to review requested operational changes.

3. Implementing institutional controls. Institutional controls are legal or administrative actions that help ensure the long-term protectiveness of the remedy. At this site, the selected remedy consists of three types of institutional controls. Variations of the first two types of institutional controls are already required in the 1990 consent decree.

First, the City of Seattle will place a notice in the records of real property kept by the King County auditor, alerting any future purchaser of the landfill property, in perpetuity, that this property had been used as a landfill and was on EPA's National Priorities List, and that future use of the property is restricted. The use restriction shall comply with the post-closure use restrictions under the State of Washington's Criteria for Municipal Solid Waste Landfills (WAC 173-351-500(1)(I) and (2)(c)(iii). The City has not yet placed any legal notice in the County's records even though a form of this notice was required by the 1990 consent decree. EPA understands that this is a subject that will be addressed through an amendment to the 1990 consent decree. EPA expects the City to place this notice on the deed within six months of the date of effective date of the consent decree amendment, unless the City has negotiated an alternative enforceable schedule with Ecology.

Second, the City needs to ensure continued operation and maintenance of the containment and monitoring systems if any portion of the property is sold, leased, transferred or otherwise conveyed.. This requirement is an element of the 1990 consent decree.

Third, notices are needed so that no water supply wells are constructed and used in areas with groundwater contamination emanating from the landfill. These notices shall include at a minimum the following:

- The City will annually notify the Seattle-King County Department of Public Health, Ecology, the local water districts (currently, the Kent and Highline Water Districts) and locally active well drillers in writing of groundwater conditions in the affected areas downgradient of the landfill. This notice will include a map showing the location of the affected areas and indicate which aquifers are affected and their elevations. This information shall be updated annually and can be part of an annual groundwater monitoring report. Locally active well drillers are all well drillers that have drilled wells within King County in the year prior to the notice. Ecology will provide the list of locally active well drillers to the City. This requirement for annual notices can be removed or modified by Ecology after groundwater cleanup standards have been met in the groundwater monitoring wells downgradient from the landfill.
- The City of Seattle will also annually notify owner of Well #37 (See figure 6-1) in writing of groundwater conditions in the area of the well. Alternatively, the City of Seattle can provide to Ecology adequate assurances that this well has been properly abandoned.

As an additional protection, state regulations forbid any private drinking water wells within 1,000 feet of a municipal landfill or 100 feet from all other sources or potential sources of contamination (WAC 173-160-171). State regulations (WAC 173-160-151) also requires a property owner, agent of that owner, or a water well operator to notify Ecology of their intent to begin well construction prior to beginning work. This notification can provide notice to Ecology if anyone plans to build a new water well too near Midway Landfill.

Ecology will continue to be the lead regulatory agency overseeing the performance of the selected remedial action by the City of Seattle. However, if necessary, EPA could use its statutory authority to ensure that actions selected by this ROD are implemented.

The groundwater cleanup standards for the current contaminants of concern can be found in Table 8-1. If other contaminants resulting from releases from the landfill are found in any down gradient monitoring well, cleanup levels, if necessary, will be established for these additional contaminants using the federal drinking water standards and MTCA.

The point of compliance for the groundwater will be at the edge of the landfill waste as specified in a Compliance Monitoring Plan to be approved by Ecology. Under MTCA, this location is considered a "conditional point of compliance." All groundwater downgradient of this point of compliance will need to meet these cleanup levels for contaminants resulting from releases from the landfill before the Midway Landfill is removed from the Superfund National Priorities List.

One of the City of Seattle's concerns is that contaminated groundwater is coming into the landfill from up gradient sources, and that this in-coming contaminated groundwater will never allow the groundwater leaving the landfill to meet the groundwater cleanup standards. Because of the major improvements in downgradient water quality in the last ten years, EPA believes it is possible that the groundwater leaving the landfill will eventually meet the groundwater cleanup standards. However, if in the future the City wants to demonstrate that it is technically impracticable for them to meet the cleanup standards at every downgradient well because of the up gradient sources, EPA and Ecology will work together with the City to determine what information is needed to support such a demonstration.

Because the selected remedy will result in hazardous substances remaining on-site above levels that allow for unlimited use and unrestricted exposure, a statutory review will be conducted under CERCLA within five years of this Record of Decision to ensure that the remedy continues to be protective of human health and the environment. Because Ecology is expected to continue to be the lead regulatory agency for this cleanup, EPA would expect Ecology to perform the five year review at this site.

The City of Seattle estimates that the closure costs of Midway Landfill amounted to about $56.5 million as of 1995. This does not include the ancillary costs associated with the landfill such as the "Good Neighbor Policy" (See Section 3.) In recent years, the budgeted and actual operation and maintenance costs have ranged from $432,000 to $535,600 annually. This amount includes monitoring costs.

11.3 Expected Outcomes of the Selected Remedy

This section presents the expected outcomes of the selected remedy in terms of resulting land and groundwater uses.

All future land use at the landfill must be designed and implemented in a manner that will maintain the integrity of the remedy required under the 1990 consent decree. A number of future land uses have been suggested by Midway Citizens Advisory Committee, working with the Cities of Kent and Seattle in 1992. While this selected remedy clarifies the legal notices that need to be in place to ensure the long-term effectiveness of the containment systems, the selected remedy does not place any additional limits on future land use at the Midway Landfill site and does not change the feasibility of the possible future uses suggested by the Advisory Committee.

Groundwater use directly under the landfill will always be restricted. Once the groundwater downgradient from the landfill meets the cleanup standards established in this ROD, nothing in this selected remedy would forbid use of this groundwater for drinking water. The cleanup levels selected in this ROD are either equal to or more stringent than the federal MCLs. However, state and local regulations place other limits on the use of the groundwater. For example, state regulations forbid any new private drinking water wells within 1000 feet of a municipal landfill.

12. Statutory Determinations

12.1 Protection of Human Health and the Environment

The selected remedy will protect human health and the environment by a combination of engineering and institutional controls. The engineering controls that have been constructed at Midway Landfill by the City of Seattle have been effective in containing gas migration and leachate release from the landfill. This effectiveness is demonstrated by the City's gas monitoring results and by the decreasing water levels in and below the landfill and the decreasing concentration of hazardous substances in the groundwater downgradient from the landfill. The selected remedy will ensure long-term protectiveness by requiring that the containment systems remain effective, that monitoring will continue and be adjusted as necessary, and by clarifying and improving the institutional controls associated with the site and the remedy to ensure that no one will be exposed to the contents of the landfill nor to contaminated groundwater. Implementation of the selected remedy will not pose unacceptable short-term risks or cross-media impacts.

12.2 Compliance with Applicable, or Relevant and Appropriate Requirements

The selected remedy for Midway Landfill will comply with all federal and state ARARs. The chemical-, action-, and location-specific ARARs are as follows:

The Washington Model Toxics Control Act (MTCA) Cleanup Regulations (Chapter 173-340 WAC) are applicable. In particular, MTCA is applicable to the determination of the order of preference of cleanup technologies (WAC 173-340-360(4)), to require the provision of a reasonable restoration time frame (WAC 173-340-360(6)), the establishment of groundwater cleanup levels (WAC 173-340-720(3)), selection of the point of compliance (WAC 173-340-720(6)), the determination of attainment of the groundwater cleanup level when the practical quantitation limit is greater than the cleanup level (WAC 173-340-707), and the format of the institutional controls (WAC 173-340-440.)
Certain landfill closure and post-closure requirements in the Washington Criteria for Municipal Solid Waste Landfills (Chapter 173-351 WAC) and in the Washington Minimum Functional Standards for Solid Waste Handling (Chapter 173-304 WAC) are relevant and appropriate. Specifically, the notation on the deed requirement in WAC 173-351-500 (1)(I) and the minimum functional standard for explosive landfill gas in WAC 173-304-460(2)(b) are relevant and appropriate.

The primary federal drinking water standards (40 CFR 141), known as the MCLs, established under the Safe Drinking Water Act, are relevant and appropriate to the establishment of the groundwater cleanup standards downgradient of the landfill.

12.3 Cost-Effectiveness

The costs of the selected remedy are proportional to its overall effectiveness. The costs of this remedy are similar to the costs of the no action alternative, but provide better long term protectiveness.

12.4 Utilize Permanent Solutions and Alternative Treatment Technologies to the Maximum Extent Practicable

The selected remedy utilizes permanent solutions to the maximum extent practical. EPA's presumptive remedy for municipal landfills is containment. Ten years of monitoring data show that the containment remedy has been successful in reducing the risks and exposures from the site. The selected remedy helps ensure that the containment remedy will continue to be protective.

12.5. Preference for Treatment as a Principal Element

The selected remedy at Midway Landfill satisfies the statutory preference for treatment as a principal element of the remedy. Extracted landfill gas is flared as part of the existing landfill gas collection system. During the RI, numerous hazardous substances were found in the extracted landfill gas including vinyl chloride, xylenes, toluene, benzene and other solvents.

12.6 Five year reviews

Because this remedy will result in hazardous substances remaining above levels that allow for unlimited use and unrestricted exposure, a statutory review will be conducted within five years of this Record of Decision to ensure that the remedy continues to be protective of human health and the environment.

13. Documentation of Significant Changes from the Preferred Alternative in the Proposed Plan

There are no significant changes between the preferred alternative described in the proposed plan and the remedy selected in this ROD

The following minor changes have been made from the preferred alternative in the proposed plan:

- An additional RAO has been added to clarify that returning groundwater downgradient of the landfill to drinking water and state cleanup standards is a goal of this remedial action.
- The ROD clarifies that details of the landfill monitoring program have been established by Ecology and the City of Seattle in a compliance monitoring plan. The proposed plan implied that Ecology would establish the details unilaterally.
- The selected remedy includes a minor changes to the institutional control requirements for notification of well drillers. The notice will be provided to well drillers that have been recently active in King County. Ecology will provide the list of locally active well drillers to the City of Seattle.
- The ROD does not contain the statement that Ecology determines when the site meets cleanup levels. The City can contact both Ecology and EPA when the City believes the site has met all of the requirements of this ROD and thus could be considered for deletion from the NPL.
- The remedy selected in this ROD has an added requirement that the City annually notify the owner of one off-property well, unless the City provides Ecology adequate assurances that this well has been properly abandoned.

These changes are a logical outgrowth of the information presented in the proposed plan and in the administrative record.

Table 5-1

Southern Gravel Aquifer, Downgradient Well
Monitoring Well 14B

Report Number	Sampling Date	Chloride (mg/L)	Manganese (mg/L)	1,2 Di-chloroethane (ug/L)	Vinyl Chloride (ug/L)
RI Average		219	4.8	50	4
1	February 1990	280 J	3.9	27	1 U
2	May 1990	175	3.6	1 U	1 U
3	August 1991	180	5	25	1 U
4	January 1991	180	4	31	3
5	April 1991	190	3.6	20	2
6	July 1991	170	4	20	4
7	October 1991	212	2.8	29	3
8	March 1992	22	3.5	19	1 U
9	June 1992	146	3.9	19	4
10	September 1992	201	3.7	16	1 U
11	December 1992	153	3.86	13	2.6
12	April 1993	162	3.49	2.3	1 U
13	June 1993	159	3.38	12	3.1
14	September 1993	168	3.45	10	3.3
15	December 1993	127	3.49	8.8	3.4
16	March 1994	165	344		
17	May 1994	154	3.19	6	1
18	September 1994	140	3.88		
19	December 1994	160	3.06	6 J	1 U
20	March 1995	190	3.3		

21	May 1995	140	3.26	20	2.2
22	September 1995	180	3.22		
23	December 1995	170	3.14	9.2	2.7
24	March 1996	150	3.19		
25	May 1996	180	3.07	6.6	2.5
26	September 1996	170	2.96		
27	December 1996	130	2.8	2.7	2.3
28	March 1997	140	2.58		
29	May 1997	120	2.73	11	2 U
30	September 1997	97	2.57		
31	December 1997	85	2.23	1.3	2.2
32	March 1998	71	1.86		
33	May 1998	51	1.91	1 U	2 U
34	November 1998	29	1.59	1 U	2 U
35	April 1999	27	1.48	1 U	1 U
36	October 1999	37	1.49	1 U	1 U

U = Indicates compound was not detected above the specified reporting limit.
J = Indicates that concentration is an estimate because all QC criteria were not met.

Table 5-2

Southern Gravel Aquifer, Downgradient Well
Monitoring Well 23 B

Report Number	Sampling Date	Chloride (mg/L)	Manganese (mg/L)	1,2 Di-chloroethane (ug/L)	Vinyl Chloride (ug/L)
RI Average		68	0.28	13	5
1	February 1990	140 J	0.37	11	1 U
2	May 1990	50	0.32	14	1 U
3	August 1991	61	0.48	10	1 U
4	January 1991	60	0.41	12	5
5	April 1991	58	0.34	10	4
6	July 1991	50	0.38	13	8
7	October 1991	61	0.35	11	7
8	March 1992	54	0.39	9	6
9	June 1992	51	0.39	12	7
10	September 1992	57.1	0.37	10	1 U
11	December 1992	43.4	0.403	9.4	5.3
12	April 1993	45.9	0.376	11	5.4
13	June 1993	47.1	0.372	8.9	5.6
14	September 1993	46.8	0.372	9.1	3.9
15	December 1993	44.5	0.361	9.3	4.9
16	March 1994	46.4	0.388		
17	May 1994	44.2	0.379	7	5
18	September 1994	43	0.434		
19	December 1994	42	0.35	8.7	1 U

20	March 1995	41	0.343		
21	May 1995	39	0.323	8.1	3.2
22	September 1995	39	0.309		
23	December 1995	40	0.311	7.1	3.5
24	March 1996	40	0.32		
25	May 1996	39	0.302	8.5	3
26	September 1996	40	0.317		
27	December 1996	38	0.304	6.8	2.7
28	March 1997	38	0.287		
29	May 1997	38	0.284	7.7	2.4
30	September 1997	36	0.312		
31	December 1997	35	0.278	9.7	4
32	March 1998	36	0.281		
33	May 1998	36	0.295	7	2.4
34	November 1998	36	0.275	6.6	2
35	April 1999	25	0.259	7.1	1.2
36	October 1999	28	0.258	7.5	2

U = Indicates compound was not detected above the specified reporting limit.
J = Indicates that concentration is an estimate because all QC criteria were not met.

Water Quality in the Sand Aquifer

Up Gradient Monitoring Wells

	Recent concentrations	MCL
MW 17-B		
1,1-dichloroethane	90 to 160 ug/L	800 ug/L*
1,1-dichloroethene	4.8 to 8.2 ug/L	7 ug/L
1,2-dichloroethane	8 to 12 ug/L	5 ug/L
MW 21-A		
1,1-dichloroethane	11 to 14 ug/L	800 ug/L*
1,1-dichloroethene	1.6 to 2.6 ug/L	7 ug/L
tetrachloroethene	24 to 35 ug/L	5 ug/L
trichloroethene	2.4 to 3.1 ug/L	5 ug/L

* 1,1-dichloroethane has no MCL. 800 ug/L is the MTCA Method B cleanup level in the 2/96 CLARC II table.

APPENDIX A
RESPONSIVENESS SUMMARY

MIDWAY LANDFILL

The responsiveness summary addresses public comments on the proposed plan for the remedial action under CERCLA for Midway Landfill NPL site in Kent, Washington. EPA's proposed plan was issued in May 2000 and the original public comment period ran from May 18 to June 16, 2000. The City of Seattle asked for an extension of the comment period on June 15, and the end of the public comment period was extended 30 days until July 17, 2000.

EPA's notices and fact sheets offered to hold a public meeting if sufficient interest was expressed by May 31, 2000. Only four requests were received and thus a public meeting was not held.

Written comments

Four written comment letters were received.

Comment: I received your fact sheet about the Midway Landfill in Kent Washington and I'm writing this letter to recommend that EPA implement their Limited Action Plan. Monitoring wells 23B and 29B are in a neighborhood and a church parking lot and should be monitored until signs of contamination no longer exist.

Response: Thank you for your comment and your support of EPA's preferred alternative.

Comment: The City of Des Moines has just completed a 5 year stream water quality monitoring program, which included the monitoring of McSorley Creek, the receiving stream of the runoff from Midway Landfill. The monitoring of the drainage outfall showed elevated levels of turbidity above water quality standards for a Class AA stream. McSorley Creek is a salmon-bearing stream containing coho and chum salmon, steelhead and cutthroat trout.

Although not conclusive, mainly because the treatment ponds on the Landfill also receive runoff from nearby Pacific Highway South, the turbidity may be the result of runoff from the Landfill clay cap. In order to fully remedy the situation, the City of Des Moines believes that the City of Seattle and the City of Kent, the owner of the Pacific Highway right-of-way in this area, need to jointly prepare a storm water pollution control plan for controlling the turbidity coming from this outfall. The City would like to have the opportunity to review such a plan.

The City of Des Moines also requests that, as part of EPA's monitoring proposal, Seattle continue to monitor the outfall for turbidity during storm events (on a periodic basis) and provide the results of the tests to the City of Des Moines Engineering Department.

Response: EPA forwarded a copy of the City of Des Moines's letter to the City of Seattle and to Ecology. In response, the City of Seattle has begun discussions with both the City of Des Moines and the City of Kent to address the turbidity issue. The City of Seattle has sent the City of Des Moines all of the 1999 storm water detention pond monitoring data. This data, as well as the earlier years of data, appear to indicate that the main source of turbidity is the pond inflow from Pacific Highway South. Also, the City of Kent has now started to identify the City of Kent's options regarding requiring the private property owners to improve the quality of water discharged from their site.

EPA's description of the selected remedy (Section 11.2) acknowledges your request for additional monitoring. Details of the monitoring program will be established by Ecology and the City under their existing agreements, or, if necessary, unilaterally by Ecology using state regulatory authority.

Comment: Public Health-Seattle & King County supports EPA's limited action alternative. Outstanding groundwater issues in proximity to the landfill need to be addressed in order to protect both the environment and the public health of the impacted community.

Response: Thank you for your comment and your support of EPA's preferred alternative.

Comment: The City of Seattle supports the "limited action remedy" alternative proposed in the plan for the ROD.

Response: Thank you for your support of the limited action alternative.

Comment: The City has reached a tentative agreement with the Washington Department of Ecology ("Ecology") concerning this issue: Ecology will adopt the EPA ROD in its entirety, and the existing Consent Decree ("CD") between Ecology and the City will be formally amended to reflect EPA's limited action remedy. Thus, Ecology will not issue a Cleanup Action Plan ("CAP") for the Midway Landfill, since the ROD will serve that same purpose.

The City is pleased to announce this approach with Ecology because it will save both the City and Ecology the staff and budget resources necessary to issue and implement a separate CAP.

Response: When EPA was writing the proposed plan, Ecology had tentatively decided that Ecology would prepare a Cleanup Action Plan under MTCA. In accordance with EPA's understanding of Ecology's current position, the ROD has been changed to reflect the fact that after this ROD is completed, Ecology will use this EPA ROD, as allowed under MTCA. EPA has worked with Ecology to incorporate language into this ROD to reflect the necessary

MTCA requirements.

Comment: Proposed Plan page 1 – delete "Additional groundwater wells may need to be installed." The City has been monitoring groundwater through an existing network described in the CMP. It is the City's understanding that Ecology will review and approve the CMP, which sets forth the well network and monitoring schedule, as previously submitted. There is neither a pending requirement nor a technical justification for additional wells beyond the network in the submitted CMP.

Response: The details of the monitoring requirements have been set out by the City of Seattle in a compliance monitoring plan recently approved by Ecology. Through the procedures outlined in the agreements between Ecology and the City of Seattle, Ecology may require the City of Seattle to install and monitor new monitoring wells if needed.

Comment: Proposed Plan, page 2 – the last paragraph needs to be re-written to reflect that Ecology will adopt the ROD and will not issue a CAP.

Response: Please see EPA's response to the City's second comment, above.

Comment: Proposed plan, page 5 – add the word "final" to the first paragraph. The edited sentence will read: "This legal agreement set forth Ecology's determination that certain *final* remedial actions…." This edit reflects the wording of the existing CD that the remedial actions performed under the CD were final actions and not interim actions.

Response: The referenced sentence from the proposed plan has not been repeated in the ROD. A sentence that begins with the same phrase can be found in Section 2.1, but concludes with Ecology's determination that undertaking certain remedial actions would provide immediate protection to public health and the environment. This determination can be found in Paragraph 6, Page 9 of the 1990 Consent Decree.

Comment: Proposed plan, page 5 – re-write the paragraph above "Site Characteristics" to state that Ecology will amend the CD and adopt the ROD in its entirety, including the limited action remedy, which addresses long-term monitoring through the CMP.

Response: As a result of discussions and reviews between the time of the proposed plan and EPA's completion of the ROD, Ecology has decided to utilize the ROD as a Cleanup Action Plan pursuant to MTCA, and to approve the CMP. The ROD reflects these recent Ecology decisions.

Comment: Proposed plan, page 7 – third full paragraph from the top of the page. Delete "most likely" from the first sentence. Based on the voluminous technical data, groundwater contamination in the Sand Aquifer to the north, northwest and west of the landfill does not come from the landfill. The present sentence is inaccurate.

Response: The phrase has been removed from the Summary of Landfill Conditions in Section 5.1.

Comment: Proposed plan, page 9 – Table 1. Proposed Groundwater Cleanup Standards. These proposed standards are acceptable to the City, with the exception of vinyl chloride. It is the City's understanding that Ecology will agree to use the practical quantification limit (PQL) for vinyl chloride as allowed by previously published Ecology directive.

Response: The concentration for determining compliance with the vinyl chloride cleanup level is 0.2 ug/L and has not changed from the proposed plan. This concentration reflects Ecology's consideration of the PQL issues for vinyl chloride, consistent with WAC 173-340-707 and the Department of Ecology's Implementation Memo No. 3, November 24, 1993.

Comment: Proposed plan, page 10 – the full paragraph under "#1 Monitor to." Delete this first sentence: "The monitoring will be done…." and insert a sentence that states that monitoring will be done pursuant to the CMP approved by Ecology.

Response: This sentence has been modified. The selected remedy reflects the City of Seattle and Ecology recent agreement on the details of the monitoring plan.

Comment: Proposed plan, page 11 – this sentence describing the third type of institutional control needs to be edited: The reference to notifying "local licensed well drillers" should be deleted because Ecology has dropped this requirement. Further, the City proposes satisfying the notification requirement to the health department and nearby water districts by sending them the annual groundwater monitoring reports. This paragraph should state this as well.

Response: Ecology has not dropped the requirement that local licensed well drillers be notified. However, this element of the selected remedy has been changed in two ways. First, the notice requirement has been re-focused to limit the notice to those licensed well drillers who have drilled wells in King County in the year just prior to the notice. This change reflects the competitive state-wide nature of the well drilling business while not requiring notices to drillers that may no longer be active. Second, Ecology will provide the list of names and addresses to the City of Seattle. Ecology's Office of Water Resources maintains a database that can provide this information.

The selected remedy allows the City to satisfy the notification requirements through distribution of the annual groundwater monitoring report, as long as the report contains the required information.

Comment: Proposed plan, page 12 – "State Acceptance" This sentence should be edited to reflect that Ecology intends to accept the limited action remedy and adopt the ROD in its entirety.

Response: The ROD now says that Ecology concurs with the selected remedy and that Ecology has decided to utilize the ROD as a Cleanup Action Plan pursuant to WAC 173-340-360(13).

Comment: Proposed plan, page 13 – delete the last two sentences of the last paragraph, which begin: "For example, Ecology believes it may be necessary to identify…." As discussed above, it is the City's understanding that Ecology will approve the previously submitted CMP. This CMP sets out the scope of the City's groundwater monitoring obligation under the CD and amended CD. The CMP does not address groundwater entering the landfill from off-site sources located on the north and northwest of the landfill.

Response: The two sentences have been deleted from the description of the selected remedy. The intent of the sentences was to provide an example of the type of information that may be necessary if the City of Seattle wishes to demonstrate it is technically impracticable to meet the cleanup standards at every down gradient well because of the up gradient sources. If in the future the city would want to make a demonstration that it is technically impracticable to meet the cleanup standards, it is possible that EPA and Ecology would require monitoring that is not part of a monitoring plan already approved by Ecology. As stated in the ROD, in this situation, EPA and Ecology would work together with the City of Seattle to determine what information would be needed to support such a demonstration.

Exhibit C
to
Amendment No. 1 to Consent Decree
(Midway Landfill Site)

Midway Landfill Operation and Maintenance Manual
December 1992

SEA MID 1992 08

EXHIBIT C

MIDWAY LANDFILL

OPERATIONS AND MAINTENANCE MANUAL

Prepared for:

SEATTLE ENGINEERING DEPARTMENT
Solid Waste Utility

Prepared by:

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Prepared by: ______________________

Checked by: ______________________

Approved by: ______________________
Project Manager

PMX # 21-1550-15
December 1992

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LIST OF TABLES

1. INTRODUCTION

1.1 USE OF THE MANUAL

This manual provides specific information for the operation of the Midway Landfill Closure Facilities and serves as a guide for attaining the most efficient and economical operation and maintenance of these facilities. It also serves as a base document for operator training and as a reference source for additional information.

This manual should be used as a working reference book. When information is needed, it can be found by looking in the Table of Contents at the front of this manual. It is very important to note all future plan modifications in this manual. The facilities operator should add pages or sections to the manual as operating and maintenance procedures are refined and as new information is learned.

The use of figures in this manual will be very helpful in understanding operation procedures. To effectively understand and use these figures, the reader should be familiar with the Valve and Well Labeling System and Indices.

1.2 MANAGEMENT AND OPERATOR RESPONSIBILITIES

1.2.1 Management Responsibilities

The management's responsibility is to insure that facilities constructed for closure of the Midway Landfill are operated in accordance with established regulatory requirements. The general purposes of the landfill closure are:

- To protect groundwater quality by minimizing surface water infiltration into the landfill,
- To protect public health by controlling the migration and discharge of landfill gases from the landfill site,
- To create a land use compatible with surrounding uses and an aesthetically pleasing appearance.

It is the responsibility of the management to provide adequate financing for both operation and maintenance of the facilities. The management should also employ competent operating staff and insure that they receive proper training and an opportunity to keep abreast of current operational techniques, environmental policies, and regulatory requirements. The management should provide the operating staff with necessary direction and leadership.

Specifically, management responsibilities include:

- Maintain efficient operation and maintenance of the facilities.
- Maintain adequate landfill closure, operation and maintenance records.
- Establish staff requirements, prepare job descriptions, develop organization charts and assign personnel.
- Provide operational personnel with sufficient funds to properly operate and maintain the facilities.
- Provide good working conditions, safety equipment and proper tools for the operational personnel.
- Establish a harmonious relationship with operational personnel.

1.2.2 Landfill Operator Responsibilities

All aspects of the operation and maintenance of the landfill closure facilities are the responsibility of the operator. In order for the facilities to function effectively and efficiently, the operator must be concerned with a rigorous maintenance program, a program for good recordkeeping, financial management and public relations concerning the landfill.

The following are the major responsibilities of each operator:

- Know all proper operation procedures as outlined in this manual.
- Comply with all appropriate permits and regulatory requirements regarding the Landfill Closure.
- Be familiar with federal and state requirements and the forms that must be completed and submitted on the operation of the landfill closure facilities.
- Maintain neat and accurate operation and maintenance records.
- Keep the management advised of potential problems of a serious nature.
- Assist management in preparing an adequate budget for the operation and maintenance of the facilities.
- Know the capabilities and limitations of the facilities and how to best operate the facilities as conditions change.

1.3 DESCRIPTION OF FACILITIES

1.3.1 Site Background

The City of Seattle Engineering Department, Solid Waste Utility, leased the 60-acre Midway Landfill site from Midway Sand & Gravel, Inc. and operated it as a landfill from 1966 to 1983. The site is currently owned by the City of Seattle.

The Midway Landfill is in South King County in the City of Kent, directly east of the City of Des Moines. Puget Sound is slightly more than a mile to the west. Residential areas surround the site, with the exception of a commercial strip along Highway 99 to the west. Two elementary schools and a community college are within 1 mile of the site. Interstate 5 (I-5) borders the site on the east. Approximately 1 mile east of I-5 is the Green River, which meanders north, becomes the Duwamish River, and enters Puget Sound (see Figure 1-1).

From 1945 to 1966, the site was operated as a gravel pit. The pit originally was adjacent to a peat bog lake, Lake Meade, located northeast of the center of the present landfill. As the pit was mined, water was drawn from the lake to wash silt and clay from the gravel and sand, then the water was returned to the lake. Silt and clay built up on the lake bottom. Near the end of the operation of the gravel mine the barrier between the lake and the gravel pit was broken, allowing the silty lake water to flow into the gravel pit. As a result, a clay/silt layer underlies much, but not all, of the landfill.

In January 1966, the City of Seattle leased the site and began using it as a landfill for nonputrescible waste. Nonputrescible waste includes organic material that decomposes more slowly, such as demolition debris and wood wastes. The landfill received demolition debris from commercial haulers and wood wastes and yard trimmings from the City's transfer stations. Records beginning in 1980 indicate that some low levels of industrial wastes also were deposited after passing a state-mandated screening and approval program administered by the Seattle-King County Health Department. Information included in the United States Environmental Protection Agency's (EPA) Emergency and Remedial Response Information System (ERRIS) files indicates that the landfill may have received industrial liquid and sludge wastes before 1980. The landfill was closed in October 1983.

During the course of operations at the landfill, an estimated 3 million cubic yards of solid waste were deposited. This waste covers approximately 40 acres and is up to about 130 feet deep in places. Solid waste gradually filled in first the northern, then the southern, part of the site. The east side of the landfill rises above the adjacent property; the landfill surface slopes downward to the northwest corner. The entire site was covered with a variable layer of soil when operations ceased.

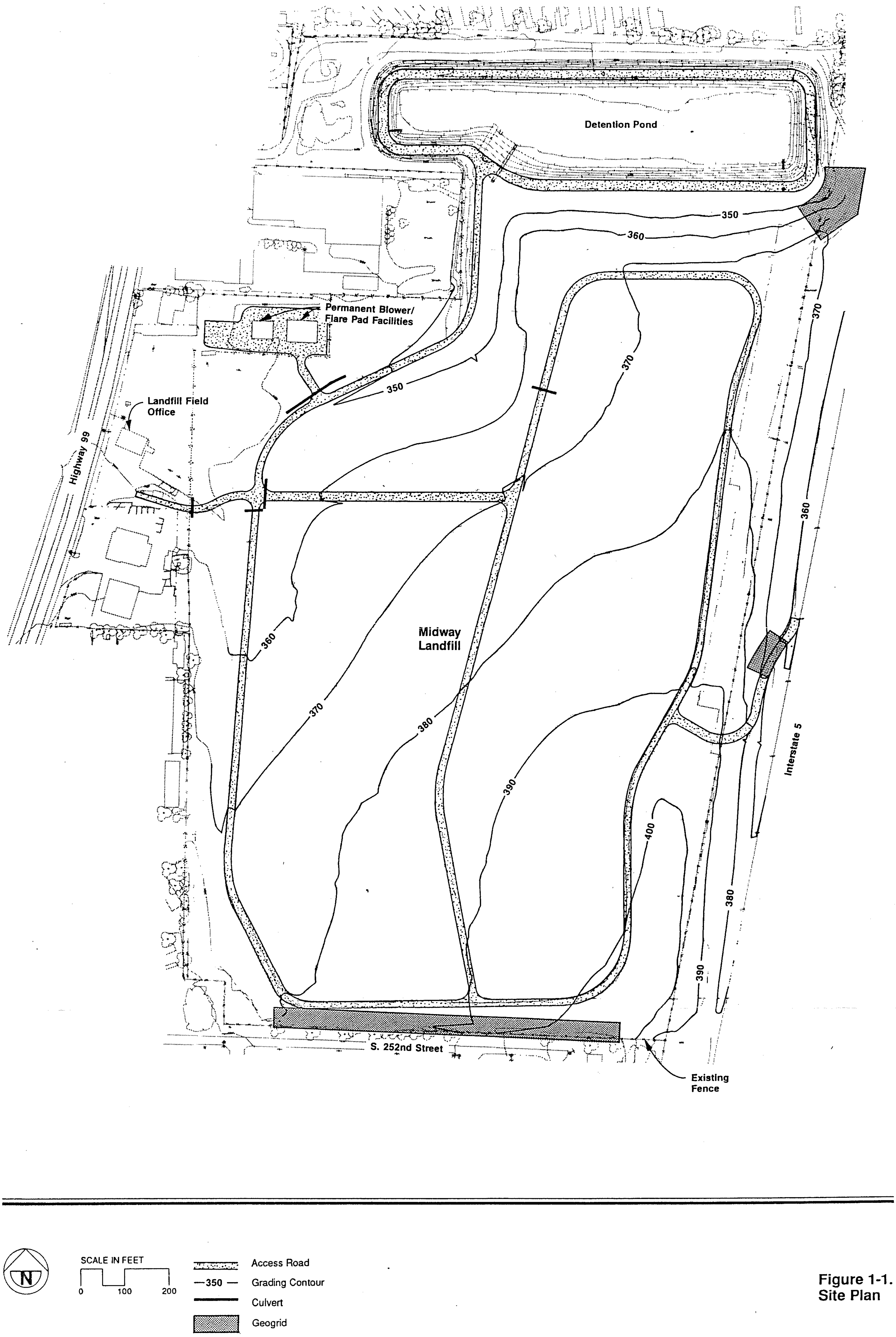


Figure 1-1.
Site Plan

1.3.2 Closure Improvements

The facilities and improvements constructed as part of the Midway Landfill Closure can be separated into ten components or systems:

- On-site Drainage and Detention Pond
- Stormwater Pipeline System
- Dewatering Pump Station
- I-5 Pump Station
- Landfill Final Cover System
- Performance Monitoring System
- Landfill Site Improvements
- Landfill Well Field
- Flare Facility
- Utilities and Support System

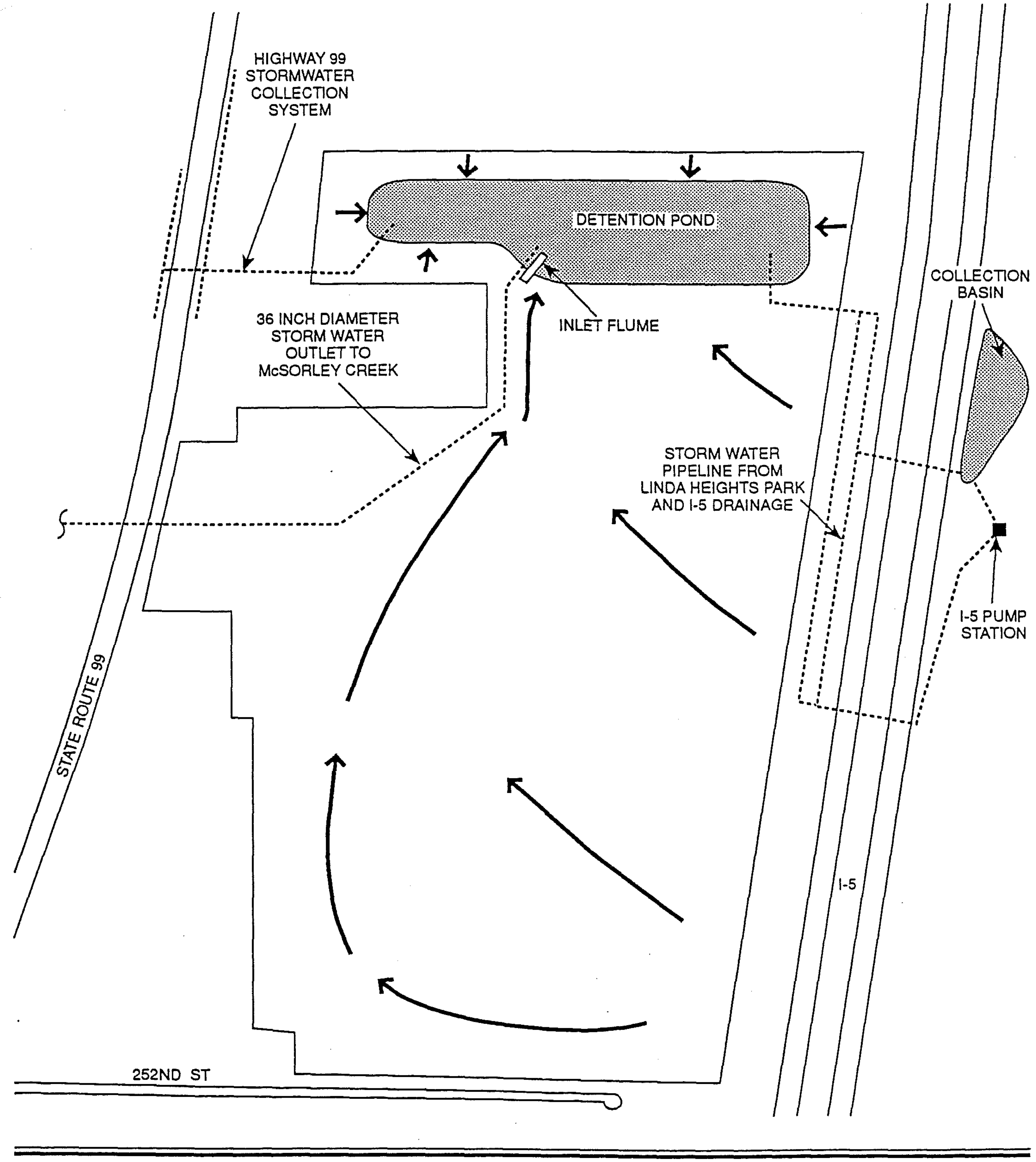
Brief descriptions of these components, their purpose, and their use follow. More thorough discussions of each system can be found in the referenced chapters of this manual.

1.3.3 On-Site Drainage and Detention Pond

Surface water runoff from the landfill site is collected by a network of drainage ditches and structures located along the landfill cover system (Figure 1-2). The ditches route the collected runoff to a detention pond located at the northern end of the site. The detention pond has been constructed with a flexible membrane liner system that prevents stormwater from infiltrating into the adjoining landfill. The liner system consists of 60 millimeter high density polyethylene (HDPE) sheeting, drainage net, and filter fabric. The detention pond outlet control structure regulates the quantity of stormwater discharged from the pond thereby minimizing impacts to downstream receiving waters and complying with regulatory discharge requirements. See Chapter 8 for a detailed description of the surface water drainage and detention pond.

1.3.4 Stormwater Pipeline System

Several stormwater pipeline systems are used to collect and convey the surface water collected from off-site sources to the on-site detention pond, and to discharge stormwater from the site (Figure 1-3). The collection pipelines convey runoff water collected along Highway 99 west of the landfill site, and the Linda Heights Park area located east of I-5. The discharge pipeline conveys released stormwater from the detention pond to a discharge outlet structure located west of the landfill site at the north fork of McSorley Creek. See Chapter 8 for a detailed description of the stormwater pipeline systems.



NOT TO SCALE — Generalized Surface Water Flow Patterns

Figure 1-2. Midway Landfill Drainage System

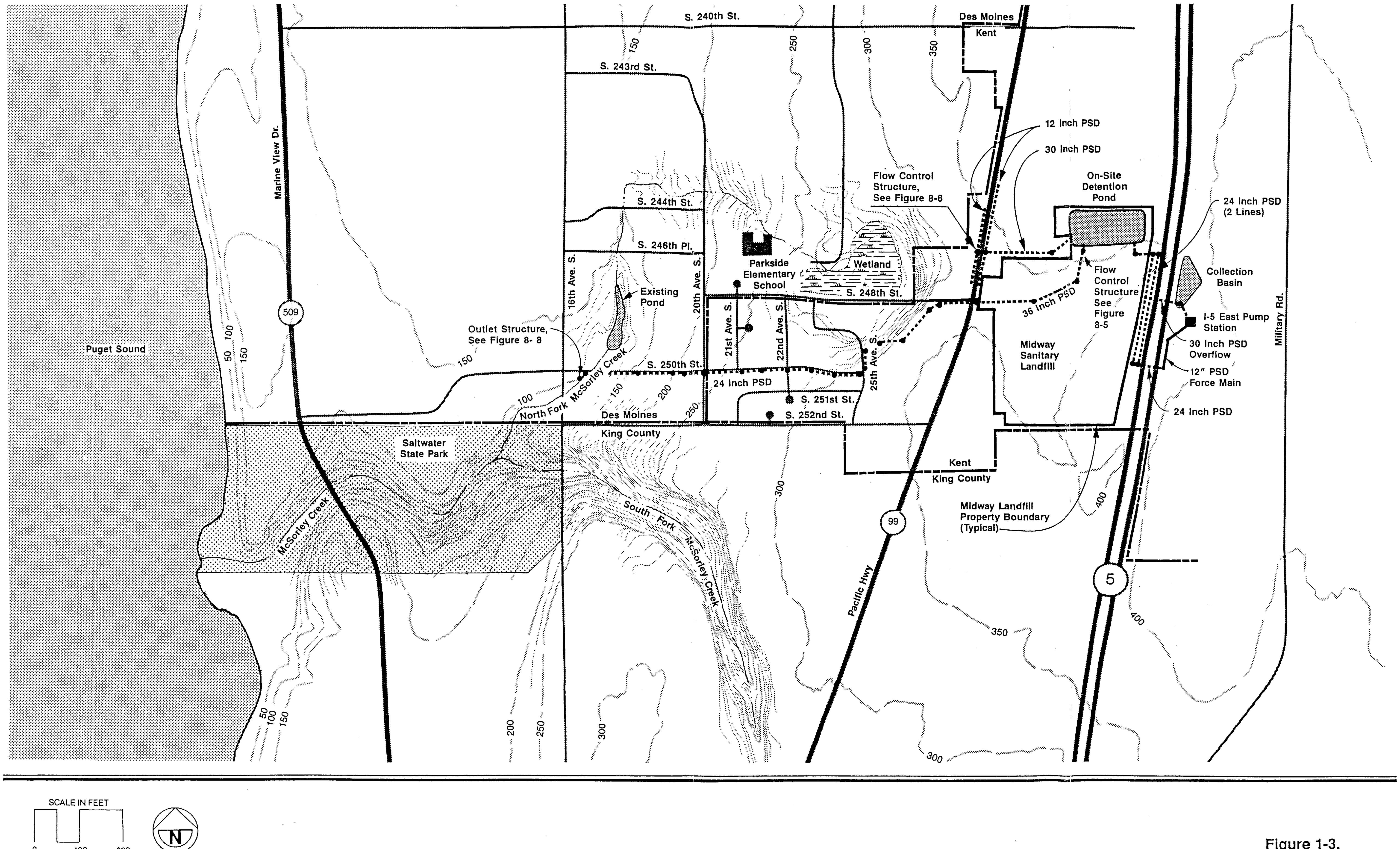


Figure 1-3.
Discharge Pipeline

1.3.5 Dewatering Pump Station

A dewatering pump station has been installed along the northern edge of the detention pond. The purpose of this pump station is to collect and discharge groundwater which has been removed by a gravity extraction system from beneath the detention pond's liner system (see Figure 1-1). The pump station consists of duel submersible pumps which operate as the water level within the pump station wet well increases. Water discharged by the pumps passes through a flow monitoring station where flow quantities are recorded prior to being discharged into the Midway Sewer District sewer system. See Chapter 9 for a detailed description of the dewatering pump station.

1.3.6 I-5 Pump Station

Surface water from the Linda Heights area located east of I-5 is collected in a natural low lying area located between Linda Heights Park and the freeway. The I-5 pump station located adjacent to this basin pumps stormwater to a pipeline system, where it is conveyed and discharged into the landfill detention pond. The I-5 pump station consists of four pumps that operate as flows within the pump station wet well increase. See Chapter 10 for a detailed description of this pump station.

1.3.7 Landfill Final Cover System

The landfill site is covered by a final cover system. The final cover consists of a combination of natural and synthetic membrane liner materials which serve to restrict the infiltration of surface runoff water through the landfill surface, reducing the potential for leachate generation. Rather than infiltrating the landfill surface, surface water flows overland and is collected by the on-site drainage improvements which remove it from the landfill site. Any surface water which may infiltrate the upper zones of the cover system is later collected within a series of subsurface collection pipelines and is subsequently discharged into the drainage system. See Chapter 12 for a detailed description of the landfill final cover system.

1.3.8 Performance Monitoring System

To monitor the performance of the landfill closure improvements monitoring systems have been established on and adjacent to the landfill. Gas probes have been installed to detect the presence of landfill gas beyond the boundaries of the landfill site and to monitor the performance of the 88 gas extraction wells that comprise the Midway Landfill well field operations. Groundwater monitoring wells have been installed to detect presence of any groundwater contamination caused by leachate from buried refuse. See Chapter 13 for a detailed description of the performance monitoring system.

1.3.9 Landfill Site Improvements

Landfill site improvements have been constructed in conjunction with the landfill closure. These site improvements include access roads, security gates and fences, as well as landscaping. Site improvements provide functional access to the site while aesthetically improving its appearance. See Chapter 12 for more details on landfill site improvements.

1.3.10 Landfill Well Field

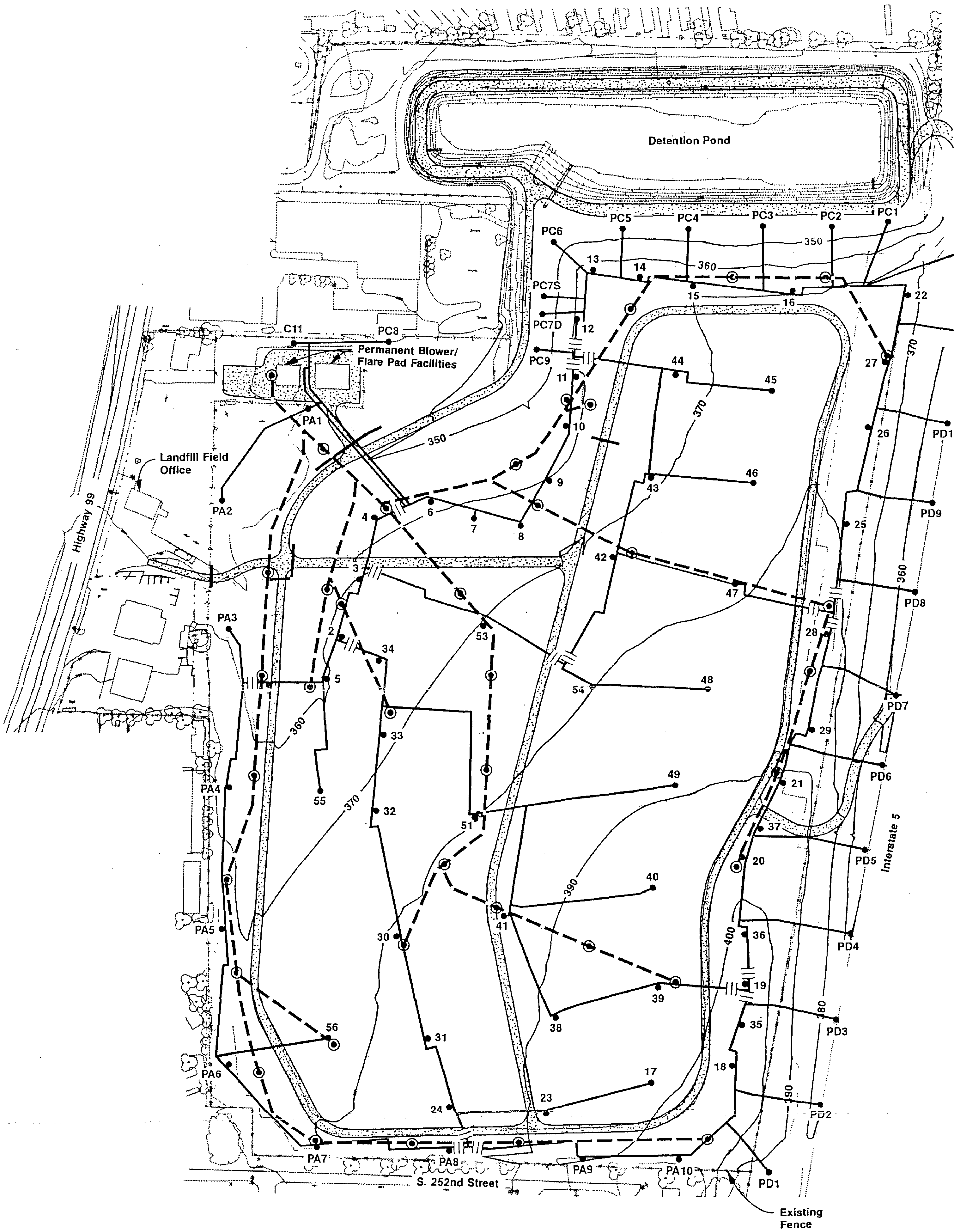
The Midway Landfill well field consists of 88 gas extraction wells used to remove landfill gas from the site (Figure 1-4). Fifty-six of these wells penetrate the buried refuse within the landfill while 31 wells are installed in native soils surrounding the landfill perimeter. Each well is connected to a vacuum manifold located along the site perimeter. The vacuum manifold collects and conveys the landfill gas under negative pressure to the motor blower/flare facility, where the landfill gases are combusted. See Chapter 14 for a detailed description of the landfill well field.

1.3.11 Motor Blower/Flare Facility

A permanent motor blower/flare facility has been installed in the northwest corner of the landfill site (see Figure 1-4). This facility generates the vacuum (negative) pressure needed to extract landfill gas from the well field. Gas is sent through the motor blower/flare facility where the condensate is removed. Next, the gas is passed through flares that combusts the gas and release emissions into the atmosphere. Combustion temperatures and emission quality are closely monitored during this process to assure compliance with regulatory requirements. See Chapter 15 for a complete description of the facility.

1.3.12 Utilities and Support Systems

Closure improvements and equipment facilities are supported by utilities and other support systems located adjacent to the landfill site and in off-site facilities. Electrical power service operates the pump stations and the motor blower/flare facility. Water service is also provided at the motor blower/flare facility and the I-5 pump station, while condensate from the flare facility and groundwater from the dewatering system are disposed of by the sanitary sewer service.



Access Road	Butterfly Valve
—350— Grading Contour	Landfill Gas Collection Pipe
Culvert	Condensate Collection Pipe
	Migration Control Wells
	Condensate Collection Pipe Cleanout

N

SCALE IN FEET

0 100 200

**Figure 1-4.
Location of On-Site
Migration Control Wells
and Vacuum Manifold**

OPERATOR NOTES AND COMMENTS

2. ADMINISTRATION

(Not submitted at this time.)

3. PERMITS AND STANDARDS

3.1 INTRODUCTION

The City of Seattle must obtain and comply with permits and requirements set forth by several agencies and municipalities with jurisdiction over the final closure and subsequent operation of the Midway Landfill. Specifically, the Washington State Department of Ecology (Ecology), City of Kent, Department of Transportation (WSDOT) and the Puget Sound Air Pollution Control Agency (PSAPCA) have direct jurisdiction over the Midway Landfill. The City must also comply with Washington State Water Quality Standards and Washington State Minimum Functional Standards For Waste Handling (MFS).

Those aspects of these permits and standards of direct concern to the landfill operations personnel are discussed in the following paragraphs. Failure to comply to these requirements can result in large fines to the City and possible legal actions.

3.2 PERMITS

3.2.1 Ecology Stormwater Discharge Agreement/NPDES Permit

In 1987, the City of Seattle applied to Ecology for an National Pollution Discharge Elimination System (NPDES) permit for stormwater discharge from the Midway Landfill. At that time, Ecology indicated that an NPDES permit was not required. However, Ecology and the City negotiated acceptable discharge parameters for stormwater discharges. Stormwater is collected in the landfill detention pond and discharged into McSorley Creek.

The stormwater discharge agreement details the operations and testing requirements for the detention pond and subsequent discharge to McSorley Creek. In addition, the agreement lists minimum water quality standards that the stormwater must meet prior to discharge (Table 3-1). The operations requirements of the agreement are included in Chapter 8 of this manual. The water quality testing procedures are detailed in Chapter 11. The minimum water quality standards for the stormwater discharged into McSorley Creek are listed below in Table 3-1.

Table 3-1 Water Quality Parameters For Normal Stormwater Discharge to McSorley Creek (Interim Discharge Agreement)

Field Measurement	Acceptable Level For Discharge
Temperature	$< 18°C$
pH	> 6.5 and < 8.5
Dissolved oxygen	> 8.0 mg/ℓ
Turbidity	< 29 NTU or $<$ background + 5 NTU
Conductivity	< 400 µmhos/cm

It now appears that an NPDES permit for discharges from the pond may be required under Part 122 of the Clean Water Act. The City will work with Ecology to determine if the permit is indeed required and to negotiate the appropriate discharge standards.

3.2.2 City of Kent, City of Des Moines and King County

The City has several of permits with Kent, Des Moines, King County and private landowners authorizing the installation of:

- Groundwater Monitoring Wells
- Gas Monitoring Probes
- Temporary Gas Extraction Wells
- Surface Water Drainage Pipeline and Outfall Structure Easements

These permits are in several forms:

- Street Use Permits
- Right of Way Permits
- Temporary Use Permits
- Property Easements
- Quit Claims
- Consent For Access Permits
- Easements

3.2.3 DOT Franchise Permit

The City has permits with the Washington State Department of Transportation for the installation and operation of several monitoring wells and extraction wells along the I-5 right of way.

3.2.4 PSAPCA Permits

The City has two current permits with the PSAPCA:

- Permit 2757 – For the Construction and Operation of Off-Site Gas Control Wells.
- Permit 3125 – For the Construction and Operation of the Permanent Blower/Flare Facility.

The PSAPCA permits include the conditions and operations/testing requirements for the control wells and permanent flare system.

3.3 CITY REGULATIONS AND OPERATING PROCEDURES

Several City of Seattle regulations and procedures affect operations at the Midway Landfill. Foremost are the health and safety procedures detailed under the *Midway Landfill Site Safety Plan*. All other applicable regulations and procedures pertaining to landfill operations are available at the downtown office of the Seattle Engineering Department or at the Seattle City Hall.

3.4 WASHINGTON STATE WATER QUALITY STANDARDS

Ecology established water quality standards for all surface and ground waters of the state in 1977 under Washington Administrative Code (WAC) 173-201 and WAC 248-54. All surface waters have been classified within the following five designations:

- Class AA Extraordinary
- Class A Excellent
- Class B Good
- Class C Fair
- Lake Class

At the outfall from the Midway Landfill surface water detention pond system, McSorley Creek is classified as Class A. Water use standards and water quality criteria for Class A waters appear on pages four and five of the Water Quality Standards for the State of Washington.

3.5 WASHINGTON STATE MINIMAL FUNCTIONAL STANDARDS

The regulations relating to the MFS for solid waste handling are under the authority of 70.95, of the Revised Code of Washington (RCW), WAC 173-304. Following is an overview of the more applicable standards for the closure and subsequent operation of the Midway Landfill:

- WAC 173-304-407 defines closure and post-closure requirements for:
  - Effective dates
  - Closure performance standard
  - Closure plan and amendments
  - Closure procedures
  - Post-closure performance standard
  - Post-closure plan and amendments
  - Post-closure procedures

- WAC 173-304-9901 defines maximum contaminant level for groundwater:
  - Maximum groundwater contaminant levels specified under WAC 248-54 (primary drinking water standards).
  - Analytical methods as specified under 40 CFR Part 141.

The above described minimum functional standards are those that most directly apply to operations at the Midway Landfill. A copy of the most current Washington State Minimum Functional Standards for waste handling appears in Appendix M and should be used for reference.

3.6 REPORTING REQUIREMENTS FOR NONCOMPLIANCE CONDITIONS

3.6.1 Surface Water

Ecology and the Midway Sewer District should be informed if the surface water samples do not meet the required standards. See Section 7.4.7 for the procedure on handling a surface water contamination problem.

3.6.2 Air Discharge

If operational requirements for the permanent flares are not met, the PSAPCA should be notified at (206) 343-8800. Depending on the operational data, PSAPCA will advise the City as to the required corrective measures.

OPERATOR NOTES AND COMMENTS

4. ENVIRONMENTAL MONITORING

4.1 DESCRIPTION

Environmental monitoring is required under the construction and operating permits issued for the Midway Landfill final closure actions. Environmental monitoring is also necessary to effectively operate the landfill gas extraction system and to accurately gauge the effects of final closure operations on the protection of the environment and human health. This chapter discusses the measures currently being taken to monitor the final closure actions. Additional monitoring may be necessary when the Washington State Department of Ecology (Ecology) finalizes the Cleanup Action Plan (CAP) for the Midway Landfill.

4.2 MONITORING REQUIREMENTS

4.2.1 Landfill Gas and Flare Emissions

The PSAPCA permits require that the inlet and outlet gas streams at the flares be monitored annually for the first five years of operation. The monitoring frequency may be reduced after two or three years, depending on the monitoring results. The gas streams are monitored for the following parameters:

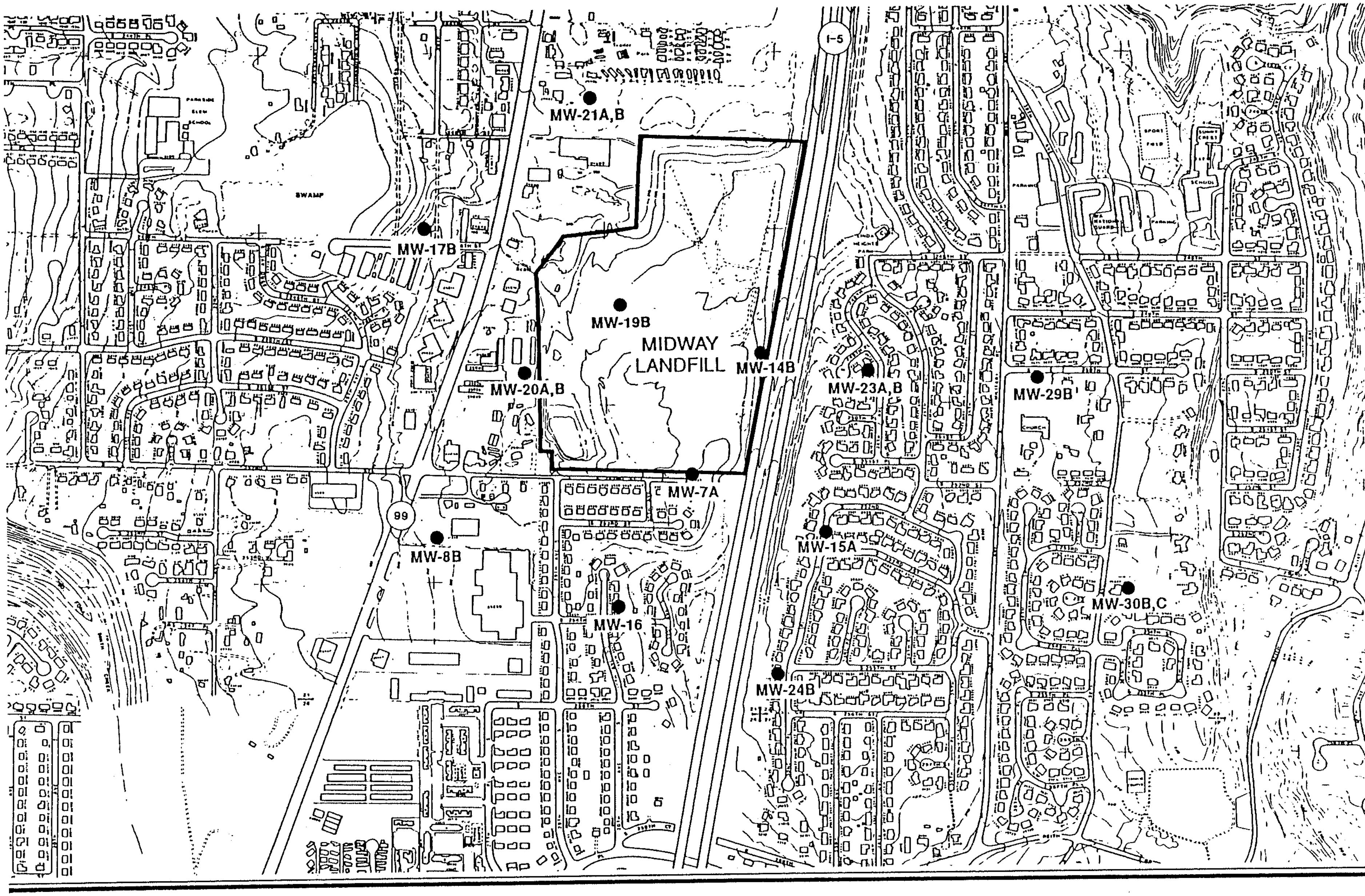
- Percent moisture
- Flow rate
- Temperature
- Carbon dioxide
- Carbon monoxide
- Oxygen
- Volatile organic compounds (VOCs)
- Hydrochloric acid (outlet only)
- Nitrogen oxides (outlet only)
- Sulphur dioxide (outlet only)
- Methane (inlet only)

4.2.2 Condensate

Condensate is currently discharged to the Midway Sewer District sewer system. Condensate discharge is unregulated and no monitoring is required. However, it will be regulated and monitored under Ecology's Cleanup Action Plan. As needed, condensate samples can be collected at the condensate manhole (see Section 14.1.4.3).

4.2.3 Compliance Monitoring

Federal and state regulations for closure of a solid waste landfill require that compliance monitoring be performed to track the migration of contaminants into and away from the site (WAC 173-304). Compliance monitoring also assesses the effect of the remedial measures for protecting human health and the environment by controlling the contaminant source. Compliance monitoring at the Midway Landfill has been expanded beyond the MFS requirements, and consists of quarterly monitoring of 17 wells that are upgradient, at the site boundaries, and downgradient of the landfill (Figure 4-1).



Source: AGI 1990d.

SCALE IN FEET

0 400 800

N

MW-21 Monitor Well Number and Approximate Location

Approximate Boundary of Landfill in 1986

Figure 4-1. Compliance Monitoring Sites

See Chapter 11 for more information concerning compliance monitoring.

4.2.4 Surface Water

Surface water runoff from the landfill is channeled through a system of ditches and is collected in the detention pond at the northern end of the landfill. Water that infiltrates through the cover soils will flow through the drainage layer to subsurface drain pipes. These subsurface pipes route the water to the detention pond. Stormwater from I-5 and a drainage basin east of the I-5 corridor (just below Linda Heights Park) will be routed to the on-site detention pond for controlled discharge to McSorley Creek (Figure 4-2).

The City has an interim agreement with Ecology which allows the pond water to be discharged until an NPDES permit can be issued. Under the requirements of the agreement, the City must monitor the water near the detention pond outlet for temperature, pH, dissolved oxygen, turbidity, and conductivity prior to discharge to McSorley Creek. The acceptable levels of the above parameters can be found in Table 3-1. The water discharges to the creek through a flow control structure that restricts the flow in the pipe to the maximum allowable rates based on 2, 25, and 100 year design storms. These design flows were agreed to by the Department of Fisheries, State Parks and Recreation Commission, City of Kent, City of Des Moines, and Department of Ecology.

4.2.5 Groundwater Level Monitoring

Groundwater level monitoring is done to track the response of the leachate liquid levels and the shallow groundwater to the remedial actions. Groundwater level monitoring includes quarterly monitoring of on-site leachate and gas extraction wells and selected off-site wells to determine the levels of APL (Aqueous Phase Liquid) and NAPL (Non Aqueous Phase Liquid) in the landfill and the direction of the shallow groundwater flow (Figure 4-3). These wells will be monitored for a period of 5 years or as long as is determined necessary from the monitoring results. Sampling and analysis of these wells is not performed.

4.3 RECORDKEEPING AND REPORTING

Detailed field notes should be collected during all environmental monitoring activities. A copy of these notes in addition to copies of laboratory analytical results should be maintained in a file on-site. At a minimum the following information should be recorded during all environmental monitoring activities:

- Monitoring Date and Time
- Monitoring Personnel
- Monitoring Location
- Weather and Barometric Pressure
- Type of Monitoring
- Field Data
- Samples Collected
- Chain of Custody Documentation
- Comments

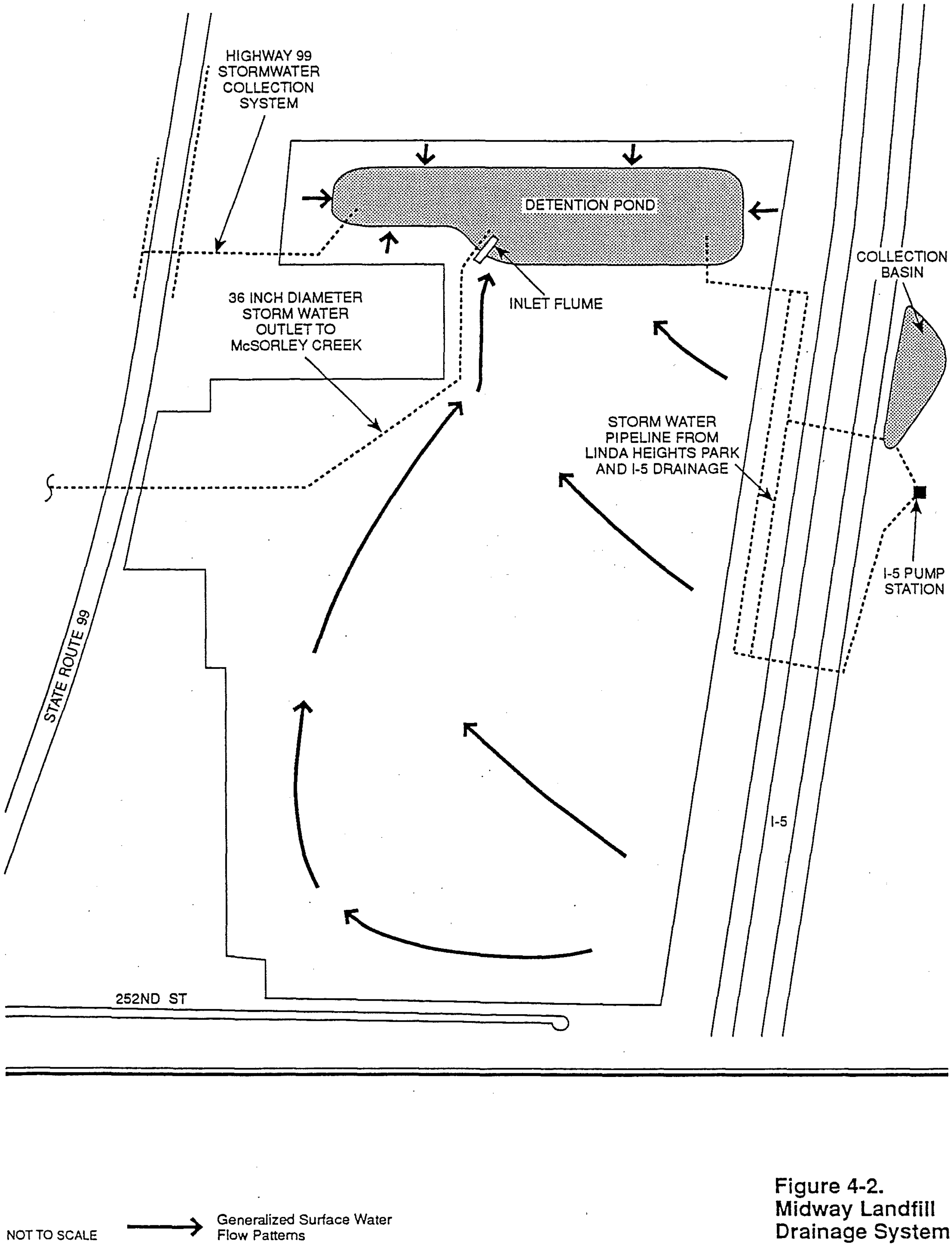
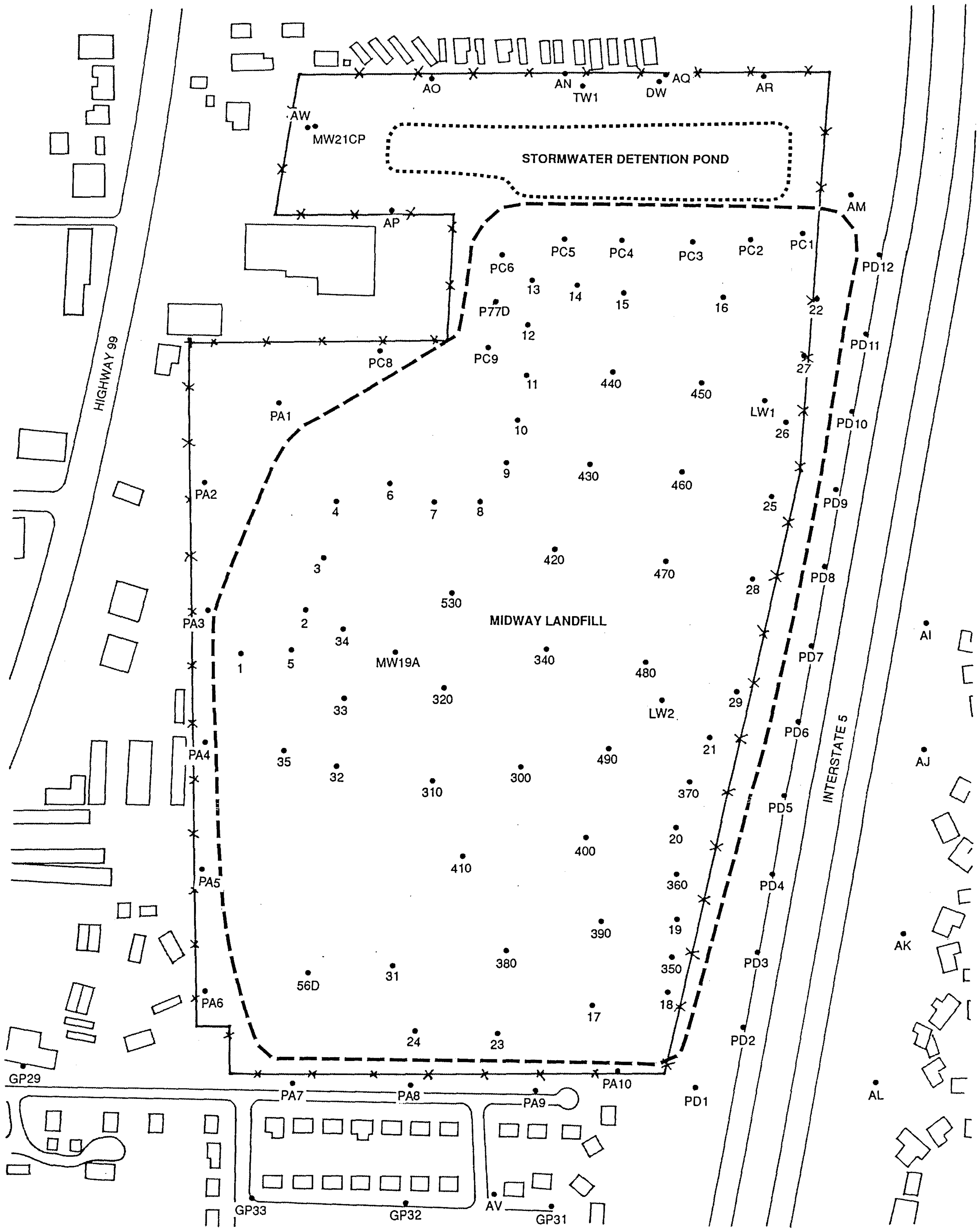


Figure 4-2.
Midway Landfill
Drainage System



Fenced Site Boundary

• AL Gas Probe, Gas Extraction Well, or Groundwater Monitoring Well Number and Location

Approximate Limits of Refuse

SCALE IN FEET 0 125 250

N

Figure 4-3. Groundwater Monitoring Sites

OPERATOR NOTES AND COMMENTS

5. SAFETY

5.1 DESCRIPTION

Safety is an important part of landfill operations. The Midway Landfill has been designated a Superfund cleanup site by the EPA. The potential for exposure to harmful substances, as well as the hazards associated with the machinery on site, exist for field personnel. The risks to personnel can be reduced by following basic safety procedures and eliminating unsafe conditions.

First aid equipment should be maintained, and on-site personnel should be familiar with the use of this equipment. All on-site personnel should complete a certified first aid and CPR training course as part of normal job training.

Before job assignment, all personnel working at the facility should undergo medical screening to determine their baseline fitness for working in hazardous environments. Records of each employee's medical testing will be maintained at the project field office. Follow-up medical testing shall be conducted on an annual basis. Medical testing will follow the most current guidelines set forth by the Occupational Safety and Health Administration (OSHA) under 29 Code of Federal Registrar (CFR) 1910.120(f), 29 CFR 1910.20, and the Washington Industrial Safety and Health Administration (WISHA) under WAC 296-62 (300-3190, Part P).

All field personnel are required to understand the *Midway Landfill Site Safety Plan* developed specifically for the Midway Landfill. This chapter is not intended to cover all safety issues. Staff must refer to the *Midway Landfill Site Safety Plan* for the complete site safety program.

5.2 SAFETY TRAINING PROGRAM

All field personnel will be trained as soon as possible after job assignment, as required by OSHA and WISHA. This training includes:

- Eighty hours of off-site safety training or acceptable equivalent
- An additional 8 hour refresher course yearly
- An additional 8 hours of management personnel training for site supervisors
- Additional hands-on training in the use of respirators and self-contained breathing apparatus (SCBA)
- Standard first aid course
- Cardiopulmonary Resuscitation (CPR)

Monthly site safety meetings will be conducted to provide additional safety training. During these meetings, site procedures will be reviewed and modified as necessary. Other common topics during these meetings will include safety equipment needs and the review of emergency procedures.

A set of complete and updated training records for all field personnel must be maintained on site.

5.3 GENERAL SAFETY PRECAUTIONS

5.3.1 Landfill Gas

Landfill gas is a potentially dangerous mixture of gases created as waste material decomposes. Three main hazards are associated with landfill gas: (1) the potential for an explosive or flammable mixture of gas, (2) the possible toxic or carcinogenic nature of landfill gas constituents, and (3) the potential for landfill gas to replace oxygen in the breathing zone and cause asphyxiation. Table 5-1 lists the major constituents of landfill gas commonly found at Midway. Hydrogen sulfide (H_2S) and carbon monoxide (CO) also have been detected on occasion. Results from the annual flare testing indicate the landfill gas stream also contains trace quantities of volatile organic compounds.

Follow these safety precautions to reduce the risks associated with landfill gas:

- Work in potentially contaminated areas only in a team of two or more. Additional personnel may be directed to standby under the discretion of the site safety officer.

- Only non-sparking tools should be used if the potential for explosive levels of flammable gas in the work area exists.

- Instrument checks for the presence of landfill gas or lack of oxygen in the breathing zone should be made before personnel enter a potentially contaminated area.

- Personnel should never enter areas where explosive gas concentrations are greater than 25% of the LEL (lower explosive limit).

- Entry into confined spaces is prohibited unless specifically authorized by the site safety officer. Entry into a confined space must be in accordance with the confined space entry procedures outlined in the *Midway Landfill Site Safety Plan.*

Table 5-1 Major Constituents of Landfill Gas at the Midway Landfill

Chemical Name	Chemical Symbol
Methane	CH_4
Nitrogen	N_2
Carbon Dioxide	CO_2
Carbon Monoxide	CO

5.3.2 Condensate

Testing of condensate at the Midway Landfill has shown concentrations of EPA Hazardous Substance List (HSL) contaminants to be well below hazardous levels. The greatest exposure to field personnel from condensate is through skin contact. A description of the contaminants found in condensate can be found in Table 5-2.

Condensate exposure through skin contact can be stopped through the use of the following safety precautions:

- Chemical-resistant gloves should be worn if there is any chance of exposure to condensate.
- Chemical-resistant boots, coveralls, and eye protection may be necessary for certain tasks.
- All tools or instruments that are exposed to condensate should be kept isolated and handled with gloves until they are decontaminated.
- Wash hands immediately after any accidental contact with condensate.
- Do not eat or smoke in areas considered contaminated; these activities are restricted to designated "clean areas."
- While working around condensate, keep hands away from your face.

Table 5-2 Listing of Chemical Hazards Found in Condensate

Chemical Name	Chemical Symbol
Acetone	CH_3COCH_3
1,2-Dichloroethylene	C1CHCHC1
Trichloroethylene	$CHC1CC1_2$
Benzene	$C_6H_5CH_3$
Toluene	$C_6H_5CH_3$
Chlorobenzene	C_6H_5C1
Ethyl Benzene	$C_2H_5C_6H_5$
Styrene	$C_6H_5CHCH_2$
1,1-Dichloroethane	CH_3CHC1_2
2-Butanone	$CH_3COCH_2CH_3$
2-Hexanone	$CH_3CO(CH_2)_3CH_3$
Arsenic	As

5.3.3 Electrical Equipment

With the presence of electrical equipment at the pump stations and motor blower/flare facility, there are many opportunities for electric shock. Electrical shocks of 10 milliamperes are severe; however, electrical shocks of 100 milliamperes are lethal. Even low voltage or amperage control circuitry may produce these shocks if a person is properly grounded. An electrical shock can produce both trivial and serious injuries. For example, if the contact is poor or of short duration, a muscular contraction and a numbing sensation may be the only results. However, good contact between a well-grounded body and current of adequate strength and duration can result in electrocution.

Low voltage (110 to 220 volts) currents sustained for over two seconds frequently cause a quivering of the heart muscles (ventricular fibrillation). High voltage currents are more likely to produce muscle contraction, unconsciousness, respiratory paralysis, cardiac arrest and severe burns at contact points.

To help avoid the risk of electrical shock, the following safety precautions should be observed:

- Never work on electrical equipment unless you are thoroughly familiar with it, know precisely what you are trying to accomplish and the safe method of accomplishing it.

- Electrical switches are particularly dangerous. When electrical problems develop, seek the help of a licensed electrician.

- Before repairing any electrical equipment, the individual starter, breaker, or switch should be locked in the off position and tagged to warn against being turned on.

- It is critical that any electrical equipment being repaired or inspected be completely isolated from all sources of electrical power. Read the circuit diagrams carefully prior to starting work. Insure control circuits in repair are totally isolated from other control circuits or devices. In some cases, even with switches in the off position, the supply side of the switch is still "live."

5.3.4 Mechanical Equipment

Most mechanical equipment at the pump station and motor blower/flare facility is electrically operated; therefore, electrical hazards exist. In addition, there are dangers from contact with rotating shafts or belts, inadvertent opening of pressurized lines, contact with heated surfaces (flare skin temperature may be higher than 400°F), and inadvertent operation of equipment during maintenance or repair.

Prevention of physical injuries can be accomplished by following these procedures:

- Follow proper lifting techniques.

- Disconnect equipment at the motor control center before working on it. Follow the tagout procedure in Section 3.3 of the Midway Landfill Site Safety Plan.

- Use good housekeeping techniques around mechanical equipment to prevent falls.

- Exercise care when working around rotating parts, shafts, belts, mechanisms, or heated surfaces.

- Wear hard hats and protective clothing as appropriate.

- Make sure the equipment you are working on is de-energized or depressurized prior to starting work.

- Never operate any machinery without guards and protective devices.

5.3.5 Explosion and Fire Hazards

The operator of the landfill gas extraction system should impress on all personnel and visitors the danger of smoking, dropping lighted matches or burning cigarettes, and using open flames.

Other sources of explosion and fire are the plant electrical system and stored flammable materials. Exercising proper site security, maintenance and housekeeping procedures is the best protection against accidental explosions or fires.

All personnel should be thoroughly familiar with fire extinguisher operation and locations. Use fire extinguishers rated as multi-purpose to serve class A, B, and C fires. Additional fire extinguishers should be maintained in all vehicles used on the site. Extinguishers should be checked annually for pressure and condition of the dry chemicals.

The plant operator and personnel should learn the classification of fires:

- **Class A:** Ordinary combustible, materials such as wood, coal, paper, or fabrics where wetting and cooling is the method of extinguishment.

- **Class B:** Flammable petroleum products or other flammable liquids and flammable gas, where oxygen must be excluded for extinguishment.

- **Class C:** Fires in or near energized electrical equipment where, because the use of water would be hazardous, a "non-conducting" extinguishing agent must be used.

5.4 SAFETY EQUIPMENT

Safety equipment is maintained at the Midway Landfill Field Office. This equipment includes the following items:

- Hard hats
- Safety glasses
- Steel-toe boots
- Chemical-resistant gloves, coveralls, boots
- Rainwear
- Respirators and SCBAs
- Ambient air quality instruments (combustible gas indicators, oxygen meters, Organic vapor detectors)
- Safety vests
- Safety belts
- Eyewash kits
- First aid kits

All field personnel must be aware of this equipment and familiar with its use. The use of safety equipment is mandatory.

5.5 ACCIDENT REPORTING

All accidents, minor or otherwise, should be reported immediately to the site safety officer. All insurance benefits and reporting procedures will be thoroughly explained to new employees.

5.6 TREATMENT FACILITIES

If a worker is injured, appropriate first aid should be administered immediately and the nature of the injury should be determined. If the injury is serious, the appropriate agency listed below should be contacted:

Agency	Phone #
Ambulance/Fire Department/Police	911
Hospital Emergency Room	
Valley Medical Center	228-3450
Auburn General Hospital	833-7711
Poison Control Center	526-2121

5.6.1 Routes to Hospitals and Treatment Facilities

Locations of hospitals and treatment facilities noted above are shown in Figures 5-1 and 5-2. Directions for driving from the Midway Landfill site to these hospitals are given below:

Valley Medical Center, 400 S. 43rd Street, Renton

Go north on Pacific Highway South to Kent-Des Moines Road. Turn right on Kent-Des Moines Road. Go under I-5, through three stop lights and move into the left lane. Take northbound Highway 167 on-ramp (beneath viaduct). Stay on Highway 167 and exit at 43rd Street. Turn right at the light. Immediately move into the left lane. Valley Medical Center is on the left.

Auburn General Hospital, 20 Second Street N.E., Auburn

Go south on Pacific Highway South to South 272nd Street. Turn left on South 272nd Street. Get on Interstate-5 South and exit at the Auburn exit (Highway 18) immediately after the second Federal Way exit. Turn left and follow Highway 18 for 3-5 miles. Turn left at C Street. Follow C Street until you reach Second Street. Turn right at Second Street. The hospital is located on the right-hand side of the street.

5.6.2 Poison Control Center

The Poison Control Center should be notified at the number listed in Section 5.6 in the event of potential exposures to toxic substances. Evidence of exposures to toxic substances may include nausea, headaches, dizziness, weakness, eye or respiratory irritation, or any other unusual symptoms.

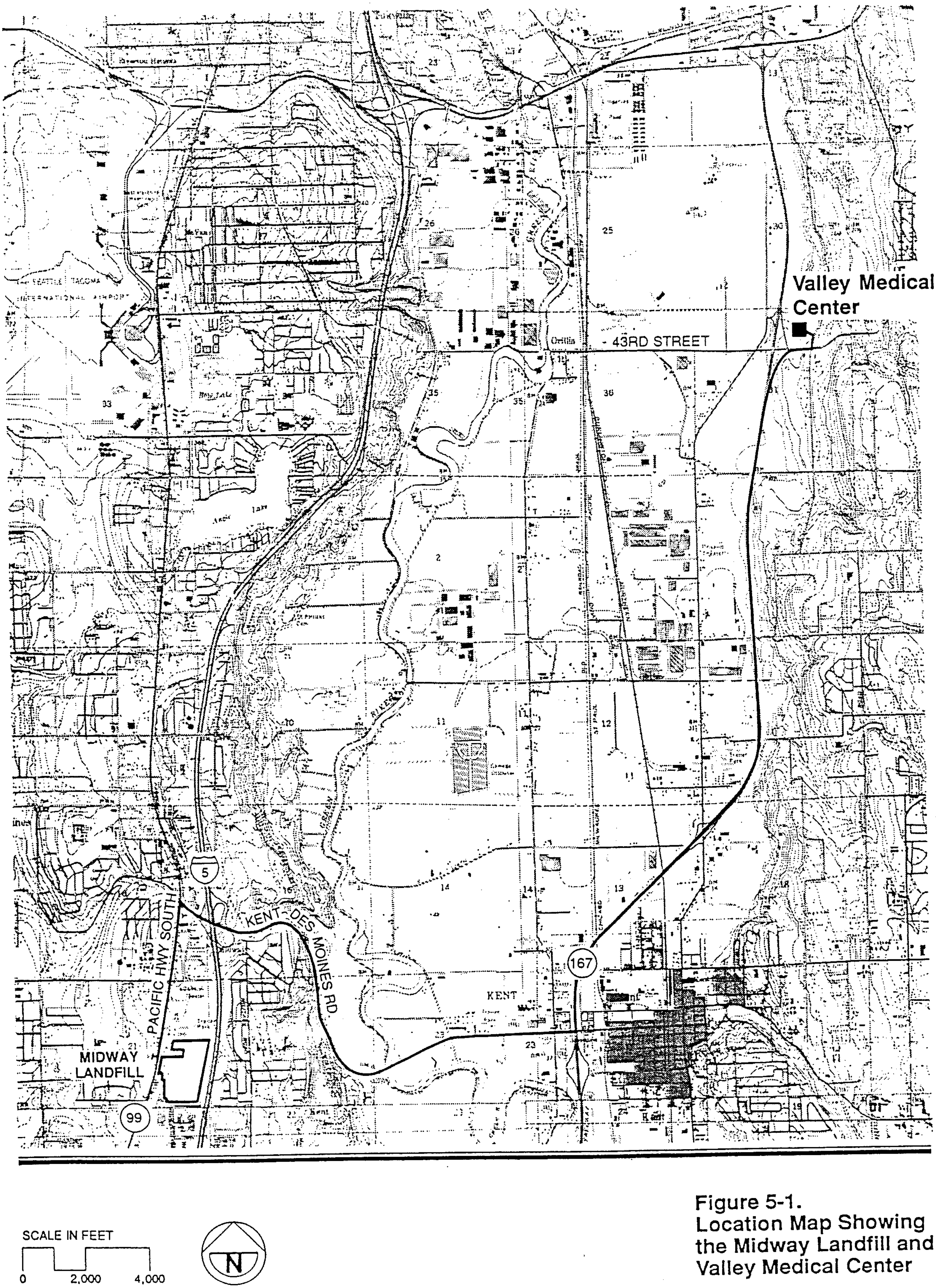


Figure 5-1.
Location Map Showing the Midway Landfill and Valley Medical Center

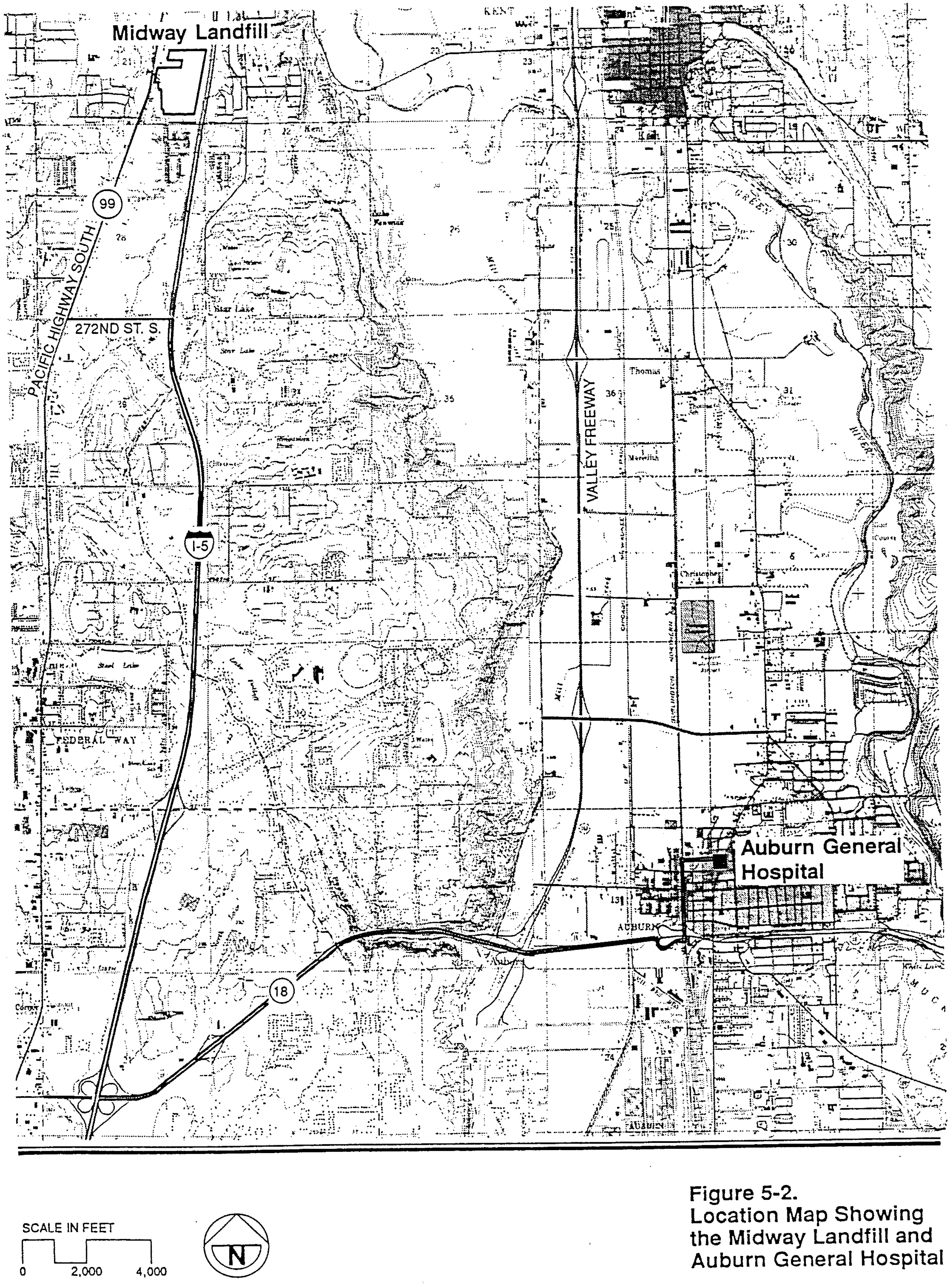


Figure 5-2.
Location Map Showing
the Midway Landfill and
Auburn General Hospital

OPERATOR NOTES AND COMMENTS

6. MAINTENANCE

6.1 INTRODUCTION

This chapter provides guidelines to aid the landfill site manager in instituting and understanding the need for an effective maintenance program. The objectives of such a maintenance program are to:

- Insure reliability of operation and limit environmental impacts
- Protect and extend the useful life of the landfill closure facilities and associated equipment
- Assure safety of personnel

6.2 IMPORTANCE OF MAINTENANCE

The landfill closure facilities represent a substantial investment by the City of Seattle to protect the public health and environment in the areas surrounding the landfill site. One of the important keys to minimizing environmental impacts resulting from the landfill is a sound maintenance program.

A sound maintenance program has an added benefit because the operations personnel are able to spend more time becoming familiar with equipment and facilities. This familiarity results in better operation of the facilities and a better ability to make judgments in emergency situations. In addition, through regular maintenance, more problems will be identified before they result in serious consequences or emergency conditions.

6.3 TYPES OF MAINTENANCE

As shown in Table 6-1, there are five different types of maintenance tasks listed by priority rather than by frequency. The anticipated percentage of maintenance time for each activity is also listed along with a brief description and some typical examples. Table 6-1 is provided as a guide to help put the different types of maintenance activities in proper perspective. The different types of maintenance are also discussed in the following subsections.

Table 6-1 Priority of Maintenance Tasks

Priority	Type of Maintenance	% of Time	Description and Example
1	Emergency	5	A situation requiring immediate attention; e.g., blower failure.
2	Preventive	60	Scheduled inspection, lubrication, and minor repairs carried out during inspection; e.g., weekly inspection of pumps and blowers, cleaning of ditches and culverts.
3	Corrective	20	Corrective maintenance required as a direct result of scheduled inspection; e.g., replace worn bearings, overhaul piece of equipment, repair torn membrane liner.
4	Special	5	Required maintenance not listed in the manufacturer's literature; e.g., wet well cleaning, fixing and/or organizing spare parts.
5	Housekeeping	10	Routine housekeeping of buildings and grounds; e.g., mowing grass, painting, and general housekeeping.

6.3.1 Preventive Maintenance

Preventive Maintenance is work done to prevent breakdown, reduce wear, improve efficiency, and extend the life of equipment and structures. It includes routine inspecting, servicing, and equipment lubrication. With the exception of routine surveillance and inspections, preventive maintenance tasks should be scheduled in accordance with the recommendations of the manufacturer's and recorded in accordance with the record system described in Section 6.4.

During routine inspections, the operator should be alert for any abnormal conditions which could indicate potential problems. If an equipment problem is caught at an early stage, it is usually easy to repair. In most instances, standby or duplicate equipment is available so that the operator can shut down a piece of equipment and take the necessary action to prevent major repairs. Equipment lubrication is one of the most important elements of preventive maintenance. Lubrication and lubricants are discussed in Section 6.5.

6.3.2 Corrective Maintenance

Corrective maintenance is the work required for repairs and other nonroutine maintenance. System operators must always be ready to handle these tasks as the need arises. Corrective maintenance procedures should follow the manufacturer's recommendations for disassembling and assembling equipment. In planning for the corrective maintenance, arrange for the assistance of an outside repair service or manufacturer's representative.

6.3.3 Special Maintenance

Special maintenance tasks are activities not listed in the equipment manufacturer's instructions but important to the successful operation of the landfill closure facilities. These activities include cleaning the storm drain pipe and cleaning pump station wet wells, as well as repairing, organizing and inventorying spare parts.

6.3.4 Housekeeping

Maintaining well-kept landfill closure facilities indicates pride on the part of the operating staff, and provides for good and efficient operations. A well-kept landfill cultivates good neighbor relations with adjacent property owners. Housekeeping tasks include mowing grass on the landfill site, controlling weeds in the detention pond, painting or coating peeling or corroded surfaces, and collecting and disposing of litter and debris.

6.4 MAINTENANCE RECORD SYSTEM

The maintenance record system is an important aspect of the maintenance management program. From a review of such records, the operator can determine the weaknesses of equipment and be able to determine which parts should be kept in stock. Such reports may be kept on cards; one card for each piece of equipment. A record of all lubrication, inspection, cleaning, replacement of worn parts, and other important data should be kept on these cards.

Some operators divide the maintenance record card into two separate cards: an equipment service card and a service record card. The equipment service card lists all the preventive maintenance for that piece of equipment and the frequency at which it is performed. The service record card shows what work was performed, when it was performed, and who performed it.

A spare parts inventory log should be maintained. For each part the log should contain:

- A description
- Its cost
- The name of the supplier(s)
- Date it was purchased
- A minimum and maximum quantity to be maintained

Other maintenance records which should be kept for each facility include:

- Cost records for maintenance of equipment
- Cost records for outside repairs
- Hours to repair and maintain equipment
- Staffing requirements
- Any corrective and special maintenance performed

6.5 LUBRICATION AND LUBRICANTS

Blowers, pumps, motors, and drives should be oiled and greased in strict accordance with the manufacturer's recommendations. The system valves at the motor blower/flare facility are factory sealed and self-lubricating. Operate valves open and closed to ensure proper lubrication. The frequency of addition or complete change of lubricant depends on how rapidly the lubricant breaks down, if lubricant is used up or lost, and various other internal and external conditions.

Greases and oil are graded and identified by viscosity. Numbers are assigned to lubricants to identify their grade or consistency such as SAE 20 or 40, AGMA 2 or 5, and NGLI 0 or 2. The smaller the number, the lighter the lubricant. It is recommended that the equipment manufacturer be contacted if there is any doubt regarding compatibility of lubricants, or if a loss of warranty is possible.

OPERATOR NOTES AND COMMENTS

7. EMERGENCY PLANS AND PROCEDURES

7.1 DESCRIPTION

The importance of having emergency plans and procedures for the City of Seattle's post-closure operations at the Midway Landfill cannot be over-emphasized. An emergency during post-closure operation is any occurrence that may arise during normal operation of the landfill facilities that can seriously endanger human life or the operation process. This section will present information and data that will assist in the safe, effective, and continued operation of the facilities under emergency conditions. It will also aid in reducing the frequency of certain emergency events through better operation, planning, and maintenance.

7.2 EMERGENCY EVENTS

The facilities operator should have a clear understanding of all emergency events and conditions that could occur at a landfill site. These events include:

- Power outage
- Manifold break
- Refuse fire
- Mechanical system failure
- Backflash
- Detention pond flooding
- Detention pond failure
- Surface water contamination
- Natural disasters

These events are briefly discussed below.

7.2.1 Power Outage

Landfill facilities such as the motor blower/flare facility and the pump stations need external electrical power to operate in an efficiently and reliably. Interruption of the electrical utility constitutes an emergency condition.

7.2.2 Manifold Break or Landfill Gas Leak

Indications of a significant vacuum manifold leak include the following symptoms as measured at the motor blower/flare facility: reduced methane concentrations, elevated oxygen concentrations, decreased vacuum and increased velocity measurements. Large changes in any of these readings indicate an emergency and should trigger a leak response action. A large manifold leak can cause a backflash condition at the flares and reduce the effectiveness of the extraction system.

A landfill gas leak can only occur if the affected section of pipe is under positive pressure. Under normal operating conditions, the vacuum manifold will not leak because it is under a vacuum. Landfill gas can potentially leak from sections of manifold that are not under a vacuum or from the piping between the blowers and the flares. The initial indicator of a landfill gas leak will be odor. Landfill gas leaks greatly increase fire hazards and allow unburned gas to vent to the atmosphere, where it can present a potential health hazard.

7.2.3 Refuse Fire

A refuse fire results from air intrusion in the landfill, causing the refuse to decompose aerobically. During aerobic decomposition, refuse decomposes in the presence of air and forms carbon dioxide, water vapor, residual nitrogen, carbon monoxide, and heat. The primary indicators of a refuse fire will be seen at the nearest extraction well and typically include: increased temperature, decreased methane concentration and the presence of carbon monoxide. The potential effects of a refuse fire include increased settlement, cover disturbance and the release of potentially toxic or explosive gases.

7.2.4 Mechanical System Failure

Mechanical system failure is probably the most likely cause of emergency conditions. If equipment is not maintained or operated properly, it could fail. In addition, some parts may fail because of defective materials. The importance of proper and timely maintenance procedures cannot be overemphasized.

7.2.5 Backflash

A backflash occurs when gas combustion occurs in the pipeline/equipment system. It will only occur when there is an explosive mixture of gas in the pipeline or equipment caused by too high an oxygen level in the gas mixture. Oxygen increases in the gas piping are typically caused by leaks in the vacuum manifold. Backflash will most likely occur at the flare. The flame arrestor should stop any flame front from propagating back into the system.

7.2.6 Detention Pond Flooding

Flooding of surface water contained in the detention pond may create a threat of damage to nearby property owners north and west of the site. While the detention pond has been built to accommodate runoff from a 100-year rain storm, other factors such as a plugged outlet may cause water levels within the pond to rise beyond those for which it has been designed.

7.2.7 Detention Pond Failure

The bottom liner system of the detention pond can potentially be impacted by hydraulic uplift forces during seasonally high groundwater periods. A groundwater collection and pumping system has been installed under the bottom liner to relieve these potential uplift forces. Damage may occur to the bottom liner if the collection system clogs or the pump fails during periods of high groundwater when the pond is empty.

7.2.8 Surface Water Contamination

Contamination of surface water constitutes an emergency condition because of its potential threat to the health and safety of people, animals, or fisheries resources which may come in contact with it. Although contamination could potentially occur because of liner failure on the landfill, the primary sources of surface water contamination are expected to occur beyond the limits of the landfill site and be carried to the pond via the storm drainage pipelines.

7.2.9 Natural Disaster

There are four basic types of natural disasters that could be experienced:

> **Earthquake:** A major earthquake could result in structural damage to the facilities and disruption of water, sewer, gas collection manifold, and electrical systems. Shorts in electrical systems could potentially result in fires following the earthquake.
>
> **Severe Weather:** Although structural damage to the facilities from high winds is unlikely, strong winds could disrupt electrical service. High wind, ice, and snow storms can create potentially hazardous working conditions at that landfill site, especially around the detention pond. During such events, outside activities should be limited and operations personnel alerted to the possibility of power outages.
>
> **Fire:** If a fire should occur, the fire department should be called immediately, and the fire controlled with portable extinguishers, if possible. All personnel should be evacuated from effected areas or structures until the fire department declares the fire out.
>
> **Flooding:** The storm drainage system outlet structure is located within the floodplain of the north fork of McSorley Creek. Personnel should verify stream condition during periods of potential flooding to assess the likely effect that additional storm drainage discharge from the detention pond may have on downstream conditions and improvements. Discharge from the detention pond should be temporarily discontinued or reduced during periods of extreme flooding in McSorley Creek.

7.3 EMERGENCY RESOURCES AVAILABLE

7.3.1 Security

The landfill site, the motor blower/flare facility, and the I-5 pump station are all protected by a 6-foot-high (minimum) chain link fence and locked access gates. The gates shall be locked at all times when the facilities are unattended.

7.3.2 Standby Equipment

All major pieces of equipment have been provided in duplicate to provide standby capacity, except for circumstances when the systems are operating in excess of design capacity.

The following pieces of equipment have been duplicated at the indicated locations:

- **Motor Blower/Flare Facility**

  Motor Blowers: Three motor blowers are provided. During normal operation only one motor blower is utilized. Therefore, two motor blowers are in a standby mode.

  Flares: Two flares are provided. During normal operation, only one flare is utilized. Therefore, one flare is in a standby mode.

- **I-5 Pump Station**

  Pumps: Four submersible pumps are provided. During normal operation, up to three pumps are utilized. Therefore, one pump is in a standby mode.

- **Gas Manifold System**

  Main Manifold (entering motor blower/flare facility): The main manifold has two pipelines bringing landfill gas into the motor blower/ flare facility. Both are used during normal operations. If one line becomes inoperable, the gas could be routed through the one remaining line until the second was back in service.

The above equipment, excluding the gas manifold system, is rotated periodically to provide even wear and longer life.

7.3.3 Warning System

Warning systems are provided with major pieces of equipment to alert the operator whenever a piece of equipment goes into an alarm condition. The system is provided with the capability of transferring alarms by radio telemetry to the Seattle Engineering Department's emergency dispatcher at the St. Charles Street station during unattended periods of nighttime and weekend operation.

7.3.4 Spare Parts Inventory

An inventory of spare parts, as recommended in the manufacturer's maintenance manual for each piece of equipment, should be maintained at the landfill site. It is necessary to maintain that inventory and make sure that all parts are on hand and in a specified location for any emergency needs.

7.3.5 Safety Equipment

General safety equipment is provided by the City of Seattle. The operators and all other personnel should be familiar with the location and use of first aid kits, landfill gas detection equipment, self contained breathing apparatus, explosion meter, and portable oxygen deficiency meter.

7.4 EMERGENCY RESPONSE AND NOTIFICATION PLANS

In any emergency, the basic rule is to be concerned first with the safety of the people, then with that of the facility. The facility operator should be doubly alert to the dangers involved in the possible exposure to unsafe conditions. In this regard, a program should be developed to simulate emergency conditions and appropriate counter measures. This program should be carefully reviewed, practiced, and updated as necessary. Emergency drills will be conducted at least semi-annually. The emergency program includes:

- Negotiation of a mutual aid agreement with other agencies and municipalities.
- Analysis of vulnerability of the facility processes and equipment to develop priorities for equipment repair.
- Development of a preventive maintenance and personnel training program to reduce the probability of an emergency event caused by equipment failure or improper personnel response.
- Preparation of a plan for emergency equipment maintenance, inventory, and acquisition program. Records should also be kept on the source of rental equipment.
- Development of emergency response plans to aid the facility operator in an emergency. Outlines for several emergency response plans conclude this section.

This section includes outlines of emergency response plans for the following conditions:

- Personnel injury
- Power outage
- Manifold break or landfill gas leak
- Fire
- Backflash
- Surface water contamination
- Earthquakes
- Severe cold weather

These plans should be periodically reviewed and updated as necessary.

7.4.1 Personnel Injury

A. For emergencies resulting from medical causes, call 911. Stay on the line until the operator instructs you to hang up or until the operator hangs up.

B. For accidents resulting from falls, fire, gas explosion, drowning, etc., dial 911 for an ambulance and fire department rescue unit immediately.

C. If qualified, render first aid. If not qualified, find someone who is.

D. Never move an injured of seriously ill person unless necessary to prevent further injury; or if bleeding through the mouth or nose (which can cause asphyxiation).

E. All injuries, no matter how minor, should be reported immediately to the field supervisor of the landfill facilities.

F. Once proper medical attention is rendered, complete an accident report form and submit it to the field supervisor.

7.4.2 Power Outage

A. Install a portable pump in the dewatering pump station as discussed in Chapter 9.

B. For a loss of power at the I-5 pump station, no action is required. Water that collects in the wet well will drain through the drainage system back into the detention pond at the landfill.

C. If power is expected to be lost for more than 24 hours, install a portable generator at the blower facility motor control center.

D. After the power outage confirm that all equipment is in operation and has not been damaged by electrical surges, voltage drops, or single phasing (where applicable).

E. Remove portable pumps from pump station(s) and restart electrical equipment in accordance with the appropriate operating procedures discussed in this manual.

7.4.3 Manifold Break or Landfill Gas Leak

A. If a manifold break or landfill gas leak is detected, first check to see that the flares are operating within temperature limits.

B. Check the oxygen level at the flare inlet. If the flares are operating safely and not in danger of backflashing due to high oxygen (generally greater than 10% oxygen by volume), then the leak can be traced and possibly repaired with the system operating. Follow steps C through E.

C. Inspect all piping between the blower feed and the manifold leg separations.

D. The affected manifold should be traced on foot and visually inspected to locate the leak.

E. When the leak is found, a determination should be made as to whether the repairs can be safely made with the manifold under vacuum.

F. If the leak is repairable under vacuum and there is no possibility of exposure to landfill gas, the repairs can be made.

G. If the manifold leg must be valved off and isolated or the break is severe enough to lose all vacuum in the manifold, then repairs can not be made until proper precautions are taken. The damaged section of pipe must be isolated from all extraction wells by closing the throttling valves at all wells within the pipe section, and personnel should be equipped with fans and/or respiratory protection as called for under the site safety plan.

H. If the system is not operable because of a severe pipe break, then the break must be located by inspection. The damaged area should then be isolated and repairs can be made under the procedures listed in step G above.

I. If a landfill gas leak is detected on the positive side of the blower, then the damaged area must be isolated before repairs can be made.

7.4.4 Fire - Refuse

A. If a refuse fire is suspected because of readings taken at an extraction well or group of wells, immediately repeat and verify those readings. If wellhead temperatures show a rapid rise from previous readings and are higher than 110°F in a refuse well, then the carbon monoxide levels should be measured. Carbon monoxide should be measured with a calibrated direct readout instrument (for example, Gastech GX 4000™) to avoid the errors common with indicator tubes.

B. If the carbon monoxide readings are greater than 10 parts per million (ppm), the instrument should be checked for calibration and the readings retaken.

C. The next steps depend on the carbon monoxide levels detected in the extraction well. The correct actions for carbon monoxide (CO) levels are as follows:

<u>CO less than 10 ppm</u>: Reduce well velocity by 35% and continue to monitor the well daily as described in Section 14.8. If temperature does not decrease continue to check CO level and reduce well velocity by 35%. Continue this process until wellhead readings stabilize within operating limits (see Section 14.8).

<u>CO between 10 and 25 ppm</u>:

- Reduce well flow by adjusting wellhead to zero gauge pressure and monitor temperature and CO levels at adjacent wells in all directions.
- Reduce well velocities by 50% in all adjacent wells that have temperatures over 90°F.
- Continue to monitor twice daily all wells with temperatures over 100°F and CO greater than 10 ppm.
- Visually inspect the surrounding cover and all nearby well surface seals to find all obvious sources of air entering the landfill.
- Any cracks should be checked for the presence of landfill gas and CO to protect personnel from exposures to landfill gas and to determine the extent of the refuse fire.
- If landfill gas is present or suspected in the breathing zone, respiratory protection as described in the health and safety plan should be worn.
- All potential air sources (surface cracks and bad well seals) should be sealed or repaired to reduce air intrusion.
- Continue to monitor all suspected wells. It is important that all monitoring data be recorded and available to field staff at all times to allow for continuous field evaluation based on complete information.

<u>CO greater than 25 ppm</u>: Respond as described above for the condition of CO between 10 and 25 ppm with the following exceptions:

- Adjust all adjacent wells to zero gauge pressure and monitor all wells within 400 feet of the affected well. These readings should be taken twice daily. Additional steps such as refuse excavation and/or chemical injection may be required to control a serious or wide-spread refuse fire.

7.4.5 Fire - Facilities

A. Call the fire department by dialing 911. Stay on the line until the operator instructs you to hang up or until the operator hangs up.

B. If the fire is small, take immediate action with a near by fire extinguisher for the type of fire. Do not use water on electrical fires.

C. Shut off power to the affected areas.

If the fire is at the motor blower/flare facility, isolate the landfill gas flow to the blowers and stay clear of the facility. The propane cylinders are under pressure and could explode.

7.4.6 Backflash

A. Shut off operating equipment.

B. Check for damage to the affected piping and equipment. Look at the pipe joints, pipe supports, and equipment.

C. Check the explosion relief valves for proper seating.

D. Following verification of the system integrity, start the system and inspect the equipment and piping while in operation (see Chapter 15).

E. Check the pressure differential across the flame arrestor. A high pressure differential indicates that the element is either damaged or dirty.

7.4.7 Surface Water Contamination

A. If the source of contamination is located on the landfill site and can easily be identified and contained or diverted away from the surface water collection system, isolate the source and collect water in tanker trucks, if possible.

B. Notify the site manager of the problem and proposed corrective actions. Discuss the procedures and methods for proper disposal of contaminated water.

C. If water quality parameters are exceeded at the outfall structure, close the detention pond discharge valve (see Chapter 8).

D. Monitor field parameters at pond inlets to determine the source of the contamination.

E. Correct the problem at its source. Notify the site manager when the problem is corrected and that discharge from the site can be resumed.

7.4.8 Earthquakes

A. Do not move during an earthquake, except to crawl under something sturdy or stand in a doorway.

B. Watch for power outages or electrical short circuiting and be prepared to cut the power supply to the affected area and to bypass damaged equipment.

C. Shut off propane gas at the cylinder valves.

D. Take precautions regarding fires.

E. After tremors have ceased and the facilities are safe for entry, inspect all structures, piping, and electrical equipment for damage. The detention pond and stormwater pipeline systems should be checked for subsidence or other damage.

7.4.9 Severe Weather

A. Drain wash down hoses, hose bibs, and hydrants that are not freeze protected.

B. Check all outdoor pipes for drainage or insulation.

C. Make sure adequate temperatures are maintained in the pump stations, control rooms, and the motor blower/flare facility control room.

D. Make sure that ice is not forming in the landfill gas collection manifold, condensate collection system, surface drainage culvert inlets, detention pond inlet structures, or the pond outlet structure.

E. Outside activities should be restricted or temporarily suspended.

7.5 ALARMS

Alarm systems have been set up to give the facility operator visual information. The alarm lights and alarm horns are located at both pump stations and inside of and outside of the control building at the motor blower\flare facility. An alarm panel for each of these facilities is also located at the Charles Street Station, where remote alarm signals are received by radio telemetry when operators are not present at the facilities. An alarm will activate whenever a piece of equipment goes into an alarm condition. The operator must acknowledge the alarm by pressing the reset button. If the equipment is still in the alarm condition after having been acknowledged or silenced, the alarm light will remain on until the condition is corrected.

Specific information on alarm conditions and operations can be found within the individual chapters covering the systems that have alarms. For example, Chapter 10 describes the I-5 pump station.

7.6 EMERGENCY CONTACTS

Emergency contacts and their telephone numbers are listed in Table 7-1. This listing must be posted in each work area and must be kept current at all times.

Table 7-1
Emergency Notification List

Contact	Telephone
Police Department	859-3315
EMERGENCIES ONLY	911
Fire Department	859-3322
EMERGENCIES ONLY	911
Ambulance	911
Hospitals	
Valley Medical Center	228-3450
Auburn General Hospital	833-7711
Poison Control Center	526-2121
Department of Ecology	1-206-649-7000
Regional Office and 24-Hour Spill Hotline	
Utilities	
Power - Puget Sound Power & Light	1-800-553-6193
Sewer - Midway Sewer District	824-4960
Water - Highline Water District	824-0375

OPERATOR NOTES AND COMMENTS

8. SURFACE WATER DRAINAGE AND DETENTION POND

8.1 DESCRIPTION

This chapter discusses the surface water collection, conveyance, detention, and discharge systems which serve the Midway Landfill. Discussions in this chapter focus on the operation and maintenance of these systems, their operation under emergency conditions, and required recordkeeping procedures.

The major components of these systems include:

- On-Site Drainage Systems
- Detention Pond
- Pipelines and Flow Control Systems

8.1.1 On-Site Drainage Systems

Surface water runoff from the landfill is collected in perimeter ditches. Ditches are located at the base of finished slopes, along roads and at swales. Ditches are lined with rock and grass to reduce potential surface erosion. Runoff collected within these ditches is then routed under the access road through culverts and into the detention pond through a concrete inlet flume.

Surface water that infiltrates through the cover soils will be transported by the drainage layer to subsurface underdrain pipes. The pipes are 4-, 6-, and 8-inch diameter perforated PVC surrounded by washed gravel. Geotextile prevents the overlying layer from intruding into the washed gravel. Cleanouts are provided along the length of the underdrain pipes. A detail of an underdrain pipe and cleanout is shown in Figure 8-1.

8.1.2 Detention Pond

The detention pond is located adjacent to the northern perimeter of the landfill. Its purpose is to detain surface water runoff collected from the landfill and adjacent collection systems. The detention pond provides a controlled release of this stored runoff through its outlet control structure to reduce potential impacts on the downstream discharge pipeline system and fisheries habitat in McSorley Creek. The detention ponds primary components include inlet structures, a flexible membrane liner system, a subsurface dewatering system, a pump station for the dewatering system, and an outlet control structure. These components are shown in Figure 8-2.

The flexible membrane pond liner system, shown in Figure 8-3, consists of a 60 mil high density polyethylene (HDPE) liner installed over a polyethylene drainage net and geotextile filter fabric placed on pit run sand. Along the southerly side slope of the pond, the liner is installed directly upon the pit run sand. The entire liner is overlain with 1.5 feet of compacted gravel backfill,

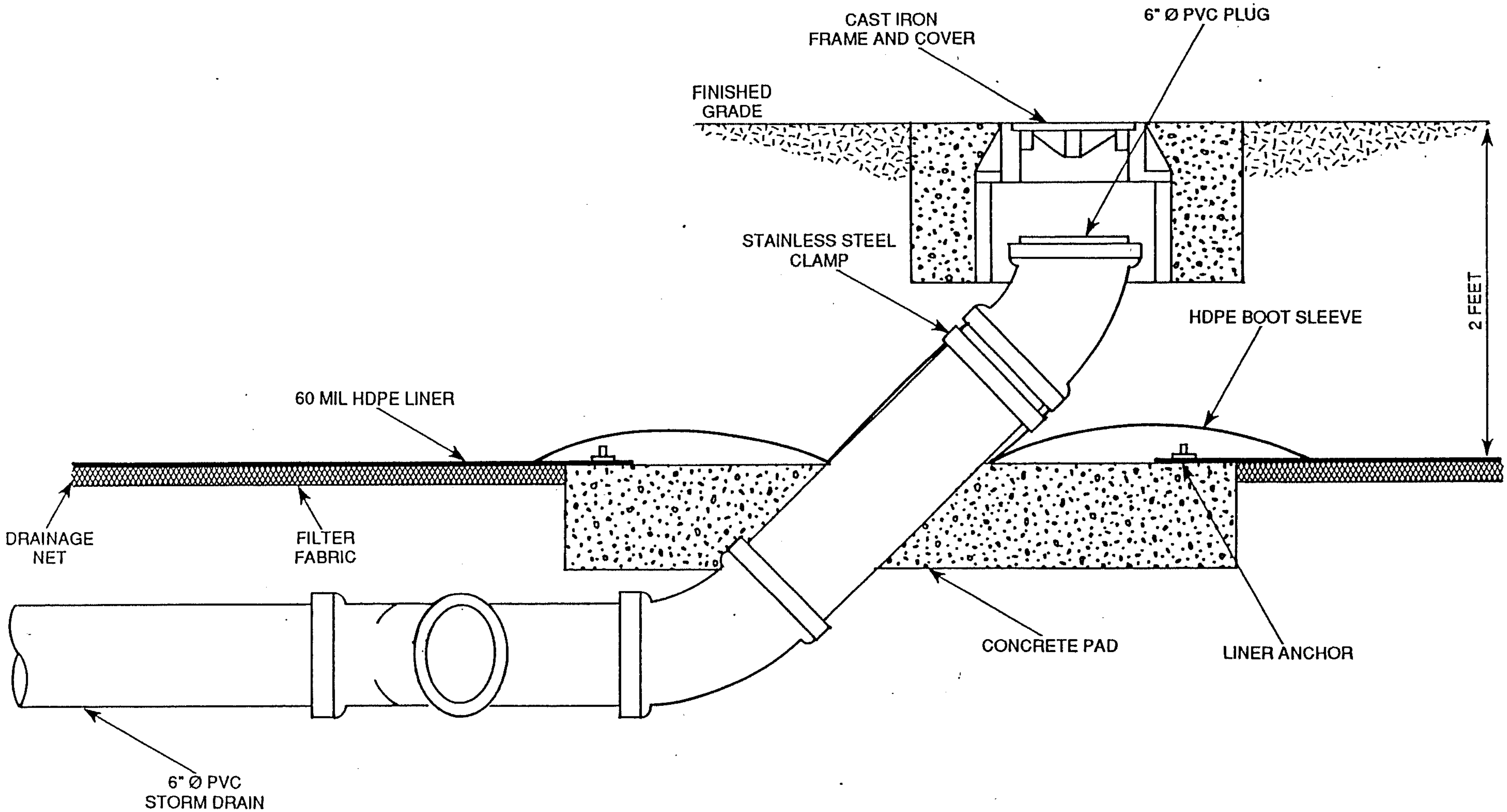
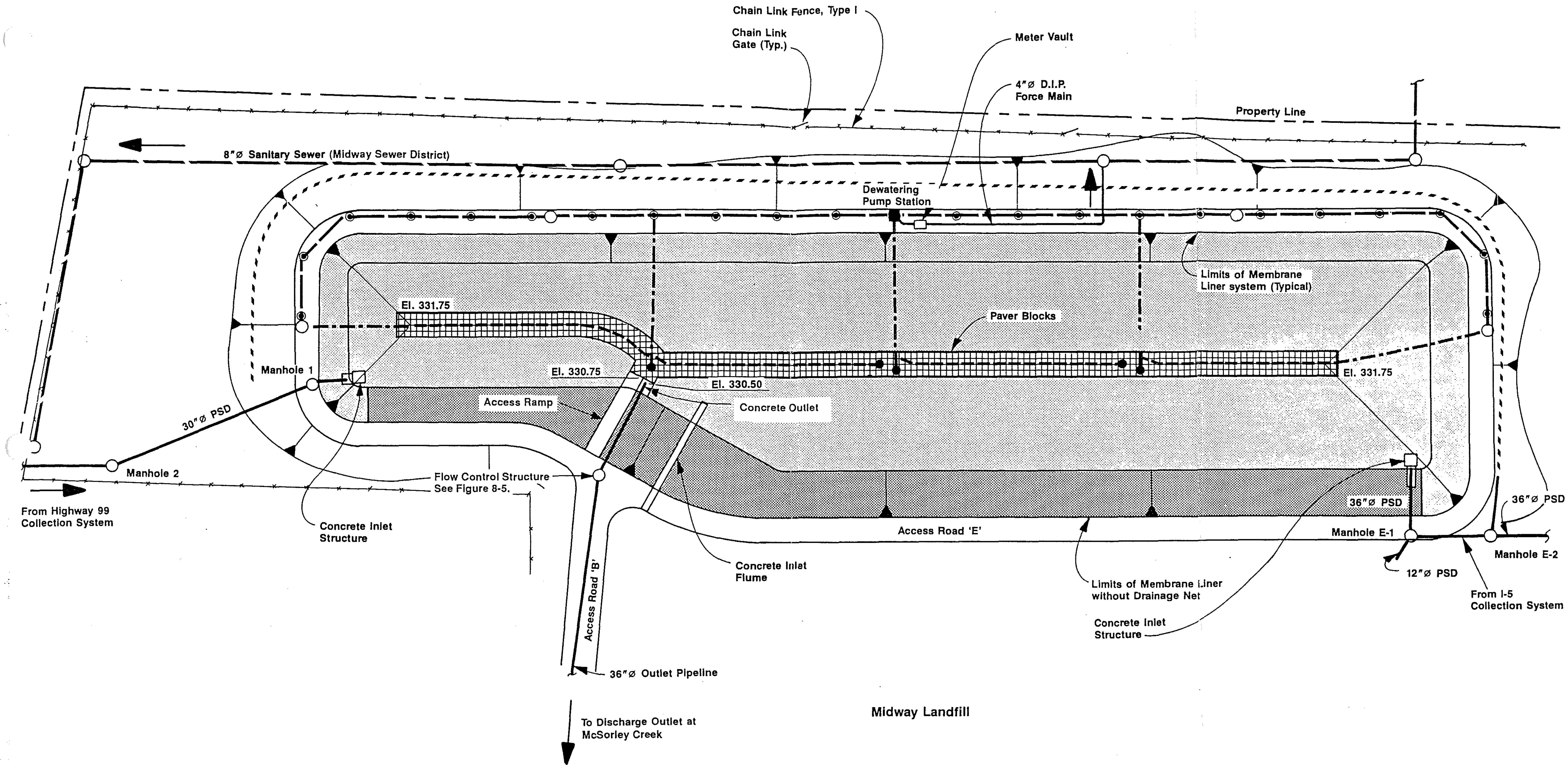


Figure 8-1.
Site Collector
Drain Clean Out



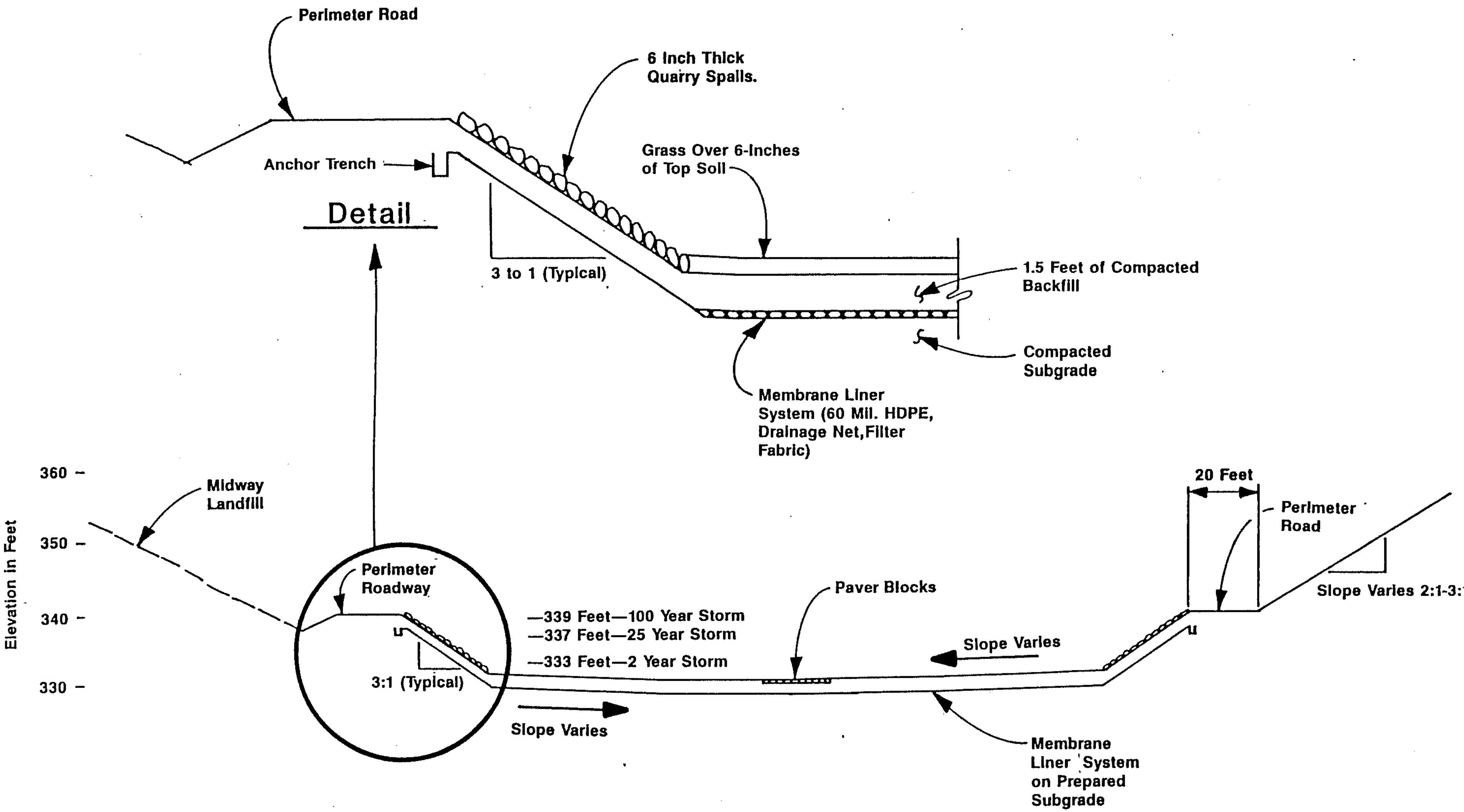
SCALE IN FEET

0 40 80

N

- Pressure Relief Well
- Manhole
- Cleanout
- Pump Station
- 6″ PVC Perforated French Drain
- 6″ PVC Perforated Slope Drain
- 6″ PVC Perforated Collector Sump
- 6″ Collector Pipe
- 8″ Sanitary Sewer
- Concrete Storm Drain (PSD)

Figure 8-2.
Storm Drain
Detention Pond



Horizontal Scale: 1 Inch = 40 Feet
Vertical Scale: 1 Inch = 20 Feet

Figure 8-3.
Detention Pond
Typical Section

with the sides slopes having an additional 0.5 feet of rock lining. The bottom of the pond is covered with soil and grass. Paver blocks are installed along the centerline of the pond to support maintenance vehicles.

At locations where pipes, flumes, clean-outs and other structures penetrate the synthetic membrane liner, sealing boot sleeves are installed to maintain the containment qualities of the liner. Wherever the liner is anchored to concrete flumes, collars and other structures, the anchor bolts are covered with geotextile fabric to protect overlapping portions of the liner from sharp edges of washers and bolts.

A slope drain is installed adjacent to and uphill of the detention pond perimeter road along the westerly, northerly and easterly cut slopes. Perched groundwater is collected and conveyed through a 6-inch-diameter perforated PVC collection pipe and is discharged to a storm manhole located near the southeast corner of the detention pond. Concrete storm drain pipes then convey the water into the detention pond.

Under the northern half of the detention pond a dewatering and pressure relief system is installed to control the static groundwater level. A "French Drain" system containing perforated PVC pipe collects and conveys groundwater to a pump station at the northern edge of the pond. The water is then pumped upslope through a 4-inch-diameter force main to a sanitary sewer system. These flows are measured through a turbine meter assembly located adjacent to the pump station. Cleanouts have been provided for the collection system as detailed in Figure 8-1.

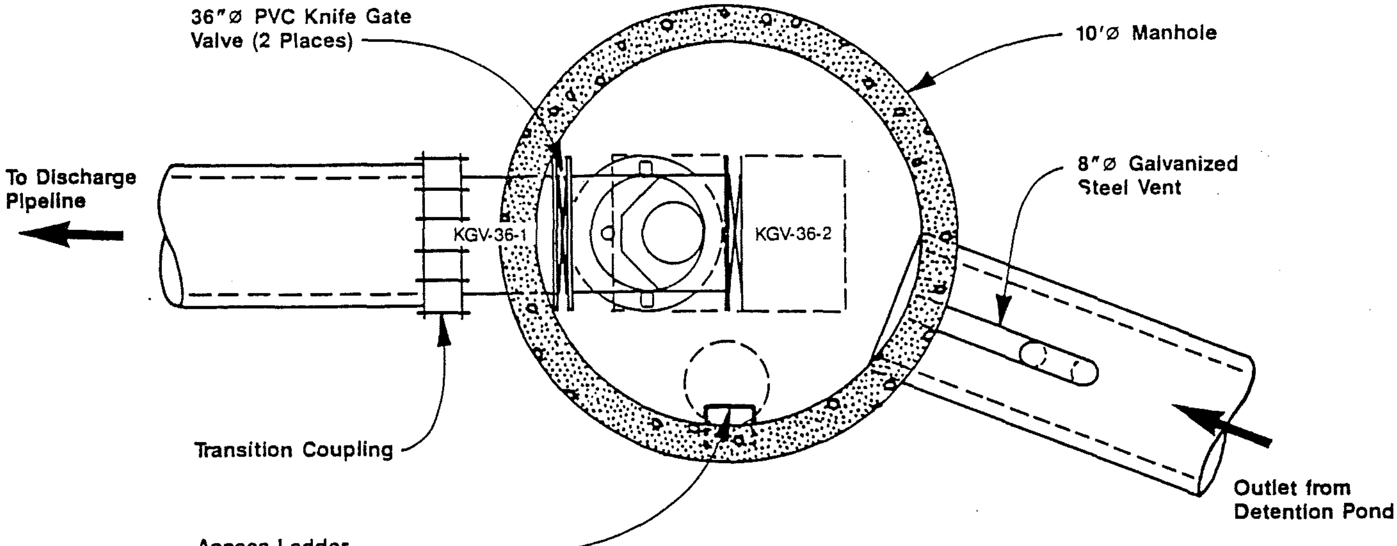
8.1.3 Pipeline and Flow Control System

Surface water runoff is conveyed to and discharged from the detention pond through a system of storm drain pipelines and ditches. Discharge of stormwater from the detention pond is regulated by a flow control structure located near the southwest corner of the pond.

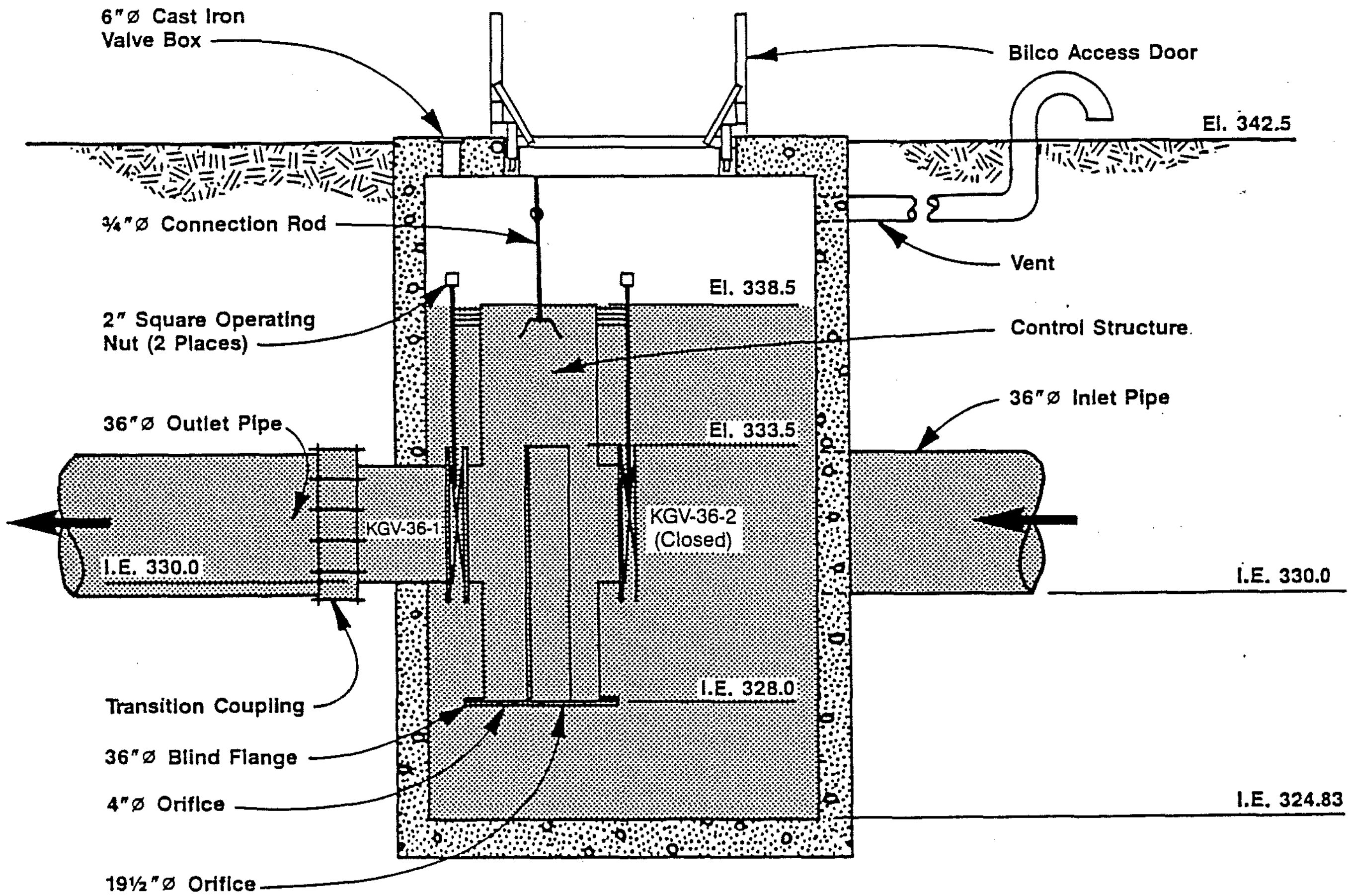
8.1.3.1 Flow Control Structures

The rate at which the runoff water is discharged from the detention pond is determined by the depth of water in the pond. As water within the pond and outlet structure builds up, it flows through the flow control structure which consists of a pre-cast 10-foot-diameter concrete manhole containing the flow control device and associated hardware. A detail of the control structure is provided in Figure 8-4. The flow control device and connection are constructed of a 36-inch-diameter steel pipe cross with a blind flange orifice plate, containing two openings, and an orifice separation plate. Also included in the flow control structure are two knife gate valves, a transition coupling pipe connection, a vent pipe and access door.

A flow control structure has also been provided along the west side of Highway 99 (Figure 8-5). Surface water is routed into the control structure. Three cubic feet per second (cfs) are allowed



Plan



Elevation

**Figure 8-4.
Detention Pond Flow
Control Structure
(Normal Operation)**

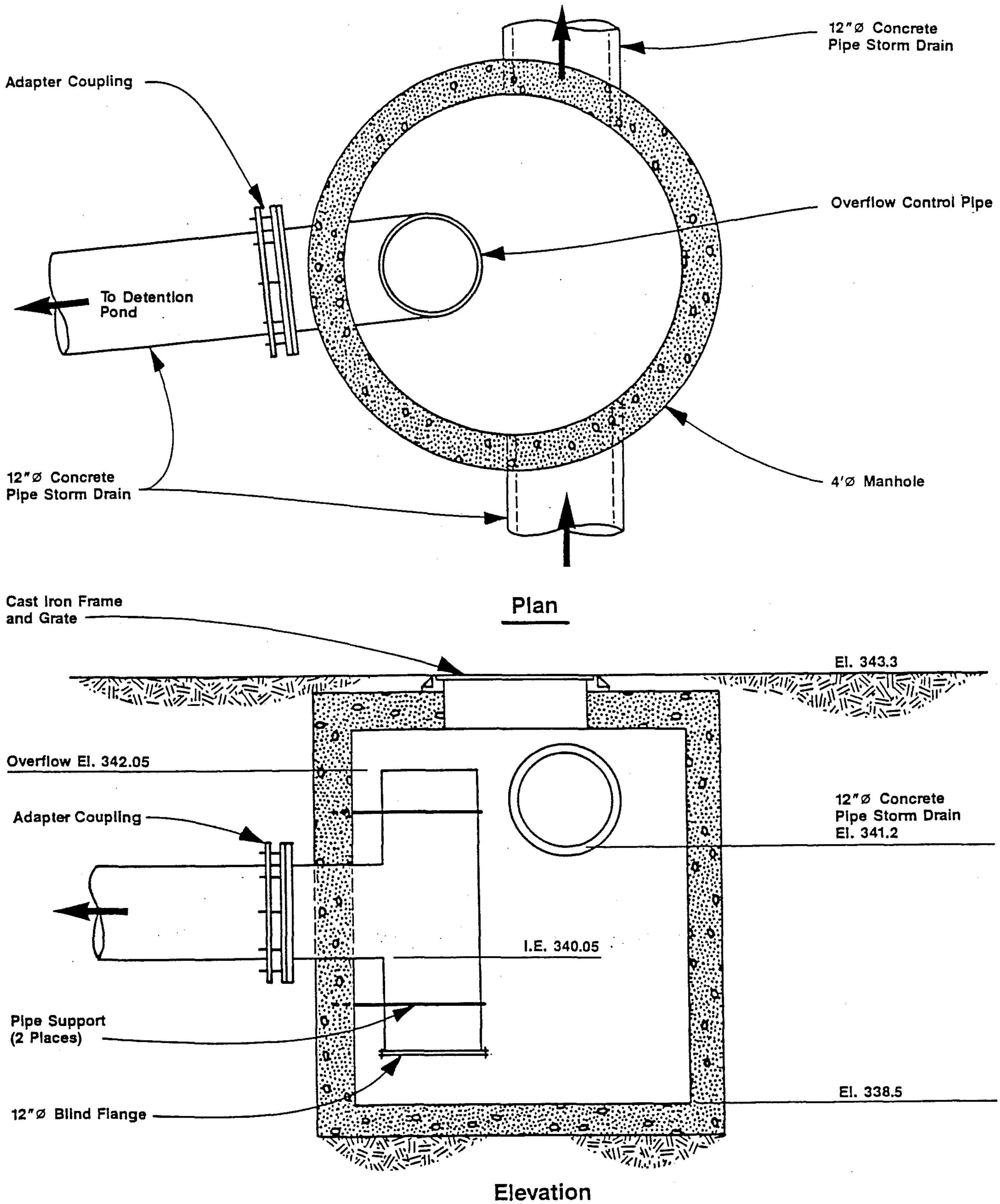


Figure 8-5.
Highway 99 Flow
Control Structure

to continue along Highway 99 and into the wetland area. When surface water flow is greater than 3 cfs, the excess water is diverted through the control structure into the storm drainage collection pipeline to the on-site detention pond.

8.1.3.2 Pipeline and Manholes

The storm drainage collection and discharge pipeline systems for surface water runoff are composed of reinforced concrete and ductile iron pipe of varying lengths and diameters. An inventory of these pipelines is provided in Table 8-1.

Table 8-1
Storm Drainage Pipeline Inventory

Pipe Size (inches)	Pipe Material	Length (feet)
12	Concrete	265
12	Ductile Iron	48
16	Ductile Iron	505
24	Ductile Iron	75
24	Concrete	4,040
30	Concrete	521
36	Concrete	2,569
	TOTAL	8,023

The purpose of the pipeline system is to route stormwater from off-site sources located east of I-5 in the Linda Heights residential area and along Highway 99 into the landfill's detention pond. The pipelines which collect and convey the surface water runoff to the detention pond are referred to as collection pipelines and are called out on the figures as pipeline storm drain (PSD). The general location of the collection pipeline system is shown in Figure 8-6.

In addition to the collection pipeline, a discharge pipeline also exists to carry stormwater from the detention pond to a discharge point located on McSorley Creek, west of the landfill site. A baffled outlet structure is located at the downstream end of the discharge pipeline system and is designed to reduce the velocity of flow as it exits the contained system (Figure 8-7). The structure is reinforced concrete with an aluminum grate which has been provided to restrict access to the interior of the structure. The location of the discharge pipeline system and the baffled outlet structure is shown in Figure 8-6.

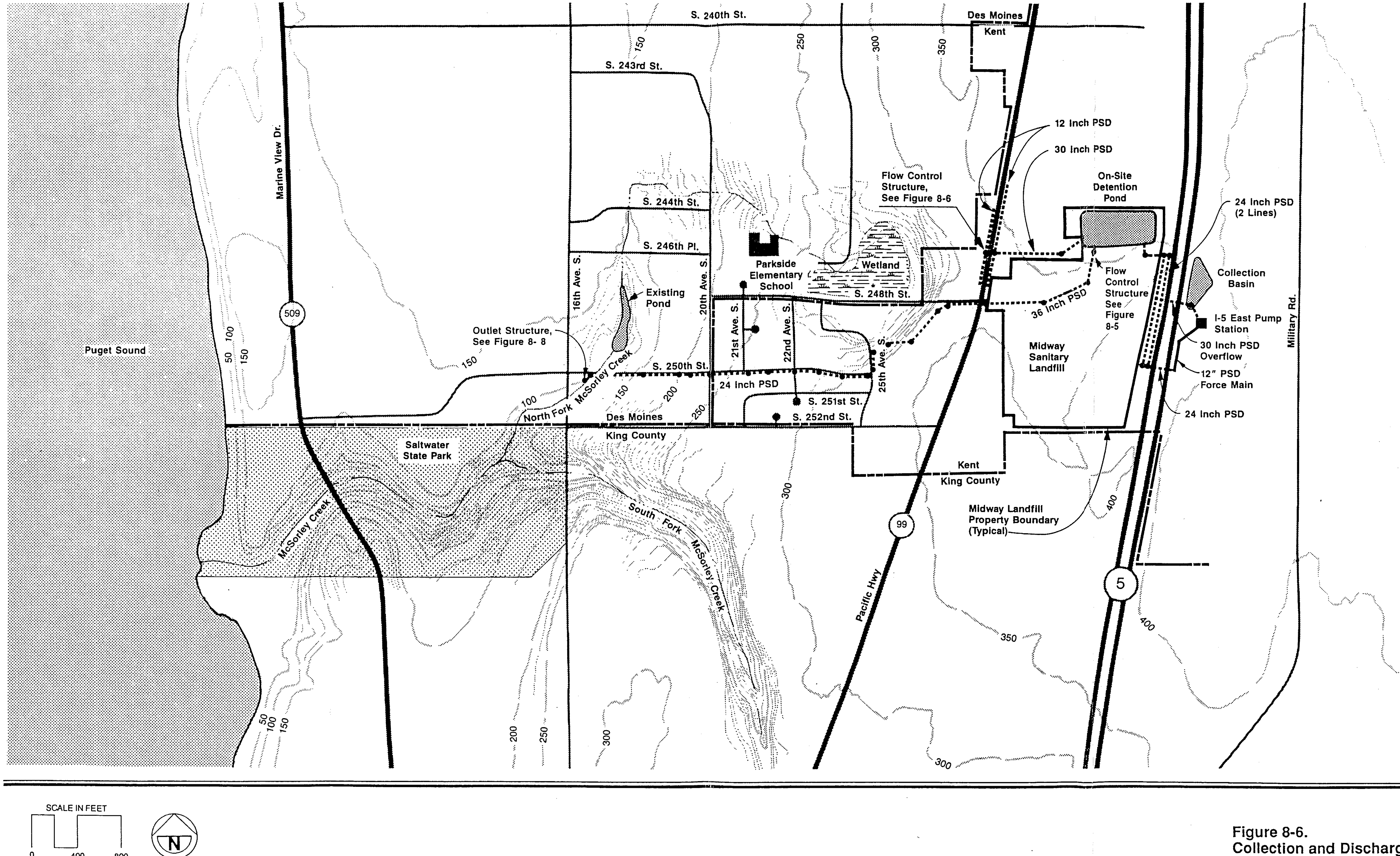
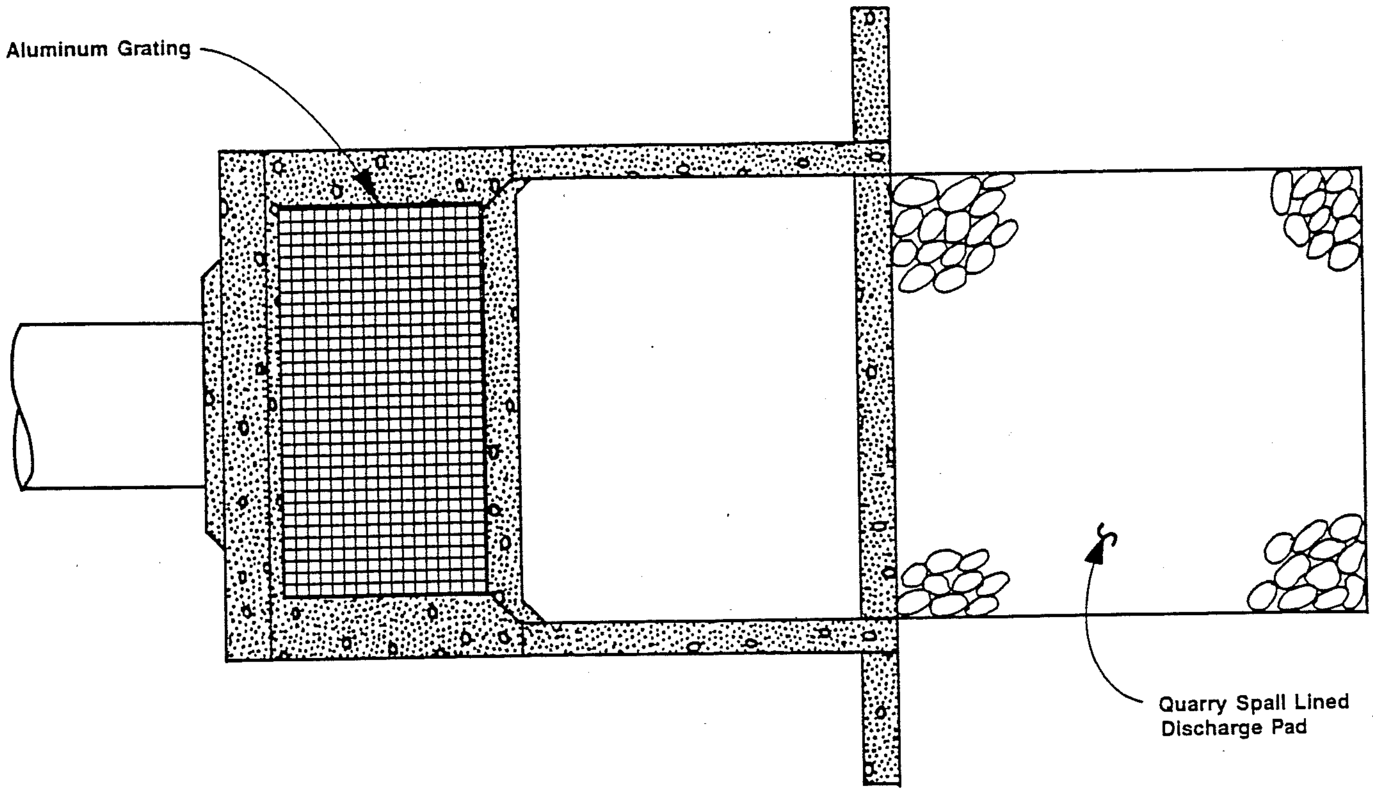


Figure 8-6.
Collection and Discharge Pipeline Systems



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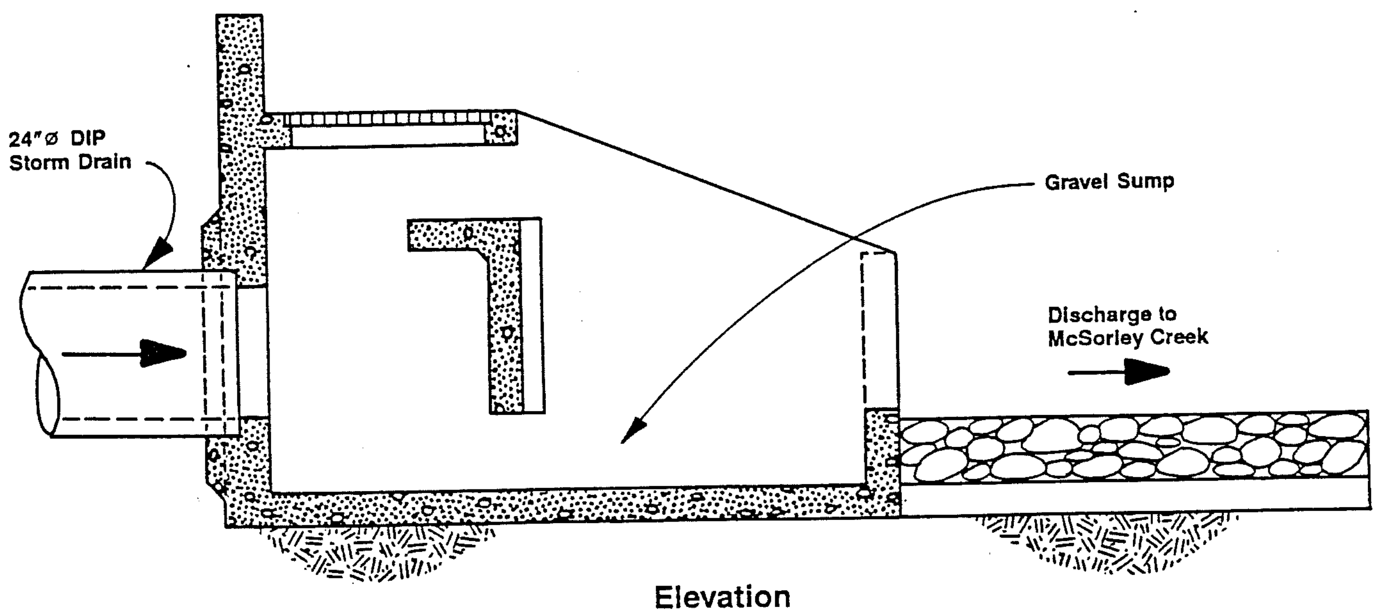


Elevation

Figure 8-7.
McSorley Creek Outlet
Control Structure

Manholes and catch basins are installed along the collection and discharge pipelines at surface water collection points, vertical grade breaks, and horizontal changes. Table 8-2 identifies manholes located within the system by size, type, and inlet and outlet pipe sizes.

8.2 NORMAL OPERATION

Under normal operating conditions, the surface water drainage system operates automatically as a function of gravity. Surface water collected from the landfill surface, as well as that runoff collected within the off-site collection systems, flows into the detention pond where it is stored. This water is slowly released through the outlet control structure into the discharge pipeline, where it is conveyed and ultimately discharged through the baffled outlet structure into McSorley Creek.

The following section briefly describes these operations and special considerations which the operator should bear in mind during the operation of the system.

8.2.1 On-Site Drainage

- Inspect drainage collection ditches for erosion and/or sedimentation buildup. Perform necessary repairs or maintenance in accordance with Section 8.3.
- Inspect ditches and culverts and remove debris or other obstructions which may impact flow.
- Inspect underdrains at the cleanout and outlet locations to check for signs of damage, clogging, etc.

Table 8-2
Pipeline System Manholes

Manhole No.	Manhole Type	Manhole Size (feet)	Inlet Pipe Size (inches)	Outlet Pipe Size (inches)
On-Site Collection System:				
MH 1	202B	6	30	30
MH 2	202A	6	30	30
MH E-1	202B	6	36	36
MH E-2	202B	6	6, 36	36
Highway 99 Collection System:				
MH 20	202B	6	12, 24	30
MH 21	202B	4	12	12, 12
MH 22	202B	6	12, 12	24
I-5 East Collection System:				
MH E-3	202A	6	36	24
MH E-4	201A	4.5	24	24
MH E-5	201B	4.5	24	24
MH E-6	201B	4.5	24	24
On-Site Discharge System:				
MH 19	202A	6	36	36
MH 20	202A	6	36	36
MH 21	202A	6	36	36
MH 22	205	10	36	36
Off-Site Discharge System:				
MH 1	201A	4.5	24	24
MH 2	201A	4.5	24	24
MH 3	201A	4.5	24	24
MH 4	201B	4.5	24	24
MH 5	201A	4.5	24	24
MH 6	201A	4.5	24	24
MH 7	201B	4.5	24	24
MH 8	201B	4.5	24	24
MH 9	201A	4.5	24	24
MH 10	201A	4.5	24	24
MH 11	201A	4.5	24	24
MH 12	201A	4.5	24	24
MH 13	201A	4.5	24	24
MH 14	201A	4.5	24	24
MH 15	202B	6	36	24
MH 16	202A	6	36	36
MH 17	202A	6	36	36
MH 18	202A	6	36	36
MH 19	202A	6	36	

8.2.2 Detention Pond

- Inspect pond side slopes and inlets for erosion. Perform necessary repairs or maintenance in accordance with Section 8.3.

- Inspect inlets to pond and remove sedimentation, debris or other obstructions which may impact flow.

- Inspect the trashrack and pond outlet (Figure 8-8) and remove any debris or obstructions which may cause plugging monthly and after storms.

- Check the dewatering pump station and flow meter vault for correct operation in accordance with Chapter 9.

- Check dewatering system cleanout covers to ensure a tight, secure fit with the frame assembly.

8.2.3 Pipeline and Flow Control Systems

8.2.3.1 Flow Control Structure

- Knife gate valves located inside the outlet control structure should be set as follows (Figure 8-4):

  - Open knife gate valve KGV-36-1

  - Close knife gate valve KGV-36-2

  Note: Access to the operating nuts for these valves is through a cast iron valve box in the structure lid. Both knife gates are operated by turning the 2-inch-square nut with the operating wrench.

- Inspect and remove all debris from inside the flow control structure which may impact flow.

8.2.3.2 Storm Drain Pipelines and Manholes

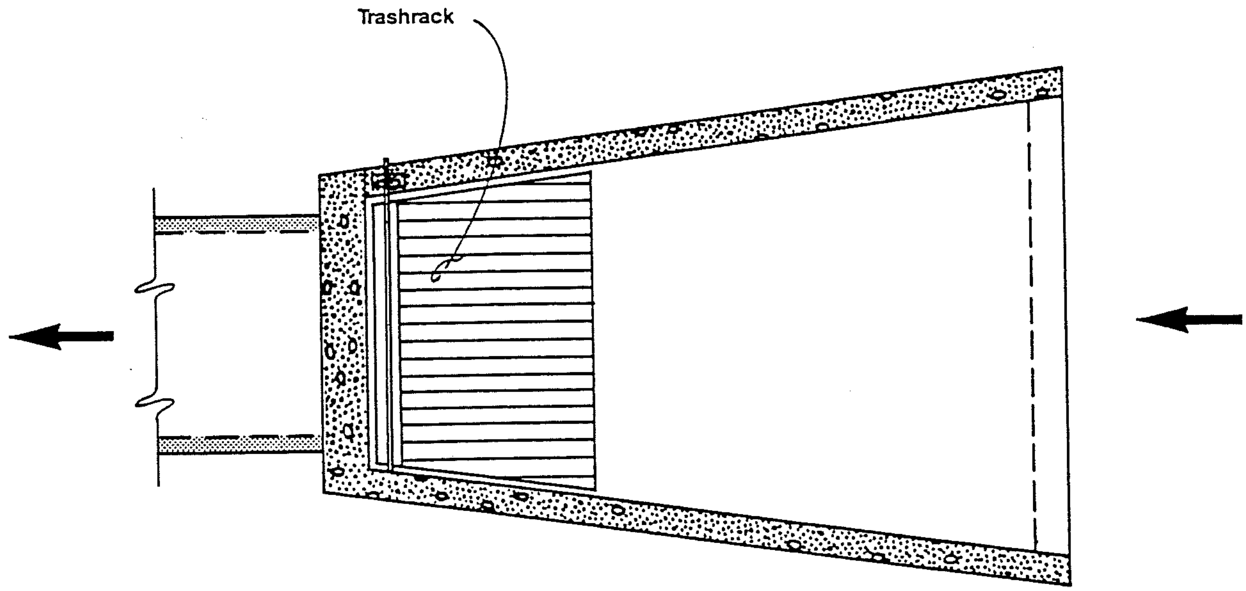
- Inspect manholes and remove all rocks, sediment, and other debris. Refer to the *Midway Landfill Site Safety Plan* for confined space entry program before attempting to enter a manhole.

- Check all manhole covers to ensure a tight, secure fit with the frame assembly.

8.2.3.3 Underdrain Pipelines

- Inspect meter boxes at cleanout locations to ensure they are properly set at grade and that all sediment and other debris is removed.

- Check underdrain cleanouts (Figure 8-1) to ensure a tight fit.



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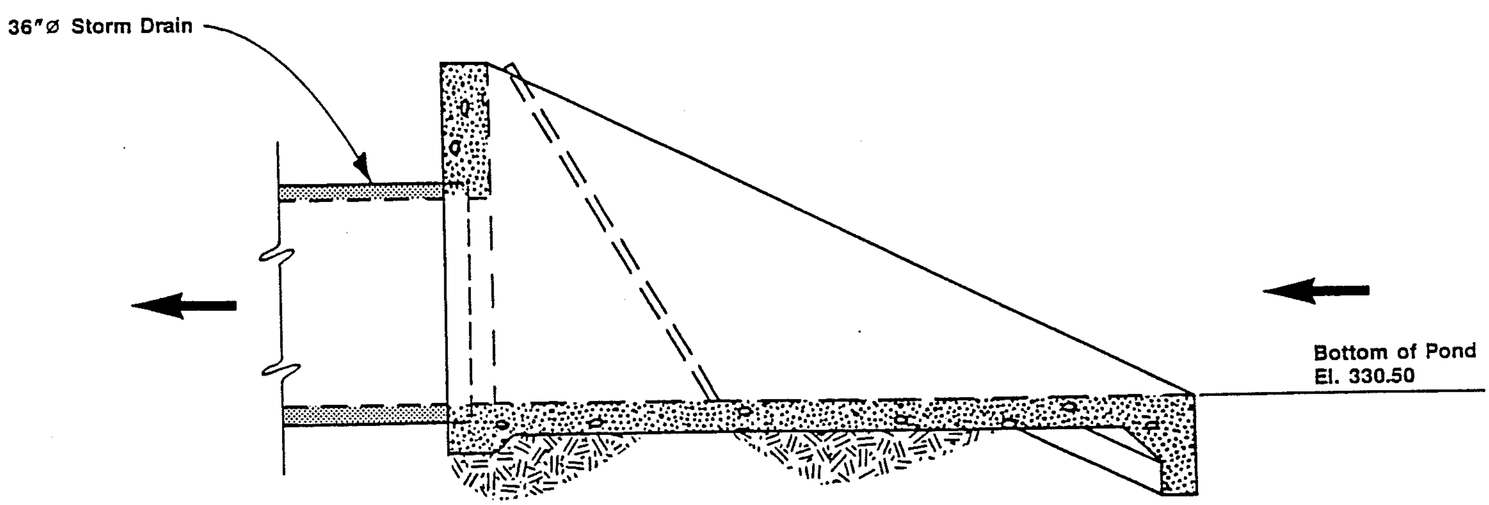


Elevation

Figure 8-8.
Pond Outlet Structure

8.2.3.4 McSorley Creek Outlet Structure and Check Dam

- Remove sediment, debris and other obstructions to ensure uninterrupted flow of discharge water.

- Inspect check dam and remove debris or sediment which may impact flow.

8.3 ROUTINE MAINTENANCE

8.3.1 General

Routine maintenance of the surface water drainage system and detention pond is required to keep the system in good operating condition. Serious health and environmental hazards, as well as extensive property damage, can result from surface water infiltrating into the landfill or from storm drain pipes which surcharge as a result of backups and overflows within the drainage system.

8.3.1.1 Preventive and Corrective Maintenance

Preventive maintenance consists of the inspection of the system and the development of a data base that provides maintenance personnel a past history of trouble areas. This gives maintenance crews some guidance to the locations and frequency of preventative maintenance and to the types of preventative maintenance which would be most effective. It includes the activities performed to prevent repairs or problems.

Corrective maintenance may be referred to as demand or emergency maintenance or repair as it is performed as a result of a problem. Corrective maintenance consists of the repair of a broken item. Corrective maintenance is a repair item which requires immediate action to correct the problem for return to normal operation.

Table 8-3 provides a listing of preventive maintenance activities for the drainage system components. This table identifies maintenance conditions, states when required maintenance should be performed, and provides a suggested frequency of when the system component should be inspected for maintenance.

CAUTION: Because the slopes at the McSorley Creek outlet structure are steep and slippery, it is recommended that personnel use a lifeline when performing inspections or maintenance at this location.

Table 8-3
Maintenance/Inspection Schedule for Surface Water Management Facilities

System Component	Defect	Inspection Frequency	Conditions When Maintenance is Needed	Maintenance Required and Results Expected
Surface Drainage				
Open Ditches	Trash & Debris	Once every year	Trash and debris exceeds 1 cubic foot per 1,000 square feet of ditch and slopes.	Trash and debris cleared from ditches.
	Sediment	Once every two years	Accumulated sediment that exceeds 20% of the design depth.	Clean/flush ditch of all sediment and debris so that it matches design.
	Vegetation	Once every two years	Vegetation that reduces free movement of water through ditches.	Cut or mow grass/pull weeds to allow water to flow freely through ditches.
	Erosion Damage to Slopes	Once per year	When any visible signs of erosion are detected.	Fill with gravel base material or quarry spalls to stop erosion.
	Rock Lining out of Place or Missing (if applicable)	Once every five years	Maintenance person can see native soil beneath rock lining.	Replace rocks as shown on design plans.
Pipes and Culverts (includes outlets and cleanouts)	Sediment & Debris	Once every two years with the TV	TV shows accumulated sediment that exceeds 20% of the diameter of the pipe.	Clean pipe of all sediment and debris.
	Vegetation	Once every two years	Vegetation that reduces free movement of water through pipes.	Remove all vegetation so water flows freely through pipes.
	Damaged	Once every five years	Protective coating is damaged; rust is causing deterioration to any part of pipe.	Repair, replace or re-coat pipe.
			Any dent that decreases the end area by more than 20%.	Repair or replace pipe.

Table 8-3 (cont)
Maintenance/Inspection Schedule for Surface Water Management Facilities

System Component	Defect	Inspection Frequency	Conditions When Maintenance is Needed	Maintenance Required and Results Expected
Detention Pond				
Side Slopes	Erosion	As Conditions Dictate	Eroded damage over 2 inches deep where cause of damage is still present or where there is potential for continued erosion.	Stabilize slopes by using appropriate erosion control measure(s); e.g., rock reinforcement, planting of grass, or compaction.
	Vegetation	As Conditions Dictate	Large weeds present.	Remove large weeds.
Storage Area	Sediment	Once every two years	Accumulated sediment that exceeds 10% of the design pond depth.	Cleanout sediment to approximate pond shape and depth; re-seed pond if necessary to control erosion.
Pond Dikes	Settlements	As Conditions Dictate	Any part of dike which has settled 4 inches lower than the design elevation.	Build dike to the design elevation.
Synthetic Liner	Exposed and/or Torn	As Conditions Dictate	Synthetic membrane liner has been exposed and/or torn to any degree.	Patch liner using a piece of 60 mil HDPE material that is 3 inches larger in all directions than the area to be patched. Fillet weld patches with molten HDPE extrusion material. Cover exposed area to design depth.
Dewatering Pipes	Sediment and Debris	Once every year with the TV	TV shows accumulated sediment that exceeds 20% of the diameter of the pipe.	Clean pipe of all sediment and debris using conventional sewer cleaning methods.
Paver Blocks	Damaged	Once every year	When blocks are cracked.	Replace damaged blocks.
Pond	Debris	Once every year	When debris is noted in the pond.	Clean the pond of all debris.

Table 8-3 (cont)
Maintenance/Inspection Schedule for Surface Water Management Facilities

System Component	Defect	Inspection Frequency	Conditions When Maintenance is Needed	Maintenance Required and Results Expected
Flow Control Structure				
Control Structure	Trash & Debris (includes sediment)	Once every year	Distance between debris build-up and bottom of orifice plate is less than 1.5 feet.	Remove all trash and debris.
	Structural Damage	Once every twenty years	Structure is not securely attached to manhole wall and outlet pipe structure should support at least 1,000 pounds of up or down pressure.	Attach structure securely to pipe.
		Once every twenty years	Structure is not in upright position (allow up to 10% from plumb).	Re-align structure to plumb.
		Once every ten years	Connections to outlet pipe are not watertight and show signs of rust.	Repair or replace connections to outlet pipe and make watertight and work as designed.
		Once every twenty years	Any holes - other than designed holes - in structure.	Repair holes in structure.
Knife Gate	Damaged or Missing	Once every ten years	Knife gate is not watertight or is missing.	Repair/replace knife gate and make watertight and work as designed.
		Once every twenty years	Gate is rusted over 50% of its surface area.	Repair/replace to meet design standards.
Orifice Plate	Damaged or Missing	Once every twenty years	Control device is not working properly due to missing, out of place, or bent orifice plate.	Repair/replace plate to work as designed.

Table 8-3 (cont)
Maintenance/Inspection Schedule
for Surface Water Management Facilities

System Component	Defect	Inspection Frequency	Conditions When Maintenance is Needed	Maintenance Required and Results Expected
Flow Control Structure (cont)				
Valves and Other Moveable Objects	Stuck	Twice per year	Valves or other moveable objects don't move.	Repair as required.
	Obstructions	Once every year	Any trash, debris, sediment, or vegetation blocking the plate.	Free plate of all obstructions, check operation.
Overflow Pipe	Obstructions	Once every year	Any trash or debris blocking (or having the potential of blocking) the overflow pipe.	Free pipe of all obstructions to work as designed.
Manhole Structure	Cover Difficult to Lift	Once every year	One maintenance person cannot open lid after applying 80 pounds of lift. Intent is to keep cover from sealing off access to maintenance.	Repair lid to allow opening by on maintenance person.
	Plugged Air Vents	Once every year	One half of end area of a vent is blocked at any point with debris and sediment.	Free vents of debris/sediment.

Table 8-3 (cont)
Maintenance/Inspection Schedule
for Surface Water Management Facilities

System Component	Defect	Inspection Frequency	Conditions When Maintenance is Needed	Maintenance Required and Results Expected
Manholes				
Manhole	Trash/Debris (includes sediment)	Twice per year	Trash or debris (in the basin) that exceeds 1/3 the depth from the bottom of basin to invert of the lowest pipe into or out of the basin.	Remove all trash or debris.
		Twice per year	Trash or debris in any inlet or outlet pipe blocking more than 1/3 of its height.	Free inlet and outlet pipes of trash or debris.
		Twice per year	Dead animals or vegetation that could generate odors or dangerous gases (e.g., methane)	Remove all dead animals or vegetation present within the manhole.
		Twice per year	Deposits of garbage exceeding 1 cubic foot in volume.	Clean condition which would attract or support the breeding of insects or rodents.
	Structural Damage to Frame and/or Top Slab	Once every 50 years	Top slab has holes larger than 2 square inches or cracks wider than 1/4 inch.	Repair holes or cracks in top slab.
		Once every 50 years	Frame not sitting flush on top slab, i.e. separation of more than 3/4 inch of the frame from the top slab.	Repair frame to sit flush on top slab
	Cracks in Manhole Walls/Bottom	Once every 20 years	Cracks wider than 1/2 inch and longer than 3 feet, any evidence of soil particles entering manhole through cracks, or maintenance person judges that structure is unsound.	Replace/repair manhole to design standards.

Table 8-3 (cont)
Maintenance/Inspection Schedule
for Surface Water Management Facilities

System Component	Defect	Inspection Frequency	Conditions When Maintenance is Needed	Maintenance Required and Results Expected
Manholes (cont)				
Manhole (cont)	Cracks in Manhole Walls/Bottom (cont)	Once every 20 years	Cracks wider than 1/2 inch and longer than 1 foot at the joint of any inlet/outlet pipe or evidence of soil particles entering manhole through cracks.	Repair cracks to where cracks are no more than 1/4 inch wide at the joint of inlet/outlet pipe.
	Settlement/ Misalignment	Once every 20 years	Manhole has settled more than 1 inch or has rotated more than 2 inches out of alignment.	Replace/repair manhole to design standards.
	Fire Hazard	Once per year	Presence of chemicals such as natural gas, oil, and gasoline which create hazard.	Remove or store all flammable chemicals present per recommended practice.
	Vegetation	Once per year	Vegetation growing in inlet/outlet pipe joints.	Remove all vegetation and root growth.
	Pollution	Once per year	Non-flammable chemicals present.	Remove all pollution present other than surface film.
	Cover Not in Place	As conditions indicate	Cover is missing or only partially in place.	Replace or reset manhole cover.
	Locking mechanism not working	Once per year	Mechanism cannot be opened by one maintenance person with proper tools. Bolts into frame have less than 1/2 inch of thread.	Repair mechanism so that it opens.
	Ladder Rungs Unsafe	Once every ten years	Maintenance person judges that the ladder is unsafe due to missing rungs, misalignment, rust, racks, or sharp edges.	Repair ladder to meet design standards.

Table 8-3 (cont)
Maintenance/Inspection Schedule
for Surface Water Management Facilities

System Component	Defect	Inspection Frequency	Conditions When Maintenance is Needed	Maintenance Required and Results Expected
McSorley Creek Outlet Structure				
Rock Pad	Missing or Moved Rock	Once every 5 years	Only one layer of rock exists above native soil in area five square feet or larger, or any exposure of native soil.	Replace rocks to design standard.
Metal Grate	Trash & Debris	Once or twice per year	Trash or debris is plugging more than 20% of the openings in the grate.	Clear grate.
	Damaged/missing bars	Once every 5 years	Bars are bent out of shape more than three inches.	Repair bars to design standards.
Internal Chamber	Worn or Damaged Baffles, Sides of Chamber	Once every 20 years	Structure dissipating flow deteriorates to 1/2 of original size or any concentrated worn spot exceeding one square foot which would make structure unsound.	Replace structure to design standards.
Ditch	Erosion	Once per year	When any visible signs of erosion are detected.	Fill with gravel base or quarry spalls to stop erosion.
Check Dam	Debris	Once per year	When debris reaches one-half the height of the dam.	Remove debris.
Hillside and Stream Banks	Erosion	Once per year	When erosion is detected.	Add riprap as required to prevent erosion.

8.4 EMERGENCY OPERATION

Emergency conditions require changes in the normal operation of the surface water drainage system. Emergency conditions which may occur during the operation of the system include:

- Water surcharging under the pond's liner system as a result of dewatering system failure. Failure to respond to this condition may result in damage to the liner.

- Surface water contamination. Discharge of contaminated water creates potential health risks to nearby residents and the environment.

- Overtopping of the lined detention pond. This condition provides the potential for flooding of the landfill, adjacent properties, and the dewatering pump station electrical controls. Therefore, the pond level should be closely monitored.

8.4.1 Surcharging of Liner System

Surcharging of groundwater beneath the detention pond's membrane liner system would likely be caused by a failure of the dewatering pump station or a related system. The operator would detect this condition by an increased water level in the pump station wet well, or in an extreme condition, by an uplifting (bulge) of the pond bottom or side slopes. When these conditions are detected the operator should refer to Chapter 9 of this manual for proper response procedures.

8.4.2 Surface Water Contamination

Contamination detected in surface water runoff may be detected in runoff stored in the detention pond. The source of the contamination need not necessarily be located at the landfill site. Off-site chemical spills could go undetected and enter into the collection system where it would be carried to the pond and later detected.

The identification of contaminated surface water may occur by the operator noticing an oil slick on the pond surface or through the course of routine water quality monitoring. Should contamination be detected the operator should follow the following emergency procedures:

- Close knife gate valve KGV-36-1 located in the flow control structure.
- Notify the Field Supervisor.
- Notify proper contamination response authorities (Chapter 7).
- Provide a pump truck to maintain normal water levels in pond.
- Determine source of contamination and take necessary actions to stop further contamination of surface water.
- Cleanup or remove contaminated runoff.
- Open knife gate valves KGV-36-1 to allow for normal release.

8.4.3 Overtopping of Detention Pond

The buildup of water within the pond above normally experienced water levels may be caused by several reasons.

A. Obstructions in the discharge pipeline which restrict the flows leaving the detention pond.

B. Plugged or partially blocked orifice openings on the outlet control structure.

C. Debris or obstructions on the trashrack or pond outlet.

D. A storm frequency which exceeds that of 100 years and results in a surface water runoff quantity which exceeds the detention ponds design capacity.

When an increased water level is experienced in the pond the operator(s) should investigate to determine the cause of the problem so that the proper course of action can be taken. These causes can be determined by using the troubleshooting guide provided in this chapter.

Once the cause is known the operator should then implement the proper course of action necessary to prevent an emergency situation from developing. The following is a description of emergency procedures which should be followed under the various described conditions.

<u>Plugged Discharge Pipeline</u>

- Open knife gate valve KGV-36-2 in the flow control structure. The opening of this valve may create enough flushing action to dislodge foreign material caught in the pipeline.

- Close knife gate valves KGV-36-1 & KGV-36-2 in flow control structure to stop pond discharge.

- Use pump trucks to lower pond water levels, as necessary, if blockage doesn't clear.

- Identify area of the blockage and take proper actions to correct the problem.

- Open knife gate valve KGV-36-1.

<u>Plugged or Blocked Orifice Openings</u>

- Open knife gate valve KGV-36-2.

- Use pump trucks to lower pond water levels, as necessary for access to orifice.

- Remove blockages or obstructions from pond outlet flow control structure.

- Close knife gate valve KGV-36-2.

Debris or Obstructions on Trashrack/Pond Outlet

- Use pumps and direct discharge to discharge pipeline or use pump trucks to lower pond water levels.

- Remove debris from trashrack/pond outlet.

Storm Frequency Greater than 100 Years

- The pond outlet flow control structure is equipped with an overflow. In the event that the overflow is not capable of passing sufficient water quantities necessary to maintain lower water levels within the pond, open knife gate valve KGV-36-2 to provide for additional release of runoff water.

8.5 TROUBLESHOOTING

This section has been provided to help the operator in identifying and solving operation and maintenance problems. Table 8-4 lists common operation and maintenance problems for the surface water drainage and detention systems, their probable causes, and control and prevention techniques.

Table 8-4
Troubleshooting Guide
for
the Surface Water Drainage and Detention Systems

Indicators/ Observations	Probable Cause	Solutions
Gravity pipelines plugged - manholes surcharge or overflow.	Obstructions in pipe blocking or causing an impediment in the flow. Low velocity caused debris such as rocks, sediments, sticks, etc. to build up in pipe.	Routinely check and clean areas which experience low flow or are on flat grade.
Intermittent flow or surging during heavy rainfall.	Infiltration of groundwater through cracked or broken pipes.	Inspect for and repair broken lines.
Detention pond outlet plugged - water levels backup in pond	a. Debris on trashrack which restricts flow.	a. Routinely check and clean trashrack and pond outlet.
	b. Obstructions in discharge pipeline which impede flow.	b. Clean pipeline.
	c. Debris on flow control structure which restrict or impede flow.	c. Routinely check and clean outlet structure and flow control orifices of debris, sediment, etc.
Runoff water won't flow in collection ditches	Obstructions or sediment in the ditch block the gravity flow of runoff.	Routinely check ditches and remove obstructions which may impede flow and remove sediment which has accumulated in the ditches.

Table 8-4 (cont)
Troubleshooting Guide
for
The Surface Water Drainage and Detention Systems

Indicators/ Observations	Probable Cause	Solutions
Runoff water backs up behind culvert, inlets	Sediment or debris create a restriction which causes the water to backup.	a. Remove sediment or debris from inlet to pipe. b. Remove sediment or debris in pipe.
Poor discharge water quality	a. Excessive oil accumulation in pond flow control structure.	a. Routinely inspect control manhole for oil buildup and clean as necessary.
	b. Blockage of light in detention pond by excessive plant growth.	b. Remove plant growth at regular intervals from pond surface.
	c. Contaminated surface water runoff.	c. Determine sources of runoff contamination and implement measures to stop further contamination.
Insect Generation	Excessive plant growth.	Remove excessive plant growth or apply insecticides.

8.6 RECORDS AND RECORDKEEPING

Maintenance and costs records should be kept for all services required for the surface water drainage system. Service records are essential for calculating operating costs, determining budget requirements, preparing maintenance schedules, and for scheduling repairs.

OPERATOR NOTES AND COMMENTS

9. DEWATERING PUMP STATION

9.1 DESCRIPTION

This chapter discusses the dewatering pump station and flow metering equipment, which functions to remove groundwater from beneath the stormwater detention pond. Discussions in this chapter focus on the operation and maintenance of these facilities, including operation under emergency conditions, and recordkeeping procedures.

Major components of this system, as shown in Figure 8-3, include:

- Dewatering Pump Station
- Flow Metering Vault
- Force Main Discharge Pipeline

9.1.1 Dewatering Pump Station

The pump station facilities shown in Figure 9-1 consist of wet well and a duplex submersible pumping system.

9.1.1.1 Pumps

The pumps are vertical, non-clog, submersible effluent type with a rated capacity of 100 (gpm) at a total dynamic head (TDH) of 30 feet each. Each pump is powered by a 3,450 RPM, constant speed, 1 horsepower, 230 volt, single phase, 60 cycle alternating current motor. The pumps are a Hydromatic Model #SPD100H and are capable of handling solids with a 3/4-inch maximum diameter.

9.1.1.2 Piping and Valves

Each submersible pump discharge pipe is fitted with a 2-inch check valve (CV-2-1, CV-2-2) and a 3-inch check valve (CV-3-1, CV-3-2), both which are contained in the wet well. A 3-inch gate valve (GV-3-1, GV-3-2) is located outside the wet well in a concrete valve vault.

9.1.1.3 Wet Well

The pump station wet well consists of a pre-cast concrete manhole. It has a 6-foot inside diameter, is 20 feet 8 inches in depth and has a capacity of 211 gallons per foot of depth.

9.1.1.4 Pump Control System

Adjustable mercury float switches are used to activate and deactivate the pumps in the automatic mode of operation. The mercury float switches are encapsulated in a smooth, pear-shaped chemical resistant polypropylene casing. One switch is used for each of the following system functions (OFF, LEAD PUMP ON, LAG PUMP ON, HIGH LEVEL ALARM). Float switches suggested setting are listed in Table 9-1.

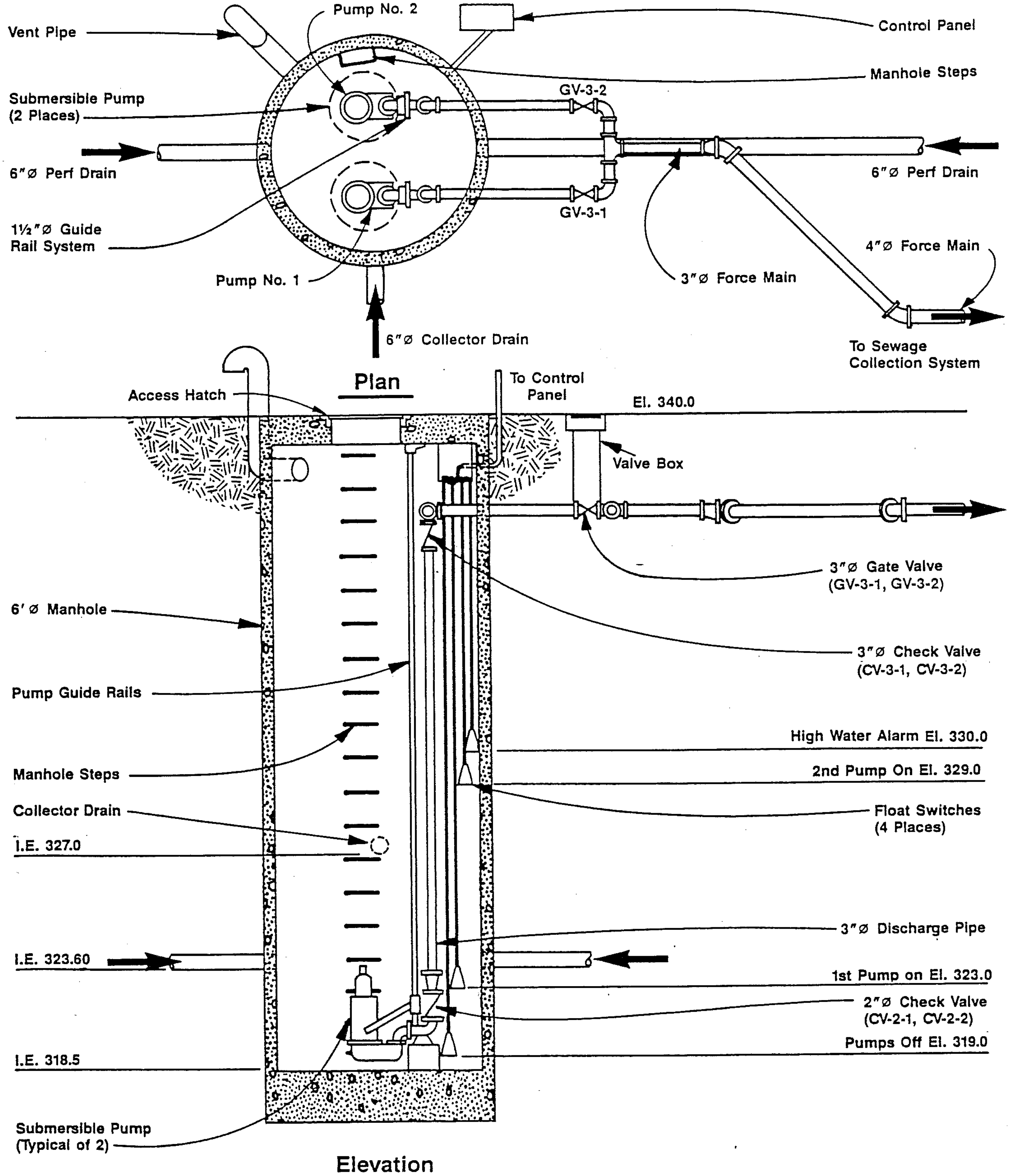


Figure 9-1.
Dewatering
Pump Station

Table 9-1
Suggested Float Control Switches Setting

Switch Function	Water Elevation	Heights from Top of West Well (Feet)[1]
Pumps Off	319.0	21.0
Lead Pump On	323.0	17.0
Lag Pump On	329.0	11.0
High Water Level	330.0	10.0

[1] Distance is measured from top of wet well (Elev. 340.0) to bottom of weight on cord immediately above the float switch.

9.1.1.5 Instrumentation and Control

Pump Selection Switches

The pumps are controlled by HAND-OFF-AUTO selector switches on the control panel inside the control panel. In the HAND setting, the pump will run continuously until the selector switch is turned to OFF or AUTO. In the AUTO position the pumps will be controlled by the float switches in the wet well. See Section 9.3 pump station normal operation for a description of the automatic operation of the system. The OFF position shuts off control voltage.

CAUTION: The main power is still present at panel and pumps until the main breaker switch is turned off.

Automatic Lead/Lag Pump Alternator

The automatic lead/lag submersible pump alternator is controlled by a relay in the control panel. When the lead pump operation is stopped by the pumps OFF switch the alternating relay will index so the lag pump will start on next operation. The function of this system is to provide even wear on the pumps, so at anytime the elapsed hour time meter on the control panel should indicate about the same operating time for each pump. This feature also prolongs the motor life by allowing longer cycle times between motor starts.

The pump alternator circuit operates independently of the pump's operational status. In other words, the alternator circuit can't tell if a pump is operational or not. Because of this, the circuit can't change the lead/lag combination due to a pump failure or a pump being in the OFF position. For example, if the lead pump were in the OFF position, the alternator circuit would still keep this pump as the lead pump and the lag pump would not turn on until the level rose to the lag pump setpoint. When the lag pump shuts off, the alternator circuit will index and the lag pump will switch to the lead pump for the next cycle.

During the next cycle, the lead pump will operate normally, but now the lag pump (which is in the OFF position) will not turn on if the level was to rise to the lag pump setpoint.

9.1.1.6 Support System

Pump Removal System

The submersible pumps are equipped with a pump disconnect system to permit the easy removal of each pumping unit for inspection or service.

The pumps are securely attached to a sliding guide bracket that travels on two guide rails. Each pump has a hydraulically sealing discharge elbow that automatically connects to the discharge pipe when the pump is lowered into place and provides a leak-proof seal when the pump is in operation.

Electrical System

The pump station is powered by 220 volt, single phase, 60 Hz power supplied by Puget Power.

9.1.2 Flow Metering Station

The flow metering station records the amount of groundwater discharged from the dewatering pump station. The flow monitoring meter and associated piping are located in a 4-foot-2-inch wide by 6-foot-6-inch long by 3-foot-8-inch deep, precast concrete utility vault, as shown in Figure 9-2. The flow meter consists of a 4-inch turbine water meter. The flow meter is equipped with three 4-inch gate valves (GV-4-1, 2 and 3) which have been provided to allow flow to bypass the meter in order to provide for its maintenance or removal.

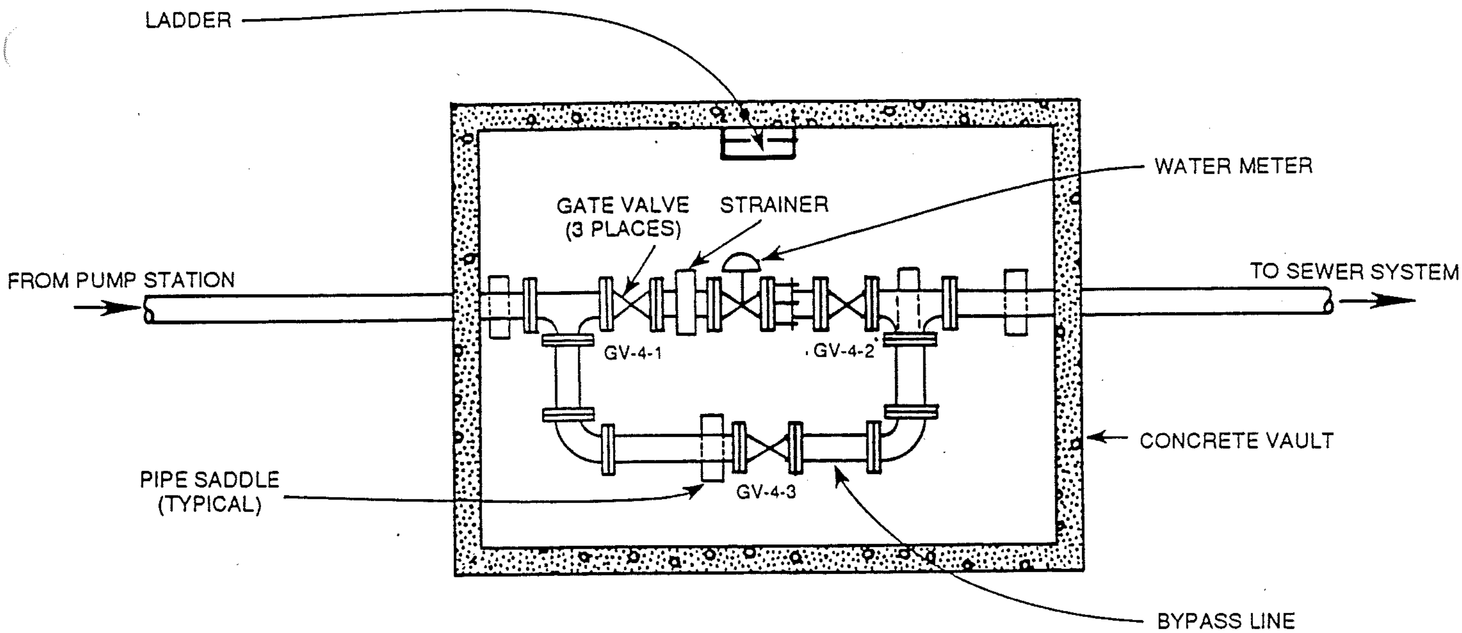
9.1.3 Force Main Discharge Pipeline

A 4-inch force main conveys the groundwater discharged from dewatering pump station to the Midway Sewer District sewage collection system.

9.2 STARTUP AND INITIAL OPERATION

If the pump station fails to function, groundwater will back up in the dewatering system collection pipes located beneath the detention pond's membrane liner system. The presence of this water beneath the detention pond creates potential risks to the liner system because of possible damage which may occur from excessive hydrostatic pressures.

The following procedures should be followed during the initial operation of the dewatering pump system.



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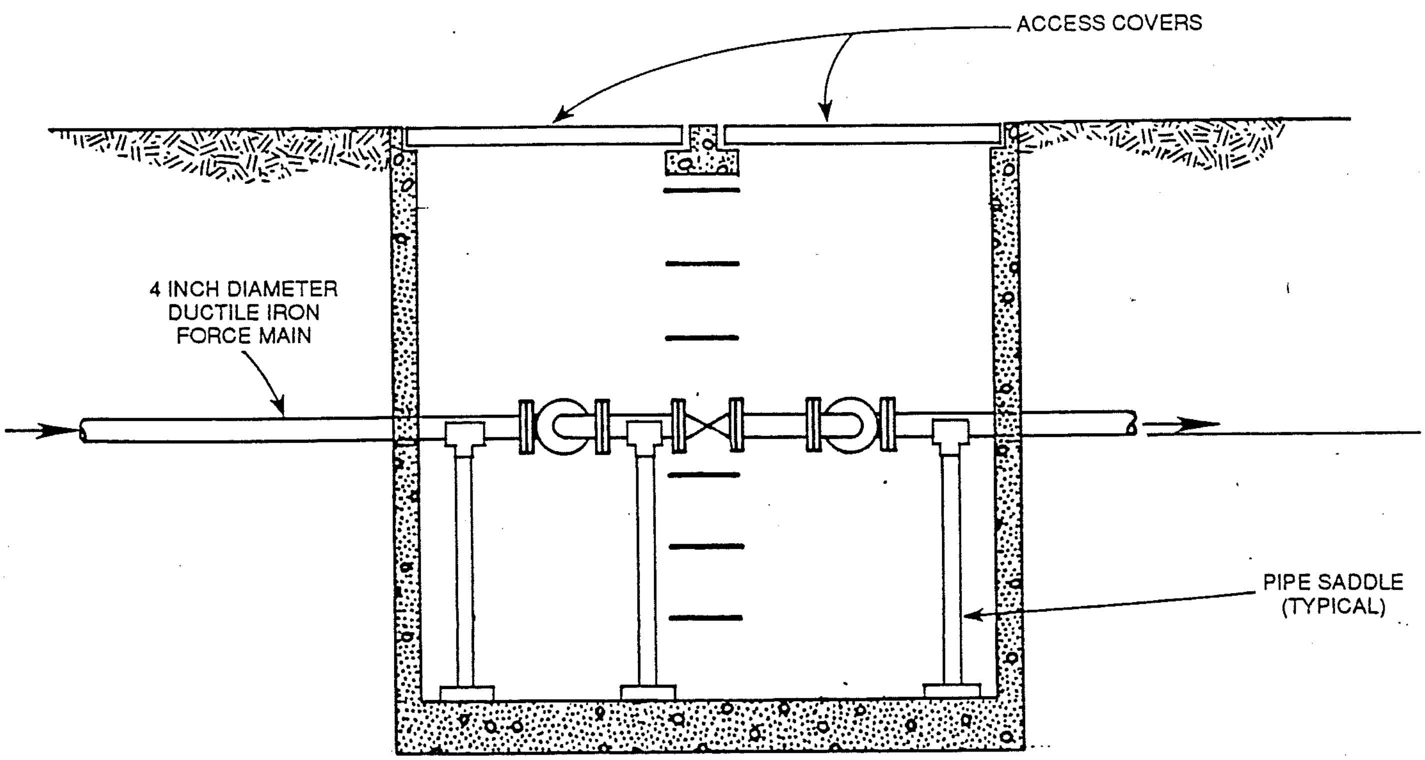


Elevation

Figure 9-2.
Flow Metering Station

9.2.1 Detention Pond

- Check dewatering system cleanouts to make sure they are securely in place.

9.2.2 Dewatering Pump Station

- Unlock and open wet well and valve vault access hatches.
- Remove any debris or sediment which has accumulated within the wet well.
- Check to see that the pumps are properly lubricated and ready for operation in accordance with the manufacturer's instruction manual.
- Verify the discharge valves for the pumps being operated are in the OPEN position (Figure 9-3).
- Inspect the Midway Sewer District manhole to make sure it is ready to receive flow.
- Check all four float switch settings to verify they are set correctly.
- Check and record the readings at the pump running time meters.
- Place the main circuit breaker located in the control panel in the ON position.
- Set the HAND-OFF-AUTO selector switch on AUTO. If necessary, introduce a simulated flow of sufficient quantity into the wet well to raise the water level above both the lead and lag ON switches. If no water is available, manually pull up floats to simulate flow.
- Observe equipment for proper operation.
- Close and lock access hatches.

9.2.3 Flow Metering Station

- Verify all valve settings for the flow meter are in the appropriate setting as shown in Figure 9-4.

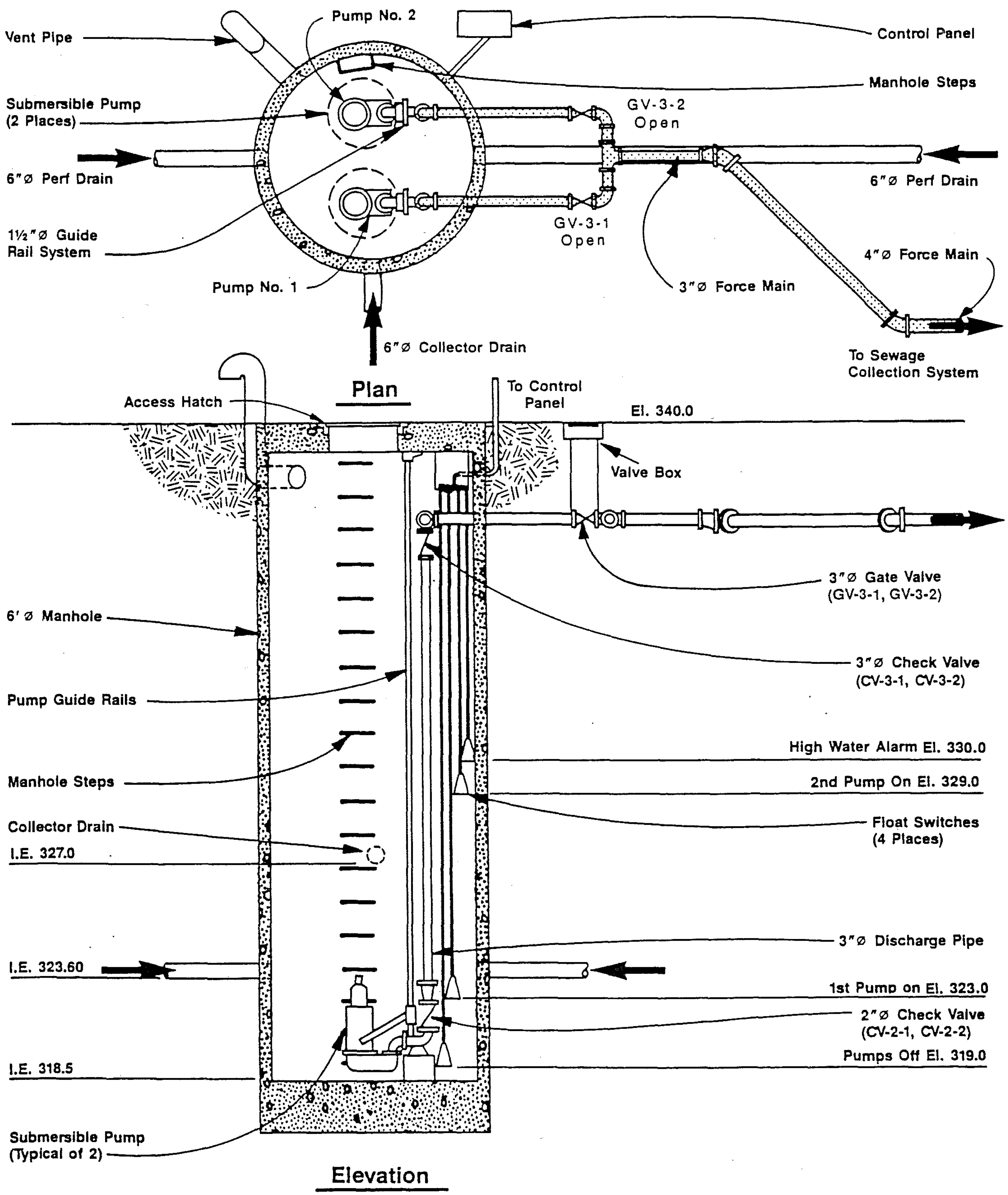
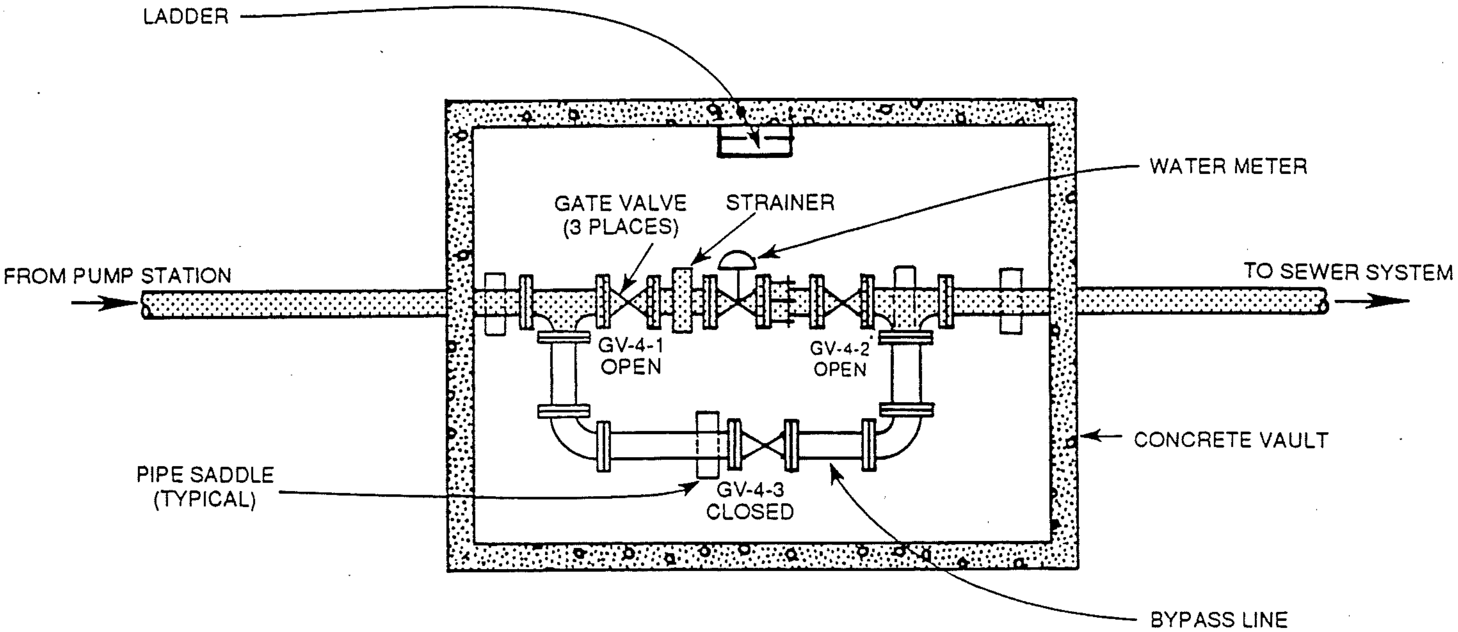
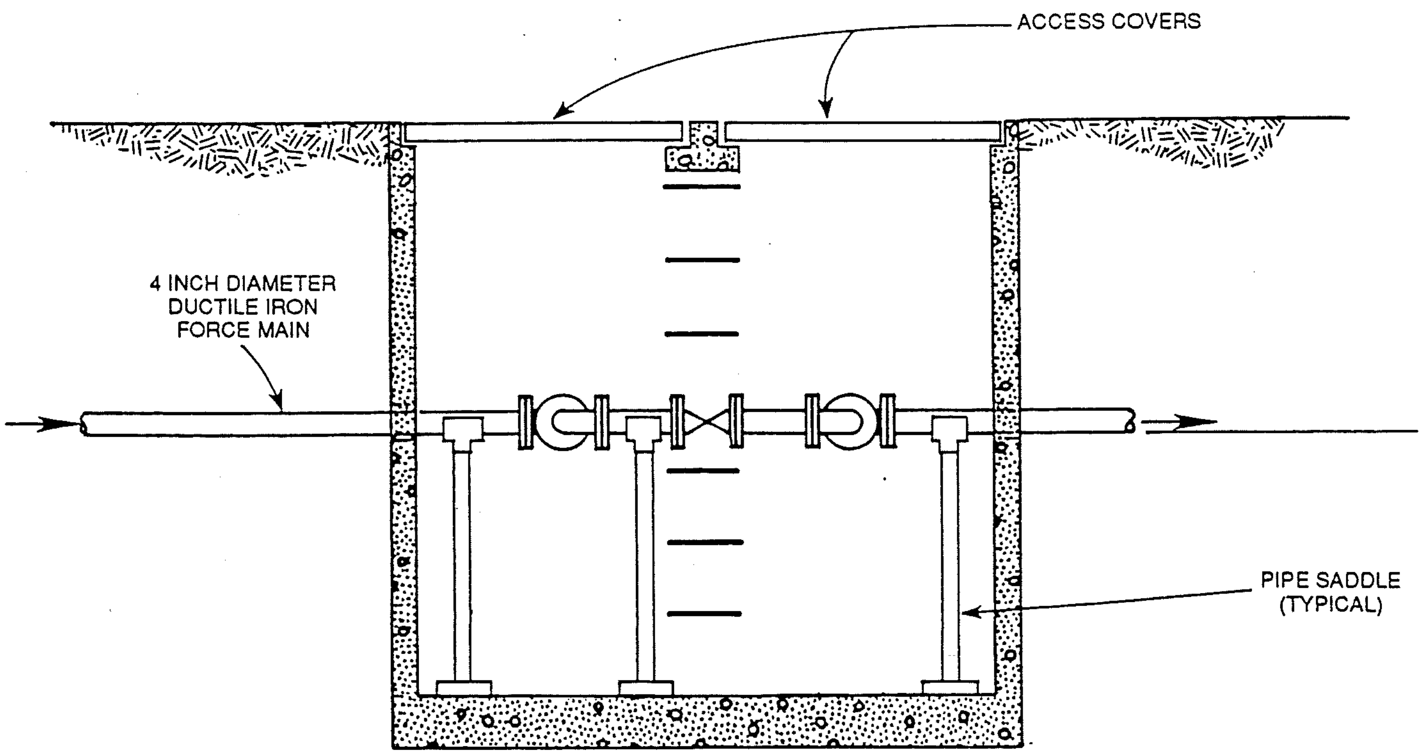


Figure 9-3.
Dewatering Pump Station -
Dual Pump Operation



Plan



Elevation

**Figure 9-4.
Flow Metering Station-
Normal Operation**

9.3 NORMAL OPERATION

During normal operation, both pumps are set to the AUTO position. The system valve lineup is as follows:

- Verify valves in the OPEN position:
  - Gate Valves GV-3-1 and GV-3-2 (Figure 9-3)
  - Gate Valves GV-4-1 and GV-4-2 (Figure 9-4)
- Verify gate valve GV-4-3 is in the CLOSED position (Figure 9-4)

When the wet well water level rises to the lead pump ON level switch position, the lead pump turns on and pumps at the specified rate (see pump manufacturer's literature for pump performance curves). When the wet well water level drops to the OFF level switch position, the lead pump will turn off and the alternating relay will index so the lag pump will start on the next cycle as the lead pump.

If the wet well level continues to rise with the lead pump in operation, the lag pump ON level switch will be activated, causing the lag pump to turn on and pump with the lead pump until the wet well level drops to the pumps OFF level switch position. When the OFF level switch position is reached, both the lead and the lag pumps turn off. The lead and the lag pumps are identically rated.

If the wet well level continues to rise when both pumps are operating, the high wet well level alarm switch will energize the high wet well level alarm.

If either of the pumps should fail, the pump alternator circuit will not be affected. This means that the remaining pump will switch back and forth between the lead and lag position.

9.4 ALTERNATE OPERATION

This subsection discusses operation of the dewatering pump system for three alternative modes of operation.

9.4.1 Manual Operation of Pumps

- Verify that all valves are in the appropriate position per Section 9.3.
- Set the HAND-OFF-AUTO selector switch for the pump(s) in question to the HAND position.

  CAUTION: When the pump(s) are in the HAND position they will run continuously, even when the water level drops to the OFF level switch position. Do not run the pump(s) in the HAND position unless there is another person monitoring the water level in the wet well. This will prevent possible damage to the pump(s).

9.4.2 Automatic Operation of Only One Pump

- Verify that all valves are in the appropriate position per Section 9.3. Close the gate valve (GV-3-1 or GV-3-2) for the pump not in operation if the pump is to be pulled out of the wet well for service. The circuit breaker for the disabled pump should be turned to the OFF position for safety.

- Turn the HAND-OFF-AUTO selector switch for the pump not being operated to the OFF position.

- The pump in service will operate in the automatic mode of operation. With each on/off cycle, the pump will switch between either the lead or lag operating setpoints.

9.4.3 Total Shutdown

If the pump station shutdown is required due to a malfunction of both pumps, the pump control system, or the electrical system the following procedure should be followed:

- Turn the HAND-OFF-AUTO for both pumps to the OFF position.

- Switch the main power disconnect switch to OFF for safety.

Water will start backing up in the wet well and the upstream groundwater collection system, and the high water level alarm float switch will energize and signal the high water alarm. For extended periods of "total shutdown," portable pumps should be used to maintain the pumping of groundwater to prevent the possibility of damage to the liner system. The portable pumps can be set up to discharge to the detention pond.

To restart the station, return the power DISCONNECT switch to the ON position, and then turn the pump operation selection switch back to the AUTO position.

9.4.4 Flow Metering Station

The flow metering station is equipped with valving which allows alternate operation for periods when maintenance or repair of the flow meter is required. When maintenance or repair of the meter is necessary, the following procedure should be followed:

- Turn gates valves GV-4-1 and GV-4-2 to the CLOSED position.

- Turn gate valve GV-4-3 to the OPEN position.

This alternate operation allows discharge water to bypass the meter and easily facilitates the meters removal for repairs or servicing.

9.5 ROUTINE MAINTENANCE

The following routine operation and maintenance tasks should be followed to keep the pump station operating in good condition. A partial list of routine tasks which may be required to keep the pump station operating in good order is provided below. This procedure should be used in conjunction with the manufacturer's recommended operation and maintenance instructions. Table 9-2 is a summary of the routine maintenance requirements of the dewatering pump station.

9.6 TROUBLESHOOTING

Common operation and maintenance problems for the dewatering pump station, their probable causes, and control and prevention techniques are listed in Table 9-3.

9.7 ALARM CONDITIONS

There are three different alarms for the dewatering pump station. They are:

- Pump seal failure
- Pump high temperature
- High water level in the well

The pump seal failure alarm activates if moisture is detected in the pump motor. The high temperature alarm activates if the pump is an overload condition which is causing the pump to overheat. The high level alarm will activate if the level in the well reaches El. 330 feet.

Both the seal fail and high temperature alarms have indicating lights located on the control panel. The high level alarm has an indicating light mounted on top of the control panel.

The high temperature and high water level alarms have reset switches located on the control panel. The reset switches must be pushed to clear the alarms. If the alarm does not clear after pushing the reset switch, then the alarm condition still exists.

The alarm system should be tested at least once a quarter.

Table 9-2
Maintenance/Inspection Schedule for Dewatering Pump Station

System Component	Defect	Inspection Frequency	Maintenance Required and Results Expected
Wet Well			
Walls/Floor	Scum Buildup	Weekly	Wash scum off of the wall and break up scum to control odor and prevent grease buildup.
	Sediments/ Debris	Weekly	Remove and dispose of sediments and floating debris which could clog pumps.
Float Switches	Scum Buildup	Weekly	Clean accumulations of scum and other materials from float switches, using a high pressure hose, if necessary. Check to make sure that the float switches are not tangled.
Pumps			
Intake	Intake Clogging	Annually	Remove pump(s) and check intake.
Impeller	Clogging	Twice per year	Inspect impeller and body for clogging.
Motor	Current Draw	Annually	Check the pump motor current draw for high power requirements.
	Unusual Noise	Weekly	Listen for unusual noises and repair/replace pump as necessary.
Control System			
Float Switches		Monthly	Regularly inspect the system and float switch settings.
Alarms		Quarterly	Simulate the wet well high water level conditions. Also push the Seal Fail Test switch and verify the alarm light turns on.
Piping and Valves			
Gate Valves	Sticking	Monthly	Regularly exercise the valves.

Table 9-3
Troubleshooting Guide for the Pump Station

Indications/ Observations	Probable Cause	Solutions
1. Force main plugged, pumps won't deliver flow, wet wells back up, high level alarm sounds, and eventually groundwater backup into collection system under pond.	1. Obstructions in force main blocking or causing impediment in the flow, or debris was picked up from the wet well and pumped into the force main.	1. Routinely check and clean wet well.
2. Pumps plugged.	2. Debris in wet well causing obstruction in pump.	2. Backflush pumps and check wet well for debris.
3. High level alarm repeats.	3. Low pumping rate caused by plug in force main. One pump failed.	3. Routinely check and clean wet well.
4. High pump time.	4. Partial plug in pumping system. Infiltration.	4. Check running time meters at each scheduled maintenance check.
5. Pumps won't start.	5. Pumps, level switch or control circuit problems. Pumps are plugged.	5. Check pump controls (level, alternator, etc.) and check to see if pumps are plugged.
6. Intermittent flow or surging.	6. Improper wet well level switches position.	6. Check and adjust level switches.
7. Pump not running.	7a. Defective control circuit.	7a. Use meter to check switching circuits and replace defective part.
	7b. Clogged pump or closed valve.	7b. Inspect pump for obstruction and remove obstruction.
8. Pump not running, circuit breaker will not reset.	8a. Short circuit.	8a. Inspect electrical equipment for damage.
	8b. Faulty breaker.	8b. Inspect electrical equipment for damage.
	8c. Pump binding.	8c. Inspect pump for obstruction and remove obstruction.
9. Pump is running, but discharge is reduced.	9a. Pump is air-bound.	9a. Bleed air from pipe and remove obstruction.
	9b. Clogged impeller.	9b. Inspect for and remove obstruction.
10. Clogged pump.	10. Grease accumulations.	10. Check grease accumulation on walls of wet well or remove grease by dewatering the wet well and scraping the bottom.

Table 9-3
Troubleshooting Guide for the Pump Station

Indications/ Observations	Probable Cause	Solutions
11. Rising power consumption.	11. Clogged pump.	11. Remove obstruction in pump.
12. Improper liquid levels.	12. Hang-ups in float level switches.	12. Remove obstruction, release float.
13. Excessive wear or damage to pumps.	13a. Sand accumulations in wet well.	13a. Inspect for eroding action, corrosion and solids build-up and remove sand from wet well.
	13b. Grease accumulations in the wet well.	13b. Inspect and clean wet well.

9.8 EMERGENCY OPERATION

Failure of the dewatering pump station to function can result in an emergency condition which, unless corrected, may result in the groundwater level rising beneath the detention pond and subsequent damage to the liner system. A pump station failure could be a result of one of the following conditions:

- Power failure
- Pump malfunction
- Control system malfunction or failure
- Severe weather

When an emergency condition does exist the operator should take the following course of action to alleviate the potential for liner damage.

- Turn HAND-OFF-AUTO selector switch to the OFF position.

- Install a portable submersible pump in the wet well. Run the discharge hose to the detention pond. Pump to maintain a high level of approximately five feet (top of the 6-inch perforated drain penetration) and a low level of about six inches.

- Follow alarm and troubleshooting response procedure provided in this chapter until the problem(s) can be identified and corrected.

- After a power outage confirm that all pump equipment is functioning properly and that it has not become damaged by electrical surges or voltage drops.

- Remove portable pump.

9.9 RECORDS AND RECORDKEEPING

Maintenance and costs records should be kept for all services required for the dewatering pump station. Service records are essential for calculating operating costs, determining budget requirements, preparing maintenance schedules, and for scheduling repairs.

OPERATOR NOTES AND COMMENTS

10. I-5 PUMP STATION

10.1 DESCRIPTION

The function of the pump station facility is to collect surface drainage from an area east of I-5 plus a portion of I-5, which formerly drained into the Midway Landfill, and pump it to the Midway Detention Pond using a portion of the existing I-5 drainage system.

The pump station facility is shown in Figure 10-1, and consists of:

- Pump Station
- Force Main Discharge Pipeline
- Overflow Structure and Detention Pond

10.2 PUMP STATION

The pump station consists of four submersible pumps in a wet well plus a separate control building. The individual elements of the pump station system are described below.

10.2.1 Pumps

There are four vertical, non-clog, submersible solids handling pumps. Up to three of the pumps are in service at a time, with the remaining pump as a spare. Pump use is rotated automatically to provide even wear and longer life. Each centrifugal pump has a rated capacity of 1500 gpm at a total dynamic head of 62 feet. Pump motors are 1750 RPM, 40 horsepower, 460 volt, three phase, 60 cycle, alternating current types. The pumps are manufactured by Hydromatic, Model No. S6LX, and are capable of handling solids up to 3 inches in diameter.

10.2.2 Piping and Valves

Each submersible pump has a 6-inch diameter discharge pipe which connects directly to a vertical 8-inch discharge line through a 6-inch elbow and a 6-by-8 inch reducer. Each 8-inch discharge line exits the wet well wall and enters a valve vault below grade. There are two valve vaults, each taking two of the four discharge lines as shown on Figure 10-1. Each line has an 8-inch plug valve and an 8-inch check valve. The two 8-inch lines leave each of the valve vaults and combine into 12-inch diameter lines which in turn combine into the 16-inch force main. The 16-inch force main delivers the stormwater to the catch basin at the east edge of the I-5 freeway. From this point the stormwater flows by gravity to the west side of the freeway and the detention pond at the Midway Landfill.

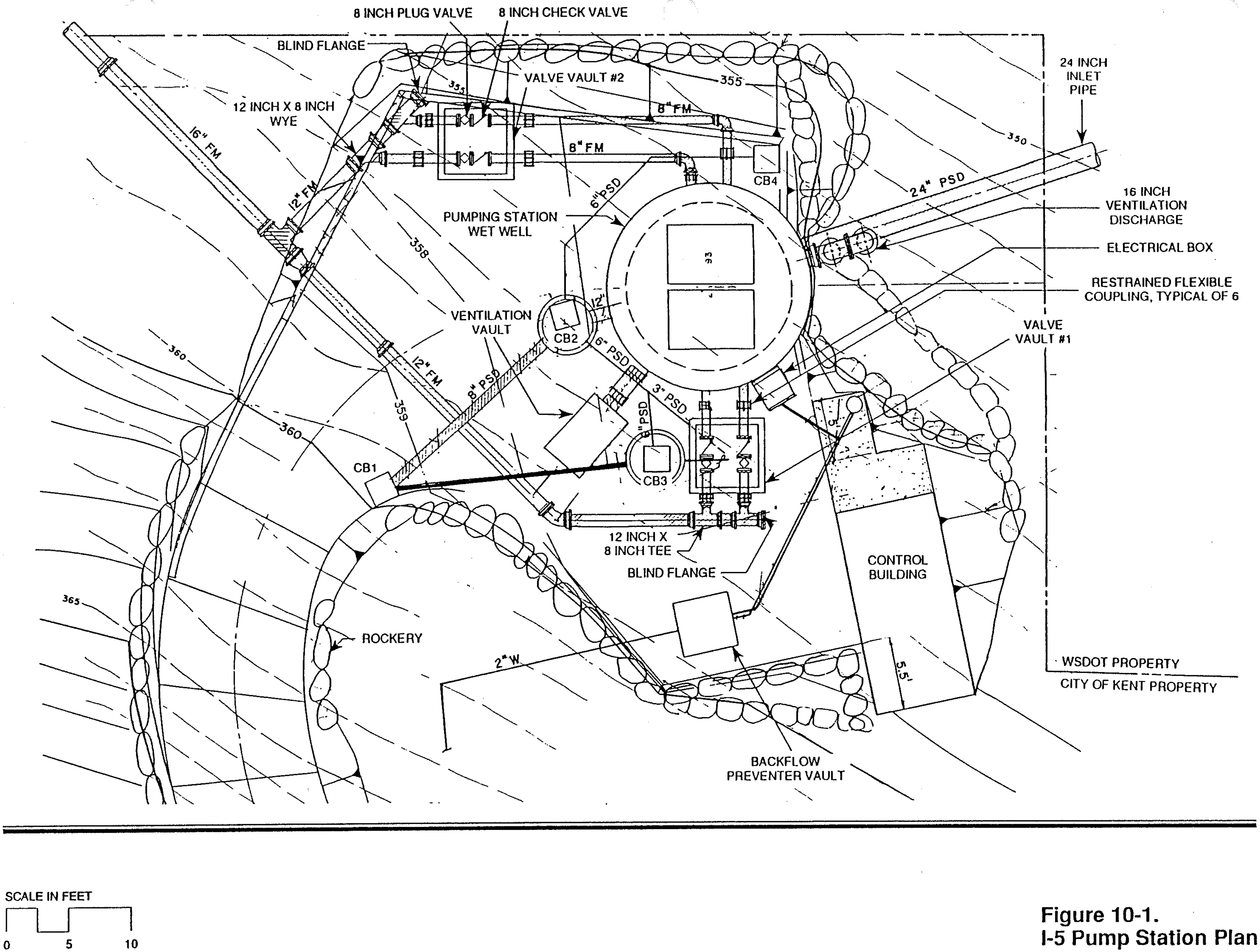


Figure 10-1.
I-5 Pump Station Plan

10.2.3 Wet Well

The reinforced concrete wet well has an inside diameter of 13 feet and is 44 feet deep. It has a volume of 993 gallons per foot of depth. An elevation view of the wet well is shown in Figure 10-2 and a plan view is shown in Figure 10-3.

10.2.4 Pump Control System

Four adjustable mercury float switches are used to activate and deactivate the pumps in the automatic mode of operation. In addition, three float switches are used to activate wet well water level alarms. Table 10-1 summarizes the individual switch functions and lists the recommended setpoints.

Table 10-1
Suggested Float Control Switch Settings

Switch	Setting	Elevation (in feet)
FS-1	Pumps off	320.7
FS-2	Lead pump on	323.3
FS-3	2nd pump on	324.3
FS-4	3rd pump on	325.3
FS-5	High water alarm	335.0
FS-6	Overflow elevation, Ventilation fan off	347.5
FS-7	Low water alarm	319.1

10.2.5 Instrumentation and Control

The pump controls, instrumentation, and electrical service are located in the Control Building shown in Figure 10-4.

10.2.5.1 Pump Selection Switches

The pumps are controlled by HAND-OFF-AUTO selector switches on the control panel. In the HAND setting, the pump will run continuously until the selector switch is turned to the OFF or AUTO position. In the AUTO position the pumps will be controlled by the float switches in the wet well. See Section 10.6 for a description of the automatic operation of the system under normal operating conditions. The OFF position shuts off the control voltage.

> **CAUTION:** Main power is still present at the panel and pumps until the main breaker switch is turned off.

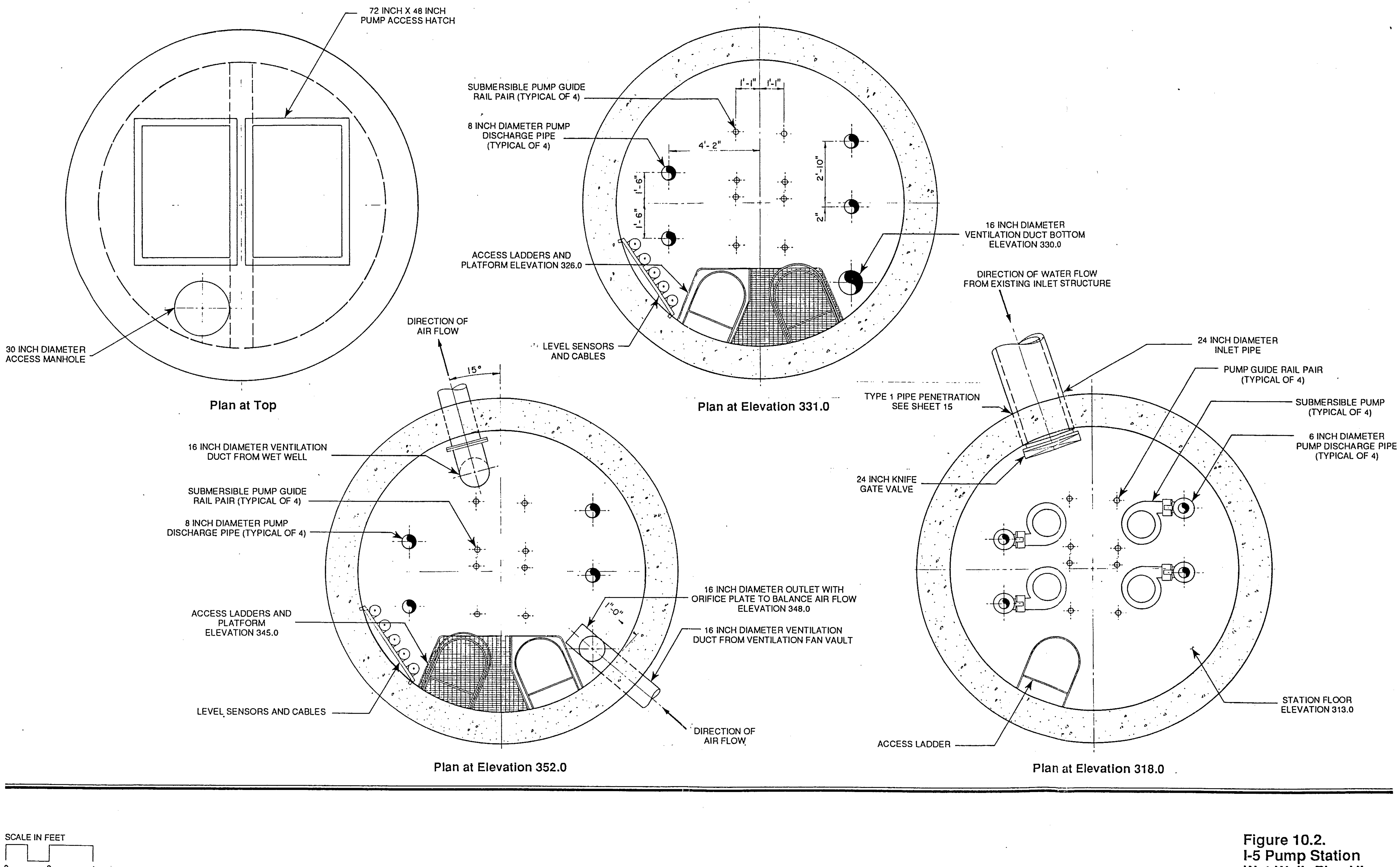
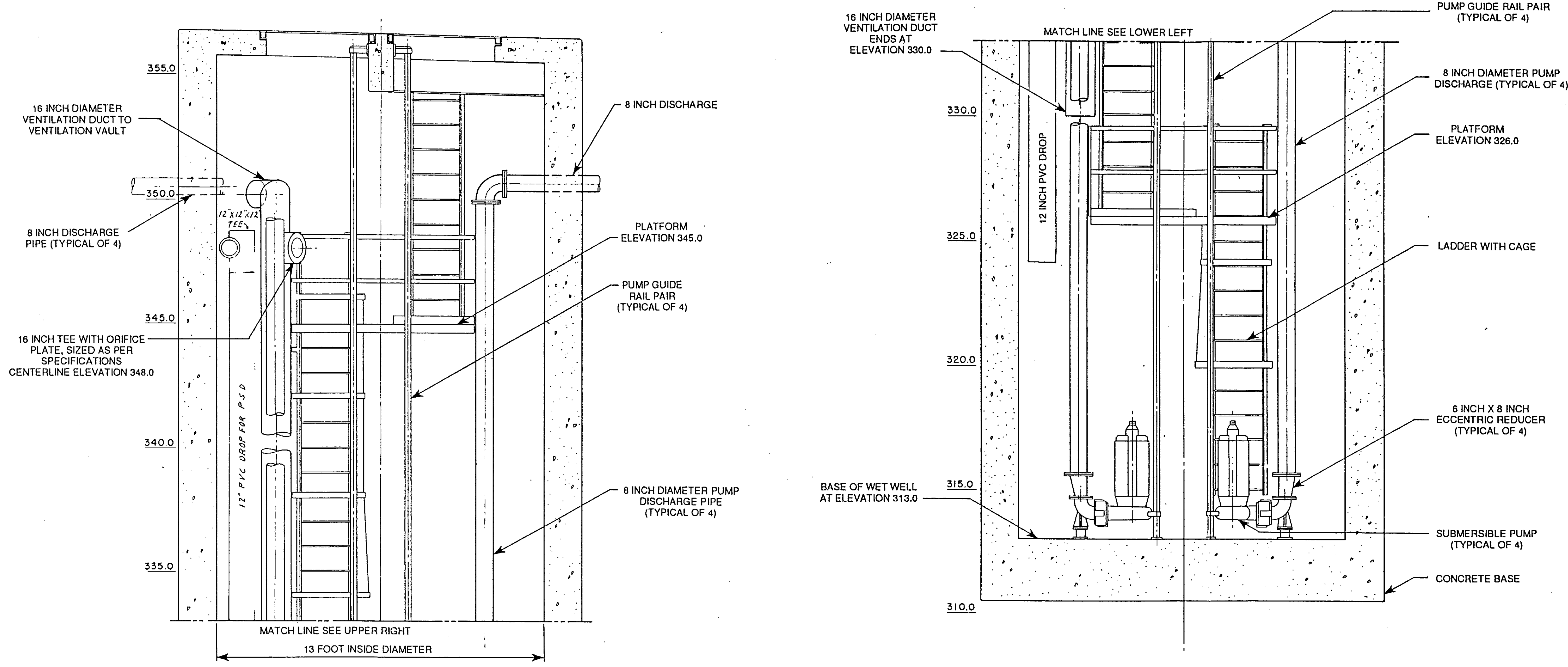


Figure 10.2.
I-5 Pump Station
Wet Well- Plan Views



Notes: 1) Wall thickness and depths shown approximately only. See structural drawings for dimensions.

2) Pipe supports not shown for clarity, pipe supports shall be placed as noted in the specifications.

3) Pump guide rail pair supports not shown for clarity supports shall be designed, approved and placed as noted in the specifications.

Figure 10-3.
I-5 Pump Station
Wet Well-Elevation View

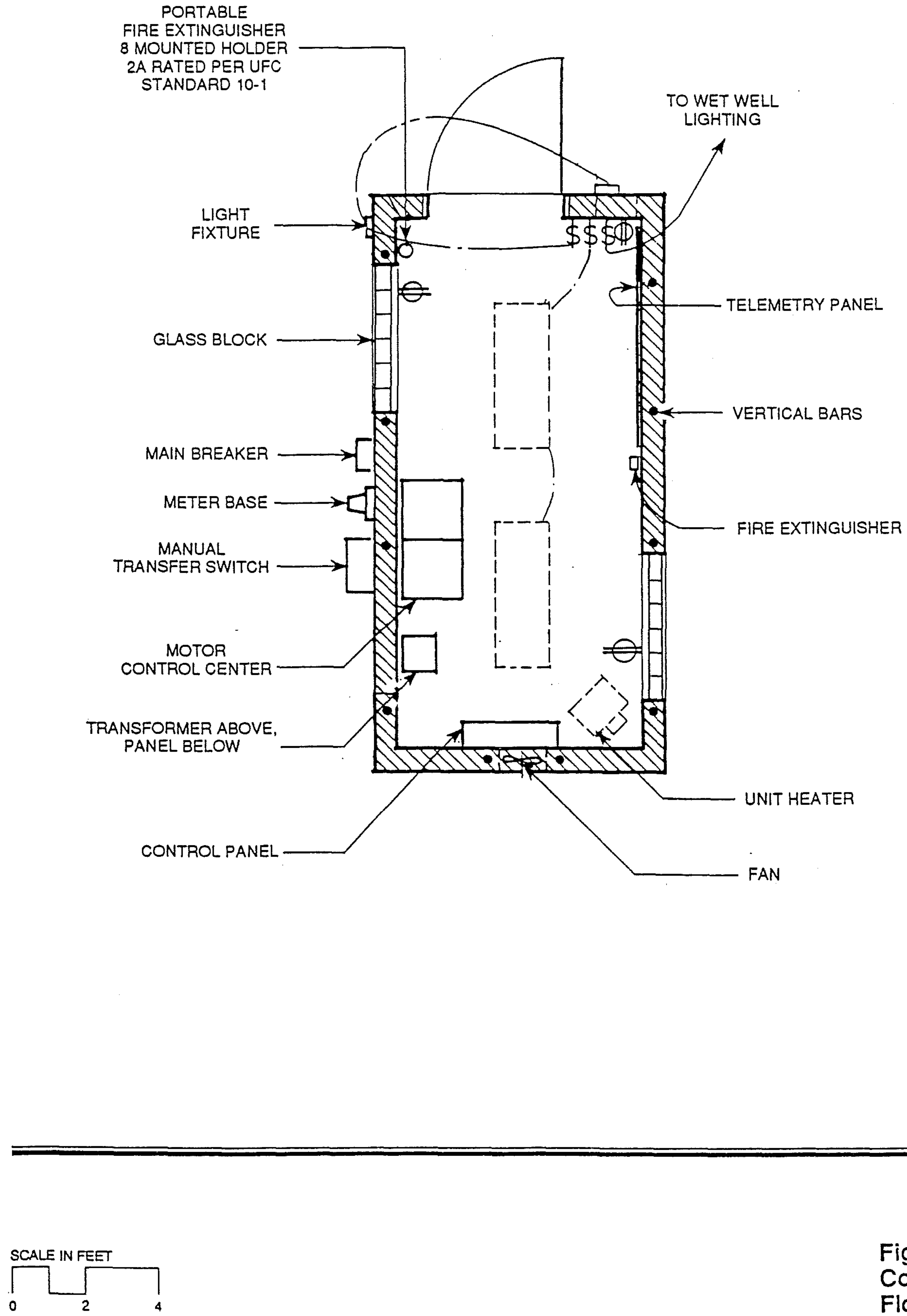


Figure 10-4.
Control Building
Floor Plan

10.2.5.2 Automatic Alternating Relay

The order in which the pumps are used during each on-off cycle is controlled by the quadraplexor. Each time all pumps in use stop, the quadraplexor chooses a different pump cycle. The function of this system is to provide even wear on the pumps, so at anytime the elapsed hour time meter on the control panel should indicate about the same operating time for each pump. This feature also prolongs the motor life by allowing longer cycle times between motor starts.

10.2.6 Alarm System

Table 10-5 summarizes all the I-5 pump station alarms and gives a basic description of how the system operates.

10.2.7 Support System

Each pump is securely attached to a sliding guide bracket that travels on two guide rails. The guide rails are used to keep the pump in proper alignment with the stationary discharge piping as the pump is being raised or lowered. All of the pumps have a hydraulically sealing discharge elbow that automatically connects to the discharge pipe when the pump is lowered into place and provides a leak-proof seal when the pumps are in operation.

10.2.8 Pump Removal System

The submersible pumps are equipped with a pump disconnect system to permit the easy removal of each pumping unit for inspection or service. Once the pumps are shut off, the pressure drop releases the hydraulic seal at the pump discharge allowing the pump to be pulled out of the wet well by a lifting chain attached to the top of each pump.

10.2.9 Ventilation System

The ventilation system consists of two fans, an exhaust fan for the control building and the wet well ventilation fan. The fan in the control building is a Loren Cook, Type AWD, steel wall fan. It is designed to put out 366 cfm at 0.5 inch water pressure. The speed and length of time this fan runs are controlled manually. The ventilation fan for the wet well is located in the ventilation vault, southeast of the wet well. The fan is a Loren Cook Model 12CVB centrifugal blower. This fan is designed for 1200 cfm at 0.5 inch water pressure. The ventilation vault is connected to the wet well by ventilation ducts. This fan is controlled by the main control panel in the control building. See Section 10.6.2 for information on this fan's controls.

10.2.10 Electrical System

The pump station is powered by 460 volt, three phase, 60 Hz power supplied by Puget Power. This line comes into the site underground. At the south exterior face of the Control Building the power comes up into the service disconnect panel, then goes to the meter and on to the manual transfer switch, before feeding the motor control panel inside the building. Below the manual transfer switch (Figure 10-4) is a panel with generator terminals to be used to hook up a generator for backup power if needed during an extended power outage.

10.2.11 Water System

Water for washdown is supplied to an exterior washdown standpipe in between the wet well and the Control Building. Water service is provided from the intersection of South 248th Street and 35th Avenue South through a 1-1/2" meter and 2-inch copper service line. The water supply is isolated from the washdown standpipe by a reduced pressure principal backflow preventer located in a vault south of the control building.

10.3 FORCE MAIN DISCHARGE PIPELINE

The 16-inch force main conveys the stormwater west and south along the right-of-way of the northbound lanes of I-5 about 500 feet to a catch basin. From this catch basin the discharge flows west under the freeway to a gravity conveyance system which routes the flow to the detention pond at the north end of Midway Landfill.

10.4 OVERFLOW STRUCTURE AND DETENTION POND

The overflow structure and detention pond are located northwest of the wet well in the ravine alongside I-5. The overflow structure is shown in Figure 10-5. It is constructed from two 12-foot sections, 54 inches in diameter, of reinforced concrete pipe on end, with a beehive trash rack on top. The top of the pipe is at El. 347.5, approximately 12 feet aboveground. The detention pond is formed by the existing ravine alongside I-5.

Under normal conditions the stormwater drains into the existing manhole east of the overflow structure. From there the water drains into the wet well. When the pumps are unable to keep up with the incoming flow, the stormwater will begin to back up in the storage pond. When the elevation of the water reaches 347.5, the water will start to drain into the overflow structure. The overflow discharges into the 30-inch corrugated metal pipe (CMP) under I-5 to Midway Landfill.

10.5 START-UP AND INITIAL OPERATION

To begin operation of the pump station initially, or after a prolonged shutdown, there are certain procedures and considerations that differ from the normal operation, as described in Section 10.6. The following items need to be checked by the operator:

10.5.1 Wet Well

- Unlock and open the wet well access hatches.
- Remove any debris or sediment which has accumulated within the wet well.

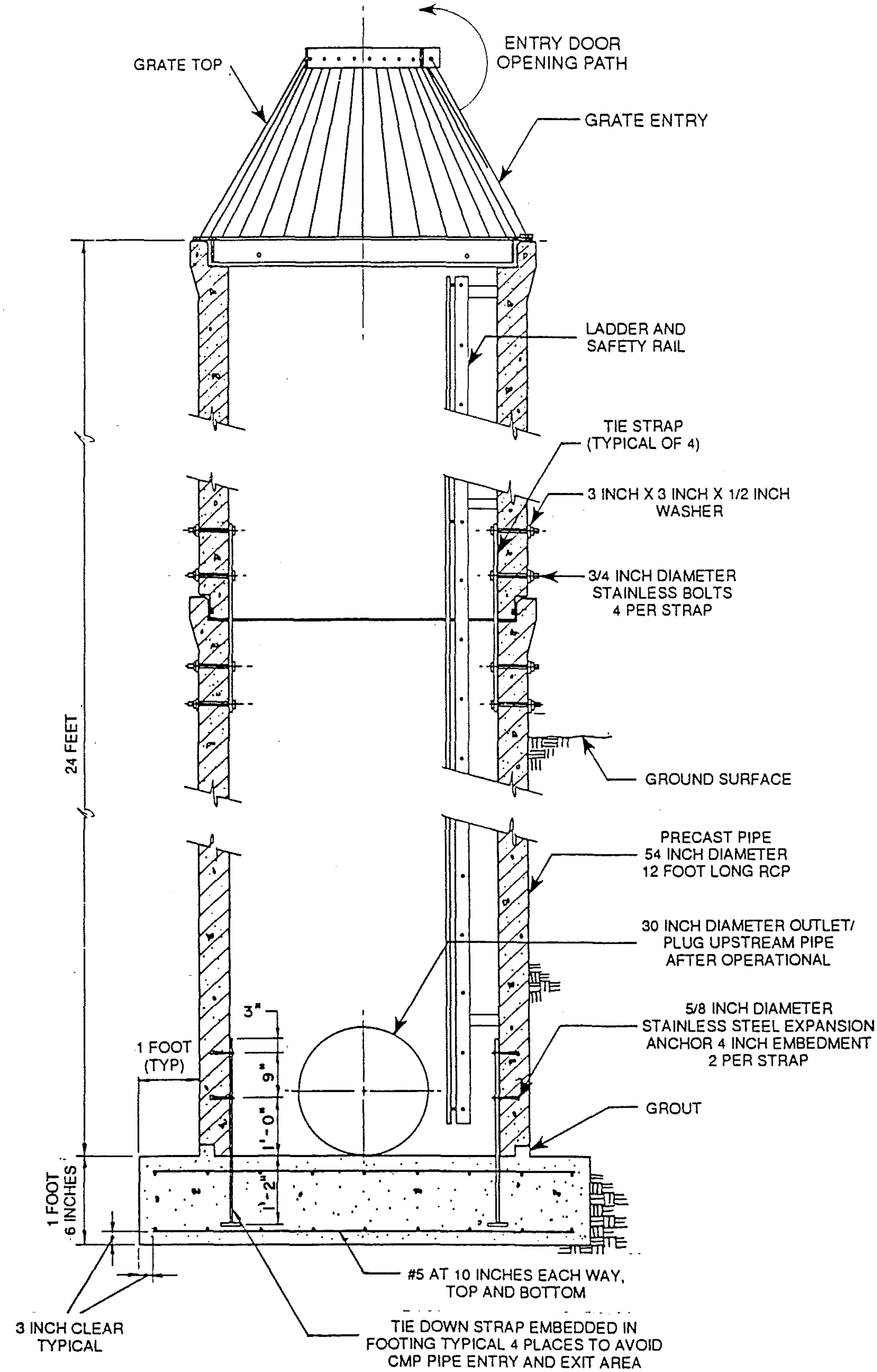


Figure 10-5.
Overflow Structure

10.5.2 Pumps and Controls

- Check that the pumps are ready for operation in accordance with the manufacturer's instruction manual.

- Check the float switch settings.

- Check and record the readings at the pump running time meters.

- Check that the main circuit breaker (located in the control panel) is in the ON position.

- Set the HAND-OFF-AUTO selector switches on AUTO. If necessary, introduce a simulated flow of sufficient quantity into the wet well from the washdown standpipe, to raise the water level above FS-4, 3rd pump on switch.

- Observe the equipment for proper operation.

10.5.3 Ventilation Units

- Check the rotation on both the control building fan and the ventilation fan for the wet well.

- Check the belt tension of the control building fan. Be sure there is a 1/2-inch play at all times.

- Check the ductwork connecting the ventilation fan to the wet well for any obstructions.

- Start both fans. The control building an is turned on at the breaker in Panel M and the ventilation fan is started at the main control panel.

10.5.4 Piping and Valves

- Check that all pipelines and catch basins are free of debris or other obstructions.

- Check that all valves are in the OPEN position.

10.5.5 Alarm System

- Simulate a "high-water" alarm condition by manually lifting the high-level alarm float switch.

- Check the telemetry transmission to Charles Street Station to verify proper communication and alarm transmission.

- Close and lock access hatches and control panel.

CAUTION: Before working on any control system connections, verify that all power is turned off at the source. Verify that no power exists.

10.6 NORMAL OPERATION

Normal operation procedure for the pump station is in the AUTO mode of operation. This is the most common mode, and it is recommended that the operator periodically review the recommended operating procedures.

10.6.1 Pumps

Starting with the pump selector switches in the AUTO position, the pumps start and stop at water levels determined by the settings of float switches FS-1, FS-2, FS-3 and FS-4. As the water level rises to FS-2 setting, the lead pump will start. If the water level continues to rise to the FS-3 setting, the lag pump will start. If the water level rises to the FS-4 setting, the Lag-Lag pump starts. Up to three pumps will run until the water level falls below the FS-1 setting. At this point all pumps stop and the quadraplexor alternates, choosing a different pump cycle for the next time the water level rises to the FS-2 setting. Examples of quadraplexor alternating cycles are in Table 10-2.

Table 10-2
Quadraplexor Alternating Cycles

Pump	Cycle #1	Cycle #2	Cycle #3	Cycle #4
NW Pump	Lead	Off	Lag-Lag	Lag
NE Pump	Lag	Lead	Off	Lag-Lag
SW Pump	Lag-Lag	Lag	Lead	Off
SE Pump	Off	Lag-Lag	Lag	Lead

10.6.2 Ventilation Units

Under normal operation, the control building exhaust fan will have power. Manual controls are located on the front of the fan for starting it and adjusting the speed.

The wet well ventilation fan will operate continuously, unless manually turned off at the control panel or the water level in the wet well reaches FS-6, overflow elevation. This setting automatically shuts the fan off if the fan is set at AUTO. The fan has an elapsed time meter to show total running hours and a counter to show total number of starts. A run light on the control panel indicates when it is operating.

10.6.3 Piping and Valves

Depending on which pump(s) are operating, the corresponding 8-inch force main carries the stormwater from the wet well to one of the valve vaults. During normal operation, the check valve and plug valve for each line in the vault are open. Outside of the valve vaults the 8-inch force mains combine into two 12-inch force mains and then into one 16-inch force main. When the pump(s) are operating, the stormwater is routed through these force mains to the catch basin south of the pump station. The flow continues by gravity under I-5 to the Midway Landfill detention pond.

10.6.4 Alarm System

Under normal operation, the alarm system will activate alarm indicating lights at the pump control panel, the Charles Street Station, or at both locations. See Table 10-5 for a complete summary of the wet well alarms.

10.6.5 Overflow Structure

The overflow structure and storage pond will be used at times of rainfall projected greater than the 10-year storm. Stormwater will only backup into this system when the pumps are unable to keep up with the amount of stormwater. The pond capacity should be sufficient to store a 10-year storm without an overflow.

10.7 ALTERNATE OPERATION

This subsection discusses operation of the pump station system for two alternative modes of operation: Manual operation and total shutdown. Alternate operation of the pump system is required when there are circumstances that do not allow for normal operation to occur. There are frequently operational sacrifices when alternate operation is required. It is therefore important that the operator consider the impacts of the desired mode of operation.

10.7.1 Manual Operation

Set the HAND-OFF-AUTO selector switch for the pumps(s) in question to the HAND position. The pump(s) will run continuously until the selector switch is turned to OFF. The water level in the wet well must be monitored to prevent the pump(s) from pumping dry. To return to automatic control, turn the selector switch to the AUTO position.

10.7.2 Total Shutdown

If a pump station shutdown is required due to a malfunction of pump(s), the pump control system, or the electrical system, the following procedure should be followed. Only qualified electricians should perform work on electrical systems and components.

- Turn the HAND-OFF-AUTO switch for all affected pumps to the OFF position.

- Switch the main power disconnect switch to OFF for safety.

CAUTION: Before working on any control system connections, verify that all power is turned off at the source. Verify that no power exists.

- Water will start backing up in the wet well and eventually into the overflow structure. From there, the stormwater will overflow to the landfill detention pond.

10.8 MAINTENANCE

Maintenance of the pump station needs to be done on a regular basis as recommended by the manufacturer of the individual components and as suggested here. The pump station is designed to operate automatically, but requires general maintenance, routine lubrication, and replacement of worn parts. To keep the pump station in good operating condition the pump station should be inspected on a daily basis for the first month of operation and a record of any unusual observations made in the log book or maintenance card.

The daily inspections then can be revised to an every-other-day or weekly schedule, should it become evident that the station does not require daily attention. A typical schedule of routine maintenance is outlined in Table 10-3.

Table 10-3
Maintenance/Inspection Schedule
for I-5 Pump Station

System Component	Potential Defect	Maintenance Required and Results Expected	Frequency
Pumps/Station	Improper Operation	Visually check the pumps, station and grounds for any obvious problems or future maintenance needs. Record observations in the pump station log and proceed with necessary repairs. Listen to the pumps for any unusual noises. Observe the hourly readings on the pumps and compare to each other to verify all of the pumps are operating close to the equivalent amount of time.	Weekly
Electrical Controls	System Shutdown	The electrical control system should be checked to verify that the pump control switches are in the proper position for automatic operation.	Weekly
Chevron Grate	Clogging	Check to make sure the chevron grate at the ventilation vault is clear of debris.	Weekly
Wet Well	Loss of Pump Prime	Look into the wet well to confirm that the float switches are operating normally. Simulate the wet well high water level conditions to test the alarm system for proper operation.	Weekly
Overflow Structure	Clogging	Clean the beehive trash rack and the inside of the Overflow Structure of any debris that has accumulated.	Monthly

NOTE: The plug valve(s) should be closed when servicing the pump(s) or check valve(s).

10.9 TROUBLESHOOTING

Performing accurate troubleshooting of a problem will lead to the quickest, easiest and least expensive way to correct the problem. A method to assist in locating the problem follows:

- Isolate the problem area by the use of valves, controls or other means that apply.
- Following the isolation of the problem area, it is important to determine the sequence of operation.
- "Think" the system operation through and determine the items of dependency.
- Perform manual operation of the items where applicable.
- Check electrical circuit continuity with a meter where applicable.

  CAUTION: Do not perform electrical checks on energized equipment. It is recommended that any electrical checks be performed by a qualified electrician.

The following troubleshooting chart is intended to assist the operator in locating the probable cause of a problem or symptom (Table 10-4). The operator is encouraged to supplement this chart, as may be necessary, when based on actual operating experiences.

Table 10-4
Troubleshooting Guide for the I-5 Pump Station

Indications/Observations	Probable Cause	Solutions
Force main plugged, pumps won't deliver flow, wet well back up, high level alarm sounds.	Obstructions in force main blocking or causing impediment in the flow, or debris was picked up from the wet well and pumped into the force main.	Routinely check and clean wet well. Take action to prevent the blockage from occurring again.
Pumps plugged.	Debris in wet well causing obstruction in pump.	Backflush pumps and check wet well for debris.
High level alarm repeats.	Low pumping rate caused by plug in force main. One pump failed.	Routinely check and clean wet well.
High pump time.	Partial plug in pumping system.	Check the pumping system for blockages.
Pumps won't start.	Pumps, float switch or control circuit problems. Pumps are plugged.	Check pump controls (float switch, quadraplexor, etc.)

Table 10-4
Troubleshooting Guide for the I-5 Pump Station

Indications/Observations	Probable Cause	Solutions
Intermittent pump operation.	Float switch malfunction.	Repair or replace float switch.
Pump not running.	A. Defective control circuit.	A. Use meter to check switching circuits and replace defective part.
Pump not running, circuit breaker will not reset.	Short circuit or thermal overload.	Inspect electrical equipment for damage.
Pump is running, but discharge is reduced.	A. Pump is air-bound.	A. Bleed air from pipe and remove obstruction.
	B. Clogged impeller.	B. Inspect for and remove obstruction.
	C. Grease accumulation.	C. Check grease accumulation on walls of wet well or remove grease by dewatering the wet well and scraping the bottom.
Rising power consumption.	A. Clogged pump.	A. Remove obstruction in pump.
	B. Infiltration.	B. Check and correct as necessary.
Improper liquid levels.	Hang-ups in float switches.	Remove obstruction, release float.
Excessive wear or damage to pumps.	A. Sand accumulations in wet well.	A. Inspect for eroding action, corrosion and solids buildup and remove.
	B. Grease accumulations in the wet well.	B. Inspect and clean wet well.

Table 10-5
Alarm Conditions

Alarm	Action
Low Water Alarm	If the water level falls below the setting of FS-7, an alarm signal will be sent via telemetry to the Charles Street Station. No warning light is provided for at the pump control panel. Once the signal has been received at Charles Street Station, site personnel must be notified to investigate the reason for the alarm and, if required, to manually shut off the pump(s).
High Water Alarm	When the water level rises above FS-5, the High Water Level light is activated on the control panel and a signal is sent via telemetry to Charles Street Station. Site personnel must be notified to investigate the reason the water level is so high (pump problems, heavy rainfall, etc.) and to take appropriate action.
Overflow Alarm	If the water level rises above FS-6, the Overflow level light is lit on the control panel, the wet well ventilation fan is shut off and a signal is sent by telemetry to Charles Street Station, if it is the AUTO mode. Site personnel must be notified by Charles Street Station to investigate the alarm.
Pump Fail	For each pump there is a separate pump fail light on the control panel. If any of the pumps overload or overheat, the pump fail circuit will be tripped, the pump shuts off and a signal will be sent by telemetry to Charles Street Station. Site personnel must be notified to investigate the alarm. To restart the pump, the pump reset must be pushed.
Pump Seal Fail	Each pump has a separate Seal Fail indicating light. If any moisture is detected in the pump motor, the Seal Fail light is activated. The pump will stop and a signal is sent to Charles Street Station by telemetry. Site personnel must be notified and the problem be repaired prior to restarting the pump.
Power Failure	In the case of a phase or power loss condition, the voltage is dropped from the pump control circuits and a signal is sent via telemetry to Charles Street Station. When normal power is returned, the pumps will restart without the need to be reset. Site personnel need to be notified to determine the cause of the power loss and duration. If required, emergency generators can be brought in to operate the pumps.

10.10 EMERGENCY OPERATION

Failure of the pump station to function results in the stormwater backing up in the storage pond and into the overflow structure. A pump station failure could be a result of one of the following conditions:

- Power Failure
- Pump Failure or Malfunction
- Control System Failure or Malfunction
- Severe Weather

When an emergency condition does exist, the operator should take the following course of action to alleviate the potential of damage to the system.

- Turn the pump selector to the OFF position.

- Follow alarm and troubleshooting response procedures provided in this chapter until the cause of the problem can be identified and corrected.

- After a power outage confirm that all pump equipment is functioning properly and that is has not become damaged by electrical surges or voltage drops.

- Remove the portable pump if used.

10.11 RECORDS AND RECORDKEEPING

Maintenance and cost records should be kept for all services required for the pump station. Service records are essential for determining operating costs, budget requirements, maintenance schedules and for scheduling repairs.

OPERATOR NOTES AND COMMENTS

11. COMPLIANCE MONITORING

11.1 DESCRIPTION

Federal and state regulations for closure of a solid waste landfill require that compliance monitoring be performed to track the migration of contaminants into and away from the site (WAC 173-304). Compliance monitoring also assesses the effect of the remedial measures for protecting human health and the environment by controlling the contaminant source. Compliance monitoring at the Midway Landfill has been expanded beyond the MFS requirements, and consists of quarterly monitoring of 17 wells that are upgradient, at the site boundaries, and downgradient of the landfill.

11.2 MONITORING LOCATIONS

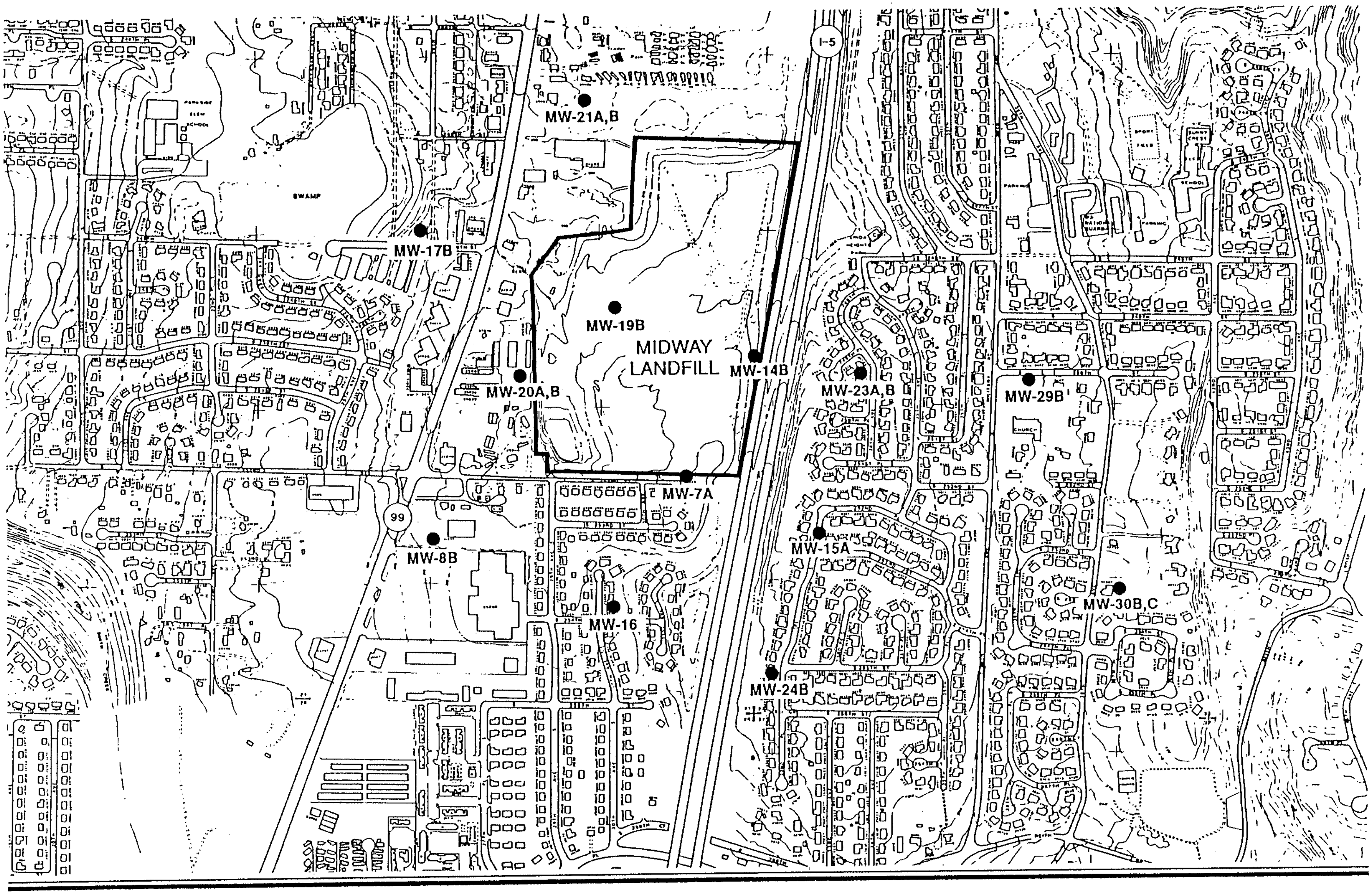
The monitoring wells listed below will be sampled during each sampling round. (See Figure 11-1 for well locations.) There is no predetermined sampling order for groundwater wells; flexibility allows for efficiency. Wells to be sampled include:

MW-7A	MW-21A
MW-8B	MW-21B
MW-14B	MW-23A
MW-15A	MW-23B
MW-16	MW-24B
MW-17B	MW-29B
MW-19B	MW-30B
MW-20A	MW-30C
MW-20B	

11.3 MONITORING PARAMETERS

All samples will be analyzed for chemical parameters required for analysis under the Minimum Functional Standards for Solid Waste Handling (WAC 173-304) which include the following:

Field Temperature	Sulfate
Field Conductivity	Dissolved Iron
Field pH	Dissolved Zinc
Chloride	Dissolved Manganese
Nitrate as Nitrogen	Chemical Oxygen Demand
Nitrite as Nitrogen	Total Organic Carbon
Ammonia as Nitrogen	Total Coliform



Source: AGI 1990d.

SCALE IN FEET

0 400 800

N

MW-21 Monitor Well Number and Approximate Location

Approximate Boundary of Landfill in 1986

Figure 11-1. Compliance Monitoring Sites

In addition to the WAC 173-304 parameters, all groundwater samples will be analyzed for volatile organic compounds. Test methods used to detect the WAC 173-304 parameters will be EPA Publication Number SW-846, "Test Methods for Evaluating Solid Waste — Physical/Chemical Methods" except for total coliform which will use the latest edition of "Standard Methods for the Examination of Water and Wastewater."

One purge water composite sample will be drawn per sampling round. The composite sample is made by drawing a sample from each well and then mixing them together. This composite sample is analyzed for the following parameters:

- Cadmium
- Chromium
- Copper
- Lead
- Nickel
- Zinc
- Volatile and semi-volatile compounds
- Organochlorine pesticides and PCBs
- Chlorinated herbicides

11.4 QUALITY CONTROL SAMPLES

There will be two complete sets of duplicate samples taken at random times during quarterly compliance monitoring sampling rounds. The duplicate samples will be taken at a given well at the same sampling time as the primary sample. This sample is obtained by first filling one bottle for the primary (i.e., MW-17A), then filing the corresponding analytical container for the duplicate sample (i.e., MW-17D). However, duplicate sample numbers will be designated so that field duplicates are not obviously duplicates to the lab.

There will also be one full set of samples taken as a "Field Blank" during each quarterly sampling event. This sample will be obtained by filling sample bottles directly from the container of deionized water. This sample will be treated in the same manner as all other groundwater samples. The field staff will take the same field measurements and complete field filtering for metals. A minimum of one trip blank will be taken per 5 days of sampling and analyzed for volatile organic compounds.

When using the dedicated Bennett pump for groundwater sampling, there is no need for any reinstate sample in a groundwater sampling round.

Analytical testing will be performed at Analytical Technologies, Inc., an EPA Contract Lab Program participant, and will be performed under their Quality Assurance Program Plan (available on request). The deliverable package will be a standard EPA 8240 package and not a CLP package.

11.5 HEALTH AND SAFETY

Health and Safety procedures for both on-site and off-site sampling and monitoring is discussed in the *Midway Landfill Site Safety Plan*.

OPERATOR NOTES AND COMMENTS

12. LANDFILL SITE AND FINAL COVER SYSTEM

12.1 DESCRIPTION

12.1.1 Site Access Roads

Access roads for the site were designed to handle light vehicle traffic used for routine site maintenance. Vehicles weighing more than 4 tons should not be allowed on the landfill. Large trucks and heavy equipment may damage the roads or underlying membrane liner and other synthetic components. The site roads have (typically) 2 inches of crushed surfacing top course over 2 feet of mineral aggregate and have drainage ditches along one or both sides.

It is anticipated that only minor maintenance should be required to keep the roads in satisfactory condition. This may include periodic grading to fix ruts and holes, and placing additional surfacing when necessary. Formal inspections of the site access roads should not be necessary since maintenance personnel will be using the roads frequently and will be aware of road conditions.

12.1.2 Utilities and Support Systems

Utilities and support systems include the following: sewer, water, electric and telephone services; security building, lighting, fencing and gates; administrative and maintenance building; storage areas.

12.1.3 Final Cover System

There are two types of final cover at the landfill, each having slightly different components. Generally, landfill side slopes with grades steeper than about 10 percent have cover system components that provide adequate slope stability. The flatter top areas of the landfill have a cover system that provides a greater protection against infiltration of surface water. Figure 12-1 shows both types of final cover. A description of each of the cover system components is given in the following subsections.

12.1.3.1 Vegetation

The cover vegetation consists of grasses as specified in Table 12-1.

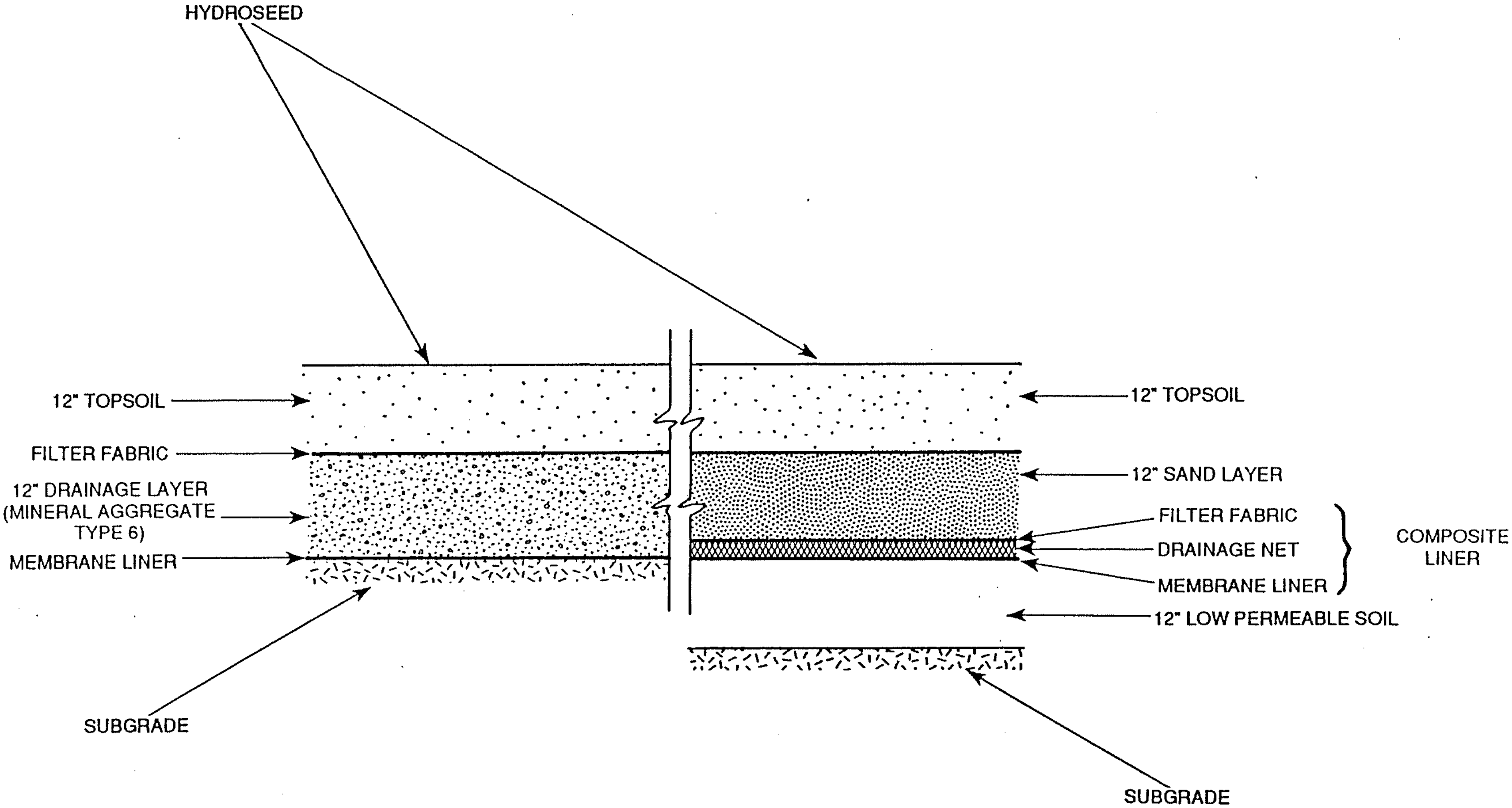


Figure 12-1.
Cover Layer (2 Types)
Typical Section

Table 12-1
Seed Mix #1 (Highway Mix)

Kind and Variety of Seed in Mixture*	Percent by Weight
Colonial Bentgrass (Highlands or Astoria)	10
Red Fescue (Illahee Rainier or Pennlawn)	40
Perennial Ryegrass	40
White Dutch Clover	10

*The rate of application shall be 4 pounds per 1000 square feet. The seed mixture shall be no less than 98% pure, and shall have a minimum germination rate of 90%.

The cover grasses are suited for the local climate and environment and should not require supplemental irrigation. The primary function of the cover vegetation is to protect the cover soils from erosion. The vegetation helps to attenuate surface water runoff during storm events which decreases the amount of sediments being carried into the surface water ditches and detention pond.

12.1.3.2 Topsoil Layer

The topsoil supports the vegetation by supplying nutrients and moisture to the plant roots. The topsoil layer was 12 inches thick at the time of placement.

12.1.3.3 Filter Fabric

Filter fabric is used in the cover system to separate the drainage layers from the overlying soils. On the landfill side slopes, the filter fabric separates the mineral aggregate drainage layer from the overlying topsoil layer. On the flatter top areas, the filter fabric protects the synthetic drainage net from intrusion of the overlying sand layer.

12.1.3.4 Sand Layer

The sand layer provides additional moisture storage to support the vegetation and attenuate surface water during storm events. This layer also serves to protect the synthetic components of the cover system.

12.1.3.5 Drainage Layer

The drainage layer provides a path for surface water to be drained away from the membrane liner. This controls the head buildup on top of the membrane liner and reduces the amount of surface water infiltration.

The drainage layer on the side slopes of the landfill consists of 12 inches of mineral aggregate. On the flatter top areas of the landfill a synthetic drainage net is used.

12.1.3.6 Membrane Liner

The membrane liner consists of a 50-mil (0.050 inches) thick sheet of High Density Polyethylene (HDPE) material. During installation, the panels of HDPE are heat welded together to form a continuous sheet that covers the entire site.

The primary function of the membrane liner is to act as a barrier to surface water infiltration. It also permits the controlled collection and removal of landfill gas through the landfill gas system.

The properties of the HDPE allow for a certain amount of stretching and deformation without tearing or puncturing. Settlement of the landfill cap to the degree expected at Midway should not damage the membrane liner. Inspections and repair procedures for the membrane liner are outlined in Sections 12.2 and 12.4, respectively.

12.1.3.7 Geogrid Reinforcing Layer

There are three areas where geogrid reinforcement has been placed in the cover system. Geogrid consists of high strength HDPE material used to reinforce soils. The locations of the three areas are shown in Figure 12-2. The exact locations of the geogrids should be obtained from record drawings if repairs are to be made in these areas.

Geogrid has been placed above the membrane on the slope near the southeast corner of the detention pond to provide adequate slope stability of the cover soils.

Along access road "E" geogrid was placed below the membrane to provide support to the cover system. During the last years of operation at the landfill, a sink hole periodically reoccurred in this area. The geogrid is designed to support the cover system over a 10-foot diameter depression in the subgrade.

Along the south edge of the cover system geogrid was placed below the membrane to provide support to the cover system. During operation of the landfill, refuse was placed against a nearly vertical rock wall left from previous quarry operations. Due to settlement of the refuse, cracks periodically formed above the rock wall. The geogrid is designed to support the cover system over a one-foot crack in the subgrade.

12.1.3.8 Low Permeable Soil Layer

On the flatter top areas of the landfill a low permeable soil layer was used in conjunction with the membrane liner. The low permeable layer consists of 12 inches of select soils that have been placed under controlled conditions of compaction and moisture content. This layer provides an additional barrier to surface water that may find its way through the membrane liner.

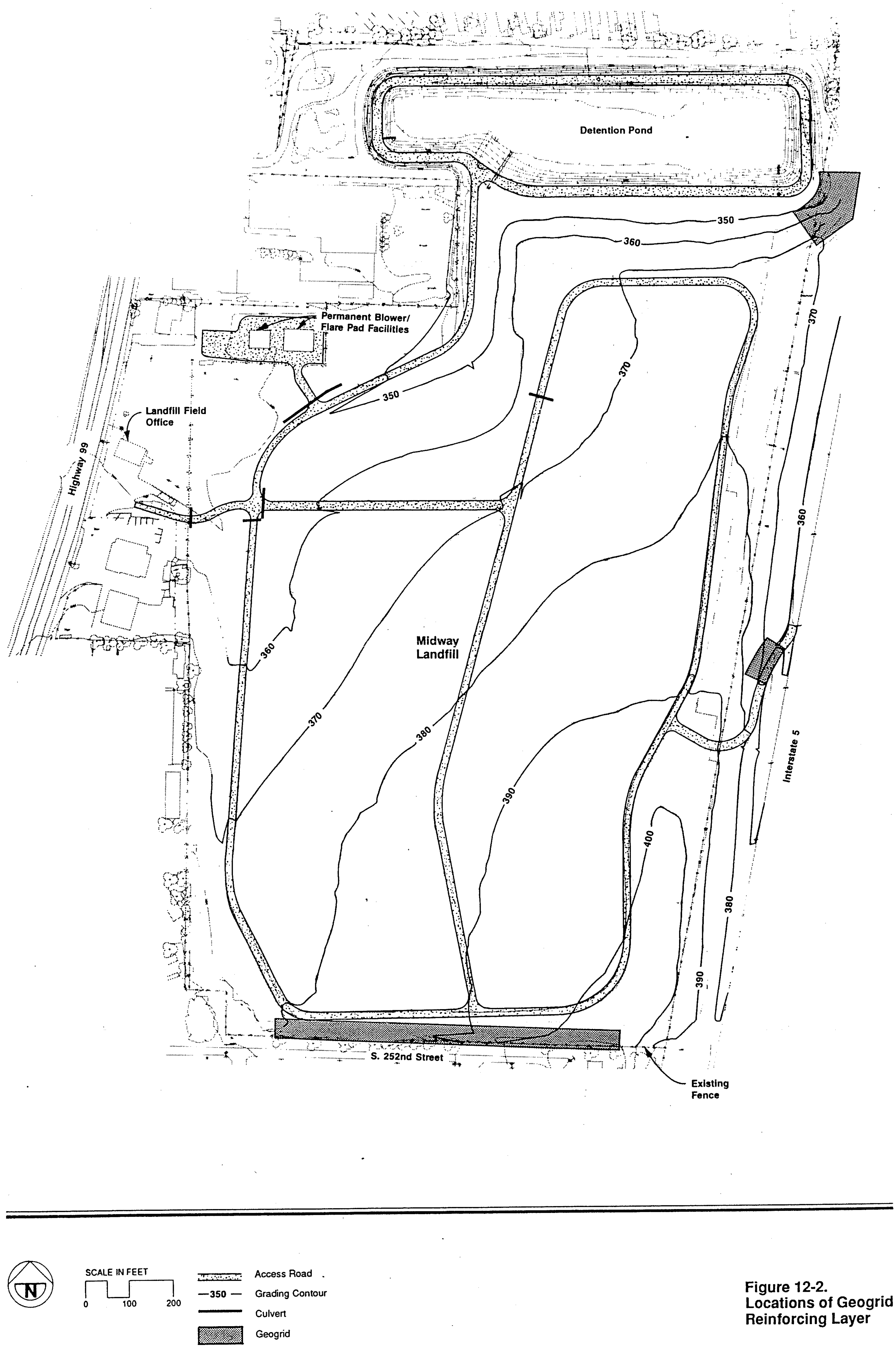


Figure 12-2.
Locations of Geogrid
Reinforcing Layer

12.1.3.9 Subgrade Soils

The subgrade soils cover the contents of the landfill and provide a foundation for the final cover system. These soils are free from sharp angular stones, particles greater than 1 inch in any dimension, sticks, debris, and other material that may damage the membrane liner.

12.2 INSPECTIONS

12.2.1 General

Periodic inspections are essential to insure that the cover system is performing adequately. The following summarizes the various inspections for the cover system. Solutions to some of the common cover system problems are discussed in Section 12.4.

The inspections of the cover system will typically involve walking the entire site in a systematic fashion that insures that the entire site is inspected. Using a check list and site map with a designated route to follow during inspections may aid in the process.

If any problem or deficiency is found, the inspector should record the location on a field sketch. A complete description of the affected area, including all pertinent data including size of area and other descriptive remarks such as exposed synthetic materials, odors, etc. should be recorded on the appropriate reporting forms.

Photographs may be helpful in documenting problems. Provisions should be made to keep a photographic log of problems, repairs, and general site conditions. This will provide valuable information when evaluating the long term performance of the cover system and when planning repair strategies.

12.2.2 Settlement/Subsidence

Inspections should focus on looking for areas of localized settlement, sink holes, ponding water, cracking of cover soils, and any other signs that may indicate cover subsidence. The approximate depth of ponded water or depression, the limits of the affected area, and other pertinent details should be recorded for each inspection. The problem areas should be monitored to determine how the problem develops over time. This will help in evaluating the need for repairs and when planning repair strategies.

12.2.3 Erosion

Any evidence of erosion should be a cause of concern. The inspector should be especially observant along steeper slopes, drainage ditches, areas of vegetative stress, and any areas previously troubled with erosion problems (such as the slope adjacent to I-5).

12.2.4 Membrane Liner Damage

Excessive subsidence or vehicle traffic on the cover may cause damage to the membrane liner. Landfill gas may become trapped in localized pockets underneath the membrane liner causing it to bulge out. This is not expected to happen as long as the gas collection system is functioning properly but the inspectors should be observant to this condition. Unless visibly evident, membrane liner damage may be difficult to detect. Any areas where the synthetic materials are exposed should be noted and a repair plan should be developed without delay.

12.2.5 Vegetative Stress

Areas where grasses are poorly established should be examined to determine the cause of the problem. The inspector should look for signs of excessive wetness or dryness, pest infestations, landfill gas or leachate seepage, rodents, weeds, insufficient depth of topsoil, and other conditions that may inhibit healthy growth of the cover vegetation.

12.2.6 Inspection Frequency

It is recommended that the inspections for the cover system be performed monthly for the first 6 months after an area is initially seeded or until the grasses are well established. Inspections should also be done immediately after each major rain event until the vegetation proves to be sufficiently established to prevent erosion.

After the vegetation is established the cover system inspections should be performed twice yearly for a period of 5 years, once in early spring and once in the fall. After 5 years, for the remaining post closure care period, the inspections should be done annually.

This schedule of inspections should be adequate to insure proper performance of the cover system and to document the overall site conditions throughout the post closure care period. Problem areas will have to be watched more closely and may require a more rigorous monitoring program tailored to the specific type of problem.

12.2.7 Documentation

It is important to have a record of site conditions at various stages after closure. Good documentation will provide valuable information to help maintenance and repair planning. Inspection checklists and cover system reporting sheets are included at the end of this section. These are provided to assist in the inspection and documentation procedures and should be modified as needed throughout the post closure care period.

12.3 ROUTINE MAINTENANCE AND CARE

12.3.1 Grass Cutting

Periodic cutting will help to establish and maintain a healthy, vigorous stand of grass. This will help control weeds and pests, reduce the potential for grass fires, and provide better erosion protection.

The following cutting recommendations were prepared by Osborn and Ray Planners of Seattle for the Midway Landfill cover and should be used as a general guideline. In most settings, meadow grass is cut to 4 to 6 inches in height and allowed to grow to a maximum height of 10 inches. Non-irrigated meadow grass should be mowed at 12 to 14 day intervals during Spring, and 12 to 18 day intervals during summer and fall. Mowing with a 58 inch power riding mower is estimated to take 1 hour per acre.

12.3.2 Spot Reseeding

It is important to keep a good stand of grasses on all areas of the cover to minimize erosion and to keep weeds and other undesirable plant species from becoming a problem. Spot reseeding should be done in late August and early September for best results. Seeding in early spring may also be effective. Seeding in the dry summer months will most likely be unsuccessful without supplemental irrigation. Reseeding should be done using the seed mix and application rate outlined in Table 12-1. The application rate is based on hydroseed methods. If hand methods are going to be used it is recommended to double the application rate.

12.3.3 Nutrient Application

It may be necessary to periodically apply nutrients or adjust the acidity of the soil. If vegetative stress is evident the topsoil may be analyzed to determine what nutrient deficiencies exist. This will prevent over applying fertilizers. Generally, when required, a slow release type of fertilizer can be applied in late summer to early fall. This is estimated to take about 2 hours per acre per application. The Soil Conservation Service, County Extension Service, or a local consultant should be contacted for additional information.

12.3.4 Weed and Pest Control

The key to minimizing necessary weed and pest control is to establish and maintain a good, healthy, dense grass cover. If weeds or pests become a problem, first identify the type of weed or pest and then develop a management strategy, chemical or manual, with the help of the Soil Conservation Service, Cooperative Extension Service, or local consultant. All pesticide and herbicide use should be cleared with the Project Manager. For maintenance planning purposes, chemical herbicide spraying can be estimated to take about 1 hour per acre per application. Weed control using chemical herbicides may typically require 2 applications per year.

12.3.5 Rodent Control

Moles and other burrowing animals may attempt to make their homes in the landfill cover soils. Mounds of loose soil resulting from tunneling animals will encourage weed growth and promote erosion. The mounds should be raked and reseeded. Some burrowing animals may damage the synthetic and low permeable layers. A significant rodent population may require the advice of a local consultant.

12.3.6 Fences

Fence posts, stakes and other objects that may puncture the membrane liner should be installed with care.

12.4 PROBLEMS/SOLUTIONS

The following section covers some problems which may be encountered during the post-closure care period. The solutions are by no means all inclusive but should serve as general guidelines indicating the elements involved for fixing typical case conditions.

12.4.1 Subsidence

When an area experiences excessive localized settlement, the cover may no longer drain properly. Even so, there may not be a problem unless the area is large, there is continued ponding, or the membrane liner is suspected to have been damaged. The problem will require a study to determine the extent of the damaged area and the potential for surface water leaking through the cover. If it is determined that a repair must be made, the necessary steps involved are:

1. Determine limits of area to be repaired.
2. Strip topsoil and stockpile.
3. Remove sand layer (drainage layer) and stockpile.
4. Cut and remove filter fabric (if present).
5. Cut and remove drainage net (if present).
6. Cut and remove membrane liner.
7. Fill depression and grade for proper drainage.
8. Place low permeable soil layer or bentonite mat (top areas).
9. Install new HDPE membrane sheet.
10. Test welds to insure integrity of repair.
11. Install drainage net (if present).
12. Replace sand layer (drainage layer).
13. Replace topsoil, reseed area and protect.

It should be noted that when replacing the membrane liner, new HDPE panels of like thickness and surface texture should be used and all seams require heat welding by certified technicians. No glues or adhesives are to be used.

Reseeding should be done according to the recommendations given in Section 12.3.2.

Subsidence around monitoring wells or the gas extraction system may involve a more complex repair procedure. Refer to the appropriate sections on these for maintenance and repair procedures.

12.4.2 Erosion

Erosion problems should typically involve a relatively minor repair operation unless the condition is left to develop over time.

Minor erosion rills in the topsoil may be filled and the area reseeded. An erosion mat of some type may prevent further erosion while the vegetation is being established. Deeper rills through the sand protection layer may require a more extensive repair possibly involving silt fencing. Persistent and reoccurring rills can be filled with gravel to allow for a controlled drainage path down the slope. Erosion in the surface water drainage channels and structures should be repaired by reconstructing according to the construction plans.

OPERATOR NOTES AND COMMENTS

13. PERFORMANCE MONITORING

13.1 DESCRIPTION

Performance monitoring refers to measurements taken to gauge the effectiveness of the final closure systems to protect human health and the environment. This primarily entails monitoring the migration of landfill gas as well as the levels and quality of the groundwater in the vicinity of the Midway Landfill.

13.2 GROUNDWATER MONITORING WELLS

Groundwater level monitoring is used to track the response of the leachate liquid levels and the shallow groundwater to the remedial actions. Groundwater level monitoring includes quarterly monitoring of onsite leachate and gas extraction wells and selected offsite wells to determine the levels of APL (Aqueous Phase Liquid) and NAPL (Non Aqueous Phase Liquid) in the landfill and the direction of the shallow groundwater flow. These wells will be monitored for a period of five years or as long as is determined necessary from the monitoring results.

13.2.1 Monitoring Procedures

SINCO electronic probes are used for water level sounding and oil thickness measurement. Probes are typically weighted with a metal sheath fitted around the probe to avoid jarring or catching the probe on well expansion joints. Weighting the probe also enables detection (at the wellhead) of true well bottoms when sounding deep wells.

During each monitoring round, data from the previous round are typically referenced before sounding each well to estimate the approximate depth required to reach fluid with the probe. This procedure also reduces the likelihood of obtaining false fluid depths. Water depths are read directly from the sounder cable at an established reference point. For EW, PA, and PC wells located on the landfill, this point is typically the top of a 2-inch well access port mounted on the top of the well cover. Where the 6- or 8-inch well cover requires removal, the well casing top (edge of the well casing) is used as the reference point. For A-series probes, off site PA wells, and PD wells, the outside rim of the manhole over the well is used as the reference elevation. In the latter case, a straightedge is typically placed across the rim and the sounder cable, held vertically, is read where it meets the straightedge at a right angle. Selected wells are measured for total depth during each round. Bottom of well data from previous rounds are compared with current data to reduce the likelihood of false readings as described above.

Wells that have historically contained oil are measured each round for oil thickness by lowering the SINCO probe to the depth at which it first sounds (indicating oil/water interface), removing the probe from the well, and measuring the length of sounder cable coated by oil. Under typical oil/water interface conditions the sounder probe may become coated with oil upon traveling through the floating oil layer and cause erroneous measurement of this interface depth. These circumstances can result in overestimated oil thickness. Actual depth to the oil/water interface is therefore typically rechecked by lowering the probe a measured distance beyond the first sounding, then raising the probe to where the sounder indicator ceases.

13.2.2 Labeling and Chain of Custody

Labels for sampling bottles will contain at least the following information:

- Project Name
- Date
- Client
- Project Number
- Sample Identification
- Sample Name
- Type of Analysis

Clear plastic tape will be wrapped around the bottle to cover the label completely allowing identification yet eliminating the possibility of eradication.

All samples will be delivered to the laboratory accompanied by a chain-of-custody form. The chain-of-custody sheet sent to the primary analytical laboratory will include measurements of field parameters.

13.3 GAS PROBES

Since 1983, 127 gas monitoring probes have been installed to monitor levels of landfill gas that have migrated offsite in the vicinity of the Midway Landfill. These probes are monitored on a varying schedule. Some are monitored weekly, some twice weekly, some monthly, and some twice monthly. The monitoring frequency is based on the results of the probe monitoring. The measurements normally taken at the gas probes include:

- Combustible gases concentration (primarily methane)
- Oxygen concentration
- Hydrogen sulfide concentration
- Static pressure

13.3.1 Monitoring Procedures

This section describes sampling techniques for sampling gas probes with the following instruments, however, similar instruments can be used besides those suggested below:

- *Neutronics PDM-10* pressure gauge
- *Gastech Model 1939-OX* combustible gas/oxygen meter
- *Gastech 1314* combustible gas meter
- *Gastech Model GX-4000* multi-gas meter

These instruments should be calibrated daily. Before monitoring, read the instruction manual for the proper use of the instrument you are using.

The following are the proper steps you must take to monitor gas probes:

1. Before any system measurements are taken, it is important to record the barometer reading. A rapidly rising or falling barometer may explain system fluctuations.

2. Calibrate and check all instruments before any probe measurements.

3. Fill out field sheets with current information.

4. Insert the pressure monitoring tube into the probe valve and open the valve. Record the pressure reading, close the valve, and disconnect the instrument.

5. Connect the *Gastech 1939-OX*, or similar instrument, to the probe, open the valve, and continuously draw a sample until the oxygen reading stabilizes. Record the reading, close the valve, and disconnect the instrument.

6. If the oxygen reading is greater than 10% by volume, measure the combustible gas level in the probe with the *Gastech 1314*, or similar instrument, in parts per million (ppm). Draw a sample continuously until the reading stabilizes, record the reading, close the valve, and disconnect the instrument.

7. If the reading is off the ppm scale or is less than 10% by volume, repeat the combustible gas measurement with the *Gastech 1939-OX*, or similar instrument, taking the reading in percent lower explosive limit (LEL). Draw a sample continuously until the reading stabilizes, record the reading, close the valve, and disconnect the instrument.

8. If the reading is off the LEL scale or the oxygen reading is less than 10% by volume, repeat the combustible gas reading with the *Gastech 1939-OX*, or similar instrument, taking the reading in percent by volume. Draw a sample continuously until the reading stabilizes, record the reading, close the valve, and disconnect the instrument.

9. If measurements are required for hydrogen sulfide use the *Gastech GX-4000*, or similar instrument. Draw a sample continuously until the reading stabilizes, record the reading, close the valve, and disconnect the instrument. Secure the probe vault when readings are computed.

10. Record any comments relating to the probe readings.

11. Repeat steps 4 through 10 on the next completion or probe.

12. After system measurements are taken, it is important to record the barometer reading. A rapidly rising or falling barometer may explain system fluctuations.

13.4 OFF-SITE CONTROL WELLS

The off-site control wells were installed as temporary remedial measures because of high levels of landfill gas detected in neighborhoods surrounding the landfill (Figure 13-1). When the wells have succeeded in removing or reducing off-site gas, the vacuum they create may begin drawing new gas from the landfill. For this reason, they must be monitored carefully and shut down when gas concentrations are reduced. Originally, 19 off-site control wells were installed. Due to reductions in gas concentrations of over time, 17 of these control wells have been shut down.

These control wells are monitored on a varying schedule. Some are monitored weekly and some twice weekly. The monitoring frequency is based on the results from the monitoring of the wells. The measurements normally taken at the gas control wells include:

- Combustible gases concentration (primarily methane)
- Oxygen concentration
- Carbon dioxide concentration
- Hydrogen sulfide concentration
- Static pressure
- Velocity

13.4.1 Monitoring Procedures

This section describes sampling techniques for sampling off-site control wells with the following instruments, however, similar instruments can be used besides those suggested below:

- *Neutronics PDM-10* pressure gauge
- *Gastech Model 1939-OX* combustible gas/oxygen meter
- *Gastech 1314* combustible gas meter
- *Gastech Model GX-4000* multi-gas meter
- *Bacharach Fyrite CO_2 Sampling Bottle*
- *Kurz Model 441* velocity meter

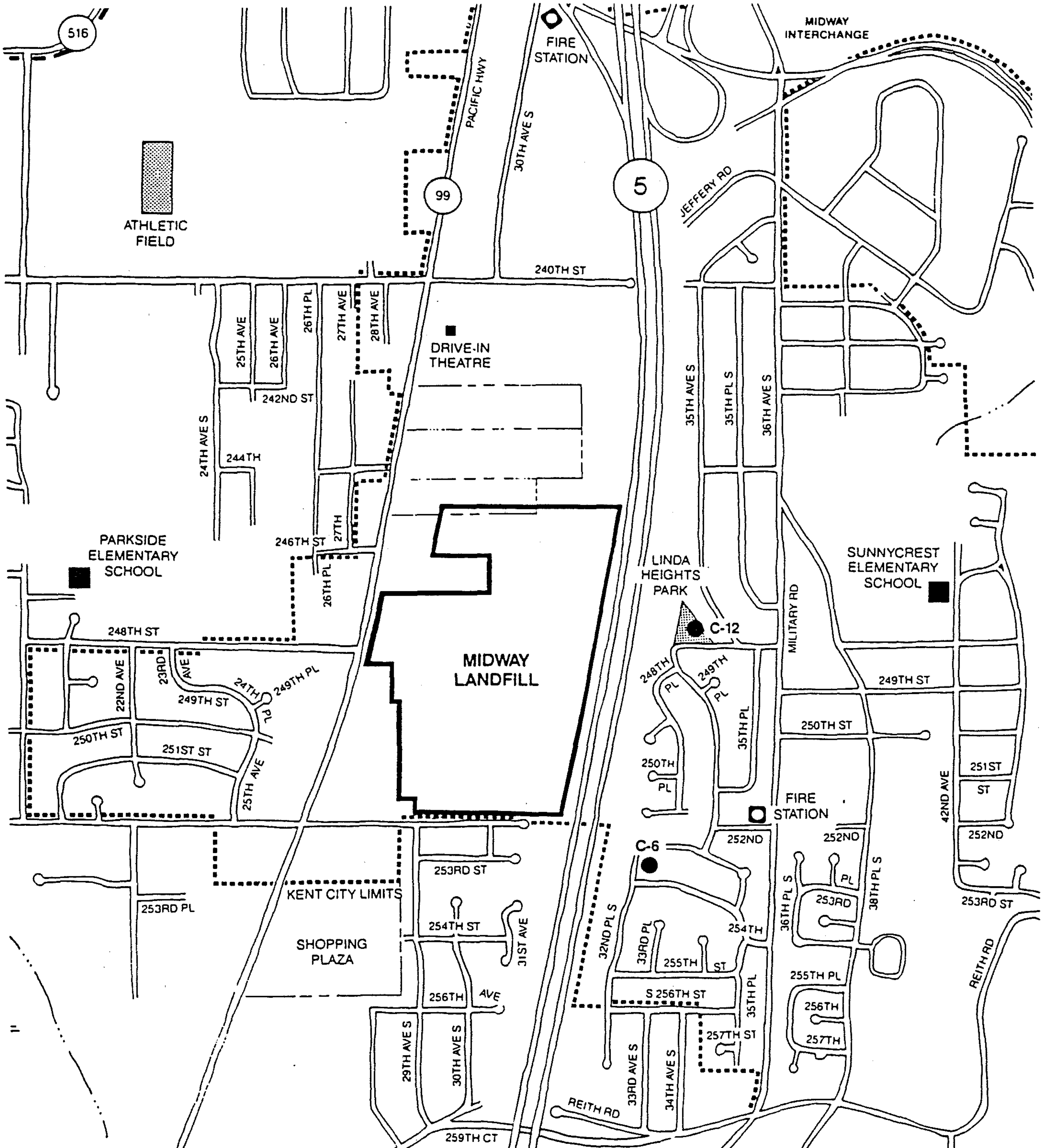
These instruments need to be calibrated daily. Before monitoring, read the instruction manual for the proper use of the instrument you are using.

The following are the proper steps you must take to monitor off-site control wells:

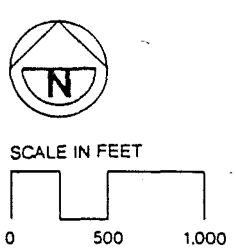
1. Before any system measurements are taken, it is important to record the barometer reading. A rapidly rising or falling barometer may explain system fluctuations.

2. Calibrate and check all instruments before any well measurements.

3. Fill out field sheets with current information.



Source: Ecology, February 26, 1986.



C-1 ● City of Seattle Extraction Well

Figure 13-1. Location of Offsite Control Wells

4. Insert the pressure monitoring tube into the monitoring port. Record the pressure reading, disconnect the instrument, and close the port.

5. Connect the *Gastech 1939-OX*, or similar instrument, to the well sampling port, and continuously draw a sample until the oxygen reading stabilizes. Record the reading, disconnect the instrument, and close the port.

6. If the oxygen reading is greater than 10% by volume, measure the combustible gas level in the well with the *Gastech 1314* or similar instrument, in parts per million (ppm). Draw a sample continuously until the reading stabilizes, record the reading, disconnect the instrument, and close the port.

7. If the reading is off the ppm scale or less than 10% by volume, repeat the combustible gas measurement with the *Gastech 1939-OX*, or similar instrument, taking the reading in percent lower explosive limit (LEL). Draw a sample continuously until the reading stabilizes, record the reading, disconnect the instrument, and close the port.

8. If the reading is off the LEL scale or the oxygen reading is less than 10% by volume, repeat the combustible gas reading with the *Gastech 1939-OX*, or similar instrument, taking the reading in percent by volume. Draw a sample continuously until the reading stabilizes, record the reading, disconnect the instrument, and close the port.

9. Insert the *Bacharach Fyrite* CO_2 *Sampling Bottle*, or similar instrument, probe into the sampling port, draw a sample, record the reading, remove the probe and close the port.

10. Insert the *Kurz* velocity meter probe, or similar instrument, into the sampling port, record the reading, remove the probe and seal the port.

11. If measurements are required for hydrogen sulfide use the *Gastech GX-4000*, or similar instrument. Draw a sample continuously until the reading stabilizes, record the reading, close the valve, and disconnect the instrument.

12. Record any comments relating to the probe readings.

13. Repeat steps 4 through 12 on the next completion or probe.

14. After system measurements are taken, it is important to record the barometer reading. A rapidly rising or falling barometer may explain system fluctuations.

OPERATOR NOTES AND COMMENTS

14. LANDFILL GAS SYSTEM

14.1 DESCRIPTION

The Midway Landfill well field consists of 88 individual gas extraction wells. Each well is connected to the vacuum manifold that encircles the site. The purpose of the extraction wells is to collect landfill gas as it is generated and recover landfill gas that has migrated off-site. The vacuum manifold is used to route the landfill gas to the motor blower/flare facility. Well locations and the current layout of the vacuum manifold are shown in Figure 14-1.

14.1.1 Well Locations

In 1986, 34 migration control wells (numbered 1 to 34) were installed in waste on 100- to 200-foot centers around the perimeter of the landfill (Phase I). This spacing was designed to create overlapping spheres of influence between wells. However, many areas of the landfill lacked sufficient clay cover to prevent air being drawn through the soil cover into the waste surrounding the wells. This air intrusion resulted in a low operational vacuum in the wells. Accordingly, these Phase I wells could not influence a large enough area to provide confidence that a vacuum barrier was being produced, especially along the eastern boundary. Therefore, three additional migration control wells, numbers 35, 36, and 37, were installed between existing migration control wells 18, 19, 20, and 21. These three new wells are double-completed. That is, they have two pipes completed at different depths so that gas flow can be adjusted to minimize air intrusion at the shallow level but maximize vacuum at the deeper level. Completion techniques for these wells are described in Section 14.1.2.

Because of the operational limitations of the Phase I migration control wells in preventing off-site migration of landfill gas, 41 additional Phase II migration control wells were planned. Forty-one of these Phase II wells were installed between November 1986 and December 1987. Twelve of the Phase II migration control wells were installed in native soil on approximately 175-foot centers along the eastern border of the landfill. These wells are labeled PD-1 through PD-12.

Nineteen of the Phase II migration control wells were installed in native soil on approximately 300-foot centers along the north, west, and south boundaries of the landfill. These wells are numbered PA-1 through PA-10 and PC-1 through PC-9. Ten of the Phase II migration control wells were installed in waste in the interior of the landfill. Six wells were placed in the north half of the landfill and four in the south. These wells are numbered 38 through 47. There is one additional native soil gas extraction well, C-11. This well was first installed as an individual off-site extraction well and later connected to the vacuum manifold. This well was installed to a depth of 73 feet.

Nine Phase III wells were constructed in 1989. Wells 48 through 54 were placed in the refuse in the center of the landfill. Wells 55 and 56 are located near the southwest boundary of the site.

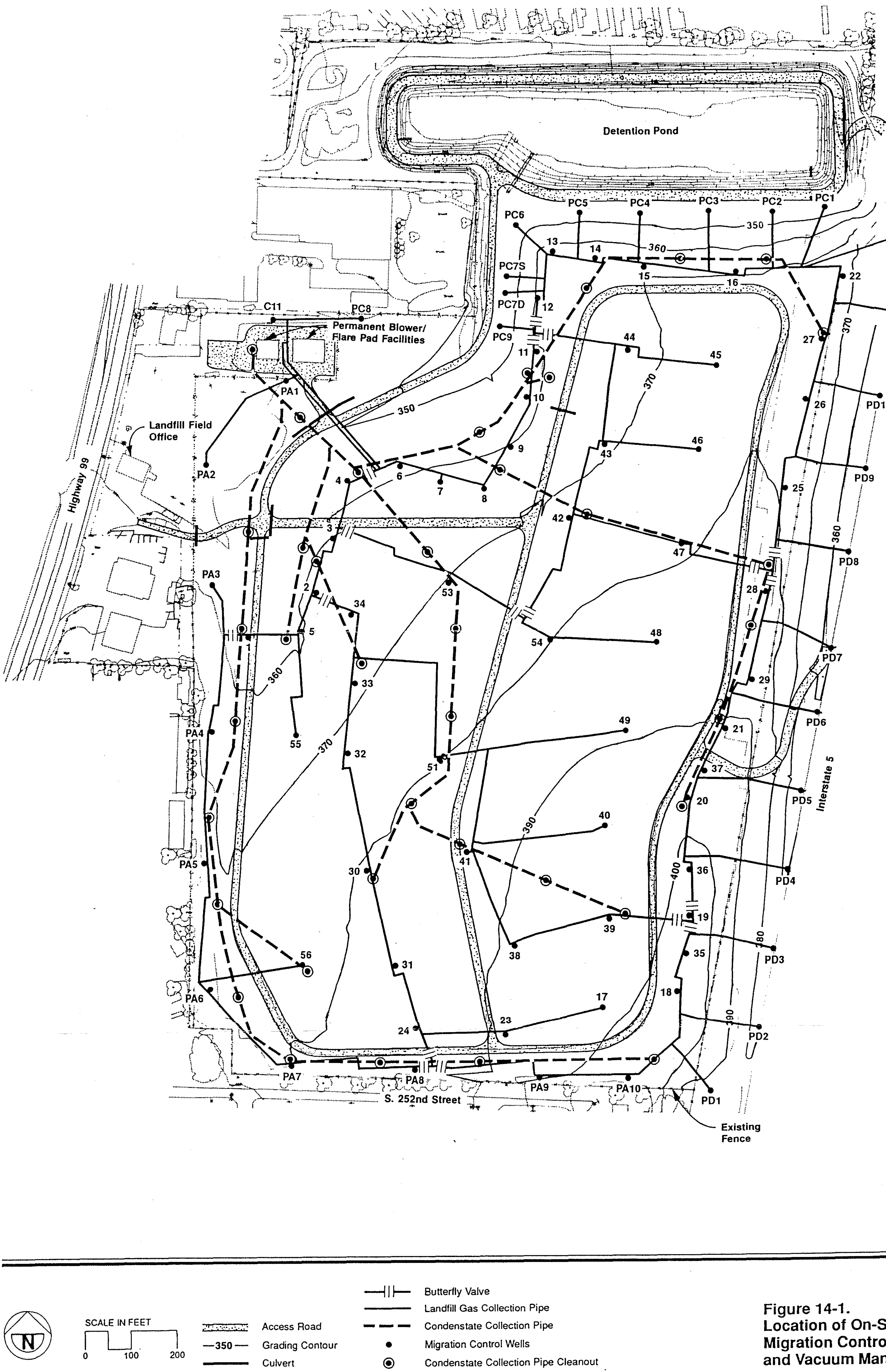


**Figure 14-1.
Location of On-Site
Migration Control Wells
and Vacuum Manifold**

14.1.2 Typical Well Installations

The 34 original Phase I migration control wells were installed in waste using a 24 or 30-inch auger. These wells were drilled to 80% of the depth of the landfill at that location. Generally, the wells were drilled between 40 and 100 feet deep. The wells are completed with a single 6-inch-diameter PVC casing which is perforated from between roughly 25 feet below ground surface to the bottom of the well. A 20-foot slip joint is installed between 5 and 25 feet below-ground surface to allow for landfill settlement.

This slip joint is made of 8-inch diameter PVC with an 8 by 6-inch slip bushing on the lower end. The well casing is inserted into this slip joint but not physically attached. The well is filled with a gravel backfill up to 22 feet below ground surface. Above the gravel backfill is an approximate 2-foot-thick bentonite or concrete plug. The remainder of the well is backfilled with native material.

The Phase II interior migration control/odor control wells were installed in waste using a 24-inch auger. These wells also were drilled to 80% of the depth of the landfill, generally over 100 feet deep. These wells are double completed with one casing 6-inch-diameter PVC casing installed to approximately one half the total depth of the well. This "shallow completion" 6-inch casing is perforated between 25 feet from ground surface to the bottom of the completion. The second completion is an 8-inch-diameter PVC casing installed to the depth of the well. The 8-inch casing is perforated from below the bottom of the shallow completion to the bottom of the well. A 2-foot-thick bentonite plug is placed between the shallow completion and the deep completion above the screened interval of the shallow completion. The screened intervals for both completions are filled with a gravel backfill. Native soil is backfilled between the upper bentonite seal and ground surface. A slip joint is installed in both completions similar to that installed in the Phase I wells.

The Phase II native soil wells are drilled with several different diameters and configurations. The completions of these wells are similar to that of the Phase II interior wells with the exception that both completions are 4-inch-diameter PVC casing and a slip joint is not required. The wells installed on the west boundary of the landfill (wells PA-1 through PA-6, PA-10, and PC-1 through PC-9) were completed simply by extending the casings above ground. The wellheads for Phase II native soil wells installed to the east and south of the landfill (wells PD-1 through PD-12, and PA-7 through PA-9) were buried in a vault as shown on Figure 14-2. The vault was required because the wells to the east were installed on the Interstate 5 southbound shoulder and the wells to the south, with the exception of PD-10, were installed outside the boundaries of the landfill on the right-of-way for South 252nd Street. Well C-11 was constructed in a similar manner as the aboveground native soil wells.

The Phase III wells were placed in the refuse and were constructed just like the Phase II refuse wells.

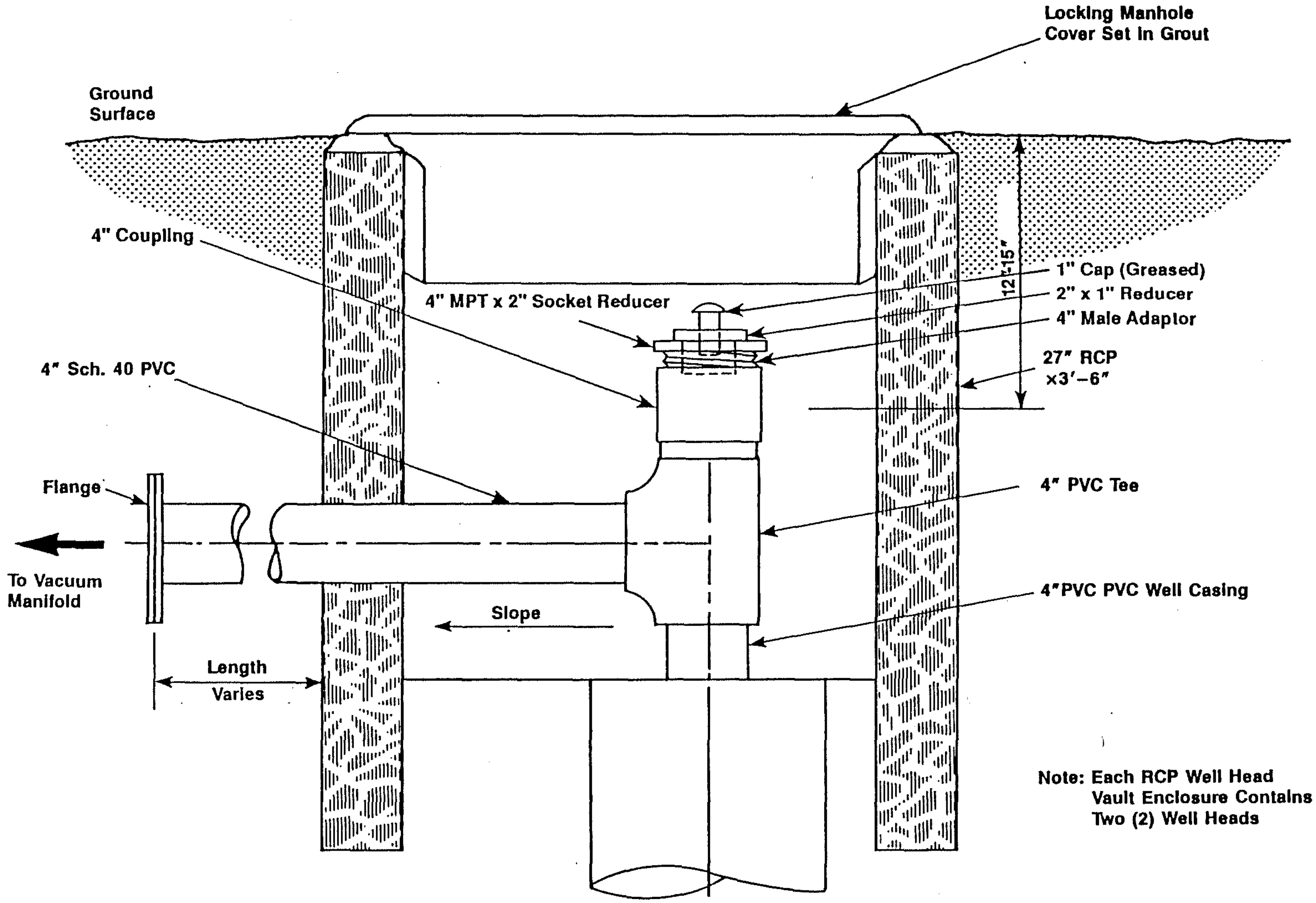


**Figure 14-2.
Typical Cross Section
of a Phase II Native
Soil Wellhead Detail**

The specific construction characteristics for each well can be found in a separate binder. Because the well details in the appendix do not show the liner penetrations, a detail of the penetrations is shown in Figure 14-3.

14.1.3 Vacuum Manifold

The vacuum manifold is constructed of high density polyethylene (HDPE) pipe which connects all on-site gas extraction wells to the motor blower/flare facility.

The vacuum manifold is sloped to provide drainage of condensate to low-point knock-out points. Bend legs are designed into the manifold routing to provide for thermal expansion and contraction. Several different diameters of piping are used in the vacuum manifold system. This is to minimize the pressure drop (vacuum loss) throughout the manifold system. Valves are placed at intersections of the vacuum manifold system to allow the operator to isolate a section of the system for repair, replacement, etc.

14.1.4 Condensate Drain System

The purpose of the condensate drain system is to collect, store, and then discharge condensate that forms in the landfill gas system. The condensate system consists of the following components:

- Condensate manifold
- Condensate collection tank
- Condensate manhole
- Vacuum operated condensate valves
- Condensate pumping system
- Vacuum system
- Automatic drip traps
- Scrubbers

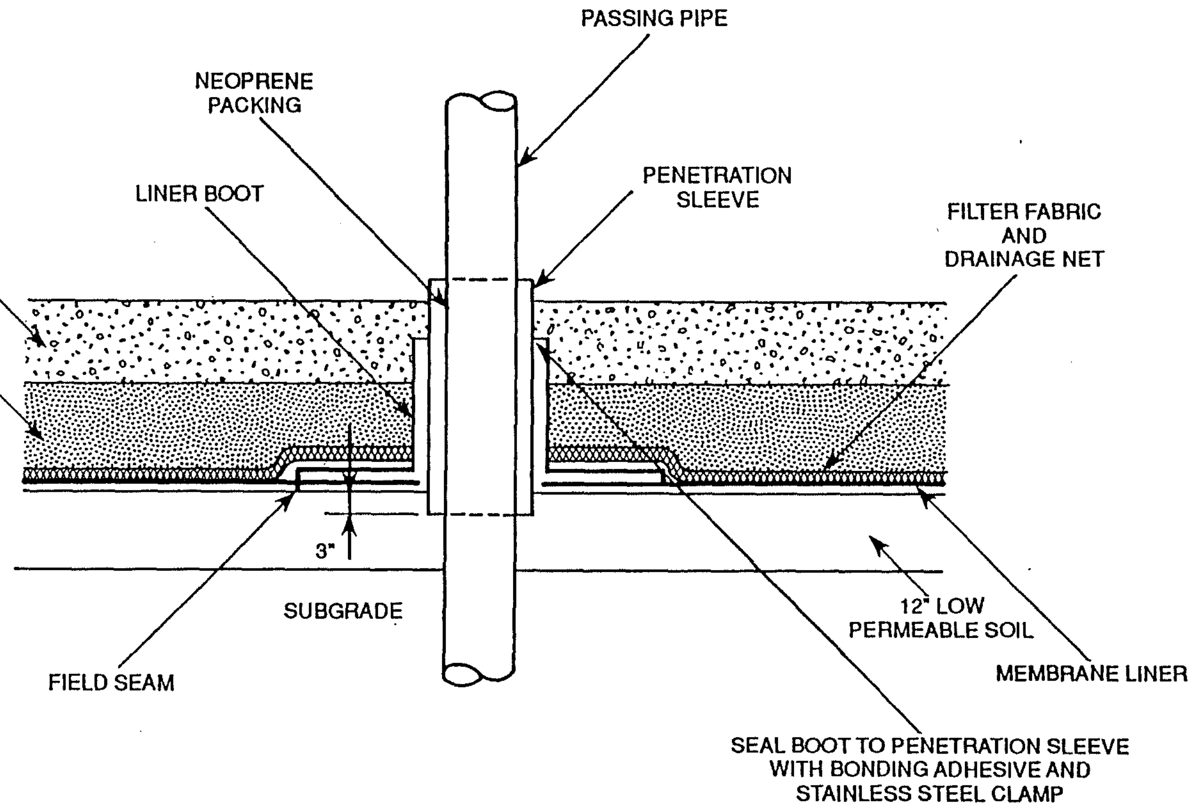
A one line diagram of the condensate system is shown in Figure 14-4.

A discussion of each component in the system is contained in the sections below.

14.1.4.1 Condensate Manifold

The condensate manifold collects condensate that forms in the gas manifold and routes it to the condensate collection tank. Figure 14-1 shows the layout of the collection manifold.

Condensate is drawn to the collection tank due to the combined effects of the vacuum drawn on the system and because the collection tank is located at the low point of the system.



Note: U.S. Geological Survey Water Resources
Type I Penetration, as Shown. (Wells 1 to 56)
Type II Penetration, Less Neoprene Cord Packing and Penetration Sleeve (Boot Attached Directly to Passing Pipe; PC, PA & PD Wells)

Figure 14-3.
Typical Refuse Wellhead Liner Penetration

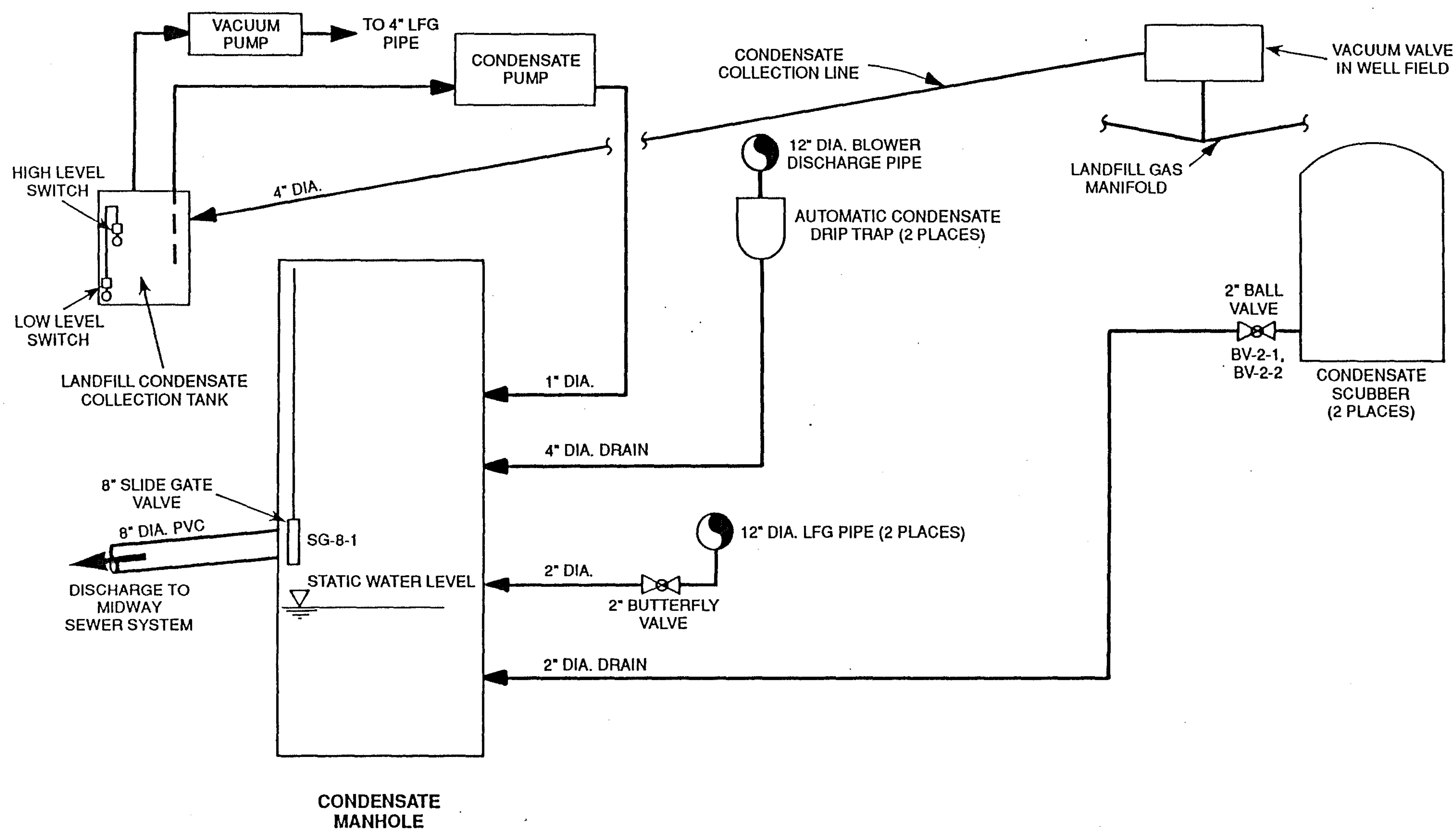


Figure 14-4.
Condensate Collection and Discharge Diagram

Condensate cleanouts are built into the condensate manifold. They provide access to the inside of the manifold in case it becomes necessary to clear blockages in the pipe. They are spaced on 200-foot increments.

The collection manifold is constructed of 4-inch-diameter HDPE pipe.

14.1.4.2 Condensate Collection Tank

The collection tank collects and stores condensate drawn from the landfill gas manifold. The tank is 24-inches in diameter and 12-feet tall. It is made of fiberglass reinforced plastic and is located on the west side of the motor blower/flare facility.

Condensate collects in the tank until the level reaches the high level setpoint. When it reaches that level one of the condensate discharge pumps will turn on and pump condensate to the condensate manhole. When the level in the collection tank is reduced to the low level setpoint, the pump turns off.

A high level alarm is activated if the water level in the tank gets too high. This might occur if the selected condensate pump were to fail or if condensate were entering the tank faster than the pump could pump it out.

14.1.4.3 Condensate Manhole

The condensate manhole collects condensate from several different places and then stores it until it is discharged into the sewer system. The manhole is located on the south side of the motor blower/flare facility.
Condensate arrives at the manhole from four sources. They are:

- The condensate scrubbers
- The auto drain traps
- The condensate collection tank
- Low point of the 12-inch landfill gas manifold located under the motor blower/flare facility

Condensate collects in the manhole until the level reaches the invert of the discharge pipe. The condensate then drains out to the Midway Sewer System. An 8-inch-diameter slide gate valve located at the discharge can be shut to prevent condensate from going into the sewer system.

14.1.4.4 Vacuum Operated Condensate Valves

Because the gas and condensate manifolds operate at different vacuums, it is necessary to isolate the two systems from each other. The vacuum operated condensate valves allow condensate to pass from the gas manifold to the condensate manifold while maintaining a seal between the systems.

The valves are APCO #65.5 Air Release Valves. They have been installed upside down for use in this particular application. See Figure 14-5 for a detail of the vacuum valve.

14.1.4.5 Collection Tank Pumping System

The purpose of the collection tank pumping system is pump condensate from the condensate collection tank to the condensate manhole. This system consists of two condensate discharge pumps, a pump control station, and the piping that connects the collection tank to the condensate manhole.

Operation of the condensate discharge pumps is controlled at the condensate control station. A selector witch allows you to select which pump will operate. The operating pump should be selected so that pump run hours stay fairly well balanced.

A pump control switch sets the operational mode of the selected pump. The switch can be set for HAND, OFF, and AUTO. The switch will normally be selected to the AUTO position. The different modes of operation are described below:

1. OFF - The selected pump will not run, no matter what the level in the collection tank is.

2. HAND - The selected pump will run continuously and will not stop until the control switch is turned to the OFF position, the pump trips on overload, or power to the pump is disconnected at an upstream breaker.

3. AUTO - Operation of the selected pump is governed by the high and low level switches in the collection tank.

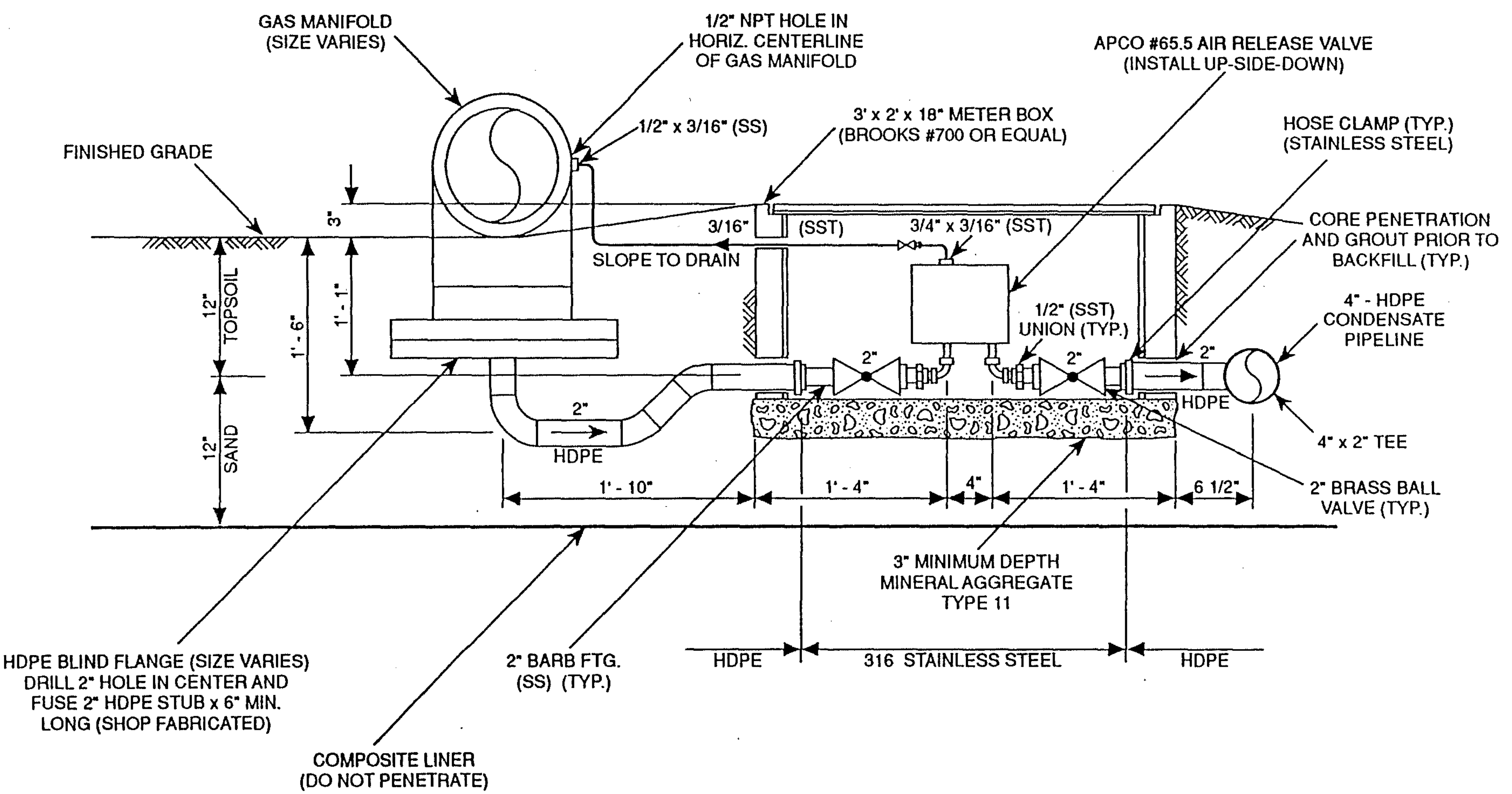
In the event the operating pump experiences an electrical overload, the pump will stop and a warning light (located at the control panel) will come on.

The pump control station also has a collection tank high level alarm. Below the high level alarm is a reset switch to clear the alarm once the high level condition has been corrected.

14.1.4.6 Condensate Vacuum System

The condensate vacuum station functions to maintain the required vacuum in the condensate drainage system. The vacuum is normally set about 20 inches WC above the blower inlet vacuum. The station consists of two pumps, a vacuum tank, and a pump control station.

Operation of the vacuum system is controlled from the pump control station. A pump control switch, one for each pump, sets the operational mode. The switch has three positions: TEST, OFF, and AUTO. Each switch will normally be selected to the AUTO position. The different modes of operation are described below:



Note: 1" Thick Polyfoam Board, Glue
to Inside of Vault, All Sides and Lid.

**Figure 14-5.
Vacuum Valve**

1. TEST - This mode checks to see if the pump is operational. The switch is spring operated so that it will return to the OFF position once it is released.

2. OFF - The pump will not run, no matter what the vacuum in the system is.

3. AUTO - The pump will cycle on and off based on the what the vacuum setpoints are.

The operational condensate vacuum setpoint is adjusted from inside the control station. There are two adjusting screws located at the bottom of the station. One screw regulates the pump on setpoint while the other regulates the span, or range, over which the pump will remain on.

Each pump has an overload reset button located on the front of the control station to reset the pump in the event of an electrical overload.

14.1.4.7 Automatic Drip Traps

The automatic drip traps collect any condensate from the blower discharge side of the landfill gas piping. There is one trap for each discharge line. The valves are connected to the invert of each pipe. Condensate drains from the pipe, through the valve, and to the condensate manhole. The valves are designed to allow condensate to pass through without causing a loss of vacuum in the condensate system.

14.1.4.8 Scrubbers

There are two scrubbers installed in the landfill gas system, each located as shown in Figure 15-2. The scrubbers remove condensate from the gas stream by changing the direction of the gas flow. Condensate is collected at the bottom of the scrubber where it drains to the condensate manhole.

14.2 START-UP, INITIAL OPERATION

At this time, initial start-up procedures only apply to new gas wells that may be installed in the future. The existing wells have already been put in operation, balanced and stabilized. Start-up procedures for in-refuse wells are more conservative than the procedures for native soil wells because of the possibilities for starting aerobic decomposition in refuse. Excessive aerobic decomposition in refuse can start a landfill fire.

14.2.1 In-Refuse Wells

Start-up procedures for new in-refuse wells include the following steps:

1. Adjust the valve to reach ambient or zero gauge pressure in the well.
2. Check the well velocity in feet per minute.
3. Monitor well after 24 hours of operation.
4. If well performance looks good, (stable methane percentage, low oxygen and no large temperature increases) increase velocity (10% increments are generally good).
5. Recheck well after 24 hours and continue to increase velocity.
6. Recheck well daily for 5 days.
7. If well output and conditions stabilize, monitoring can be reduced to once a week.

If the sequence of steps for well start-up is interrupted, the well should be monitored daily for at least three consecutive days to insure that the well stabilizes in a safe condition.

14.2.2 Native Soil Wells

Start-up procedures for new native soils wells depend on the well's location and its distance from probes and to the nearest area of refuse. The closer a well is to refuse, the more conservative start-up procedures should be. On the other hand, if a well is installed far from refuse, the start-up can be less conservative. The initial target vacuum for a native soil extraction well is 1-inch H_20 unless otherwise determined by the project engineer based on the above considerations.

At a minimum, start-up procedures for native soil wells should include the following steps:

1. Adjust the well to its initial target vacuum.
2. Check the well velocity in feet per minute.
3. Monitor the well after 24 hours of operation.
4. If well performance data does not indicate aerobic decomposition, readjust the well vacuum to target if required.
5. If well performance data indicates a problem, reevaluate the target vacuum with the project engineer.
6. Monitor well after an additional 48 hours of continuous operation.
7. Readjust well vacuum if necessary.
8. Monitor the new well and any nearby in refuse wells or gas probes after an additional 48 hours of continuous operation to check for increased temperature, vacuum, or other indications of aerobic decomposition.
9. If any of this data indicates a potential problem, the project engineer should again reevaluate the target well vacuum.
10. If all data indicates a stable well condition, the well should be monitored on a weekly basis.

If the sequence of steps for well start-up is interrupted, the well should be monitored daily, at least three more times to insure that the well stabilizes in a safe condition.

14.2.3 Condensate Drain System

Start-up procedures for the condensate drain system are as follows:

1. Obtain approvals to discharge, as required, from the Midway Sewer District.

2. Verify that the Midway Sewer District manhole is ready to receive condensate.

3. Open the 8" fiberglass slide gate SG-8-1 in the condensate manhole.

4. Prime the vacuum seal in the drain lines by filling the condensate manhole to the 8" overflow with water.

5. Open valves BV-2-1 and BV-2-2 for scrubbers #1 and #2.

6. Close valves BV-2-3 and BV-2-4 for the scrubber vents.

7. Open valves BFV-2-1 and BFV-2-2 for the landfill gas manifold drain.

8. Add water to the condensate collection tank to a level just above the low level switch.

9. Check that all condensate manifold isolation valves and vacuum valves are open.

10. Select a condensate discharge pump and turn the control switch to AUTO.

11. Record the vacuum at the suction side of the operating blower.

12. Check that vacuum and pressure relief valves are operating correctly at vacuum pump station.

13. Open inlet and outlet valves at the vacuum pump.

14. Start the vacuum pump and adjust the vacuum to 5 inches of mercury. As the landfill settles, it may be necessary to increase the vacuum to allow adequate vacuum to pull condensate out of low areas in the condensate manifold system.

    CAUTION: Do not allow vacuum to exceed 20 inches of mercury in the condensate system.

14.3 START-UP AND NORMAL OPERATION

Normal start-up procedures depend on the length of time an individual extraction well or group of wells have been off-line. For example, if the entire system goes down for a short period (from 1 to 48 hours), then no adjustments are necessary prior to restarting the system. Table 14-1 outlines restarting procedures for a variety of conditions.

Table 14-1
Normal Well Start-up Procedures

Condition	Start-Up Procedures
Entire field or group of wells off-line for between 0-48 hours.	Restart gas and condensate system at previous vacuum. No individual well adjustment necessary.
Individual well off-line for between 0-48 hours.	Restart at last recorded well velocity (velocity taken prior to shutdown preferred).
Individual well or group of wells off-line for 2 to 14 days.	Restart individual wells at 75% of last recorded velocity. Readjust individual wells during normal monitoring over several weeks. Restart condensate system at last recorded vacuum.
Individual well or group of wells off-line for over 2 weeks.	Restart individual wells at 50% of last recorded wellhead velocity. Monitor after 48 hours of operation. Readjust well during normal monitoring over several weeks. Restart condensate system at last recorded vacuum.

14.4 NORMAL OPERATION

The landfill gas collection system at the Midway Landfill operates continuously under normal conditions. The vacuums and gas flows in the manifold and individual wells will normally remain fairly stable and show minor fluctuations that depend on current barometric trends. The most important aspect of normal operations is maintaining a constant influence on the landfill and surrounding areas.

14.4.1 Extraction Wells

Gas extraction wells should be kept under a steady vacuum. This vacuum will collect landfill gas from a large underground area. This gas is routed through the well to the manifold. The size of the underground area influenced by an extraction well depends on the strength of the vacuum, soil type, and a number of other factors.

During normal operations, monitoring results from the in refuse wells, perimeter wells, and off-site gas probes should be reviewed together. Reviewing the results together will make it easier to detect potential gas migration problems.

Anytime adjustments are made to the extraction wells (particularly the perimeter wells) the off-site probes should be watched carefully for any signs of gas migration.

Adjustments to the perimeter wells should be made immediately if migration is suspected to be occurring. In addition, an analysis of the in-refuse wells near the migration site should be done to determine what, if any, adjustments need to be made to the in-refuse wells. Monitoring frequency at all off-site probes and wells near the migration point should be increased. The monitoring results should be reviewed carefully to determine if further adjustments are required. Increased monitoring and adjustments to the wells should continue until the threat of gas migration has been eliminated.

14.4.2 Manifold

The vacuum manifold routes gas from the extraction wells to the blowers. Figure 14-6 is a flow diagram showing the normal direction of the gas flow through the manifold. The gas flow in the manifold should be steady under normal circumstances.

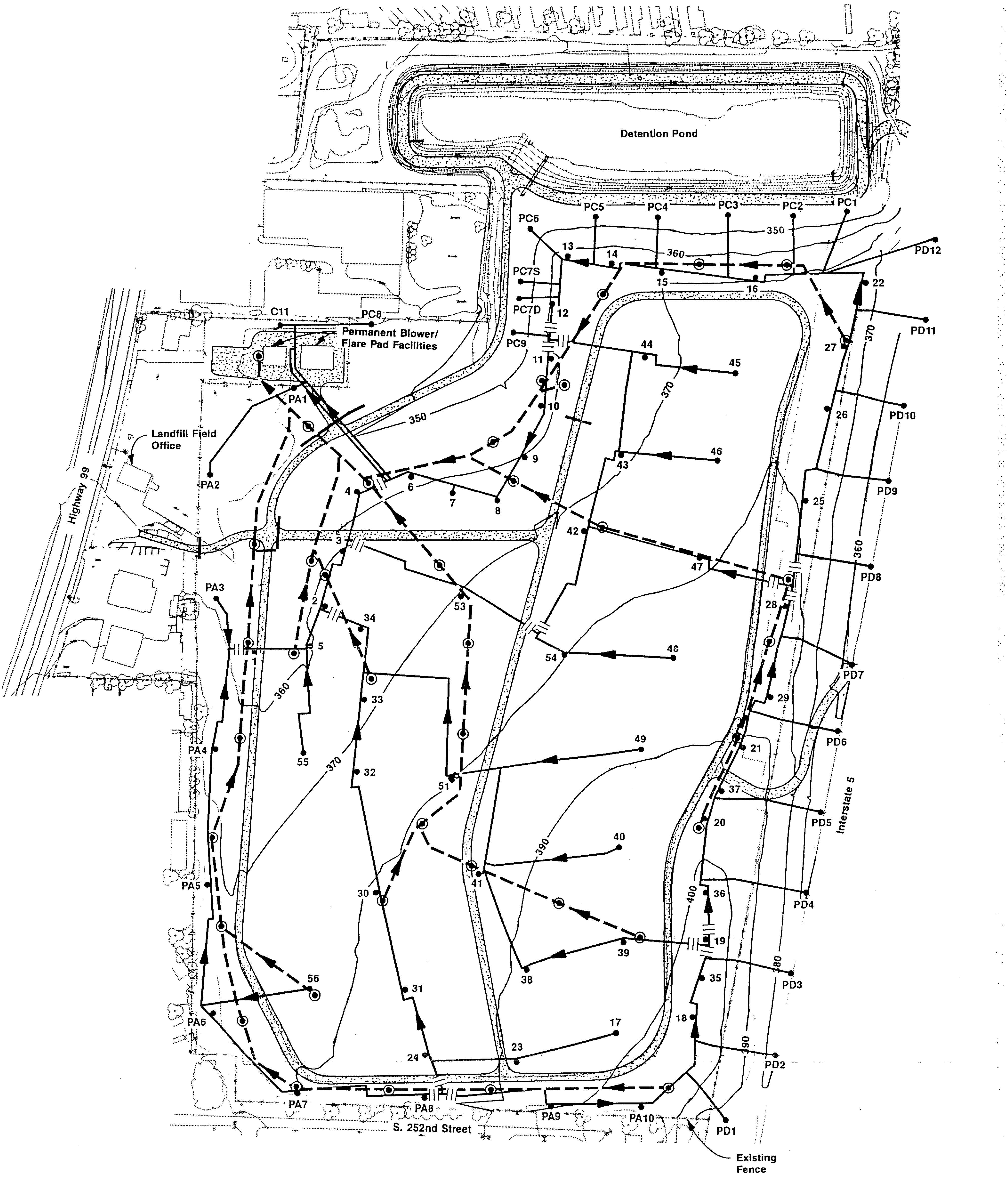
14.4.3 Condensate Drain System

During normal operation, the condensate drain system discharges condensate collected in the gas collection system to the sanitary sewer. The drain system is virtually self operating. The only adjustments necessary are occasional adjustments to the vacuum in the condensate system to overcome differential settlement in the landfill.

14.5 ALTERNATE OPERATION

14.5.1 Extraction Wells

During conditions of alternate operation, the extraction wells will continue to operate normally if the vacuum in the adjacent manifold is maintained.



Access Road	Butterfly Valve
Grading Contour (—350—)	Landfill Gas Collection Pipe
Culvert	Condensate Collection Pipe
	Migration Control Wells
	Condensate Collection Pipe Cleanout

SCALE IN FEET: 0, 100, 200

N

Figure 14-6.
Direction of Gas Flow in Vacuum Manifold During Alternate Operation

14.5.2 Manifold

During alternate operation conditions, the manifold valves will have to be adjusted to route the gas flow in the desired path. Examples of various valving scenarios are shown on Figures 14-7 through 14-10.

These figures indicate only a few examples. The important thing for the operator to remember is that gas can flow in either direction in a gas manifold, and any valving scenario that maintains a vacuum on the largest possible portion of the landfill is appropriate for short-term operation.

14.5.3 Condensate Drain System

When the condensate drain system is operating under "alternate operation" as described above, certain portions of the condensate manifold may be valved off to assure against drawing air into the condensate system from an open gas manifold and thereby reducing the condensate system vacuum.

Unlike the gas collection manifold, there is not a great deal of flexibility built into the condensate system with respect to taking certain portions of the system off-line. However, tests have shown that portions of the system can continue to collect condensate for periods up to one week without discharging to sanitary sewer. Therefore, the condensate system will continue to operate as a "condensate storage facility" even if portions are valved off from the main system for a period of up to one week. It is important to effect any repairs to the gas manifold within this time period to allow normal operations to resume.

14.5.3.1 Condensate Discharge

Conditions may require the termination of the direct discharge to the Midway sewer system. This issue will most likely be initiated by the Sewer District. This requires that all condensate be hauled to an acceptable location for discharge. The location must be determined by the operations supervisor. The following procedures are required when performing this task.

- Have a tank truck ready.

- Provide a self-priming or submersible pump for withdrawal of condensate from the condensate manhole. Provide an isolation valve on the discharge end of the pump hose, or a drain at the pump, to prevent spillage of condensate following the filling of the truck.

  CAUTION: Never pump condensate lower than one foot above the bottom of the manhole. Liquid must cover the lower drain lines to provide a seal for the vacuum in the manifold. Should the liquid be drawn below the pipes and the system start to suck air, immediately shutdown the motor blower/flare facility and refill the manhole so the pipes are covered. The system may be restarted after the water is added.

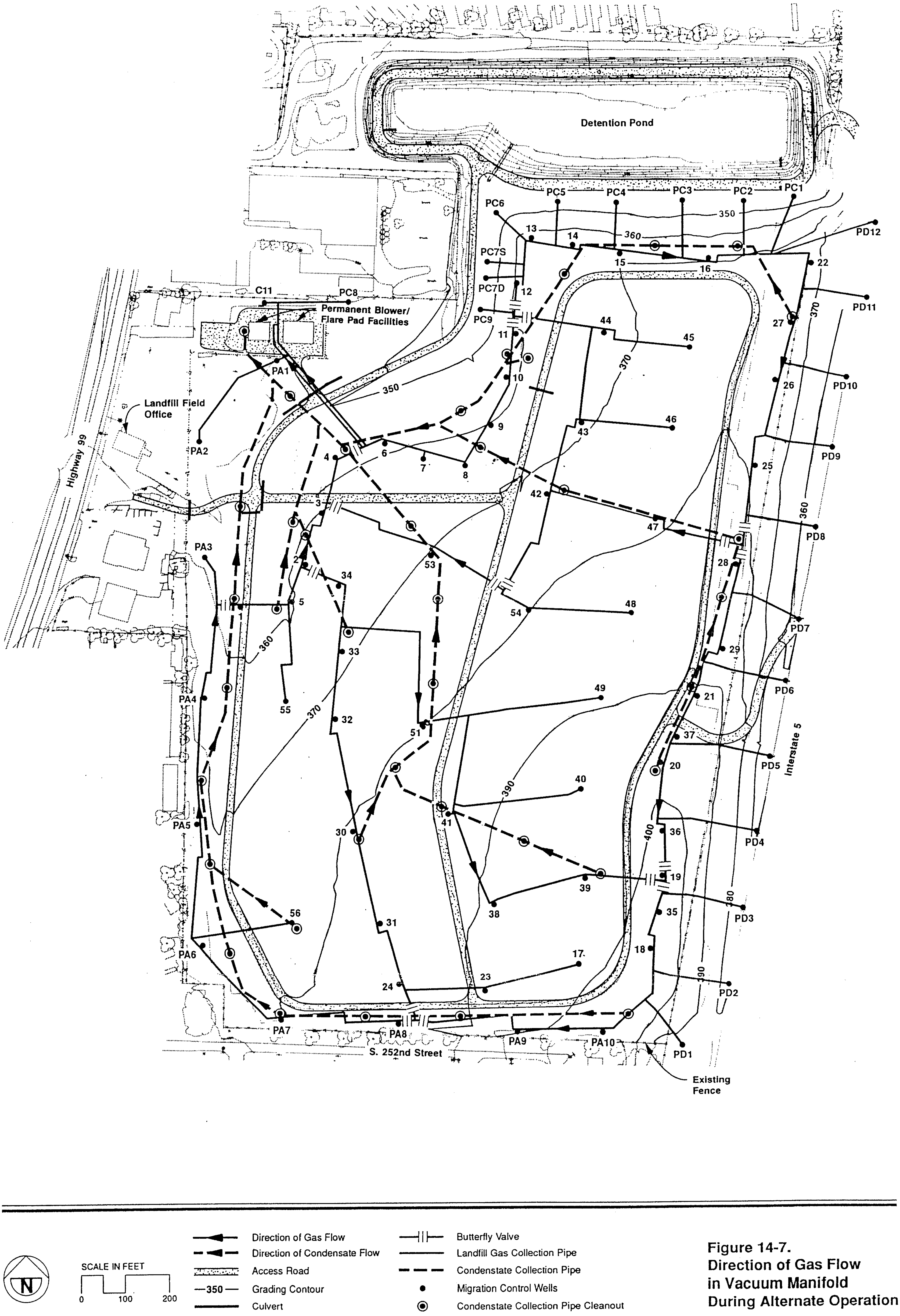
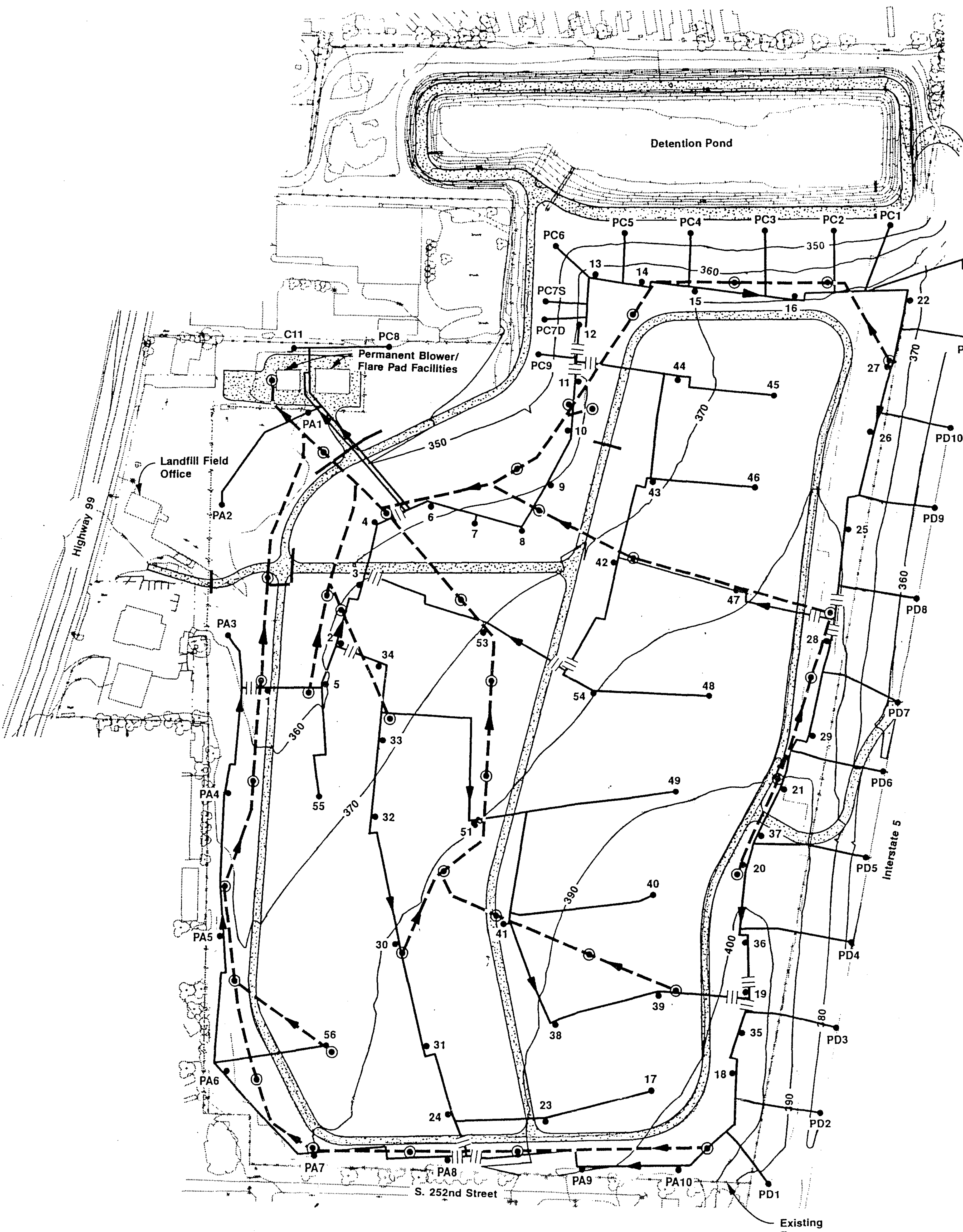


Figure 14-7.
Direction of Gas Flow in Vacuum Manifold During Alternate Operation



Direction of Gas Flow

Direction of Condensate Flow

Access Road

—350— Grading Contour

Culvert

Butterfly Valve

Landfill Gas Collection Pipe

Condenstate Collection Pipe

Migration Control Wells

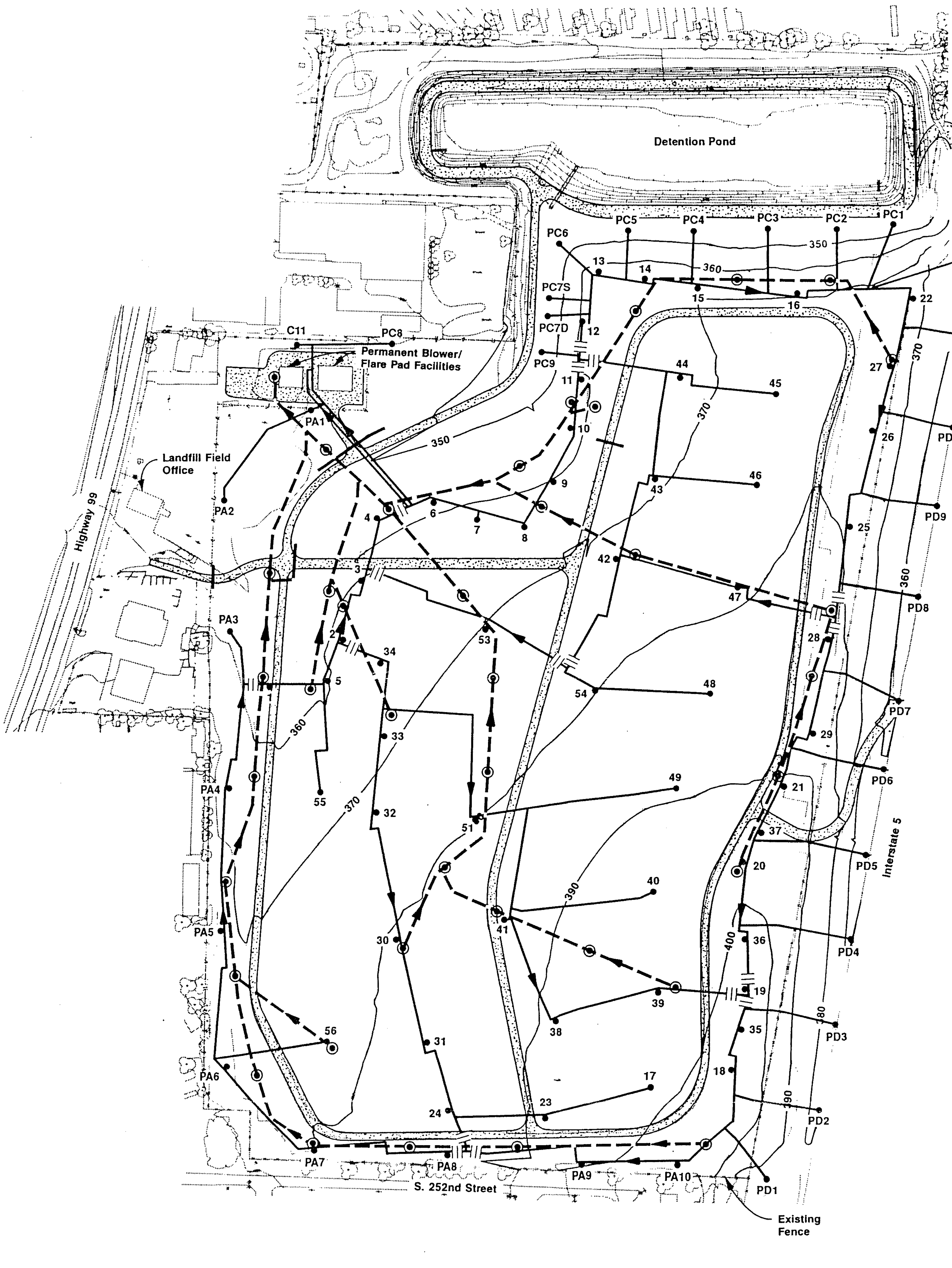
Condenstate Collection Pipe Cleanout

SCALE IN FEET

0 100 200

N

Figure 14-8.
Direction of Gas Flow in Vacuum Manifold During Alternate Operation

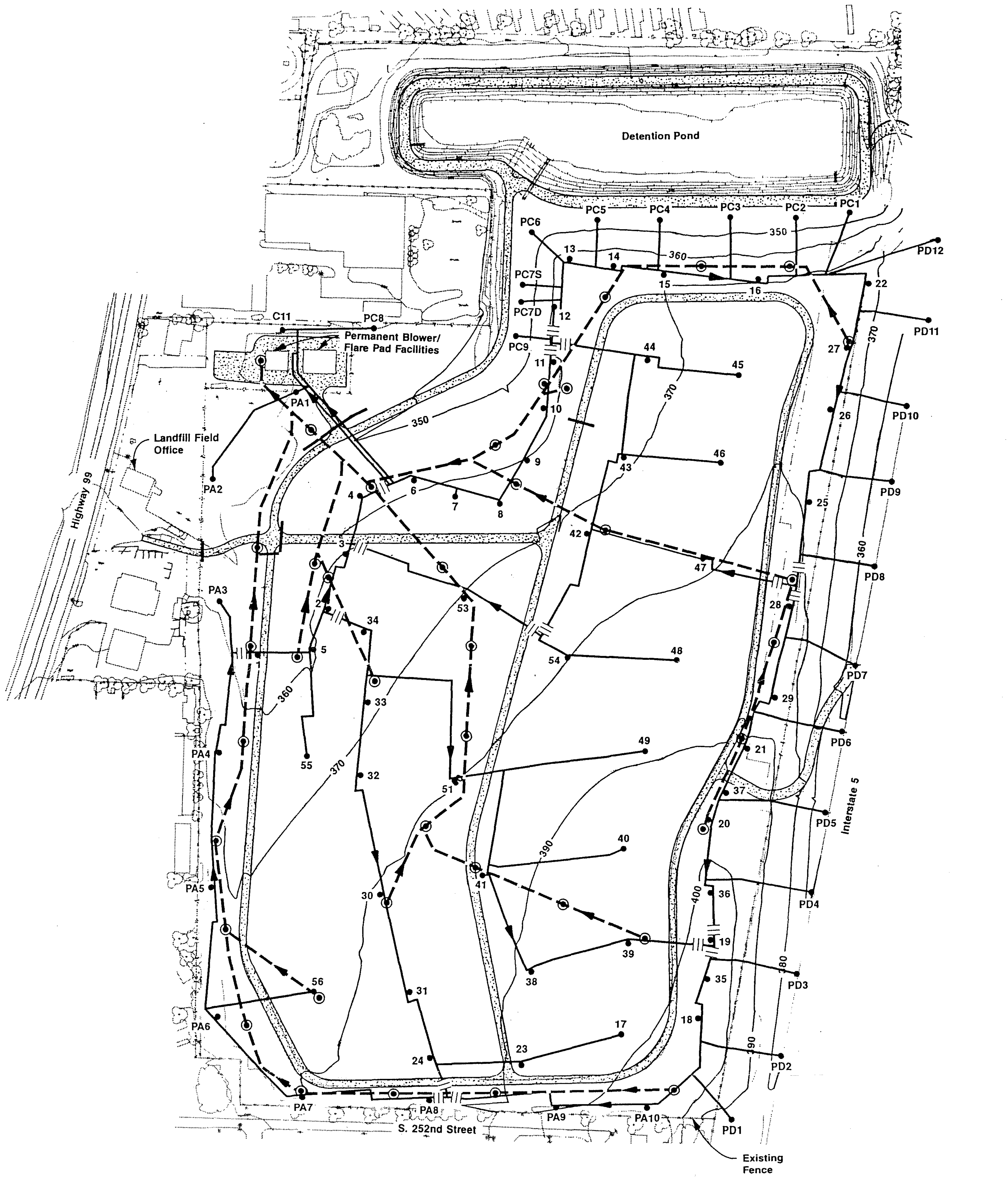


Direction of Gas Flow	Butterfly Valve
Direction of Condensate Flow	Landfill Gas Collection Pipe
Access Road	Condensate Collection Pipe
—350— Grading Contour	Migration Control Wells
Culvert	Condensate Collection Pipe Cleanout

SCALE IN FEET
0 100 200

N

Figure 14-9. Direction of Gas Flow in Vacuum Manifold During Alternate Operation



SCALE IN FEET 0 100 200

Direction of Gas Flow	Butterfly Valve
Direction of Condensate Flow	Landfill Gas Collection Pipe
Access Road	Condensate Collection Pipe
—350— Grading Contour	Migration Control Wells
Culvert	Condensate Collection Pipe Cleanout

Figure 14-10.
Direction of Gas Flow in Vacuum Manifold During Alternate Operation

- Close the 8-inch fiberglass slide gate SG-8-1 in the condensate manhole.
- Pump the manhole when the level of condensate rises within 11 feet of the top of the manhole.
- Plan the haul and return trip within the time allowed for system storage. The time between trips is determined by monitoring the fill rate of the condensate manhole.

In performing condensate storage by the above procedure, the system storage level is limited by the operating vacuum in the gas manifold.

This approach will be adequate for short term hauling. Should hauling of condensate be required for an extended period of time, a storage tank should be considered. This will be less labor and equipment intensive.

14.5.3.2 Condensate Scrubber

The condensate scrubbers normally drain on a continuous basis to the condensate manhole. When work is required in the condensate manhole, the scrubbers may serve as a very short-term storage vessel. The time is dependent on the volume of condensate collection precipitating. To perform this, refer to Figure 14-4 and perform the following tasks:

- Close ball valves BV-2-1 and BV-2-2 to stop flow from the scrubbers to the condensate manhole.
- Close butterfly valves BFV-2-1 and BFV-2-2 to terminate flow from the landfill gas collection header.

Each scrubber will provide storage for about 90 gallons of condensate before the blowers start surging. Surging can occur when the condensate collects in the low point of the manifold. To correct this, the accumulation of condensate must be drained to the manhole by opening valves BV-2-1, BV-2-2, BFV-2-1, and BFV-2-2.

14.6 EMERGENCY OPERATION

Emergency operations of the landfill gas extraction system would be necessary after major pipeline breaks or during a underground refuse fire. In the event of major breakage, the section of pipe should be isolated and repaired. In the case of a suspected underground refuse fire, all wells in the area should be turned down to a condition of zero gauge vacuum and monitored for carbon monoxide and temperature.

14.7 MONITORING

Daily monitoring of the gas extraction manifold is recommended so that problems in the system can be quickly identified and corrected. Weekly monitoring of individual extraction wells provides a continuous database of well performance. This database is analyzed to determine well adjustments and balance the extraction system. A list of the measurements that are made during routine manifold and well monitoring includes the following:

14.7.1 Daily Manifold Monitoring

- Manifold vacuum
- Manifold methane and oxygen concentrations
- Gas stream velocity in manifold

14.7.2 Weekly Extraction Well Monitoring

- Wellhead vacuum
- Wellhead methane and oxygen concentrations
- Wellhead carbon dioxide concentrations
- Wellhead temperature
- Gas stream velocity in wellhead

14.8 . DATA ACQUISITION AND ANALYSIS

The most important consideration during data collection and analysis is accuracy. All instruments should be calibrated prior to use and all unusual readings should be repeated. All field notes should be checked for completeness and accuracy and all calculations should be double checked.

14.8.1 Data Acquisition

It is important that the gas extraction system be operating normally to allow for accurate data collection. Readings taken while the gas extraction is shut down or in a fluctuating condition (e.g. - within 1 hour of start-up) are not accurate indicators of well performance. Note - Manifold readings may be taken any time the system is operating to evaluate operating characteristics or problems.

Data collection techniques are identical for manifold monitoring and extraction well monitoring. All monitoring ports throughout the gas extraction system are 1/2" NPT ports with threaded plugs. All monitoring instruments should have adapters that create tight seals in the monitoring ports.

The following are the steps for each type of measurement required are listed and additional information for each instrument is available in the instrument manual.

- **Pressure.** Insert probe into measuring port, seal and record measurement in inches WC (water column). Allow instrument to stabilize before recording. Measurements can be made with analog gauge such as a Dwyer Magnahelic, or digital electronic instrument such as a Neutronics PDM-10.

- **Methane and Oxygen.** Insert probe into measuring port, seal and allow instrument pump to draw sample gas through instrument. Set instrument to percentage oxygen and continue to sample until oxygen reading stabilizes, switch meter to percentage methane and record oxygen and methane readings in percent by volume. Methane and oxygen readings should be taken with an instrument such as the Gastech Model 1939 OX. Individual oxygen and methane meters with squeeze bulb sampling pumps can also be used for these measurements.

- **Carbon Dioxide.** Insert probe into sampling port and seal. Place male fitting (on the end of sampling hose) over female fitting on sample bottle. Squeeze hand aspirator bulb three times to clear previous sample from hose. Push male fitting into sampling bottle depressing spring; bottle must be kept upright), then squeeze hand aspirator 19 times. Following the 19th stroke remove male fitting from sample bottle allowing the spring loaded cap to close. The sample bottle should then be inverted until all gas bubbles pass through the fluid, then returned to the upright position. invert the bottle a second time and return to the upright position. The carbon dioxide concentration in percent by volume can then be read off the scale on the side of the sampling bottle. The sample bottle should be cleared after each reading by depressing the cap while the bottle is upright. Carbon dioxide readings should be taken with an instrument such as the Fyrite CO_2 Indicator with a 0 - 60% scale.

- **Well Temperature.** Insert probe into sampling port and seal. Allow reading to stabilize and record the highest temperature seen to the nearest degree F. Temperatures should be measured with an instrument such as the Fluke digital thermometer.

- **Gas Velocity.** Set probe length to match the diameter of pipe to be measured and orient the probe so that the gas flow will pass through the probe, then insert probe into sampling probe and seal. Switch the instrument on and take the reading on the lowest scale that is not "pegged". Velocity measurements should be made with an instrument such as the Kurz Model #441 Anemometer and recorded in feet per minute (FPM).

- **Data Recording.** Field data should be recorded in bound field notebooks with water hard paper. In addition to the data, field books should also contain the following information; note taker, instrument operator, weather conditions, time of day, AM and PM barometer readings, and any pertinent comments or notes. Extraction well data can also be entered directly into a hand-held computer if that equipment is available.

14.8.2 Data Analysis

The data collected during vacuum manifold monitoring is used as an indicator of overall system performance. Current operating parameters should be constantly compared to previous data.

The gas extraction system should operate in a stable condition, and any significant changes in the operating parameters should be analyzed. Large swings in barometric pressure will cause significant changes in the system.

The data collected during extraction well monitoring should be analyzed on a well by well basis to evaluate well performance and determine needed adjustments. To understand the analysis of extraction well data it is important that the basic concepts of aerobic and anaerobic decomposition be clearly understood. The methods used to analyze well data are presented following a explanation of aerobic and anaerobic decomposition.

Refuse decomposition proceeds with or without air. Aerobic decomposition is decomposition in the presence of air. In aerobic decomposition, refuse + air are changed into CO_2 + H_2O + Residual N_2 + Unconsumed air + heat. The heat produced in this chemical transformation is capable of igniting the refuse and starting an underground fire.

Anaerobic decomposition is decomposition in the absence of air. In anaerobic decomposition, refuse + H_2O are changed into CH_4 + CO_2. This is the type of decomposition which produces methane (CH_4).

By understanding these two different types of decomposition, it is possible to adjust individual extraction wells to minimize the amount of aerobic decomposition and maximize anaerobic decomposition taking place in the refuse surrounding the extraction point.

14.8.3 Gas Extraction Point Adjustment Determinations

Once the operator understands the relationship between aerobic and anaerobic decomposition, he can determine how to best adjust or "balance" a gas extraction point. To determine the relative amounts of aerobic and anaerobic decomposition taking place in the landfill, it is important to know how to interpret the data recorded when the extraction point is monitored. Typically, the measurements taken at each extraction point are the following:

- Methane (CH_4) percentage
- Oxygen (O_2) percentage
- Carbon Dioxide (CO_2) percentage
- Extraction Point Pressure (or vacuum) in inches water column ("WC)
- Temperature (°F)
- Gas Stream Velocity (f/m)

Using these readings it is possible to determine, within $\pm$ 10%, the entire chemical makeup of the gas from the extraction point and the anaerobic vs. aerobic decomposition ratio.

The first step in this process is to determine what percentage of the gas stream being sampled is water vapor. This is done by using a formula derived from Antoine's Number, a formula to determine liquid vapor concentration in a gas stream based on the partial pressure of H_2O vapor. The constants shown are determined empirically. The formula is as follows:

$$Wv = \frac{10^{(7.89 - \frac{3207}{395.43+T})}}{Pa + Pt} \, x \, 100$$

Where:

Wv	=	Percent Water Vapor
T	=	Gas Stream Temperature (°F)
Pa	=	Atmospheric Pressure (WC)
Pt	=	Gas Stream Pressure (WC) – (Note: if gas stream being sampled is under vacuum, the gas stream pressure will be a negative number.)

For example, the percentage of water vapor in a particular gas collection trench can be determined with the following readings:

Trench Number	=	X
CH_4%	=	21
O_2%	=	7
CO_2%	=	18
Temperature (°F)	=	48
Pressure (WC)	=	-5.0
Gas Stream Velocity (fpm)	=	300
Barometric Pressure (WC)	=	29.5 Hg x 13.57 WC/Hg = 400 WC.

Inserting the temperature, trench pressure, and barometric pressure in the above formula, the percent water vapor equals 1.15 percent. (For these calculations, 1 percent is acceptable.)

After using this formula to find the water vapor percentage, the major constituents of the gas stream can then be determined. However, based on past experience, it is assumed that the gases present in landfill gas, whether a product of aerobic or anaerobic decomposition, are CH_4, O_2, CO_2, N_2, and H_2O (vapor). Some trace particulates of various elements might be present in the gas. However, for this discussion we will ignore their presence since they will not affect the overall performance of the system. Therefore, since CH_4, O_2, and CO_2 values have been determined by field instrumentation, and the percentage of water vapor has been calculated in the above formula, the remainder of the gas in the sample can be assumed to be N_2.

The percentage of aerobic and anaerobic decomposition in the gas stream can now be calculated. On average, anaerobic decomposition produces CH_4 and CO_2 at a ratio of approximately 1.45:1. Therefore, by taking the percent of CH_4 recorded on a sample in the field and dividing by 1.45, the percentage of anaerobic CO_2 can be determined. The balance of CO_2 present represents aerobic CO_2. Also, free, (ambient) air contains approximately 21 percent O_2 and 79 percent N_2, a ratio of 1:3.76. Multiplying the percentage of O_2 recorded in the field by 3.76 will indicate the amount of N_2 in the gas stream associated with free air. The balance of N_2 present in the gas stream can be considered residual N_2 (or N_2 left over from the consumption of oxygen in the process of aerobic decomposition).

GAS COLLECTION SYSTEM ANALYSIS EXAMPLE:

Using the same sample readings described previously:

Trench Number	=	X
CH_4%	=	21
O_2%	=	7
CO_2%	=	18
Temperature (°F)	=	48
Pressure (WC)	=	-5.0
Gas Stream Velocity (fpm)	=	300
Barometric Pressure (WC)	=	29.5 Hg x 13.57 WC/Hg = 400 WC

Calculated Quantities:

H_2O% (Wv from formula)	=	1%
Anaerobic CO_2 (21% CH_4 / 1.45)	=	14%
Aerobic CO_2 (18% total CO_2 - 14% anaerobic CO_2)	=	4%
Total N_2% (100% - CH_4% - O_2% - total CO_2% - H_2O%)	=	53%
N_2% from free air (7% O_2 x 3.76)	=	26%
Residual N_2% (53% total N_2 - 26% N_2 from free air)	=	27%.

After going through the above calculations, should you find the numbers do not make sense (for example, getting a negative value for a percentage of gas), two things may have occurred. Either (1) the readings taken are faulty, or (2) some other gas generation process is occurring near the gas collection trench. After verifying your results, if the collection rate from a specific gas collection trench is critical to maintaining a flame in the flare or to preventing lateral or vertical migration of landfill gas, send a sample of the gas to a lab for a chromatograph reading for major constituents, including hydrogen. Discuss with the laboratory proper sampling and storage requirements as landfill gas is sensitive to sunlight, gases can react with each other and gas can escape through porous containers. Hydrogen affects the constituent percentages because it adds five times the hydrogen percentage to the CH_4% reading on a combustible gas meter.

To maintain the greatest "vacuum curtain" around the portion of the landfill influenced by the extraction system, and reduce odors most efficiently, it may be necessary to draw a higher flow from certain extraction points than the above minimum percentage of CH_4 would allow. By studying the amount of residual N_2 in the gas stream sampled, it is possible to ascertain the percentage of the influenced area around the extraction point which is under aerobic decomposition and the percentage which is under anaerobic decomposition. 30% maximum residual N_2 is an acceptable indicator of the percent of aerobic decomposition allowable in the vicinity of the extraction point. The formula for adjusting a well based on maximum allowable residual N_2 is as follows:

$$V_2 = V_1 \, x \left[1 - \frac{4.76 \; x \; (Nr - Nrt)}{376} \right]$$

Where:

V_1	=	Measured Velocity
V_2	=	Target Velocity
Nr	=	Residual Nitrogen (%)
Nrt	=	Target Residual Nitrogen (%)

Using again, the same sample from above:

Trench Number	=	X
CH_4%	=	21
O_2%	=	7
CO_2%	=	18
Temperature (°F)	=	48
Pressure (WC)	=	-5.0
Gas Stream Velocity (fpm)	=	300
Barometric Pressure (WC)	=	29.5 Hg x 13.57 WC/Hg = 400 WC

Calculated Quantities:

H_2O% (from formula)	=	1%
Anaerobic CO_2 (21% CH_4 / 1.45)	=	14%
Aerobic CO_2 (18% total CO_2 - 14% anaerobic CO_2)	=	4%
Total N_2% (100% - CH_4% - O_2% - total CO_2% - H_2O%)	=	53%
N_2% from free air (7% O_2 x 3.76)	=	26%
Residual N_2% (53% total N_2 - 26% N_2 from free air)	=	27%.

By inserting the appropriate figures into the formula, the amount of adjustment necessary for the gas in this example to reach the maximum amount of residual N_2 acceptable is as follows:

$$V_2 = 300 \; x \left[1 - \frac{4.76 \; x \; (27\% - 30\%)}{376} \right]$$

$$V_2 = 311 \text{ feet/minute}$$

It is important to note that while using this formula to adjust a well based on target N_2 will, in most cases, greatly reduce the possibility of starting a landfill fire, temperature and O_2% should be closely watched. However, the temperature in an extraction point in native soil will be a slow indicator of increasing temperatures in the influenced area of the landfill. Therefore, extraction points in native soil which have a residual N_2 percentage close to the target should also be tested for CO. If CO amounts greater than 25 ppm are detected, the extraction point's flow should be reduced and the CO levels checked daily until the level of CO drops below 10 ppm. The percentage O_2 should be checked only to guard against allowing a great amount of O_2 into the system, thereby increasing the possibility of creating an explosive mixture in the gas manifold.

By using the above parameters for adjusting extraction points, we can now determine with a reasonable amount of certainty how high a flow to draw from each extraction point.

It is necessary to keep in mind that the different parameters discussed above are only generalizations which should work in most cases. All extraction points well react differently based on the surrounding geology, amount of cover, etc. Therefore, it is important that the operator in the field "get to know the wells". A knowledge of a well's history is the most important factor in determining what, if any, adjustments should be made.

14.9 OPERATION ADJUSTMENTS

Individual gas extraction well adjustments are made following the analysis of the monitoring data. The changes that are indicated by the data analysis are not the only factor in determining operational changes. General guidelines for the safe operation of in-refuse extraction wells, and the native soils well have been developed to limit the amount of aerobic decomposition near the extraction point and reduce the potential for creating a explosive mixture of methane and oxygen in the vacuum manifold. These guidelines are as follows:

14.9.1 In-Refuse Wells

- 30% methane (CH_4) minimum
- 30% residual nitrogen (N_2) maximum
- 2% oxygen (O_2) maximum
- 105°F maximum

Generally in-refuse extraction wells should be throttled down if these parameters are exceeded. Wells with flows less than 3 cfm (velocity less than 150 feet per minute in a 2" wellhead) are not throttled down any further unless increasing temperature is observed with a residual nitrogen level over 30%.

14.9.2 Native Soil Wells

- 30% residual nitrogen (N_2) maximum
- Well temperature maximum = 10°F above ambient air temperature
- individual well temperature maximum = 10°F above adjacent native soil wells

Generally native soil extraction wells should be throttled down if these parameters are exceeded. Wells with flows less than 3 cfm (velocity less than 150 fpm in a 2 inch wellhead) are not throttled down any further unless increasing temperature is observed with a residual nitrogen level over 30%. Specific native soil wells can also be throttled down to reduce the amount of aerobic decomposition (or high temperatures) observed in a nearby in-refuse extraction well. Native soil wells with high concentrations of oxygen (greater than 7%) and high flows (flows over 20 cfm or 1000 fpm velocity in a 2 inch wellhead) may be throttled down to decrease the oxygen concentration and/or increase the methane concentration in the extraction manifold if there is not a specific nearby off-site methane concentration buildup.

14.10 ROUTINE MAINTENANCE

A conscientious preventative maintenance program combined with prompt corrective maintenance will reduce system downtime and improve operations efficiency. Frequent system inspections are the main form of preventative maintenance for the gas extraction system. Inspection frequency and specific inspection points are listed in Table 14-2.

When performing maintenance on landfill gas system equipment, be sure to follow the tag out procedures in Section 3.3 of the *Midway Landfill Site Safety Plan* so that inadvertent operation of the equipment under repair will not occur. This will help prevent personal injury and/or equipment damage.

Table 14-2
Maintenance/Inspection Schedule
Landfill Gas System

System Component	Maintenance/Inspection Required and Results Expected	Frequency
Extraction Wells	Monitoring port repair. If the monitoring port is leaking badly you can hear a loud sucking noise. These ports generally leak slightly and no repair is needed for this type of leak. To repair a port the threads can be chased with a 1/2" NPT tap and/or the plug can be replaced. During this type of repair the well should be under a vacuum to stop any exposure to landfill gas. If a monitoring port becomes too oversized to repair it can be glued in place and a new port can be redrilled and tapped.	As Required
	Valve replacement. If the well control valve is cracked or will not adjust it should be replaced with an identical 2" valve. These valves are inexpensive and fairly easy to replace. Before replacing a valve the original well velocity should be measured. To replace a valve the wellhead should be removed and the well capped with a greased fitting. During this process personnel should be protected from landfill gas exposure with a fan or protective respirators. The valve is threaded in place so it can be removed by unscrewing the wellhead assembly from the valve. When the valve is removed the line to the manifold will be under vacuum and air will enter the extraction system. The amount of air entering the system can be reduced if all needed parts are on hand and only one repair is performed at a time. When the valve has been replaced the wellhead should be reinstalled, again using fans or respirators to protect personnel. Once replaced, the valve should be adjusted so the velocity measured at the wellhead is back to normal. This adjustment should be rechecked after 1 hour.	As Required
	Extraction well connections, wellheads, and flex connectors are to be routinely inspected to assure proper operation.	Weekly

Table 14-2 (cont)
Maintenance/Inspection Schedule
Landfill Gas System

System Component	Maintenance/Inspection Required and Results Expected	Frequency
Extraction Wells (cont)	Pipe joint repair. Leaking wellhead fittings can sometimes be repaired by applying solvent and glue to the leak, the system vacuum will draw the glue into the leak and seal it. If the leaks are too large to be repaired or a fitting is cracked the wellhead can be removed from the well and the problem can be cut out and replaced. The procedures for wellhead removal will be identical to those used when replacing a valve.	As Required
	Surface repair. The ground surface around extraction wells should be kept slightly mounded. This mounding tends to keep surface water from running down the well. Sometimes due to settlement, the ground surrounding an extraction well sinks.	As Required
Vacuum Manifold	Leak repair. When a manifold leak is found a determination must be made as to whether the repair can be completed with the area under a vacuum. Typically, most HDPE repairs will be performed with the system off-line (or at least the repair section valved off). If the manifold leg must be valved off and isolated, repairs can not be made until the section of pipe is totally isolated from any extraction wells or personnel are properly equipped with fans and/or protective respirators as called for under the site safety plan. After the proper precautions have been taken the repair can be completed. It is important to have a good supply of replacement parts for the manifold on hand to reduce system downtime. When repairs to the system have been completed and the system appears to be operating normally all manifold readings should be repeated to ensure that multiple leaks are detected.	As Required
	Pipe slope adjustment. Pipe slope adjustments can normally be made with the extraction system on-line. Pipe slopes frequently need to be increased so that condensate will drain to the vacuum valve stations. These slopes are increased by adjusting pipe supports, adding additional supports, or cribbing underneath the manifold. A hand level, marked in percent slope is used to check pipe slopes. If condensate is draining with the direction of the gas flow a pipe slope of 1-2% is required. For condensate to drain against the gas flow, slopes of 3-4% toward the condensate traps are needed.	As Required
	All manifold expansion loops shall be inspected routinely to assure proper position and to check for any obstructions.	Weekly
	All manifold valves shall be exercised regularly to ensure proper operation.	Monthly

Table 14-2 (cont)
Maintenance/Inspection Schedule
Landfill Gas System

System Component	Maintenance/Inspection Required and Results Expected	Frequency
Condensate System	Vacuum Pump Maintenance. Refer to the vacuum pump maintenance manual provided with the equipment for specific maintenance requirements. Typically, maintenance to the vacuum pump will include oiling, belt adjustment, and component replacement.	As Required
	Condensate Discharge Pump. Refer to the condensate discharge pump maintenance manual provided with the equipment for specific maintenance requirements. Typically, maintenance to the vacuum pump will include oiling, belt adjustment, and component replacement. A spare condensate discharge pump has been included in the system to allow for continued system operation during repair/maintenance to one of the condensate discharge pumps.	As Required
	Vacuum Valve Station. Typical maintenance to the vacuum valve station will include cleaning and/or replacement of the inverted air release valve. Isolation valves and piping unions are provided in each vacuum valve station to facilitate the removal of air release valves for repair/replacement. The vacuum valve station should be isolated from both the gas and condensate collection systems prior to removal of the air release valve. Repair/replacement of the air release valve should be accomplished within 2-3 hours of removal from the system to allow for continuous system operation. All connections between the vacuum manifold and the vacuum valve stations shall be inspected regularly for leak tightness and un-even settlement.	As Required
	Condensate Drain Piping. The condensate drainage piping may collect sediment which can eventually clog the drain system. System cleanouts are provided every 200 feet along each condensate drain pipe (see Figure 14-1). Cleaning of this system should only be required on an as-needed basis. To clean the condensate drain piping you need to first turn off the vacuum pumps. Release the vacuum on the system by opening the vent plug on the condensate cleanout flange. Open the condensate collection tank and install a submersible pump. Run the pump discharge to the condensate manhole. The pump will be used to keep the collection tank from overflowing while the water jet is on. Remove the cleanout flange and insert a water jet hose into the pipe. Run the hose down the pipe far enough to clear the blockage. Once the pipe is clear, remove the water jet and reinstall the cleanout flange. Pump any water and debris out of the collection tank before closing it. Turn on the vacuum pumps to restore vacuum to the system.	As Required

Table 14-2 (cont)
Maintenance/Inspection Schedule
Landfill Gas System

System Component	Maintenance/Inspection Required and Results Expected	Frequency
	Condensate Isolation Valves. Exercise all valves associated with the condensate system.	Yearly
	Condensate Scrubbers. Check the pressure at the vacuum ports on both sides of each scrubber. A high differential pressure (>2 inches WC) indicates the MistMaster™ pad in the chimney basket is becoming plugged. Clean or replace the pad.	Quarterly

14.11 TROUBLESHOOTING

The early detection of system problems will reduce system downtime and keep corrective maintenance jobs simple. It is important that personnel visually inspect the entire manifold at least once a week and check manifold conditions at the blower and each manifold leg daily. These inspections are listed in Section 14.10. The blower feed and manifold leg measurements that should be made include methane and oxygen percentages, pressure readings, and gas stream velocities. Table 14-3 is a troubleshooting guide for use in the gas collection system.

Table 14-3
Troubleshooting Guide for the Gas Collection System

Indicators/ Observations	Probable Cause	Solutions
Excessive Oxygen in Manifold	Vacuum system leak	Readings that indicate a large leak include reduced methane concentration, elevated oxygen readings, reduced vacuum, and increased velocity readings in the blower feed line or a single manifold leg. If these conditions are seen in the blower feed line, all exposed pipe between the blower feed measuring port and the manifold leg separations should be visually inspected and conditions in each manifold leg should be checked immediately. Once the manifold leg with the leak is identified, that leg should be isolated and repaired.
Reduced velocity/ increased vacuum in manifold	Flow Restriction	Reduced velocity readings and possible increases in vacuum and methane concentration readings at the blower feed or in specific manifold legs indicate a flow restriction in the system. Typical causes of flow restrictions are partially closed leg valves, water buildup in the manifold, or ice formation in the manifold. To locate a flow restriction the problem leg must first be identified. If all the valves controlling the restricted section of manifold are in normal (open) operating positions inspect the manifold leg. Check all low spots in the manifold for condensate build up by jarring the pipe or lifting it with a steel bar. Sections of pipe blocked by condensate will be heavier than other sections of pipe and water can sometimes be heard sloshing in the pipeline. If a condensate buildup is located, the nearest downslope vacuum valve station should be inspected. If the valve station is operating normally, increase the pipe slope between the blockage and the nearest down slope vacuum valve station. It may also be necessary to increase the vacuum in the condensate drain system if vacuum in the drain system is less than the vacuum in the gas manifold at that point. Pipe slope adjustment and/or vacuum adjustments should remove condensate caused flow restrictions.

Table 14-3 (cont)
Troubleshooting Guide for the Gas Collection System

Indicators/ Observations	Probable Cause	Solutions
Rhythmic fluctuations in velocity or vacuum in manifold	Manifold Surge	A surge in the blower feed line or a manifold leg will cause rhythmic fluctuations in vacuum and velocity measurements. A surge can affect blower speed and put additional strain on that equipment. Surges are usually caused by a buildup of condensate in the manifold. The location of a surge can be found by identifying the problem leg and inspecting that line on foot. A condensate surge sounds like a wave breaking in the manifold. The solution to a surging area involves re-sloping the affected length of pipe to increase pipe slope to the nearest vacuum valve station.

14.12 RECORDS AND RECORDKEEPING

It is important that current gas extraction system data be available to field operators. Copies of all field notes, extraction well data, and daily monitoring records should be maintained in the landfill field office. Extraction well data should be stored on weekly spreadsheets and filed by date. Daily monitoring records should be kept in notebooks that remain on-site.

OPERATOR NOTES AND COMMENTS

15. MOTOR BLOWER/FLARE FACILITY

15.1 DESCRIPTION

The motor blower/flare facility is located in the northwest corner of the landfill site. The system generally consists of:

- Blowers
- Flares
- Electrical service and control system
- Flame safeguard system
- Alarm system

The function of the motor blower/flare facility is to withdraw landfill gas from the manifold and efficiently burn the gas. The flares provided for this project incorporate design features to meet the Best Available Control Technology (BACT) at the time of this installation.

There are numerous operational features incorporated into the system to insure safe and efficient operation. The operations personnel should familiarize themselves with the features of the system to achieve safe and reliable operation. These features include:

- Automatic relight of flare on loss of flame - one try
- Loss of flame alarm if the flare does not relight
- System shutdown and alarm for high flare temperature
- Flare pilot verification prior to main burner start-up
- High flare temperature alarm
- Low flare temperature alarm
- Explosion relief valves for system protection in the event of backflash
- Flame arrestors to inhibit flame migration in the event of backflash

All major components, with the exception of the flares, are located under the cover structure on the blower pad. The electrical service and controls are located in the control room. The control room has space for the operator to perform the recordkeeping duties associated with the operation and maintenance.

An outline diagram of the system components is shown in Figure 15-1. The valve and piping system at the motor blower facility is shown in Figure 15-2. This figure shows an example of the landfill gas flow path through the blower facility.

15.1.1 Blower

15.1.1.1 Introduction

The blowers create a vacuum on the gas collection header to allow the withdrawal of gas from the landfill. Following gas withdrawal, the blowers then feed the landfill gas to the flares for combustion.

The size of the blowers is intended to provide a wide range of flows and pressures. The blowers are rated at 1500 SCFM at 62-inch water column at high speed. The blowers are equipped with spare belts and sheaves to allow for flow adjustment of each blower. This will be necessary as the landfill gas production decreases.

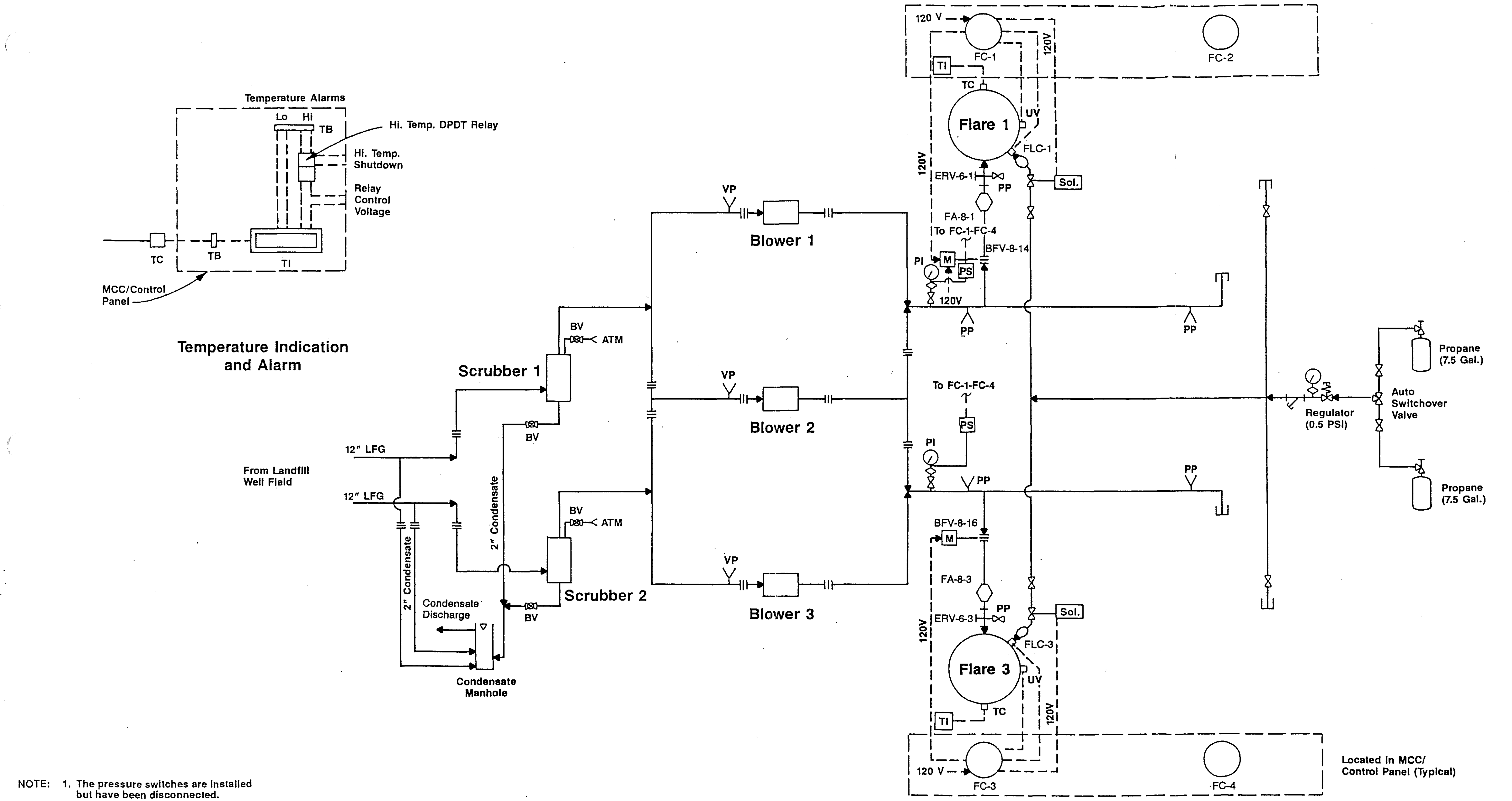
Peak conditions require that two blowers and four flares operate together. The third blower is a standby unit to provide standby service in the event of service or repair to a unit.

The blower is specially designed for landfill gas service. It is constructed to eliminate the potential of sparking that could cause explosion or backflash.

15.1.1.2 Effect From and On Related Items

Proper operation of the blower(s) is essential. Operation of the blower affects the following items:

- The ability to withdraw gas effectively to prevent gas migration. Too low a vacuum level in the well will not provide proper gas draw to the well.
- The vacuum level in the gas manifold. Manifold vacuum must be high enough to provide adequate adjustability at each well.
- The discharge pressure for flare gas combustion must be adequate to overcome pipeline system losses between the blower and the flare.
- The emission level of the flue gas.
- Energy efficiency of operation.



NOTE: 1. The pressure switches are installed but have been disconnected.

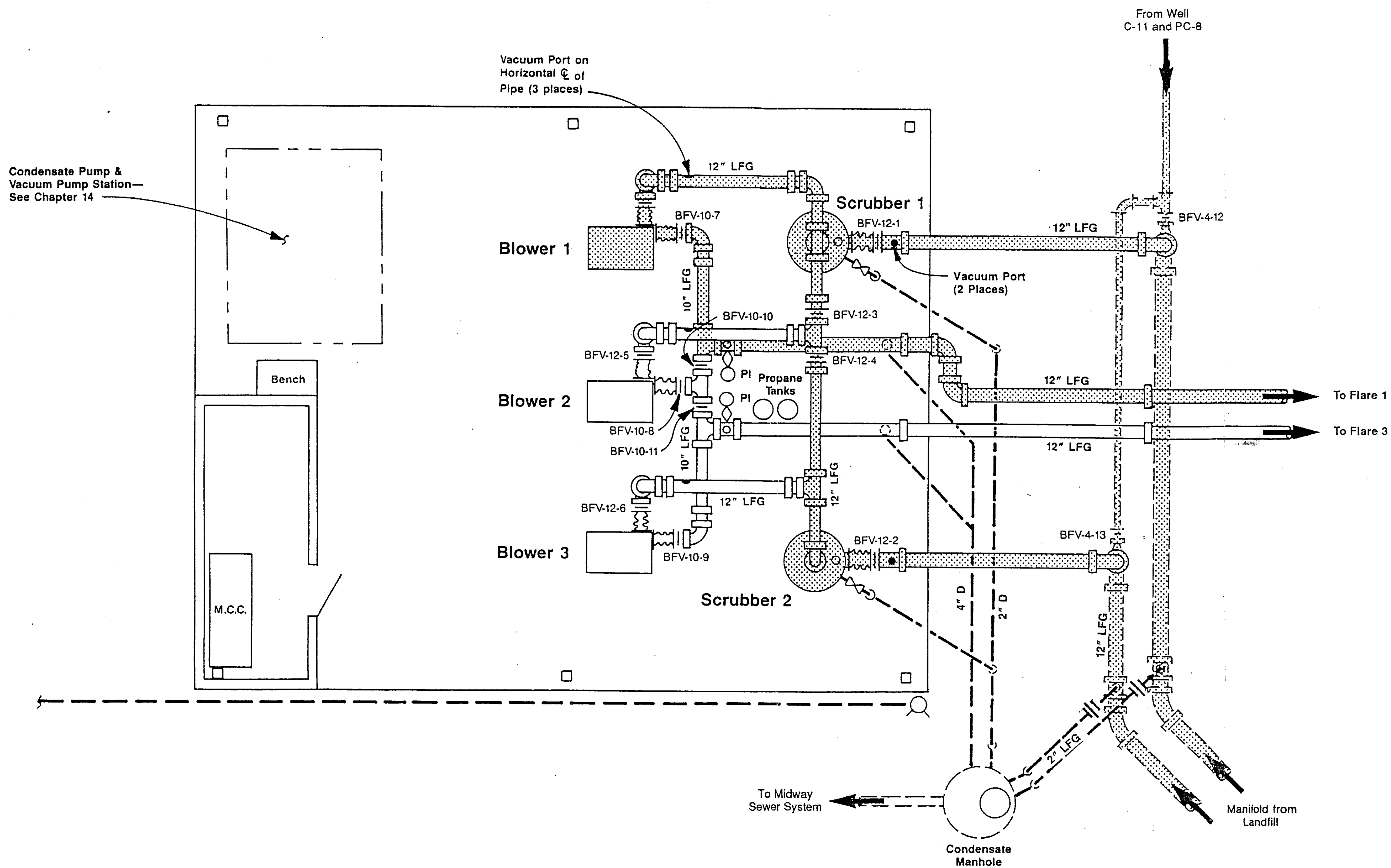
2. Flares 2 and 4 have been removed, but the piping has been left in place.

PP	Pressure Port	PS	Pressure Switch
FA	Flame Arrestor	VP	Vacuum Port
FC	Flare Controls	DT	Automatic Drain Trap
ERV	Explosion Relief Valve	I	Igniter
FLC	Flame Check	TC	Temperature Thermocouple
BV	Ball Valve	TB	Terminal Block
UV	Ultra Violet Light Sensor	TI	Temperature Indicator
		PI	Pressure Indicator

Process
Electrical
Butterfly Valve
Gate Valve
Ball Valve

Valve Motor Operator (Fail/Closed)
Wye Strainer
Pressure/Vacuum Gauge with Diaphragm Isolator

Figure 15-1.
Process and
Instrumentation Diagram



Flow Path - Open Valves In Flow Path;
Close All Other Valves

Figure 15-2.
Single Blower Operation
Blower #1

15.1.2 Flare

15.1.2.1 Introduction

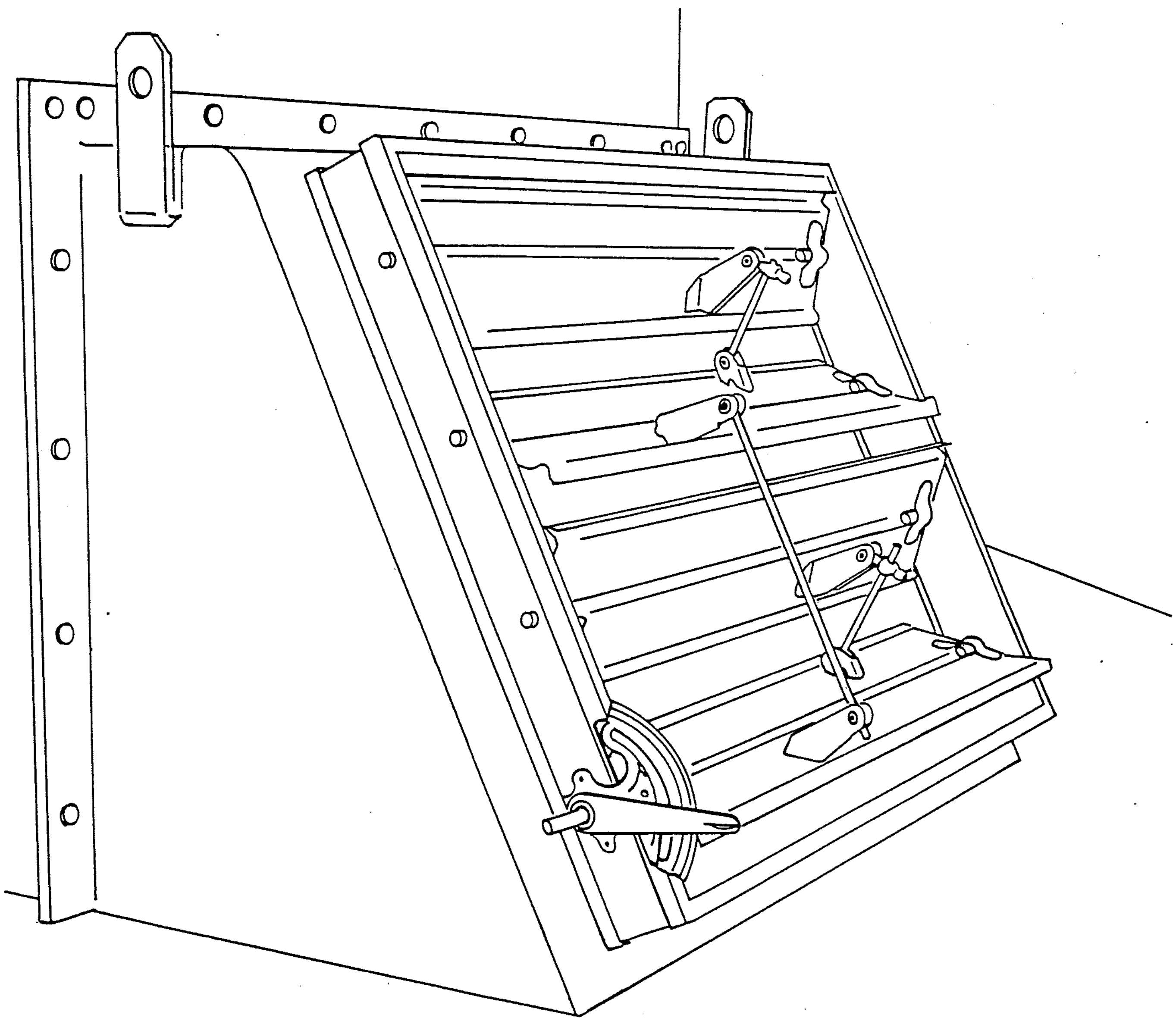
The performance criteria for the flares are governed by Puget Sound Air Pollution Control Authority (PSAPCA). The design criteria states that the flue gas discharge needs to meet the BACT for each flare. South Coast Air Quality Management District (SCAQMD) standards have been a focal point for the regulations and requirements for this area.

The flares are designed to perform in accordance with the information noted in Table 15-1. Each flare is rated for a maximum flow of 750 Standard Cubic Feet per Minute (SCFM), assuming 55 percent methane by volume. However, it is possible to operate at a higher flow rate as long as the maximum BTU loading is not exceeded.

The burner design allows for the maximum mixing of air and gas to create the most uniform blend of gas for combustion. Air into the burner chamber is manually regulated by the operator through louvers (Figure 15-3). The objective of air regulation is to maintain a set temperature of the combusted flue gas. The louvers are constructed to allow retrofit of automatic positioners at a future date, should they be required.

Inside each flare is a thermocouple which is used to measure temperature. Flare temperature is displayed on the blower control panel.

Six sample ports have been installed in each flare to allow sampling of the combusted gas. There are four primary ports and two secondary ports.



NOT TO SCALE

Figure 15-3.
Flare Damper

Table 15-1
Flare Design Parameters

	Low BTU	High BTU
O2	13%	1%
CH4	20%	55%
CO2	20%	41%
N2	47%	3%
BTU Loading-million BTU/hour	1.5	24.75
Landfill gas flow rate-SCFM	200	750
Landfill Gas temperature-deg F	40	110
Ambient Air temperature-deg F	10	90
Altitude	400 feet above MSL	
Combustion retention time (min) at 1500 degrees F.	0.5 seconds	
Estimated Actual Retention Time	1.3 seconds	
Required turndown ratio	4:1	
Periodic slug of entrained H2O	0.5 gallons	
Housing freeboard above Main sampling ports	7 feet	
Miscellaneous hydrocarbons	0.5%	
H2S	100 ppm	

The safe and efficient operation of the flares is dependent on satisfactory operation of other related items in the system. Other items in the flare system are:

- The flame arrestor is a safety device to protect the system from backflash combustion into the system.
- A motor operated butterfly valve isolates the gas from the flare. It operates from the flame safeguard unit and system controls.
- The thermocouple provides measurement of the temperature in the flare stack. The temperature indication is displayed at the control panel.
- The controls provide the logic for the operation of the system and the monitoring of the flares. The controls allow the operator flexibility in the combination of motor blower/flare facility components.

15.1.2.2 Effect From and On Related Items

The flare is the focal point of the final by-product of landfill gas withdrawal: emissions. It is therefore essential that the operation of the flare(s) is within the allowable performance limits. The operation of the flares has impacts on, and is impacted by, the following:

- Ability of the flue gas to meet the permit emission limitations set forth by PSAPCA
- The blowers ability to pump the gas through the burner
- The thermocouple to accurately display the temperature
- The main landfill gas fuel valve operation
- The pilot and pilot gas valve operation
- The flame arrestor

15.1.3 Electrical Service and Control System

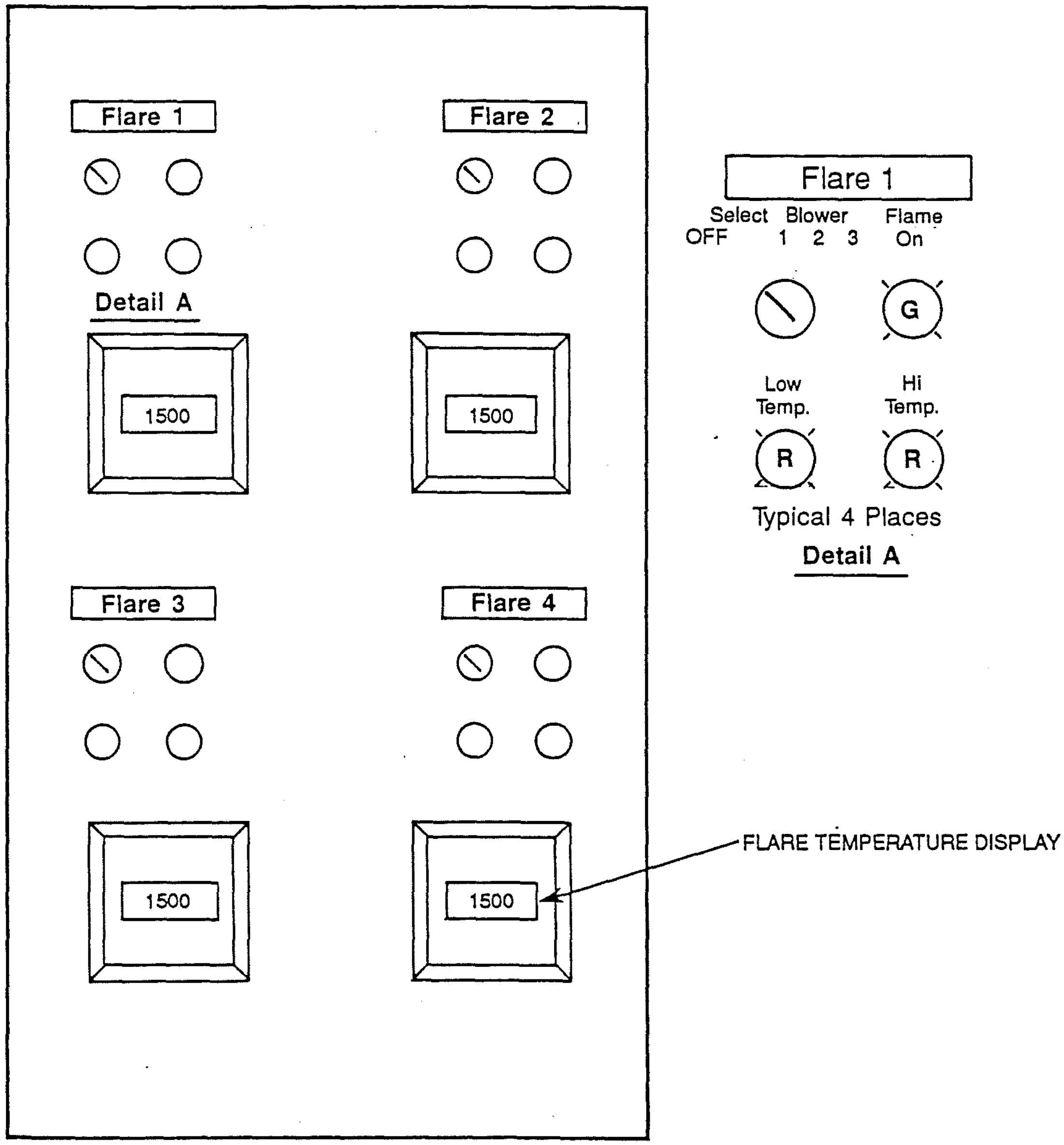
15.1.3.1 Introduction

The motor control center and flare controls are located in the control room. The main switch gear, motor starters, motor circuit protection devices, and flare control panels are located here to provide a suitable environment for the equipment and the operator.

Some of the facility is classified by the National Electrical Code as class I, division 2, group D; otherwise known as explosion proof. This area is shown on the construction plans and consists of an area 10 feet around the blowers, flares, piping, and 18 inches above the top of the blowers. The control room is outside this area and is classified NEMA 1 which doesn't require explosion proof rated equipment.

The control system for the motor blower/flare facility is comprised of duplicate controls for each flare control system. The controls on the control panel are:

- Blower selector switches
- Flare control system green operation light
- High and low temperature red warning lights
- Flare temperature indicator



NOTE: Flares 2 and 4 have been removed, but their controls and indicators are still installed.

Figure 15-4.
Blower Control Panel

The control panel also has space for future expansion of controls. There is space available for the addition of a controller to automatically control air to the flare burner. This addition will occur if PSAPCA requires this added control due to regulatory changes, or if testing of the flue gas demonstrates the need for added control.

15.1.3.2 Effect From and On Related Items

The electrical service and control system has an immediate effect of the operation of all electrically powered and controlled items. Loss of electrical service, or improper operation of control systems can impact the correct operation of the entire gas migration control system. The items related to the electrical service and controls are:

- The main power service to all electrically powered equipment
- The control circuits for the equipment powered by three phase power
- Single phase power
- Temperature indication for the flares
- Alarm system will operate during a main power outage but will only report loss of power; not other alarm functions
- Safety shutdown features for the flare feed system
- Flare pilot ignition and operation
- Landfill gas fuel valve operation

15.1.4 Flame Safeguard System

Each flare is controlled by a flame safeguard control unit. This item is very critical to insure proper system operation and for the safety of personnel. The control unit is installed in the motor control center section and interfaces with the flare control panel. There is one flame safeguard unit for each flare. The major purpose of the flame safeguard control unit is to control the equipment that are associated with the flare. The equipment that it controls are:

- Blower to operate with the flare
- Solenoid valve that provides pilot gas
- Spark ignition transformer for the pilot
- Ultraviolet flame sensor for the flare burner

- Main landfill gas fuel valve operation

- Alarm for loss of flame

An electrical outline diagram of the flame safeguard system is shown in Figure 15-5.

15.1.4.1 Effect From and On Related Items

The flame safeguard control system is a critical item to insure that start-up and shut-down procedures, and safe operation are achieved. The flame safeguard unit affects the operation of the following items:

- Operation of the flare pilot

- Starting of the flare and one relight trial following loss of flame

- Operation of the blowers

- Operation of the main landfill gas fuel valve

- Reporting of the loss of flame alarm

15.1.5 Alarm System

The alarm system is a radio transmission type with alarm reporting to the Charles Street station. The equipment at the landfill consists of a radio, encoder, and carrier operated relay. The Charles Street station equipment consists of a new annunciator panel, mounted into the existing alarm console, and a receiver.

The alarm system reports one alarm for any of the following events:

- Blower overload for each blower

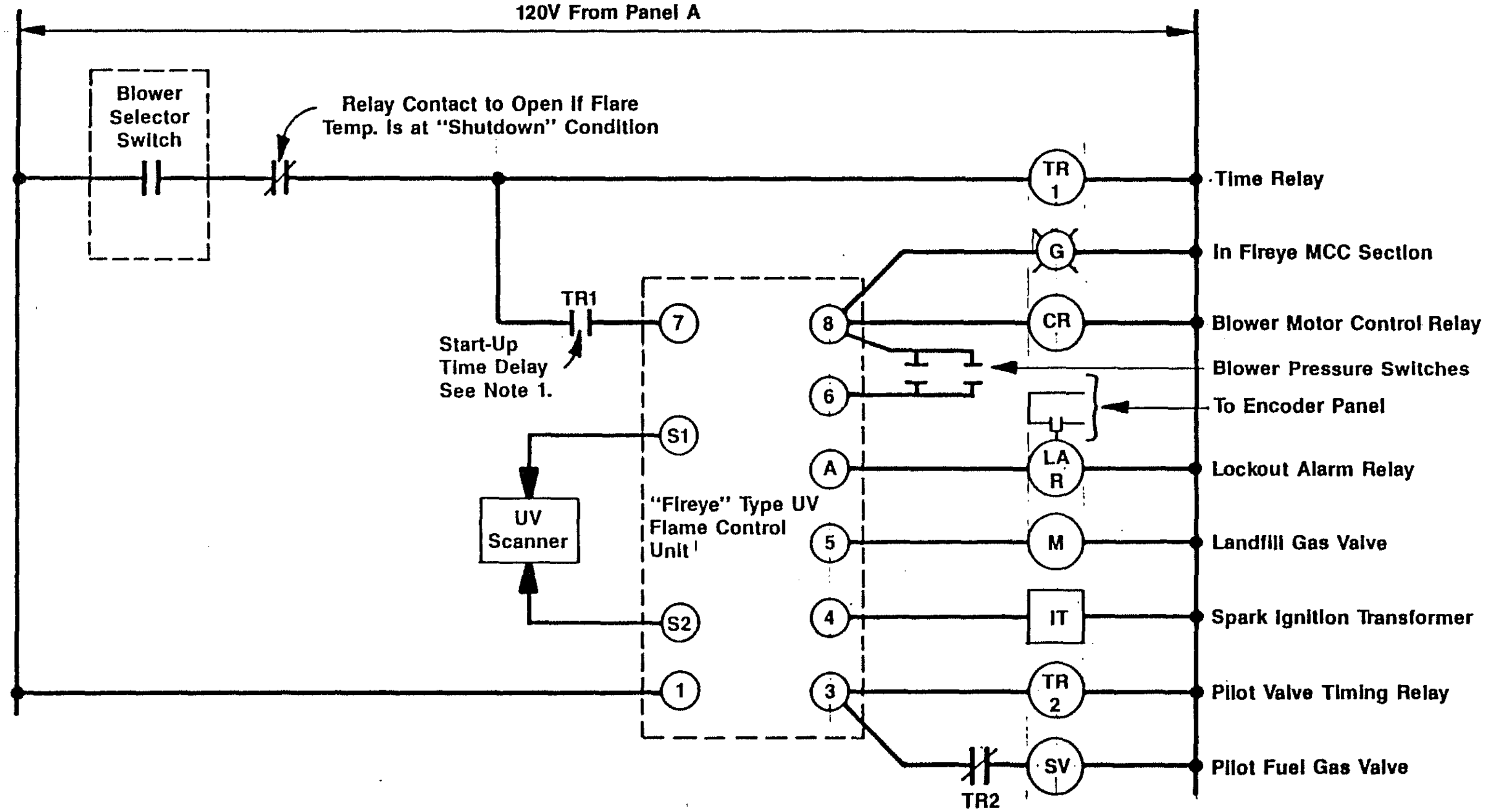
- High temperature for each flare

- Low temperature for each flare

- Flame failure for each flare

- Loss of power

An electrical outline diagram of the alarm system is shown in Figure 15-6.

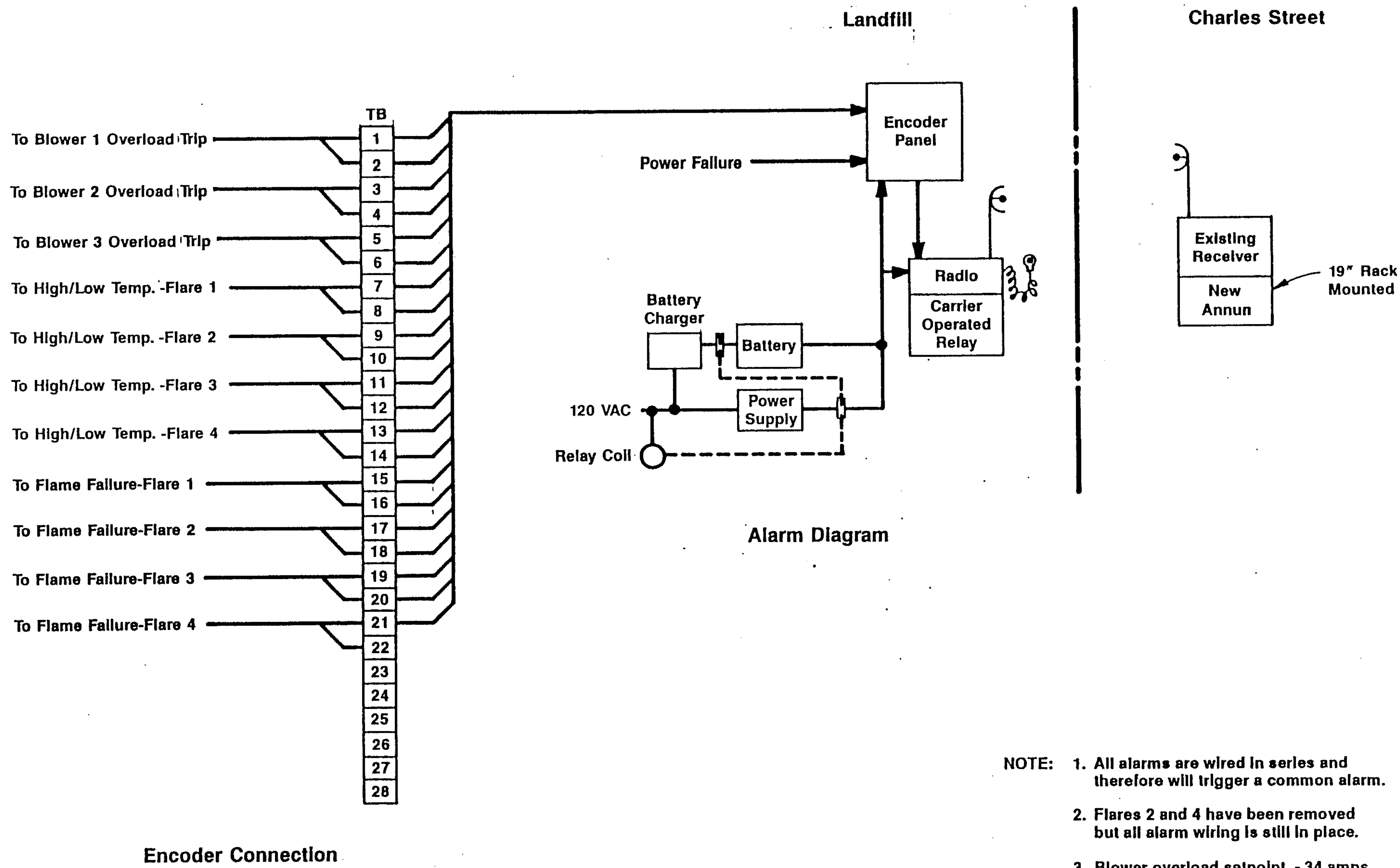


Flare, Flame Safeguard Unit

Note:

1. Start up time delay will stagger starting of blowers to reduce power surge to Puget Power
2. The blower pressure switches are currently disabled

Figure 15-5.
Flame Safeguard
Diagram



NOTE:
1. All alarms are wired in series and therefore will trigger a common alarm.
2. Flares 2 and 4 have been removed but all alarm wiring is still in place.
3. Blower overload setpoint - 34 amps
   High temperature setpoint - 1800°F
   Low temperature setpoint - 1100°F

Figure 15-6.
Alarm Connection Diagram

15.1.5.1 Effect From and On Related Items

Failure of the alarm system to accurately and reliably report alarm conditions can have adverse impacts on the facility, as noted below:

- Loss of blower operation due to blower overload will stop gas withdrawal from the well field.
- Low temperature and high temperature in the flare will shutdown and lock out the system. Alarm failure will cause this to go undetected.
- Low temperature conditions at the flare leave the potential that flared gas will not achieve destruction of emissions to meet PSAPCA requirements.
- Flame failure can cause system shutdown.
- Loss of power will shut down all system operation.

It is therefore critical that the alarm system operation be maintained for reliable operation.

15.2 BLOWER FACILITY START-UP

This section lists the specific steps required to start-up the blower facility.

15.2.1 Preliminary Checks

The following steps should be completed prior to system start-up:

- Inspect all anchors and supports for piping and equipment.
- Verify all circuit breakers at the electrical control station are shut.
- Check the radio transmitter and receiver with the Charles Street station to verify proper radio communication.
- Check the status of the alarm system encoder panel.

15.2.2 System Start-up

- Open the louvers on the operating flare about 50% to provide combustion air to the flare.
- Open the propane bottle valves to provide pilot gas for the flare.
- Close the blower inlet valve and open the discharge valve.
- Perform a valve line up for the blower/flare combination you want to bring on line.

- Install a vacuum gauge in the vacuum port on the suction line to the blower.
- Close the condensate scrubber vent valves and open the drain valves.
- Place the blower control switch for the desired blower to the SELECT position.
- Select the desired motor blower/flare combination on the control panel.
- Open the blower inlet valve to about 5% open (about one notch) as the main fuel valve opens. Observe the pressure at the suction and discharge pressure gauges. The suction gauge should read greater than 40 inches WC with the discharge gauge at 5 inches WC.
- Measure the gas flow using the designated device. Approximate blower output can be estimated using Figure 15-7. For example, the blowers currently run at 4000 RPM. Assume that the total pressure is 62-inches WC (total pressure is the sum of the suction and discharge pressures). Looking at Figure 15-7, we start at 62-inches WC and move to the right until we intersect the 4000 RPM curve. Then look down to read the flow rate. In this example the flow rate is 1500 SCFM.
- Maintain a flare temperature of 1500°F to 1700°F by manually operating the louvers (Figure 15-3). Closing the louvers will cause the temperature to increase and opening them will cause the temperature to decrease. Do not completely close the louvers as this will cause them to overheat. As a guide, leave a ¼-inch minimum gap in a louver opening for cooling.

15.3 EMERGENCY OPERATION

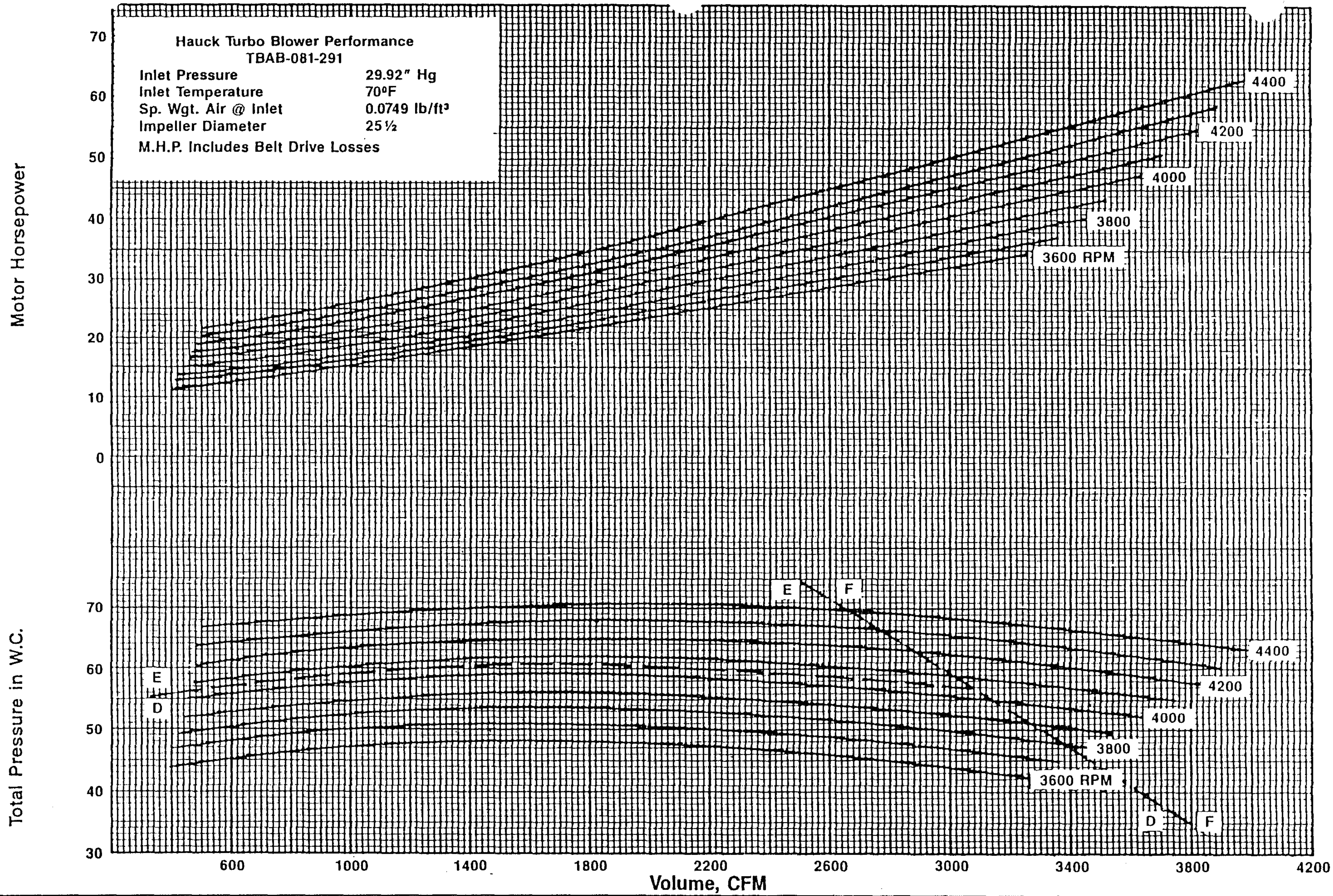
Normal operating conditions for the gas migration control system provide a system that is normally stable and is rarely affected easily to create emergency conditions in the gas system. Emergency conditions are the result of equipment failure, operation deficiencies, or they may result from outside conditions. Landfill well field systems are discussed in Chapter 14.

When outside conditions occur, such as a power outage, there can be an impact on gas migration. The duration of a power outage has the most significant impact on the start of gas migration.

15.3.1 Power Outage

Power outage events are usually relatively short and should have no major effect on the operation of the landfill gas migration system. Following the loss of power and the shutdown of the blowers, there is still a slight vacuum present on the landfill. Should a power outage last for more than 24 hours, the level of vacuum may deplete enough to allow the start of gas migration. Such migration is only determined by monitoring the gas migration wells.

Following the return of normal power, the motor blower/flare facility must be manually restarted per Section 15.2.



Steps for Use:
1) Determine Total System Pressure (Inlet Pressure and Outlet Pressure).
2) Project Operating Pressure to Intersect Curve for Blower Operating Speed.
3) Project Down and Read the Flow.

Figure 15-7. Blower Curve

Should an extended power outage occur and gas migration be of major concern, an emergency generator can be connected to provide power service to the motor blower/flare facility. This is performed by making the connection to the system downstream of the main service breaker with the breaker in the OFF position. The generator should always have a breaker. This work should only be performed by qualified electricians.

15.3.2 Refuse Fire

The outbreak of a refuse fire requires a change in the operational adjustments of the wells in the area of the fire. Refer to Section 7.4.4 for more detailed information regarding refuse fires. As fires are generally localized, there is usually no adjustment necessary to the motor blower/flare facility.

15.3.3 Backflash

Backflash is the combustion of landfill gas within the gas control system piping (or equipment). Combustion can only occur if the gas mixture within the pipe is within the explosive range (between 5 percent and 15 percent by volume methane in air) and is ignited. Therefore, it is important to maintain the gas/air mixture in the pipeline well above the upper explosive limit for methane.

The conditions for backflash can only occur in the event of multiple failures, such as a pipeline break in conjunction with blower failure or gross neglect in normal gas system monitoring and adjustments. The flare is the most likely ignition source, and most backflash events will originate there. The flame arrestor will prevent most backflashes from entering the piping, but there is no device that can stop backflashes with 100 percent certainty.

Following an occurrence of backflash, check the following items:

- Shut off operating equipment.
- Check for damage to the affected piping and equipment. Look at the pipe joints, pipe supports and equipment.
- Check the pressure differential across the flame arrestor. If the differential exceeds 4-inches WC, clean or replace the element.

15.3.4 Manifold Break

Over the life of the landfill, the ground surface will settle and the pipeline may break. This will be evident by changes in the system operation. Some items to look for are:

- Low vacuum level in the manifold

- High oxygen level in gas samples taken at the manifold or at the motor blower/ flare facility

- Whistling or hissing in the area of the pipeline

- Inability to adjust the landfill well flow

Manifold breaks can occur under one of two operating conditions. A break on the vacuum portion of the pipeline requires less concern of gas saturation in the area of the break. Where a break occurs in the pressure portion of the manifold (between the blowers and flares), extra caution is necessary for personal safety and to reduce the potential for fire or explosion.

Always use care and wear SCBA per the *Midway Landfill Site Safety Plan* when working on manifold breaks. Where explosive gas mixtures are present, provide ventilation or allow gas to dissipate prior to performing any work on the pipeline.

The following procedures and considerations should take place when dealing with a manifold break.

- Isolate the area of the leak and close the nearest isolation valves. Be sure to isolate the area from adjacent wells, also.

- Have the materials for repair at the landfill prior to cutting out the broken section of pipe. Where polyethylene pipe requires repair, a coupling that provides restraint of the pipe is required. Standard compression flexible couplings are not acceptable.

- Cut the affected area of piping from the system and make the necessary repairs.

- Open the manifold isolation valves and place the section back into service.

- Monitor the repaired area to insure adequate repair.

- Inspect manifold pipe supports and adjust pipe grade where required to prevent other manifold breaks.

15.4 ROUTINE MAINTENANCE

The landfill gas migration system not only represents a major investment in construction, but also significant importance to contain, extract, and flare the gas generated in the landfill. Routine maintenance is therefore most important in preserving the investment and insuring the best performance of the gas migration system.

The operator has the responsibility to attend to the operation of the system to eliminate gas migration and operate the system at peak efficiency. This not only occurs from good operation but from a good program for routine maintenance. The execution of routine maintenance will allow equipment to perform more efficiently for a longer period of time. This will lead to more reliable operation with fewer system operation and maintenance problems.

The following maintenance recommendations (Table 15-2) are intended to provide general recommendations for the respective item. Specific operation and maintenance procedures for items and equipment are found in the manufacturer's operation and maintenance literature.

The frequency of the following routine maintenance items is a recommended frequency. Some items are governed by the specific requirements of the equipment manufacturer, while the operator may choose other frequencies based on operating experience.

Table 15-2
Maintenance/Inspection Schedule
Motor/Blower Flare Facility

System Component	Maintenance/Inspection Required and Results Expected	Frequency
Blowers	The blower(s) will operate on a continuous basis for extended periods of time. It is important to rotate the blower(s) that are in the standby position into operation periodically. Perform this at the same time as the flares are rotated.	Monthly
	Lubricate the motor and blower bearings.	Monthly
	Measure current and voltage to each leg of the motor and check for even power distribution.	Semiannually
	Check that the blowers are operating without vibration and with no abnormal noises. Do not allow a noisy, surging, or vibrating blower to operate.	Weekly
	Measure the suction and discharge pressures to determine if any unexpected change has occurred.	Monthly
	Inspect the drive belts for wear. Always replace belts in sets.	Monthly
Flares	Check the pressure difference across the flame arrestor. High differential pressure indicates that the element is becoming plugged from gas debris or is damaged from backflash. Normal differential pressure for a clean element is 1.2-inch WC. When differential pressures exceed 4-inches WC, the effective area of flow in the element is reduced by 50%. Clean or replace the element.	Quarterly
	Check the propane cylinders to make sure that there is adequate gas for ignition of the flare pilot.	Annually
	Lubricate the air damper pivot pins.	Semiannually
	Rotate the standby and operational flares. Perform this at the same time as the blowers are rotated.	Monthly
Alarm Systems	Check the breaker overload for each motor blower breaker.	Annually
	Check the high and low flare temperature alarms and the temperature shutdown circuits.	Quarterly
	Check the flame failure alarm.	Quarterly
	Check the power failure alarm.	Quarterly

15-2 (cont)
Maintenance/Inspection Schedule
Motor/Blower Flare Facility

System Component	Maintenance/Inspection Required and Results Expected	Frequency
System Controls	Remove dust from controls by vacuum and compressed air.	Annually
	CAUTION: Always turn power off in equipment being cleaned.	
System Piping and Mechanical Items	Exercise the main gas piping butterfly valves. This includes buried valves.	Annually
	Calibrate all pressure gauges.	Annually
	Check the pressure in the vacuum and pressure piping headers. Monitor for unexpected changes that indicate a potential problem.	Monthly
Utility Systems[1]	Water	
	Test the reduced pressure backflow preventor per recommendations of the utility.	Annually
	Check the water meter box prior to winter to insure there is adequate insulation to prevent freezing of the pipe.	Annually
	Sewer	
	Exercise the slide gate in the condensate manhole.	Annually
	Check the sewer pipe to make sure that sediments are not accumulating in the pipe. This is done by closing the slide gate in the condensate manhole and the ball valves and butterfly valves to isolate pipe entering the manhole. Fill the manhole with water. Open the slide gate and witness the discharge at the discharge manhole. Open all valves once testing is complete.	Annually

1 The maintenance to the utility systems performed by the operations personnel is limited to the facilities in the landfill. Problems associated with the system owned by the purveyor of the utility should be addressed to the controlling authority. The utilities are provided by:

Water	Highline Water District
Sewer	Midway Sewer District
Power	Puget Power

15.5 TROUBLESHOOTING

Performing accurate troubleshooting of a problem will lead to the quickest, easiest, and least expensive way to correct the problem. Problems tend to occur where they are least expected so don't rule out any possibility within the system.

15.5.1 Isolation of the Problem

Isolating a problem is done by removing as many other items of the system from operation as possible. This will limit the number of items that can be the potential problem. The following general considerations are helpful when isolating the problem.

- Isolate the problem area by the use of valves, controls, or other means that apply.
- Following the isolation of the problem area, it is important to determine the sequence of operation.
- "Think" the system operation through and determine the items of dependency.
- Perform manual operation of items where applicable.
- Check electrical circuit continuity of operation functions with a meter where applicable.
- Switch suspect items with other like items in the system. This is not good practice where electrical controls are involved as damage to other components may occur.

15.5.2 Troubleshooting Guide

The following troubleshooting guide (Table 15-3) is intended to assist the operator in locating the cause of a problem or symptom. The operator is encouraged to supplement this chart, as may be necessary, based on actual operating experience.

TABLE 15-3
TROUBLESHOOTING GUIDE

FLARE

Indicators/ Observations	Probable Cause	Check or Monitor	Solutions
Flame Failure during operation	- Poor gas quality	- Check gas composition - Manifold leak	- Adjust system wells - Find & repair leak
	- Gas manifold restriction	- Condensate system discharge interrupted - High differential pressure across scrubber - High differential across flame arrestor	- Isolate restriction & correct - Replace MistMaster™ pad in chimney basket - Clean element
	- Dirty Ultra Violet Light Sensor	- Sensor eye	- Remove sensor from flare and clean sensor eye with clean soft cloth
	- Controls	- Relay operation - Thermocouple/temperature	- Replace faulty relay - Reset timing relay - Adjust air damper - Reset temperature shutdown - Replace thermocouple - Replace temperature indicator
	- Blower Problems	- Change in pressure @ suction & discharge of blower	- Correct blower performance - Adjust valve
	- Flame Safeguard Unit	- Operation sequence logic	- Repair or replace unit
	- Main Fuel Valve	- Power to valve - Valve operation - Flame safeguard unit logic	- Reset breaker/correct problem - Repair or replace - Repair or replace

TABLE 15-3 (cont)
TROUBLESHOOTING GUIDE

FLARE

Indicators/ Observations	Probable Cause	Check or Monitor	Solutions
Flame Failure during startup	- Pilot Problems - Dirty or Broken Ignitor	- Out of Propane - Solenoid valve stuck - Flame check plugged - Flame safeguard unit - Pilot control timing relay	- Refill bottles - Replace valve - Clean/replace element - Repair or replace unit - Adjust or replace relay - Clean/repair ignitor
	- Flame safeguard unit	- Start-up sequence logic - Spark ignition transformer - Breaker Tripped or off	- Repair or replace unit - Repair problem or replace unit - Reset or turn on
	- Main Burner doesn't light	- Gas composition - Fuel valve - Flame arrestor - Air louvers - Well field gas oxygen level @ scrubber - Blower/flare gas oxygen level in header to flares	- Purge gas line - Repair or replace valve - Clean or replace element - Adjust louvers - Find leak in pipe and repair - Repair leak in suction piping @ motor blower/flare facility - Repair blower shaft seal - Repair blower housing seal - Close scrubber vent valve
	- Control Circuit	- Control circuit timing relay for pilot	- Adjust or replace relay

TABLE 15-3 (cont)
TROUBLESHOOTING GUIDE

BLOWER

Indicators/ Observations	Probable Cause	Check or Monitor	Solutions
Low gas volume	- Gas passage blockage	- Check impeller @ @ suction & discharge	- Remove & clean blockage away
	- Condensate in manifold	- Manifold leakage - Manifold gas flows (low) - Manifold vacuum level	- Repair manifold - Drain condensate - Repair leaks in pipeline
	- Damage to Impeller or housing	- Visual drainage - Excess wear	- Replace damaged item - Replace item
	- Blower isolation valves	- Valve positions	- Correct valve positions for desired mode of operation
Gas Leakage	- Shaft seal	- Seal wear	- Replace seal
	- Leaking flex coupling or gasket	- Bubble test area	- Tighten bolts or clamp - Replace gasket or
Vibration or Noise	- Impeller	- Damage to impeller - Debris on impeller	- Repair or replace - Clean debris
	- Suction/discharge valves	- Valve adjustment	- Adjust for vibration free operation

TABLE 15-3 (cont)
TROUBLESHOOTING GUIDE

BLOWER

Indicators/ Observations	Probable Cause	Check or Monitor	Solutions
Vibration or Noise	- Bearing (blower or motor)	- Excess heat from bearing	- Lubricate - Replace
Flow Surge	- Isolation Valve open	- Valve(s) isolating operating blowers	- Close isolation valves so one blower doesn't affect the other
	- Condensate accumulation in system	- Condensate manhole level	- Open slide gate - Clean sewer line - Pump condensate
		- Scrubber drain valve	- Open valve
		- Condensate drains plugged	- Clean drains
		- Automatic Driptrap	- Repair or replace
		- Well field condensate drainage system	- Repair condensate drainage component
Won't Operate	- Motor	- Motor	- Replace/Rebuild
		- Breaker	- Turn breaker on - Correct overload problem
	- Flame Safeguard Unit & controls	- Control Panel switch position	- Turn to proper blower/flare combination
		- Blower control relay	- Replace
		- Flame safeguard unit logic	- Repair or replace

TABLE 15-3 (cont)
TROUBLESHOOTING GUIDE

FLAME SAFEGUARD UNIT

Indicators/ Observations	Probable Cause	Check or Monitor	Solutions
No pilot	- No propane to pilot burner - Dirty or broken ignitor	- Propane tanks - Propane valves - Propane regulator - Solenoid valve - Flame check	- Fill tanks - Open valves - Adjust or replace - Repair or replace - Clean or replace element
	- Circuit logic operation	- Spark ignition transformer - Pilot timing relay - Safeguard unit logic for pilot valve & spark	- Repair or replace - Adjust or replace - Repair or replace unit
No main burner	- No landfill gas	- Blower/flare combination on control panel - Isolation valves	- Switch for proper blower/flare assignment - Correct valve position for desired blower/flare operation
	- Main fuel valve	- Power to valve	- Turn power on or correct problem - Replace control relay
		- Flame safeguard unit logic - Valve operation	- Repair or replace unit - Repair or replace valve
Re-light trial malfunction	- Flame safeguard unit	- Logic for re-light - Lock out relay	- Repair or replace unit - Replace

TABLE 15-3 (cont)
TROUBLESHOOTING GUIDE

FLAME SAFEGUARD UNIT

Indicators/ Observations	Probable Cause	Check or Monitor	Solutions
No alarm	- Lockout alarm relay - Alarm system	- Relay - Alarm transmission	- Replace - Repair or replace faulty element
No power	- Power source	- Breaker	- Turn on - If tripped, correct problem
		- Control panel switch - Timing relay for start-up	- Turn switch to desired blower - Adjust or replace relay
	- Flame safeguard unit	- Power to unit	- Repair or replace unit
Blowers don't operate	- Control/power circuit	- Control relay - Breaker	- Replace relay - Correct short circuit

ALARM SYSTEM

Indicators/ Observations	Probable Cause	Check or Monitor	Solutions
No Alarm transmission	- Radio	- Check power - Voice communication - Alarm function logic	- Repair or replace battery back-up - Repair or replace radio - Repair or replace alarming device
	- Encoder	- Check power - Alarm function logic	- Turn power on - Repair re replace defective item
	- Alarm sensor	- Alarm function	- Repair or replace alarm sensor item

TABLE 15-3 (cont)
TROUBLESHOOTING GUIDE

SYSTEMS OPERATION

Indicators/ Observations	Probable Cause	Check or Monitor	Solutions
Blower/Flare combination not operating	- Control/electrical	- Circuit breakers	- Turn on
		- Control panel	- Turn switches for desired combination
		- Flame safeguard unit logic	- Repair or replace
		- Spark ignition transformer	- Repair or replace
	- Valves	- Isolation valve positions	- Operate valve(s) for proper flow pattern
		- Main fuel valve	- Correct operation, repair, or replace
	- Pilot	- Pilot System	- Repair or replace faulty item
Low Gas Volume at Flare	- Blower	- Blower item described in BLOWER Trouble-shooting Guide	- Correct as described
	- Flame Arrestor	- Differential pressure across flame arrestor	- Clean or replace element
	- Scrubber	- Differential pressure across scrubber	- Open drain valve - Replace MistMaster™ in chimney basket

TABLE 15-3 (cont)
TROUBLESHOOTING GUIDE

SYSTEMS OPERATION

Indicators/ Observations	Probable Cause	Check or Monitor	Solutions
	- Piping System	- Gas leaks - Valve closed or partially closed - Condensate accumulation in piping	- Repair leaking area - Open valve - Correct per CONDENSATE SYSTEM troubleshooting chart
	- Condensate accumulation in piping	- Flows in manifold	- Correct drainage in affected area

CONDENSATE SYSTEM

Indicators/ Observations	Probable Cause	Check or Monitor	Solutions
No condensate flow	- Valve closed	- Slide gate in condensate manhole - Drain valve at scrubber	- Open slide gate - Open drain valve
	- Plugged line	- Flow from each line	- Remove blockage
Excess condensate between blower & flare	- Valve closed	- Drain valve at scrubber	- Open valve
	- Automatic Drip trap	- Condensate discharge from drain cock	- Repair drip trap

OPERATOR NOTES AND COMMENTS

OPERATOR NOTES AND COMMENTS

OPERATOR NOTES AND COMMENTS

APPENDIX A

FORMS

On-Site Surface Water Drainage System
Checklist and Reporting Form
Midway Landfill

Date:____________________
Time:____________________

If any of the following questions are answered "Yes," describe below in area provided.

Are ditches clean of debris and sediments?	☐ Yes	☐ No
Is grass in ditches healthy and in good condition?	☐ Yes	☐ No
Is there erosion in ditches?	☐ Yes	☐ No
Is there evidence of over topping?	☐ Yes	☐ No
Is there settlement or ponding in ditches?	☐ Yes	☐ No
Are there excessive weeds in drainage structures?	☐ Yes	☐ No
Do underdrains appear to be clogged?	☐ Yes	☐ No
Are culvert inlets and outlets in good condition?	☐ Yes	☐ No
Are culverts clean of debris and excessive sediments?	☐ Yes	☐ No

Description of Problem(s):

Action Taken:

Inspected by:__________________________

Cover System Checklist and Reporting Form
Midway Landfill

Date:____________________

Time:____________________

If any of the following questions are answered "Yes," describe below in area provided.

<u>Settlement/Subsidence</u>

Are there any areas of excessive localized settlement?	☐ Yes	☐ No
Are there any areas of ponded water?	☐ Yes	☐ No
Is there any evidence of cracking or bulging in cover soils?	☐ Yes	☐ No

<u>Erosion</u>

Is there any erosion?	☐ Yes	☐ No

<u>Membrane Liner Damage</u>

Are there any exposed geosynthetic materials?	☐ Yes	☐ No
Are there any areas suspected to be damaged?	☐ Yes	☐ No

<u>Vegetative Stress</u>

Are there any areas of excessive dryness or wetness?	☐ Yes	☐ No
Are there bare spots or thin areas?	☐ Yes	☐ No
Are there excessive weeds?	☐ Yes	☐ No
Is there evidence of pest infestations or rodents?	☐ Yes	☐ No
Are there areas of insufficient topsoil?	☐ Yes	☐ No

Description of Problem(s):____

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Action Taken:____

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McSorley Creek Outlet Structure and Check Dam
Checklist and Reporting Form
Midway Landfill

Date: ____________________

Time: ____________________

If any of the following questions are answered "Yes," describe below in area provided.

Has debris accumulated in outlet structure?	☐ Yes	☐ No
Has creek bottom eroded downstream of outlet structure or check dam?	☐ Yes	☐ No
Has debris accumulated upstream of check dam?	☐ Yes	☐ No
Has stream bank around outlet structure eroded?	☐ Yes	☐ No
Has stream bank in vicinity of check dam eroded?	☐ Yes	☐ No
Has outlet structure or check dam been damaged?	☐ Yes	☐ No

Description of Problem(s):____

Action Taken:____

Inspected by:______________________________

Pipelines and Manholes Checklist and Reporting Form
Midway Landfill

Date: ____________________

Time: ____________________

If any of the following questions are answered "Yes," describe below in area provided.

Has manhole settled?	☐ Yes	☐ No
Is manhole cracked?	☐ Yes	☐ No
Are the manhole lids tightly secured in place?	☐ Yes	☐ No
Has debris collected in the manhole?	☐ Yes	☐ No
Do the pipelines appear to be plugged?	☐ Yes	☐ No
Has settlement occurred above the pipelines?	☐ Yes	☐ No
Have construction activities occurred near pipelines?	☐ Yes	☐ No

Description of Problem(s):____________________

Action Taken:____________________

Inspected by:____________________

Highway 99 and On-Site Flow Control Structure
Checklist and Reporting Form
Midway Landfill

Date: ____________________
Time: ____________________

If any of the following questions are answered "Yes," describe below in area provided.

Has debris collected in the structure?	☐ Yes	☐ No
Are valves operating smoothly?	☐ Yes	☐ No
Is vent plugged?	☐ Yes	☐ No
Is paint peeling?	☐ Yes	☐ No
Is there rust on any metal parts?	☐ Yes	☐ No
Are the orifices plugged?	☐ Yes	☐ No

Description of Problem(s): ____________________

Action Taken: ____________________

Inspected by: ____________________

Detention Pond Checklist and Reporting Form
Midway Landfill

Date: ____________________

Time: ____________________

If any of the following questions are answered "Yes," describe below in area provided.

Has debris blocked inlets, outlets, or flumes?	☐ Yes	☐ No
Are paver blocks cracked or damaged?	☐ Yes	☐ No
Is there erosion on the sides or bottom of the pond?	☐ Yes	☐ No
Are inlet and outlet structures in good condition?	☐ Yes	☐ No
Are cleanout lids tightly secured in place?	☐ Yes	☐ No
Is grass on the pond bottom healthy and in good condition?	☐ Yes	☐ No
Is the liner bulging?	☐ Yes	☐ No

Description of Problem(s): ____

Action Taken: ____

Inspected by: ____________________

Motor Blower Facility Checklist and Reporting Form
Midway Landfill

Date: ____________________
Time: ____________________

If any of the following questions are answered "Yes," describe below in area provided.

Is the operating blower surging or making an excessive amount of noise?	☐ Yes	☐ No
Is the flare temperature below 1500°F or above 1700°F?	☐ Yes	☐ No
Are there any alarm lights on at the Motor Control Center?	☐ Yes	☐ No
Do any pipes and pipe supports need repair?	☐ Yes	☐ No
Is the condensate system vacuum outside its operating limits?	☐ Yes	☐ No
Are there any alarm lights on at the condensate control station?	☐ Yes	☐ No

Description of Problem(s): ____________________

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Action Taken: ____________________

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Inspected by: ____________________

Landfill Gas Piping Checklist and Reporting Form
Midway Landfill

Date: ____________________

Time: ____________________

If any of the following questions are answered "Yes," describe below in area provided.

Are there any hissing noises coming from the pipes?	☐ Yes	☐ No
Are there any valves that do not work correctly?	☐ Yes	☐ No
Are there any pipe joints that are cracked?	☐ Yes	☐ No
Do any pipes need painting?	☐ Yes	☐ No
Are there any condensate surges in the gas pipes?	☐ Yes	☐ No

Description of Problem(s): ____________________

Action Taken: ____________________

Inspected by: ____________________

Exhibit D
to
Amendment No. 1 to Consent Decree
(Midway Landfill Site)

Midway Landfill Compliance Monitoring Plan (CMP)
April 2000

EXHIBIT D

MIDWAY LANDFILL

COMPLIANCE
MONITORING PLAN
(CMP)

APRIL 2000

Midway Landfill Monitoring Plan

City of Seattle

Seattle Public Utilities

Parametrix, Inc.

April 2000

Midway Landfill

Prepared for

City of Seattle
Seattle Public Utilities
Solid Waste Operations
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Seattle, Washington 98104-1713

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PLAN AMENDMENT OR MODIFICATION

This Monitoring Plan is intended for all future groundwater, surface water, and gas monitoring and is based in part on agreement between City of Seattle Public Utilities (SPU) and Washington State Department of Ecology (Ecology). Amendments and/or modifications to the Plan must be made in writing, and once approved by SPU and the regulatory agencies shall become incorporated by reference into this Plan. Such amendments or modifications would include but not be limited to:

- Adding or deleting field or analytical parameters;
- Adding or deleting sampling wells; and
- Adding or deleting sampling events.

Minor deviation from specific sampling protocols that occur as a result of changed or variable field conditions (e.g. changing sampling sequence) need not be approved, but must be documented on the appropriate form(s) for consideration during evaluation of sampling results.

1. INTRODUCTION

This Monitoring Plan is intended to be used as a permanent guideline for groundwater, surface water, and gas monitoring at Midway Landfill, Kent, WA, owned and operated by the City of Seattle (Figure 1).

Groundwater monitoring involves both performance and compliance monitoring. Performance monitoring includes collection of groundwater level and oil thickness measurements within the saturated portion of Midway Landfill (termed Saturated Refuse) and groundwater levels in the shallow groundwater surrounding the landfill during the post-closure period. The purpose of performance monitoring is to:

- Document the continued effectiveness of the final remedy at Midway Landfill as shown by the performance monitoring results.

Compliance monitoring includes collection and qualitative analysis of groundwater samples collected from monitoring wells located upgradient and downgradient of the landfill and groundwater flow determination. The purpose of compliance monitoring is to:

- Report groundwater chemistry in the vicinity of the landfill consistent with this Plan.
- Comply with post-closure monitoring requirements under Minimum Functional Standards (WAC 173-304-407) (Ecology 1988) consistent with this Plan.
- Evaluate groundwater flow relationships in the vicinity of the landfill.

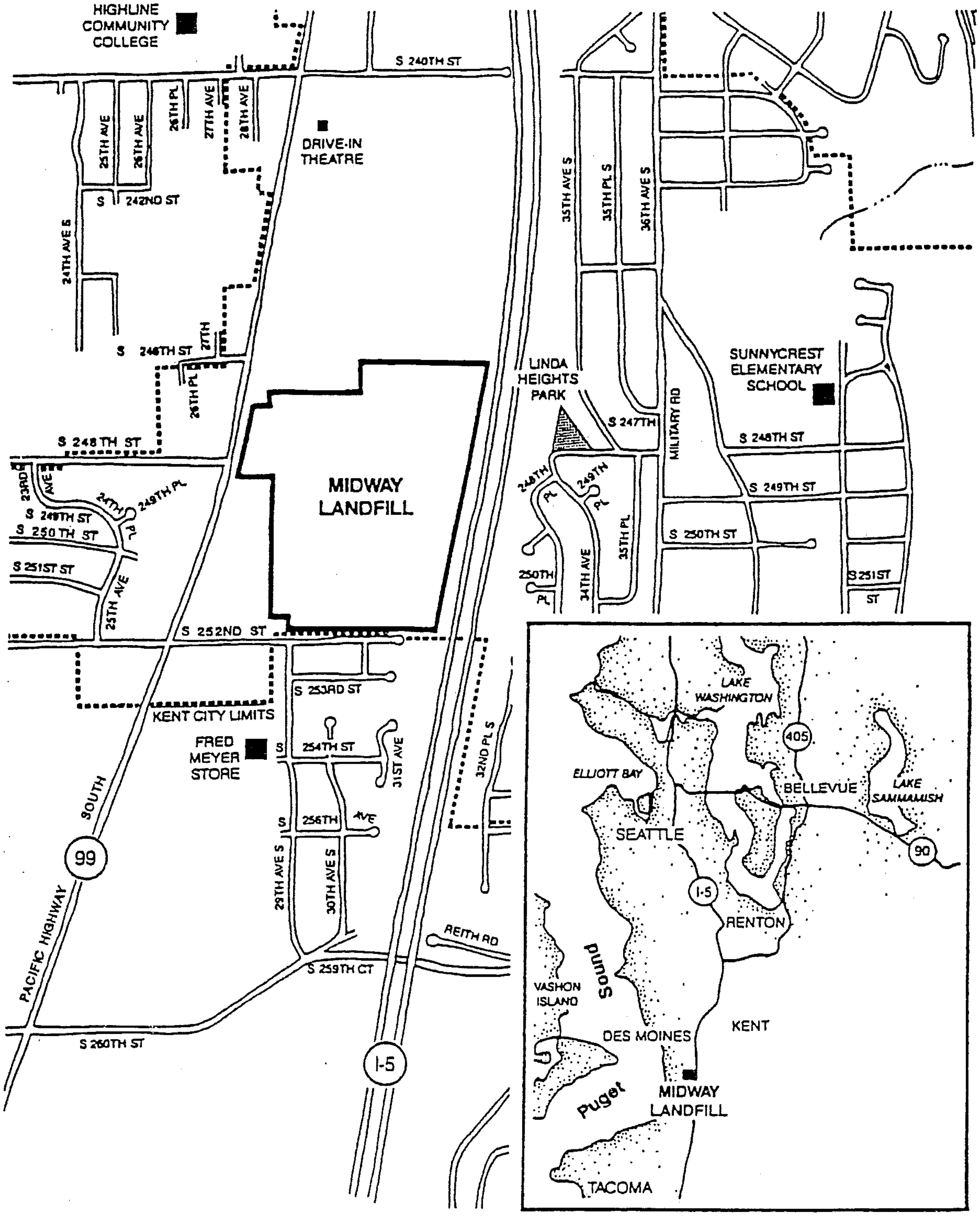
Surface water monitoring involves collection of water samples from the detention pond. The purpose of the monitoring is to ensure compliance with water quality standards prior to discharging storm water to McSorley Creek. Gas monitoring involves taking measurements at 63 off-site probes. The purpose of the monitoring is to detect subsurface landfill gas.

1.1 MONITORING PLAN ORGANIZATION

This Monitoring Plan outlines sampling locations, parameters, and quality assurance procedures; describes the required sampling event preparation, field sampling techniques, and task sequence; and identifies subsequent sample handling requirements for monitoring at the site. The Plan was developed to maintain consistency between each monitoring event, and is intended for repeated use in the field by sampling personnel. The body of this Plan provides a discussion of the field routine required to complete each sampling event.

1.2 PURPOSE AND OBJECTIVES

The purpose of this Plan is to provide specific field procedures and laboratory requirements to be implemented at the Midway Landfill during each monitoring event. This Plan and the Midway Landfill Operations and Maintenance Manual (O&M Manual) (City of Seattle 1992) are equivalent to the Operations, Monitoring, and Maintenance Plan required under Minimum Functional Standards.



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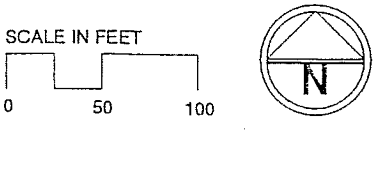


Figure 1
Site Location Map
Midway Landfill
Kent, Washington

1.3 TEAM ORGANIZATION AND RESPONSIBILITIES

Responsibility for executing the Monitoring Plan lies with SPU. The City may contract for services as needed to conduct the program. The City will be assisted by one consulting firm and one analytical laboratory. Responsibilities for each group include:

- City of Seattle (SPU). As owner of the landfill, the City will provide overall direction and coordinate all interaction with regulatory agencies; conduct groundwater level and oil thickness measurements, groundwater sampling, surface water measurements, and gas monitoring; provide access to and secure the site after sampling; and provide an environmental field specialist (EFS) team to perform field sampling duties.

- Parametrix, Inc. Responsible for project management; overseeing data management and analyses; preparing semi-annual and annual groundwater monitoring reports; preparing and reviewing groundwater field data sheets; preparing laboratory notification letters; preparing variation memorandums based on review of field data sheets; conducting QA/QC of laboratory data; updating chemical and fluid databases; and assisting SPU with purge water disposal.

- Analytical Resources, Inc. (ARI). Responsible for laboratory analysis of groundwater samples.

1.4 HEALTH AND SAFETY

On-site work at the Midway Landfill must be conducted using appropriate health and safety practices. Because health and safety protocols are set and monitored by employers, a project-wide plan is not included in this document. Each employer shall provide an appropriate plan under separate cover for their on-site personnel and shall be responsible for the health and safety of their own personnel.

2. GROUNDWATER PERFORMANCE AND COMPLIANCE MONITORING

2.1 SAMPLE LOCATION, PARAMETERS, AND QUALITY ASSURANCE

This section describes the well locations to be used for the performance and compliance monitoring programs and the frequency of monitoring. In addition, this section describes compliance monitoring parameters and quality assurance samples.

2.1.1 Well Locations

Locations of the performance monitoring wells are on Figure 2 and listed in Table 1. These wells monitor fluid levels within the saturated portion of the landfill (termed the Saturated Refuse) and the shallow groundwater surrounding the landfill. Locations of the compliance monitoring wells are on Figure 3 and listed in Table 2. These wells monitor groundwater chemistry in the Upper Gravel Aquifer (UGA), the Sand Aquifer (SA), and the Southern Gravel Aquifer (SGA). Compliance monitoring also includes determining groundwater flow direction in the UGA, SA, and the SGA. Wells used for groundwater flow determination include the compliance monitoring wells plus additional wells located upgradient and downgradient of the landfill. These wells are on Figure 4 and listed in Table 3. Boring logs and construction details for compliance and performance monitoring points are provided in Appendix A.

2.1.2 Monitoring Frequency

The performance and compliance events are targeted to coincide with the high (November) and low (May) groundwater surface elevations during each calendar year. The compliance monitoring wells are sampled on an annual to biannual basis as outlined in Section 2.3.3.

2.1.3 Compliance Monitoring Parameters

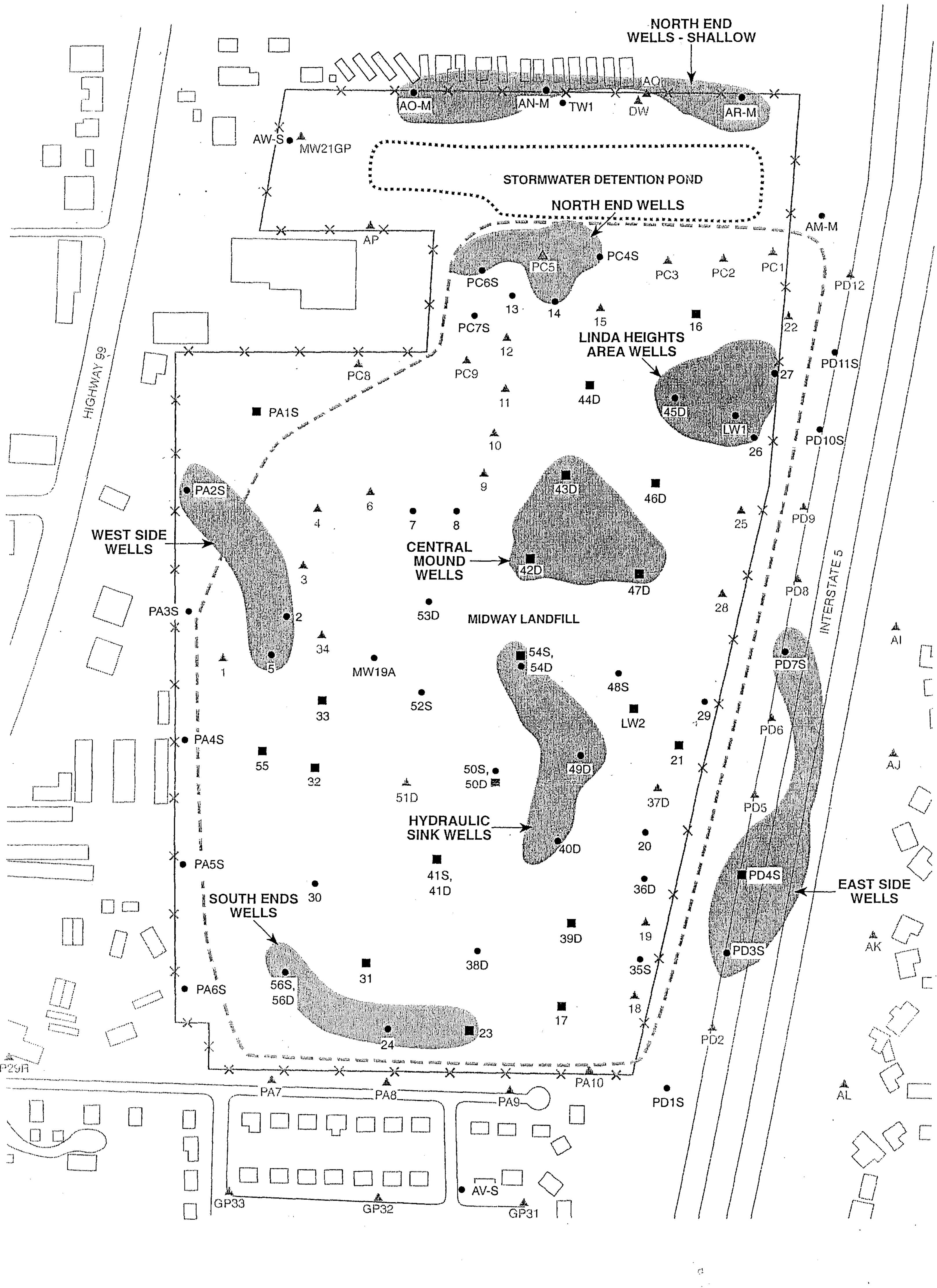
The analytical requirements for the compliance monitoring program include field parameters, chloride, sulfate, dissolved iron and dissolved manganese, chemical oxygen demand (COD), total organic carbon (TOC), and volatile organic compounds. Table 4 lists the number and type of samples for each sampling event. Table 5 lists the sample bottles required for each analysis. Quality assurance samples will be collected during compliance monitoring, as described below.

2.1.4 Quality Assurance Samples

The field quality control plan consists of collecting two field duplicates and one field blank from each sampling event. In addition, trip blanks for volatile organic analysis will be included during each sampling event where volatile analysis is being performed. Standard sample volumes are sufficient for the laboratory to perform matrix spike/matrix spike duplicate (MS/MSD) analyses.

2.1.4.1 *Field Duplicates*

There will be two complete sets of duplicate samples taken at random times during groundwater monitoring sampling rounds. The duplicate samples will be taken at a given well at the same sampling time as the primary sample. This sample is obtained by first filling one bottle for the primary sample (i.e., MW-17A), then filling the corresponding analytical container for the duplicate sample (i.e., MW-31). However, duplicate sample numbers will be designated so that field duplicates are not obvious to the lab.



Base Map Source: City of Seattle Department of Engineering
Midway Landfill Vicinity Map, 5-15-86

Parametrix Midway/Groundwater Monitoring Plan/555-1550-039(04) 3/00 (K)

41 — Gas probe, gas extraction well, or groundwater monitoring well number and location. Included in performance monitoring network.

GP33 — Gas probe, gas extraction well, or groundwater monitoring well number and location. Not included in performance monitoring network.

42D — Oil thickness monitoring wells included in performance monitoring network

Approximate limit of refuse

Fenced site boundary

SCALE IN FEET
0 125 250

N

Figure 2
Performance Monitoring Well Locations
Midway Landfill
Kent, Washington

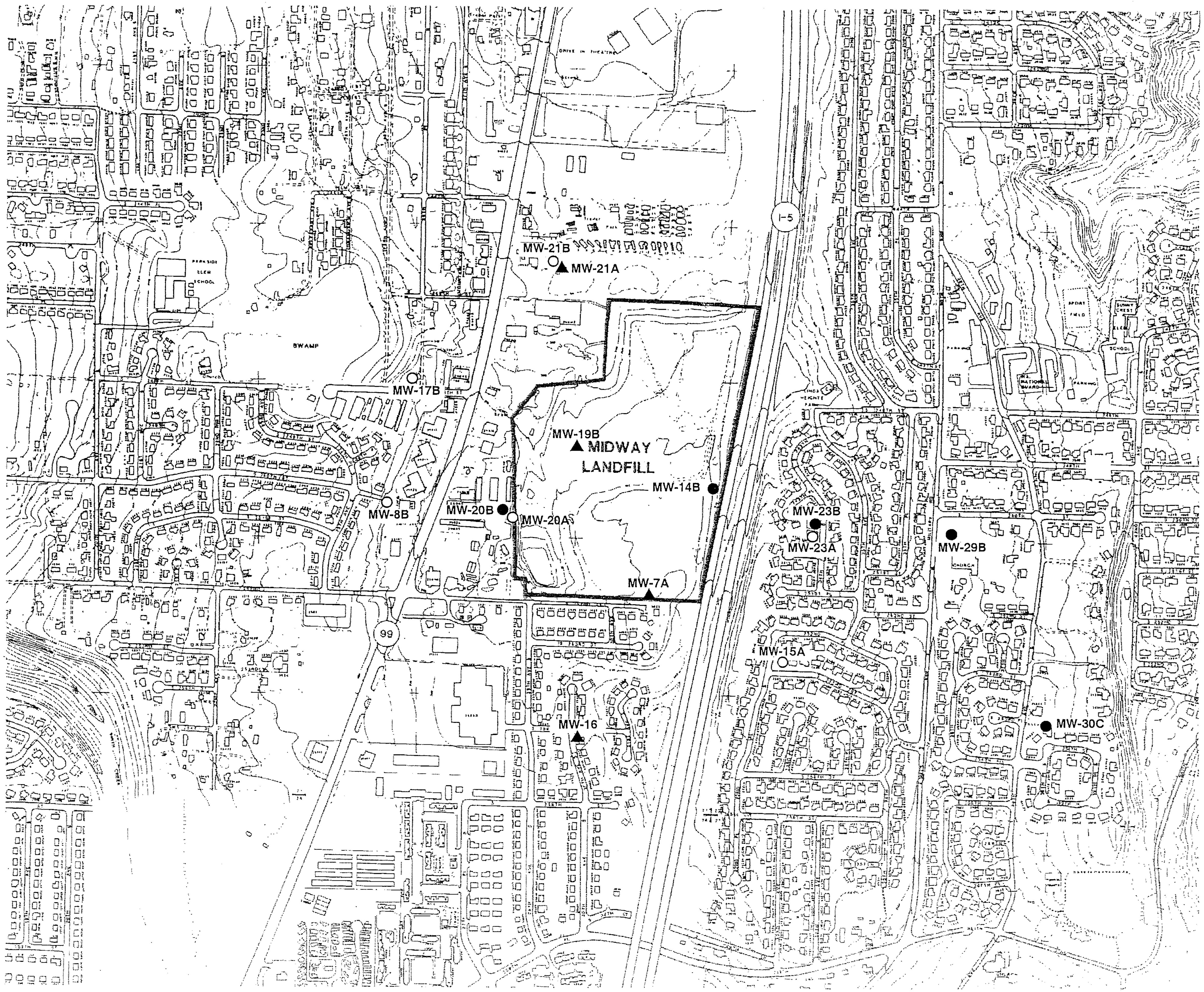


Figure 3
Compliance Monitoring Well Locations
Midway Landfill
Kent, Washington

MW-16 ▲ Upper Gravel Aquifer Monitoring Well Number and Approximate Location

MW-17B ○ Sand Aquifer Monitoring Well Number and Approximate Location

MW-14B ● Southern Gravel Aquifer Monitoring Well Number and Approximate Location

Base Map Source: Supplemental Hydrogeologic and Hydrochemical Investigation, AGI 1990

SCALE IN FEET
0 300 600

N

Parametrix, Inc. Midway Landfill/555-1550-039(04) 4/00 (K)

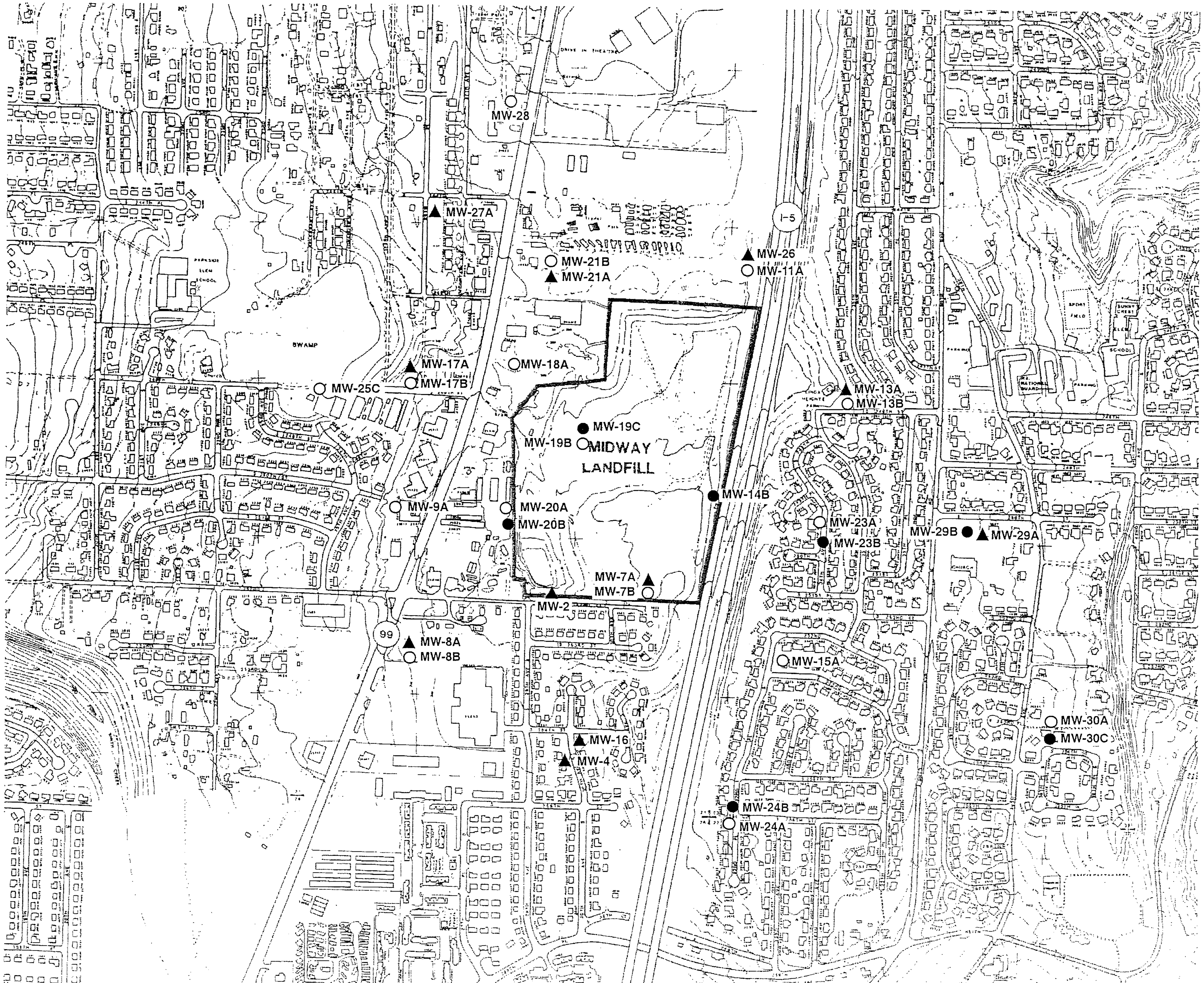


Figure 4
Groundwater Flow Monitoring Well Locations
Kent, Washington

▲ Upper Gravel Aquifer Monitoring Well

○ Sand Aquifer Monitoring Well

● Southern Gravel Aquifer Monitoring Well

Base Map Source: Supplemental Hydrogeologic and Hydrochemical Investigation, AGI 1990

Parametrix, Inc. Midway Landfill/555-1550-039(04) 3/00 (K)

Table 1. Performance Monitoring Network.

Landfill Gas Extraction Wells (EW)		A Series Gas Probes	PA Series Gas Extraction Wells	PC Series Gas Extraction Wells	PD Series Gas Extraction Wells	Groundwater or Leachate Wells
2	39D*	AM-M	PA1S*	PC4S	PD1S	LW-1
5	40D	AN-M	PA2S	PC6S	PD3S	LW-2*
7	41S*	AO-M	PA3S	PC7S	PD4S*	MW-19A
8	41D*	AR-M	PA4S		PD7S	TW-1
13	42D*	AV-S	PA5S		PD10S	
14	43D*	AW-S	PA6S		PD11S	
16*	44D*					
17*	45D					
20	46D*					
21*	47D*					
23*	48S					
24	49D					
26	50S					
27	50D*					
29	52S					
30	53D					
31*	54S*					
32*	54D					
33*	55*					
35S	56S					
36D	56D					
38D						

Notes:

* Wells typically monitored for oil thickness.

Performance Monitoring Network based on the June 3, 1994 *Amendment to the Midway Landfill Compliance* and *Performance Monitoring Technical Memorandum* prepared by Parametrix and Emerald Consulting.

Table 2. Compliance Monitoring Network.

Aquifer	Well Number	Location
Upper Gravel	MW-16	Upgradient, approximately 850 ft south of the landfill
	MW-21A	Upgradient, approximately 850 ft south of the landfill
	MW-7A	Downgradient, on the southern edge of the landfill where the UGA groundwater discharges into the SA
	MW-19B	In the middle of the landfill, near where leachate is believed to leave the UGA and enter the underlying SA
Sand	MW-8B	Upgradient, approximately 850 ft southwest of the landfill
	MW-17B	Upgradient, approximately 650 ft west of the landfill
	MW-21B	Upgradient, approximately 400 ft north-northwest of the landfill
	MW-15A	Downgradient, approximately 600 ft east of the landfill
	MW-20A	480 feet north of the southwest corner of the landfill
	MW-23A	Downgradient, 600 feet east of the landfill
Southern Gravel	MW-14B	Upgradient, on the eastern edge of the landfill at the crest of the groundwater divide
	MW-20B	Downgradient, on the western edge of the landfill
	MW-23B	Downgradient, approximately 600 ft east of the landfill
	MW-29B	Downgradient, approximately 1,450 ft east of the landfill
	MW-30C	Downgradient, approximately 2,200 ft southeast of the landfill

Table 3. Groundwater Flow Monitoring Network for the UGA, SA, and SGA.

Well ID	Aquifer
MW-2	UGA
MW-4	UGA
MW-7A*	UGA
MW-7B	SA
MW-8A	UGA/SA
MW-8B*	SA
MW-9A	SA
MW-11A	SA
MW-13A	UGA
MW-13B	SA
MW-14B*	SGA
MW-15A*	SA
MW-16*	UGA
MW-17A	UGA
MW-17B*	SA
MW-18A	SA
MW-19B*	SA
MW-19C	SGA
MW-20A*	SA
MW-20B*	SGA
MW-21A*	UGA
MW-21B*	SA
MW-23A*	SA
MW-23B*	SGA
MW-24A	SA
MW-24B	SGA
MW-25C	SA
MW-26	UGA
MW-27A	UGA
MW-28	SA
MW-29A	UGA
MW-29B*	SGA
MW-30A	SA
MW-30C*	SGA

UGA = Upper Gravel Aquifer
SA = Sand Aquifer
SGA = Southern Gravel Aquifer
* Compliance monitoring wells

Table 4. Number and Type of Samples for Biannual and Annual Groundwater Monitoring Events.

Parameter Group	Groundwater Quality Samples	QC Samples (a) FD	FB	TB	Total
Biannual Event (b)					
Conventionals:					
Chloride	11	2	1	0	14
Sulfate	11	2	1	0	14
TOC	11	2	1	0	14
COD	11	2	1	0	14
Dissolved Metals:					
Iron	11	2	1	0	14
Manganese	11	2	1	0	14
Total Metals (c):					
Chromium	1	0	0	0	1
Cadmium	1	0	0	0	1
Copper	1	0	0	0	1
Lead	1	0	0	0	1
Nickel	1	0	0	0	1
Zinc	1	0	0	0	1
VOCs	11	2	1	1	15
Field Parameters (d):	11	0	0	0	11
Annual Event (e)					
Conventionals:					
Chloride	15	2	1	0	18
Sulfate	15	2	1	0	18
TOC	15	2	1	0	18
COD	15	2	1	0	18
Dissolved Metals:					
Iron	15	2	1	0	18
Manganese	15	2	1	0	18
Total Metals (c):					
Chromium	1	0	0	0	1
Cadmium	1	0	0	0	1
Copper	1	0	0	0	1
Lead	1	0	0	0	1
Nickel	1	0	0	0	1
Zinc	1	0	0	0	1
VOCs	15	2	1	1	19
Field Parameters (d)	15	0	0	0	15

(a) QC samples defined as: field duplicate (FD), field blank (FB), and trip blank (TB).

(b) Biannual event monitoring wells = MW-7A, MW-14B, MW-15A, MW-17B, MW-19B, MW-20A, MW-20B, MW-21B, MW-23A, MW-23B, and MW-29B.

(c) Purge water parameters

(d) Field Parameters include temperature, specific conductivity, and pH.

(e) Annual event monitoring wells = biannual event wells listed above plus MW-8B, MW-16, MW-21A, and MW-30C.

Table 5. Sample Bottle Requirements by Parameter Group.

Analytical Parameters	Analytical Method	Number and Type of Bottle	Preservative	Holding Times[a]
Volatile Organic Compounds	*8260	(3)-40 ml glass vials	HCl, cool to 4°C	14 days
Dissolved Metals: Iron and Manganese	*6010	(1)-1 liter HDPE	HNO_3 cool to 4°C	6 months
Total Metals[b]: Cadmium, chromium, copper, lead, nickel, zinc	*6010	(1)-1 liter HDPE	HNO3 Cool to 4°C	6 months
COD	**410.4	(1)-250 ml amber glass	H_2SO_4, cool to 4°C	28 days
TOC	**415.2			
Chloride	**325.2	(1)-1 liter HDPE	cool to 4°C	28 days
Sulfate	**375.2			28 days

[a] Holding time listed is the shortest time indicated for analysis or extraction.
[b] Purge water only
* Test Methods for Evaluating Solid Waste. U.S. EPA SW 846, September 1986.
** Methods for Chemical Analysis of Water and Wastes. U.S. EPA 600/4-79-020, March 1983.
COD Chemical oxygen demand
TOC Total organic carbon

2.1.4.2 *Field Blanks*

There will also be one full set of samples taken as a "field blank" during each annual and biannual sampling event. These samples will be obtained by filling a sample bottle directly from the container of deionized water supplied by the laboratory. This sample will be treated in the same manner as all other groundwater samples.

2.1.4.3 *Trip Blanks*

Volatile organic trip blank samples will be prepared and supplied by the laboratory for monitoring events where samples for volatile organic analyses are being collected. The trip blanks will be stored with the volatile organic sample bottles. A minimum of one trip blank will be taken per day of sampling and analyzed for volatile organic compounds. All volatile organic samples taken during the day should be held in the same cooler as the trip blank for that time period.

2.1.4.4 *MS/MSD*

The laboratory will randomly select samples to be analyzed for MS/MSD. Additional sample volume will not be required.

2.2 PREPARATION FOR EACH MONITORING EVENT

Preparation for each monitoring event will start approximately two weeks before actual field work. A two week lead time is necessary in order to meet notification requirements, coordinate personnel, obtain sample bottles, and compile field equipment. The following sections detail specific requirements for monitoring preparation that must be conducted prior to each event.

2.2.1 Premonitoring Notification

Two weeks prior to the monitoring event, SPU will initiate the premonitoring notification by coordinating with staff to confirm and coordinate the dates for performance and compliance monitoring. SPU will also notify Parametrix of the scheduled monitoring event. Parametrix will then generate a laboratory notification letter that outlines the upcoming monitoring event. These notifications are intended to keep all affected parties informed of the monitoring schedule.

2.2.2 Laboratory Bottle Request

Parametrix will generate a bottle order for the upcoming monitoring event and send it to SPU. SPU will then contact the laboratory to coordinate the analytical schedule and to obtain appropriate sample bottles, and confirm required laboratory services and anticipated sample delivery dates. The lab will provide clean bottles with any necessary preservatives added prior to pick-up by SPU. Table 4 lists the number and type of samples to be collected during the sampling events. The required sample bottles for the designated analyses and required QA/QC testing are listed in Table 5.

2.2.3 Field Equipment Preparation

Mobilization for each sampling event will require preparation of the equipment and supplies required for sampling and personnel protection. SPU will supply all equipment needed to measure groundwater levels and oil thickness the week prior to sampling and to collect samples. Before each sampling round begins, all field instruments will be calibrated using methods given in the instrument manuals. Notations relative to instrument calibration should be included on field forms. Any difficulties with calibration and/or operation of field equipment will be reported to the site supervisor as soon as possible. Appendix B contains technical specifications for the dedicated pumps and sampling equipment.

The following is a list of supplies required for each event:

Health and Safety: Per City of Seattle Health and Safety Plan.

Equipment: Water level indicator, pump controller, and compressed nitrogen bottles.

Field Parameters: pH, conductivity, and temperature meters.

Supplies: 0.45 micron filters, plastic garbage bags, permanent markers, clear tape, deionized water, and Alconox.

Sample Containers: Lab supplied bottles, fresh ice or blue ice, coolers, and disposable containers for field parameters.

Field Forms: Groundwater Sampling Field Data Sheets, Chain-of-Custody forms, and pens.

Keys: Master Lock #2022 for gates.

2.3 FIELD METHODS AND PROCEDURES

SPU will measure groundwater elevations and oil thickness in the performance monitoring wells prior to groundwater compliance sampling. In addition, groundwater elevations will be measured in the groundwater flow monitoring wells prior to sampling. For planning purposes, all groundwater elevations and oil thickness will be measured approximately one week prior to sampling.

2.3.1 Access and Security

The Midway Landfill is located in Kent, Washington, approximately 14 miles south of Seattle (see Figure 1). The site is bounded to the east by Interstate 5, to the west by Pacific Highway South, and to the south by South 252nd Street. The site can be accessed at the main entrance off of Pacific Highway South. Access is restricted and the following procedures shall be observed when accessing the site:

- Upon entering the site, all non-SPU personnel must check in at the SPU site office located at the Kent Highlands Landfill;

- SPU will be responsible for securing any locked gates open for sampling access; and

- All non-SPU personnel shall check out at the SPU site office at the end of each day.

2.3.2 Measurements in Performance Monitoring Wells

Each monitoring event will begin with the SPU staff measuring groundwater elevations in 68 performance monitoring wells, as shown on Figure 2 and listed in Table 1. Twenty-one of these performance monitoring wells are also used to evaluate onsite oil (NAPL) thickness. The measurements will be taken approximately one week prior to sampling. Measurements will also be taken in the 34 groundwater flow monitoring network wells as described in Section 2.3.3. Field notes taken during monitoring will be recorded on a Midway Groundwater/Oil Thickness Measurements form (example provided in Appendix C) and will include at a minimum:

- Well designation;
- Time and date of measurement;
- Depth to groundwater in feet;
- Total depth of well in feet (measured annually);
- Description of reference point used for measurement; and
- General observation of wellhead condition, including notes for repair if necessary.

SINCO electronic probes are used for water level sounding and oil thickness measurement. Probes are typically weighted with a metal sheath fitted around the probe to avoid jarring or catching the probe on well expansion joints. Weighting the probe also enables detection (at the wellhead) of well bottoms when sounding deep wells. If a probe malfunctions, the replacement probe should be of similar manufacture. After completing each measurement, the portable equipment will be decontaminated.

During each monitoring round, data from the previous round are typically referenced before sounding each well to estimate the approximate depth required to reach fluid with the probe. This procedure reduces the risk of obtaining false fluid depths. Water depths are read directly from the sounder cable at an established reference point. For wells with prefixes EW, PA, and PC located in the Landfill, this point is typically the top of a 2-inch well access port mounted on the top of well cover. Where the 6- or 8-inch well cover requires removal, the well casing top (edge of the well casing) is used as the reference point. For A series probes, off-site PA wells, and PD wells, the outside rim of the manhole over the well is used as the reference point. For wells with prefixes LW and TW, top of PVC casing is used as the reference point. For A series probes, off-site PA wells, and PD wells, the outside rim of the manhole over the well is used as the reference elevation. In the latter case, a straightedge is typically placed across the rim, and the sounder cable is read where it meets the straightedge at a right angle. Wells are measured for total depth every other round. Well bottom data from previous rounds are compared with current data to reduce the likelihood of false readings as described above.

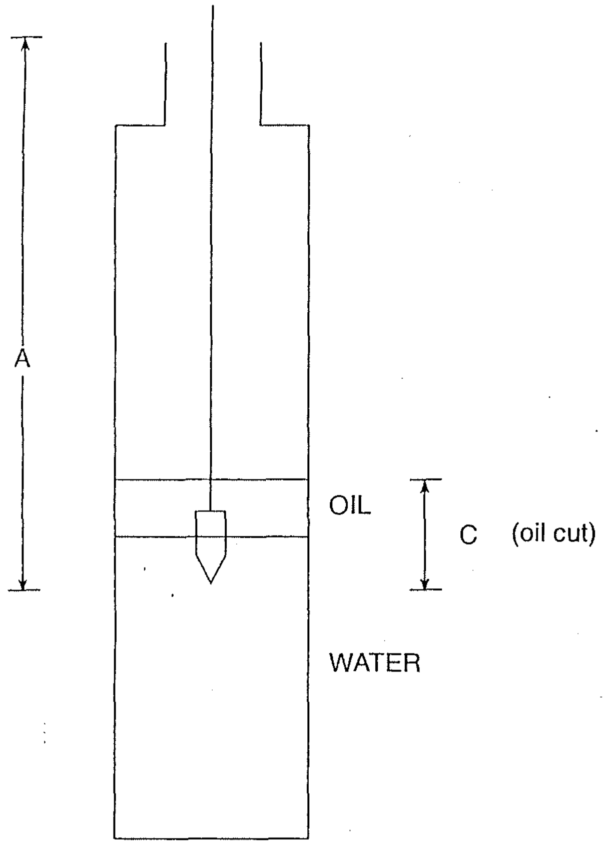
It should be noted that depths to fluid in wells connected to the Landfill gas collection system may be influenced by the vacuum applied by the system at the wellhead. When this vacuum is broken (i.e., when the well cover is removed), fluid level in the well may fall. Therefore, fluid levels may not have reached an equilibrium level when measured. Although this effect has not been quantified, it is expected that following the same procedure in a consistent manner each round reduces its significance, and therefore, the effect may be considered negligible.

Wells that have historically contained oil are measured each round for oil thickness by lowering the SINCO probe to the depth at which it first sounds (indicating oil/water interface), removing the probe from the well, and measuring the length of sounder cable coated by oil. Under typical oil/water interface conditions, the sounder probe may become coated with oil after traveling through the floating oil layer and cause erroneous measurement of the interface depth. These circumstances can result in overestimated oil thickness. The procedure for oil thickness measurements is presented in Figure 5.

Fluid levels represent top-of-fluid measurements whether water or non-aqueous liquid (oil) is present. Fluid levels for wells containing oil are not corrected for specific gravity differences between oil and leachate. Wells listed in Table 1 without an alphabetical prefix are gas extraction wells (EWs) screened in landfill refuse. Leachate well LW1 and LW2 are also screened in refuse. Other gas extraction wells are located around the perimeter of the refuse and screened in native sediments. These wells are designated with the prefixes PA, PC, and PD. Some of these wells, specifically PC4S, PC6S, and PC7S are screened in refuse.

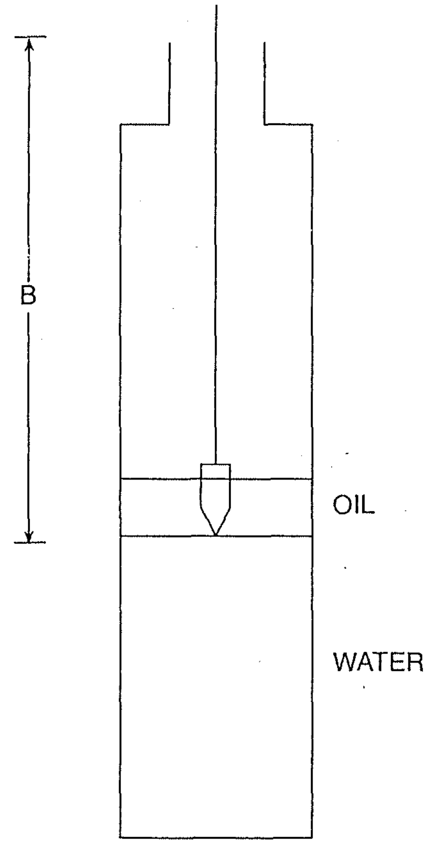
"A" prefixes indicate the wells are small-diameter gas probes. Suffixes S and M indicate the relative elevation of the screened interval of each probe. Screened elevations of these wells are as follows: S probes, greater than approximately 340 feet; M probes, greater than approximately 305 feet. "A" series probes are nested. MW refers to a groundwater monitoring well; TW refers to an aquifer parameter test well.

STEP 1



- Slowly lower water level probe until sounder goes “on”.
- Record measurement (A)
- Length of time for water level probe to go “on” as it passes oil/water interface depends on oil viscosity.

STEP 2



- Slowly bring water level probe up until sounder goes “off”.
- Record measurement (B)
- If you re-measure to confirm oil/water interface, do not exceed A value.

STEP 3

- Bring water level probe to surface.
- Measue length of oil cut on water level probe. Measuement is from top of probe to end of oil cut.

STEP 4

Calculate values

i) oil thickness = C - (A - B)
ii) depth to fluid (oil) = A - C
iii) depth to water = B

Note: Do not try to re-measure again immediately because oil/water interface has been disturbed.

Figure 5
Oil Thickness Measurement

2.3.3 Sampling of Compliance Monitoring Wells

During each sampling event, samples will be collected and analyzed to assess the quality of groundwater from the monitoring wells. Because the sampling requirements vary by sampling event, care must be taken to refer to Table 4 prior to sampling. All field sampling efforts will be documented on a Groundwater Sampling Field Data Sheet (example provided in Appendix C).

The following groundwater monitoring wells will be sampled during each monitoring event:

- MW-7A
- MW-14B
- MW-15A
- MW-17B
- MW-19B
- MW-20A
- MW-20B
- MW-21B
- MW-23A
- MW-23B
- MW-29B

And during the annual sampling event the following additional wells will be sampled:

- MW-8B
- MW-16
- MW-21A
- MW-30C

The sampling schedule for the next 5 years is shown in Table 6.

2.3.3.1 *Water Level Measurements*

Water level measurements will be collected from the 15 groundwater compliance monitoring wells plus the additional 19 wells that make up the groundwater flow monitoring network, as shown on Figure 4 and listed in Table 3. The measurements will be taken approximately one week prior to sampling. Field notes taken during monitoring will be recorded on a Midway Groundwater/Oil Thickness Measurements form (example provided in Appendix C) and will include at a minimum:

- Well designation;
- Time and date of measurement;
- Depth to groundwater in feet;
- Total depth of well in feet (measured annually);
- Description of reference point used for measurement; and
- General observation of wellhead condition, including notes for repair if necessary.

Table 6. Sampling Schedule.

Date	Event
May 1999	Biannual
November 1999	Annual
May 2000	Annual
November 2000	Biannual
May 2001	Biannual
November 2001	Annual
May 2002	Annual
November 2002	Biannual
May 2003	Biannual
November 2003	Annual
May 2004	Annual
November 2004	Biannual

Biannual wells = MW-7A, MW-14B, MW-15A, MW-17B, MW-19B, MW-20A, MW-20B, MW-21B, MW-23A, MW-23B, and MW-29B.
Annual wells = MW-8B, MW-16, MW-21A, and MW-30C.

For all wells, measurements will be taken with an electric well sounder or pressure gauge using procedures detailed below. If a probe malfunctions, the replacement probe should be of similar manufacture.

Water Level Probe Method

Depth to water measurements will be determined by lowering a SINCO electronic probe. Probes are typically weighted with a metal sheath fitted around the probe to avoid jarring or catching the probe on well expansion joints. Weighting the probe also enables detection (at the wellhead) of well bottoms when sounding deep wells.

The depth to water will be measured from the top of the PVC well casing or from the top of the outer steel casing, whichever is more elevated. Depth to water measurements will be made to the nearest 1/10th of a foot and will be recorded on the Groundwater Sampling Field Data Sheet. Total depth of well will be measured every other round. Previously collected values for total depth of well will be used to calculate casing volumes. After completing each measurement, the portable equipment will be decontaminated.

Air Line/Pressure Gauge Method

The air line should consist of a small-diameter pipe or tube of sufficient length to extend from the top of the well to a point several feet below the water level. The length of the air line must be known in order to estimate depth to water in the well. A gauge capable of measuring pressure in feet of water is preferred, and a compressor or hand pump is needed to displace the water inside the air line. Pressurize the air line until all water is forced out of the air line; at this point, pressure will cease to build. Record the reading in feet of head (this equals the amount of air line that is submerged). Then subtract this number from the total length of the air line to obtain a value for depth to water. A simple equation illustrates the relationship:

$D = L - h$ Where: D = depth to water (ft)

L = depth to bottom of air line (ft)

H = pressure head (ft)

If any gauges read in PSI, multiply by 2.31 to obtain feet of head. For any flowing artesian wells, a pressure gauge that measures in feet of head or PSI should be dedicated and attached to a sealed well cap. The water level elevation will be above the reference point, which will be equal to the base of the pressure gauge.

2.3.3.2 *Well Purging*

Dedicated pumping equipment installed in each well will be used for purging. Whenever possible, a minimum of five casing volumes will be purged before sample collection begins. Field parameters (pH, conductivity, and temperature) will be measured at the initiation of purging and after each purge volume. The final measurement is taken just prior to groundwater collection. If the parameters do not stabilize (within 10% of the previous measurement) after the fifth casing volume, purging will continue one casing volume at a time until stabilization is observed. SPU field sampling staff will record the purged volume, field parameter measurements, and any general observations (turbidity, odor) on a Groundwater Sampling Field Data Sheet. The purge volume will be calculated by using the following formula:

$$p = \pi r^2 h \times 7.48 \times 5$$

Where: p = calculated purge volume

$\pi = 3.14$

r = radius of well casing in feet

h = height of water column in feet

2.3.3.3 *Sample Collection*

Each groundwater sample will be collected using the dedicated pumping equipment to directly fill each sample bottle. Samples are taken through Teflon tubing, which is thoroughly rinsed with sample water prior to actual sampling to ensure homogenization. Teflon tubing will be dedicated to each well; therefore, no decontamination is necessary.

Each sample will be tested for field parameters as soon as it is collected. Field parameters include: pH, conductivity, and temperature. The first samples to be taken are those for volatile organics analysis (VOA). There will be no headspace or air bubbles within the VOA container. There is no pre-determined order to filling other analyses containers. Other samples will be placed in the appropriate bottle and preserved according to the applicable analytical technique. Samples for metals will be filtered through a 0.45-micron disposable filter prior to collection in an acid-preserved container. All samples will be stored on ice prior to daily delivery to the designated laboratory.

2.3.3.4 *Management of Purge Water*

Standing water in each well will be purged, as described in the section labeled "well purging", until the well contains non-stagnant water representative of the surrounding formation. Water collection from well purging will be collected at the well head in 55-gallon drums. A composite sample of the purge water from the 55-gallon drums is collected and tested for the parameters listed below. Parametrix reviews the analytical data and compares the results to Metro discharge requirements. Parametrix then generates a Purge Water Disposal Memorandum that recommends suitability for discharge. SPU will transport the drums and dispose of purge water at the Kent Highlands leachate treatment pond.

Purge water composite sample parameters for Midway Landfill are as follows:

- Total chromium
- Total copper
- Total cadmium
- Total zinc
- Total nickel
- Field pH

2.4 FIELD DOCUMENTATION AND SAMPLE MANAGEMENT

Field documentation of the monitoring program consists of three primary forms; a Midway Groundwater/Oil Thickness Measurements form, a Groundwater Sampling Field Data Sheet, and a Chain-Of-Custody form. Examples of the data forms are contained in Appendix C.

2.4.1 Performance Monitoring Documentation

Field notes taken during groundwater level monitoring will be recorded on a Midway Groundwater/Oil Thickness Measurements form (included in Appendix C) and will include a minimum:

- Well designation
- Time and date of measurement
- Depth to groundwater in feet
- Total depth of well in feet measured annually
- Description of reference point used for measurement
- General observation of wellhead condition, including notes for repair if necessary
- Oil thickness and/or presence or absence of oil in appropriate wells will also be noted.

2.4.2 Compliance Monitoring Documentation

Field groundwater sampling data will be recorded on the Groundwater Sampling Field Data Sheet. Data to be recorded includes the following:

- Project name, number, location
- Well designation
- Time and date of measurement
- Depth to groundwater in feet

- Well volume calculations
- Well purging method and total volume removed
- Equipment used for calibration and sampling
- Field parameters measured during purging
- Summary of any QC samples collected at well site

Depth to groundwater measurements for groundwater flow determination will be recorded on a Midway Groundwater/Oil Thickness Measurements form as described above in Section 2.4.1.

2.4.2.1 *Well Purging*

Data to be recorded on the Groundwater Sampling Field Data Sheet prior to and during purging includes:

- Depth to groundwater in feet
- Calculated purge volume in gallons
- Field parameters (pH, specific conductance, and temperature).

Total depth of well will not be measured each round because the pump and the probe may get tangled.

2.4.3 Sample Management

Proper procedures are required to ensure that the samples taken arrive at the lab in good condition. This includes proper sample labeling, handling, chain-of-custody procedures, and sample shipment.

2.4.3.1 *Sample Documentation*

Labels and sampling bottles will contain at least the following information:

- Date
- Parametrix Project No.
- Sample Name
- Client
- Sample ID
- Type of Analysis

Clear plastic tape will be wrapped around the bottle to cover the label completely, allowing identification, yet eliminating the possibility of eradication.

All samples will be delivered to the laboratory by SPU staff accompanied by a Chain-of-Custody form.

2.4.3.2 *Sample Handling*

Immediately after collection in the field, all groundwater samples will be placed in coolers containing ice for the remainder of the field day. After groundwater sampling has been completed for the day, the samples will be properly packaged for delivery to the lab. The exterior of all sample bottles will be cleaned and dried. Sample labels will be checked to ensure all pertinent information is clearly written and the label is covered with clear tape.

2.4.3.3 *Chain-of-Custody Procedures*

Sample custody will be tracked from the field to the laboratory using a chain-of-custody form. The original chain-of-custody form will travel with the samples (enclosed in a plastic bag and taped to the inside lid of the cooler), with both the sender and receiver signing the form to document sample transfer.

2.4.3.4 *Sample Shipment*

Samples will be delivered by SPU staff directly to the laboratory, on the same day the well is sampled.

2.5 MONITORING WELL AND EQUIPMENT MAINTENANCE

To maintain the longevity of the groundwater monitoring system, routine maintenance and checking of the wells and sampling equipment must be performed. Some of the equipment will likely have major malfunctions that cannot be dealt with by site personnel, and should be referred to the manufacturer for repair or replacement. If repairs are made to the well monument or the pump well head completion the well should be resurveyed.

2.5.1 Monitoring Wells

During each monitoring event, the wells should be visibly inspected for any defects prior to sampling or collection of fluid level data. The inspection should include, but not be limited to, checks for broken or cracked well monuments and proper function and integrity of sampling pump mechanisms and piping.

The compliance monitoring wells are equipped with dedicated Bennett pumps and routine maintenance and repair shall be performed as per manufacturer's recommendations.

2.5.2 Sampling Equipment

Routine maintenance of equipment used during groundwater level measuring and groundwater sampling shall be performed as per manufacturer's recommendations. The pneumatic pump controller is manufactured by Bennett Sample Pumps. The pump controller is generally maintenance free, but should the pump controller require servicing then Bennett Sample Pumps should be consulted.

Due to the wide variety of electric water level indicators and pH, conductivity, and temperature meters available on the market, a specific guide to maintenance is not possible. Again, follow manufacturer's recommendations. Of note is the pH meters which generally require that the probe tip be kept wet at all times.

2.6 LABORATORY QUALITY ASSURANCE

2.6.1 Quality Assurance Methods for PARCC Parameters

The quality assurance objectives of this plan are to develop and implement procedures to provide data of known and appropriate quality. Chemical data quality is assessed by precision, accuracy, representativeness, completeness, and comparability (PARCC). Documentation from the laboratory will be used to determine whether PARCC requirements are being met. This documentation may include reports on sample results, surrogate recoveries, spike recoveries, laboratory instrument calibrations, and copies of actual gas chromatographs. The documentation of PARCC allows validation of results against previous sampling rounds and identifies data uses and/or limitations prior to the actual use of the data.

2.6.1.1 *Precision and Accuracy*

Precision is a measure of mutual agreement among individual measurements of the same property under prescribed similar conditions. It is expressed in terms of the standard deviation or relative percent difference (RPD). Accuracy is the degree of agreement of a measurement (or an average of measurements of the same property), X, with either an accepted reference or true value, T. Accuracy is a measure of the bias in a system and will be expressed as the percent recovery of the samples (100[X-T]/T).

Accuracy and precision are determined through quality control parameters such as surrogate recoveries, matrix spikes, matrix spike duplicates, QC check samples, and field duplicates. The project DQOs for the evaluation of these parameters are based on those given in the current edition of Test Methods for Evaluating Solid Waste SW-846 (EPA 1986).

QC objectives (control limits expressed as percent) for surrogate recoveries and percent recovery and RPD for matrix spikes, matrix spike duplicates, and laboratory duplicates for this project will be those currently established by the testing laboratory. These limits will meet the requirements of SW-846 (EPA 1986). If the QC objectives are not met after corrective action is performed, the Project QA Officer will be notified by the laboratory before data submittal, and will determine whether or not additional corrective action should be taken, such as re-analysis, if applicable.

Field duplicate samples will be analyzed as QC samples for verification of precision and accuracy. If the differences between field duplicates are outside the control limits, corrective action and/or data qualification will be determined after review by the Project QA Officer. Field duplication can be poor because of sample heterogeneity. Therefore, corrective action will be determined by the Project QA Officer and discussed in the data validation report.

2.6.1.2 *Representativeness*

Representativeness expresses the degree to which sampling data accurately and precisely represent a characteristic of a population. Sample locations and field sampling procedures have been chosen to maximize representativeness, as described in Sections 2.1 and 2.3 of this document. Representativeness will be assessed from review of sampling records and QA audit(s) of field activities.

2.6.1.3 *Completeness*

Completeness is a measure of the amount of valid data obtained from a measurement system compared to the total data collected. The QA objective for completeness during this project is 95 percent.

2.6.1.4 *Comparability*

Comparability expresses the confidence with which one data set can be compared to another. All measurements will be made so that results are comparable with other measurement data for similar samples and sample conditions and with relevant action levels, criteria, or standards. The samples will be collected and analyzed using standard techniques, and analytical results will be reported in units consistent with EPA guidelines.

2.6.2 Laboratory Selection

The selected laboratory must meet the requirements stated here and any additional applicable requirements requested by appropriate regulatory bodies or standard practices of the industry. The laboratory must meet the following minimum requirements:

- Washington State Department of Ecology Certification
- EPA Certification
- Ability to meet required method detection limits and reporting limits
- Ability to meet project schedule and budget needs

2.6.3 Analytical Methods and Detection Limits

The analytical methods, method detection limits, and reporting limits for the requested parameters are presented in Table 7. The analytical laboratory is required to establish its own Method Detection Limits (MDLs) per 40 CFR 136, Appendix B for certification (EPA 1999). The contracted laboratory will be required to supply analytical results down to the reporting limit (RL).

2.6.4 Laboratory QA/QC Procedures

The laboratory will be responsible for following its own established QA/QC procedures. The following minimum QA/QC procedures apply:

- Sample holding and preservation requirements as specified in Table 5

- Analytical methodologies as specified in Table 7

- Instrument and tuning calibration will be performed as required by the specific analytical method

- Laboratory internal QC checks will follow the frequencies and limits specified in the analytical method

Non-CLP (Contract Laboratory Program) QA/QC protocol methodology will be used as part of this plan and the minimum QA/QC requirements are as follows:

- Maintain corrective action per predefined laboratory specific criteria limits
- Initial and continuing calibration per method requirements
- Laboratory Control Standards - Standards to be run at a frequency of one per batch
- Laboratory Method Blanks – Blanks to be run at a frequency of one per batch
- In addition, duplicate and MS/MSD analyses will be run during each sampling event

2.6.5 Laboratory Data Review

Data for all parameters will undergo internal review and validation at the analytical laboratory. Data reduction, validation, and quality review will be carried out at a level of effort equivalent to EPA CLP QA/QC protocol. Data validation will also be carried out by Parametrix, Inc.

Table 7. Reporting Limits and Method Detection Limits for Groundwater.

Parameter	Units	Analytical Method	Method Detection Limit (MDL)	Reporting Limit (RL)
Conventional Parameters:				
Chemical Oxygen Demand	mg/L	410.4 / 415.2	NA	5
Chloride	mg/L	325.2	NA	1
Sulfate	mg/L	375.2	NA	2.5
Total Organic Carbon	mg/L	410.4 / 415.2	NA	0.5
Dissolved Metals:				
Iron	mg/L	6010	0.0059	0.02
Manganese	mg/L	6010	0.0003	0.001
Total Metals:[a]				
Cadmium	mg/L	7000	0.0001	0.0002
Chromium	mg/L	6010	0.0021	0.005
Copper	mg/L	6010	0.0011	0.002
Lead	mg/L	7000	0.0009	0.001
Nickel	mg/L	6010	0.0068	0.01
Zinc	mg/L	6010	0.0018	0.004
Volatile Organics:				
1,1,1-Trichloroethane	ug/L	8260	0.51	1
1,1,2,2-Tetrachloroethane	ug/L	8260	0.94	1
1,1,2-Trichloroethane	ug/L	8260	0.49	1
1,1,2 - Trichlorotrifluoroethane	ug/L	8260	0.42	5
1,1-Dichloroethane	ug/L	8260	0.73	1
1,1-Dichloroethene	ug/L	8260	0.51	1
1,2-Dichlorobenzene	ug/L	8260	0.69	1
1,2-Dichloroethane	ug/L	8260	0.56	1
1,2-Dichloropropane	ug/L	8260	0.61	1
1,3-Dichlorobenzene	ug/L	8260	0.69	1
1,4-Dichlorobenzene	ug/L	8260	0.65	1
2-Butanone	ug/L	8260	2.8	5
2-Chloroethyl vinyl ether	ug/L	8260	0.67	5
2-Hexanone	ug/L	8260	3.55	5
4-Methyl-2-pentanone	ug/L	8260	3.15	5
Acetone	ug/L	8260	3.56	10
Acrolein	ug/L	8260	4	50
Acrylonitrile	ug/L	8260	1.2	5
Benzene	ug/L	8260	0.4	1
Bromodichloromethane	ug/L	8260	0.55	1

Table 7. Reporting Limits and Method Detection Limits for Groundwater. (Continued)

Parameter	Units	Analytical Method	Method Detection Limit (MDL)	Reporting Limit (RL)
Bromoform	ug/L	8260	0.66	1
Bromomethane	ug/L	8260	1.1	2
Carbon disulfide	ug/L	8260	0.58	1
Carbon tetrachloride	ug/L	8260	0.46	1
Chlorobenzene	ug/L	8260	0.73	1
Chlorodibromomethane	ug/L	8260	0.52	1
Chloroethane	ug/L	8260	0.52	2
Chloroform	ug/L	8260	0.87	1
Chloromethane	ug/L	8260	0.59	2
cis-1,2-Dichloroethene	ug/L	8260	0.84	1
cis-1,3-Dichloropropene	ug/L	8260	0.88	1
Methylene Chloride (Dichloromethane)	ug/L	8260	0.66	2
Ethylbenzene	ug/L	8260	0.47	1
o-xylene	ug/L	8260	0.82	1
m,p-xylene	ug/L	8260	1.57	1
Styrene	ug/L	8260	0.54	1
Tetrachloroethene	ug/L	8260	0.51	1
Toluene	ug/L	8260	0.45	1
trans-1,2-Dichloroethene	ug/L	8260	0.61	1
trans-1,3-Dichloropropene	ug/L	8260	0.81	1
Trichloroethene	ug/L	8260	0.51	1
Trichlorofluoromethane (F-11)	ug/L	8260	0.54	2
Vinyl Acetate	ug/L	8260	0.98	5
Vinyl Chloride	ug/L	8260	0.51	2

[a] = Purge water parameters

2.6.6 Data Reporting

The laboratory will prepare a standard analytical report, which will include a tabular summary, which includes, at a minimum, the following:

- Project data
- Method blank data
- Surrogate recoveries and target limits
- Matrix spike accuracy and precision
- Laboratory matrix duplicate accuracy and precision
- Reference material results
- Laboratory control sample results
- Dates of receipt, extraction/preparation and analysis

The laboratory will provide a narrative summary of the project QA, outlining any data quality problems encountered and an explanation of actions taken to correct the problems.

3. SURFACE WATER MONITORING

This task involves the collection and analysis of water samples from the surface water detention pond located on the north end of the landfill site. Surface water from I-5, Pacific Highway and the Midway Landfill all flow into the detention pond. The detention pond is inspected each morning by City staff. Whenever the water level in the pond exceeds 1.0 ft, samples are collected from the pond near the three inflow locations and the pond outlet (Figure 6) in the early morning, and from the pond outlet only in mid-afternoon.

When sufficient storm water enters the pond and the water level reaches the outlet pipe, then water is discharged into McSorley Creek. McSorley Creek is designated a Class A (excellent) water body by the Water Quality Standards for Surface Waters of the State of Washington (Chapter 173-201A) (Ecology 1992). A flow control structure equipped with knife gates allows the City to shut off the discharge in the event that monitoring shows that water quality is unacceptable for discharge. For example, discharge from the detention pond is shut off if turbidity exceeds 100 NTU.

Samples collected in the morning are field tested for the following parameters:

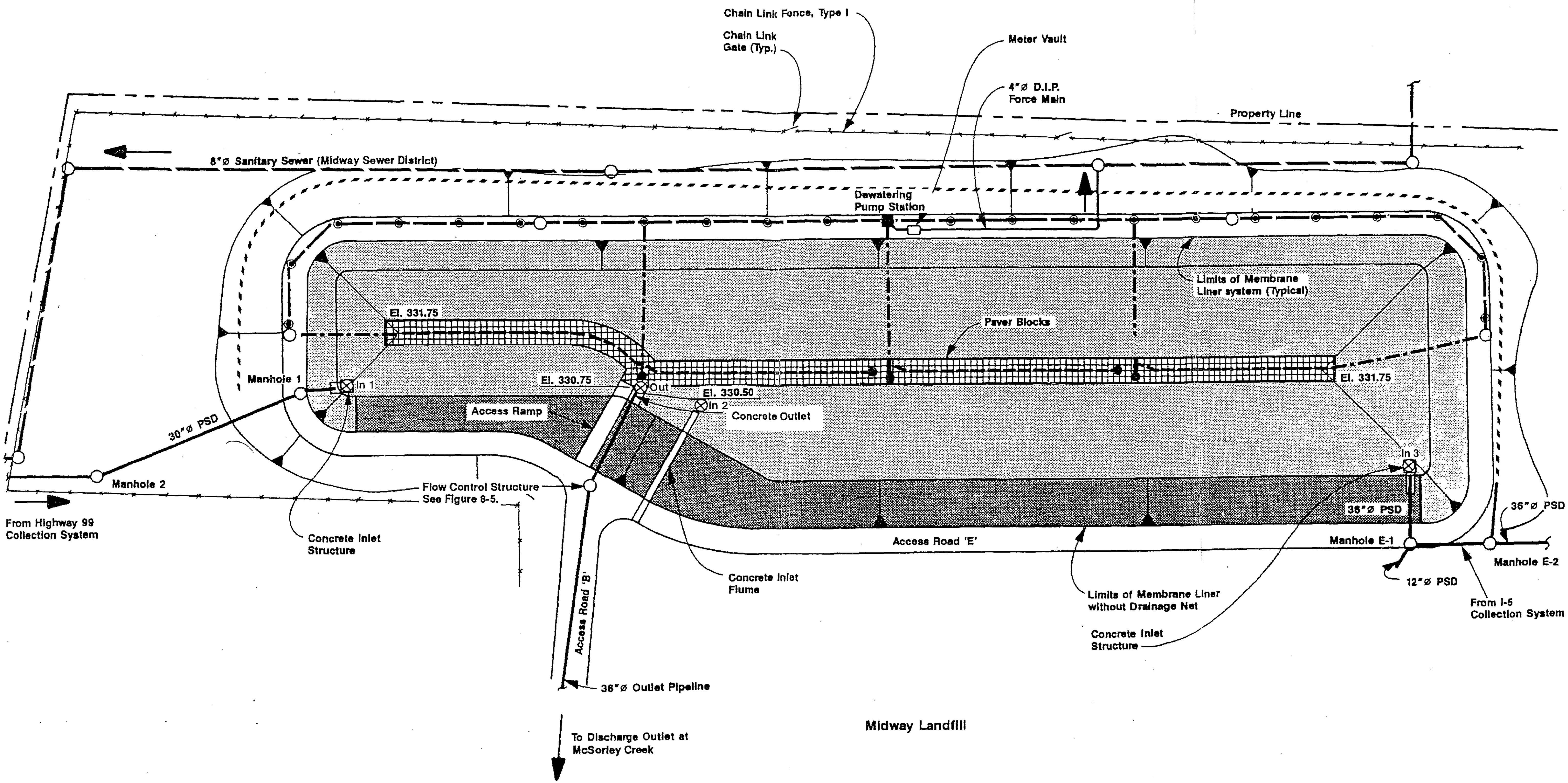
- Water Ttmperature
- pH
- Dissolved oxygen
- Turbidity
- Conductivity

Water temperature, pH, dissolved oxygen, and conductivity are measured immediately after sample collection with portable field meters and probes. Turbidity is measured immediately after sample collection with a portable nephelometer. Field instruments are calibrated and operated according to manufacturer instructions. Samples collected in the afternoon are tested for turbidity only.

In 1987, the City applied to Ecology for a National Pollution Discharge Elimination System (NPDES) permit for storm water discharge from Midway Landfill. At that time, Ecology indicated that an NPDES permit was not required, but acceptable discharge parameters were negotiated for detention pond operations. The acceptable water quality limits for the stormwater discharged into McSorley Creek are listed below in Table 8. City staff performing the sampling contact the SPU supervisor if any of the parameters in Table 8 are exceeded.

Table 8. Water Quality Parameters for Routine Stormwater Discharge to McSorley Creek.

Field Measurement	Acceptable Level for Discharge
Temperature	no higher than 18°C
pH	between 6.5 and 8.5
Dissolved oxygen	>8.0 mg/l
Turbidity	no higher than 100 NTU
Conductivity	<400 μmhos/cm



Parametrix, Inc. Midway Landfill/555-1550-039 (04) 4/00 (K)

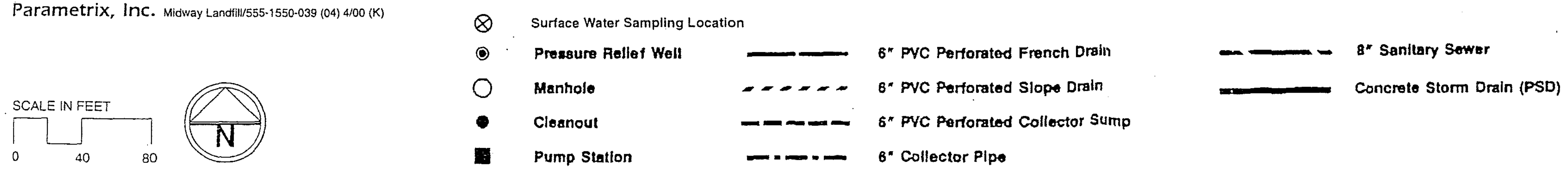


Figure 6
Surface Water Sample Locations
and Detention Pond
Midway Landfill
Kent, Washington

4. GAS MONITORING

SPU monitors 63 gas probes for landfill gas. These probes are monitored on a varying schedule. A summary of the schedule is presented in Table 9. The locations of the probes are shown in Figure 7. The measurements normally taken at the gas probes include:

- Combustible gases concentration (primarily methane)
- Oxygen concentration
- Hydrogen sulfide concentration
- Static pressure

The probes are measured using the following equipment (similar instruments can be used besides those suggested below):

- Neutonics PDM-210 pressure gauge, Dwyer Mark III, or similar instrument
- Gastech Model GT Land Surveyor combustible gas/oxygen meter or similar instrument
- Gastech GT Land Surveyor combustible gas meter or similar instrument
- Gastech Model GT-402 multi-gas meter or similar instrument

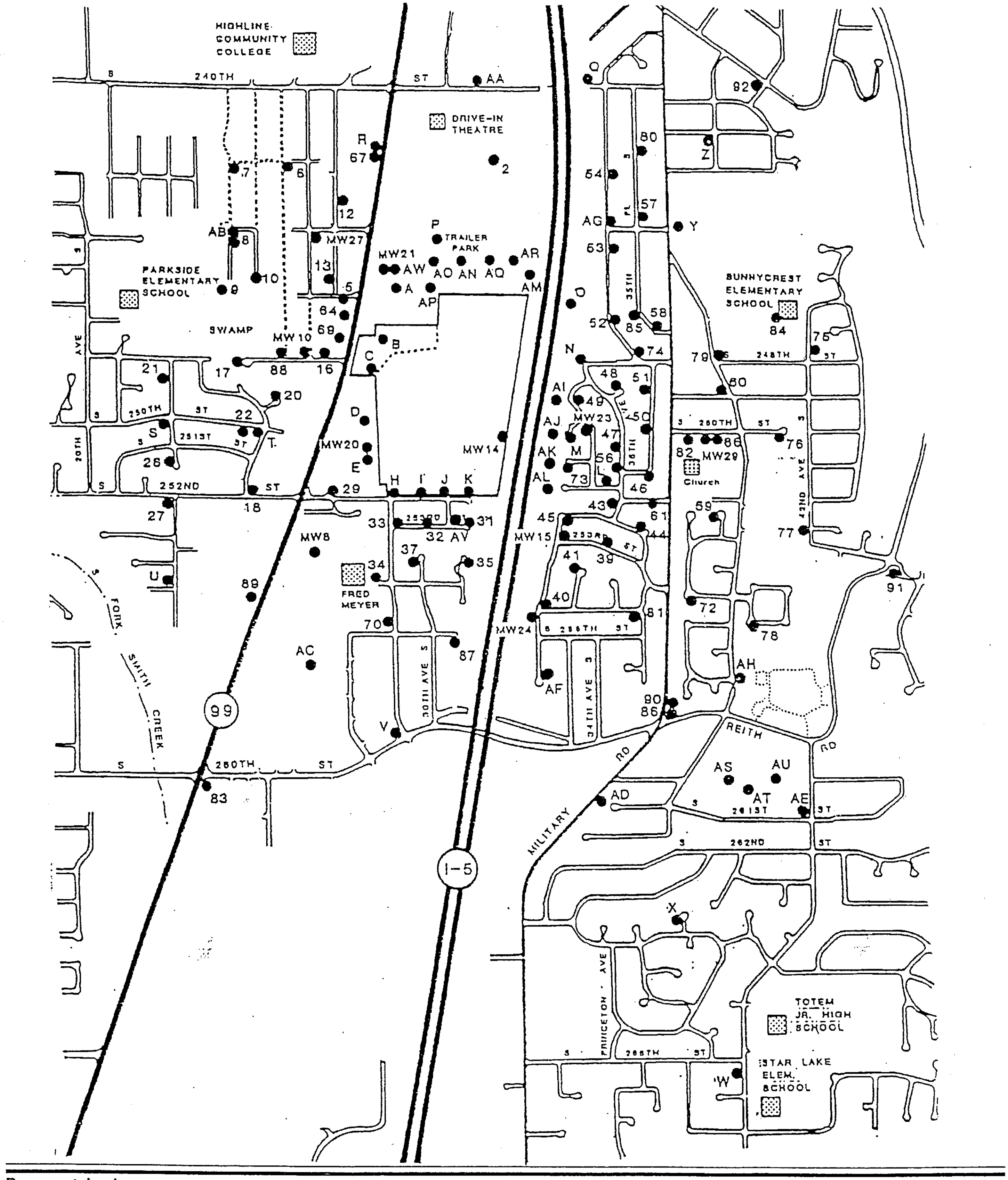
These instruments should be calibrated weekly and when recharged. Before monitoring, the instruction manual for use should be reviewed.

Table 9. Gas Probe Monitoring Schedule.

Frequency	
Probes Monitored Weekly	AM, AK, C16, MW-20, H, I, J, K, MW-24, MW-15, 61, and 85
Probes Monitored Monthly	C, 37, AV, M, 79, 44,81, 45,AN, AO, AP, AQ, AR, AW, D, 64, 69, 87, 88, MW-8, MW-27, 76, MW-29, 50, 59, and 60
Probes Monitored Quarterly	29, 31, 32, 34, 35, 39, 43, 49, 58, 80, 82, AF, AG, AI, AJ, AL, B, L, MW-10, MW-14, MW-23, N, O, Q, and R

The following are the proper steps you must take to monitor gas probes:

1. Before any system measurements are taken, it is important to record the barometer readings. A rapidly rising or failing barometer may explain system fluctuations.
2. Calibrate and check all instruments before any probe measurements.
3. Fill out field sheets with current information.
4. Remove standing water at the valve top with the aspirator.
5. Zero the machine at the LEL scale and percent by volume scale in ambient air.



Parametrix, Inc. Midway Landfill/555-1550-039(04) 4/00 (K)

Figure 7
Location of Gas Probes
Midway Landfill
Kent, Washington

6. Insert the pressure monitoring tube into the probe valve and open the valve. Record the pressure reading, close the valve, and disconnect the instrument.

7. Connect the GT Land Surveyor, or similar instrument, to the probe, open the valve, and continuously draw a sample until the oxygen and gas readings stabilize in accordance with the probe testing time table (see Appendix D). Record the reading, close the valve, and disconnect the instrument.

8. If the oxygen reading is less than 10 percent by volume in the LEL scale, check the combustible gas reading in percent by volume range before disconnecting.

9. If measurements are required for hydrogen sulfide use the GT-402 or similar instrument. Draw a sample continuously until the reading stabilizes, record the reading, close the valve, and disconnect the instrument. Secure the probe vault when readings are computed.

10. Record any comments relating to the probe readings.

11. Repeat steps 4 through 10 on the next completion or probe.

12. After system measurements are taken, it is important to record the barometer reading. A rapidly rising or falling barometer may explain system fluctuations.

5. REFERENCES

City of Seattle. 1992. Midway Landfill Operations and Maintenance Manual. Prepared for the Seattle Engineering Department, Solid Waste Utility. December 1992.

Ecology (Washington State Department of Ecology). 1988. General closure and post-closure requirements, Chapter 173-304-407, Minimum Functional Standards for Solid Waste Handling. October 1988.

Ecology (Washington State Department of Ecology). 1992. Water Quality Standards for Surface Waters of the State of Washington, WAC 173-201A.

EPA (U.S. Environmental Protection Agency). 1986. Test methods for Evaluating Solid Waste. SW-846. 3rd ed. November.

EPA (U.S. Environmental Protection Agency). 1999. Title 40, Code of Federal Regulations, Part 136, Appendix B. Updated 1999.

APPENDIX A

Boring Logs and Well Construction Details

(Note: Boring Logs and well construction details are not available for: gas extraction wells 35, 36, 37; gas probe AW-S; and aquifer parameter test well TW-1.)

GAS WELL DRILLING LOG

WELL No. 2

Landfill name: MIDWAY GAS MIGRA. CONTL. Project No. ________ Date 9-25-85

Time drilling commenced: 2:00 PM - 3:30 PM @ 24'

Time drilling completed: 8:00 AM 9-27-85

DESCRIPTION OF DRILLING SPOILS:

Cover soil depth: 4.5' Description

@ 10'	Garbage to
@ 20'	24' HIT WATER Stopped @ 24 (9-25) 21-28' CLAYEY SILT
@ 30'	9/26 29 - 48 WOOD, PAPER DRILLING WITH DIGGING BUCKET
@ 40'	47' WATER
@ 50'	DECOMPOSED WOOD, PAPER TO 60', SOME GRAVEL
@ 60'	60.5 END OF WELL 9-27-85
@ 70'	
@ 80'	
@ 90'	
@ 100'	
@ >100'	

SAMPLES TAKEN FOR ANALYSIS:

Sample No.	Sample weight	Sample depth
None		

Total depth of well 60.5 (Diam. 24'')

Total drilling time

DRILLING CONDITIONS

(Weather, obstructions, etc.) CLEAR, SUNNY HIGH 75°F

Drilling company DBM CONTRACTORS, INC

Drilling equipment HENDERSON LL 100,000 lb TRUCK MTD DRILL, 6" KELLY BAR

Operators names C FENSTERMACKER, M. OLNEY (OILER)

PMX 455-1550-07(3)

GAS WELL CONSTRUCTION LOG

WELL No. 2 Coord's N ____ E ____

Landfill name: MIDWAY GAS MIGRATION Date 9-27-85

CRM

I. DIMENSIONS:

a. Total depth of well 61.5'

b. Diameter of well 24"

c. Well casing interval 61.5'

d. Diameter of well casing 6"

e. Slotted interval of well casing 28.5'
from 32' to 60.5'

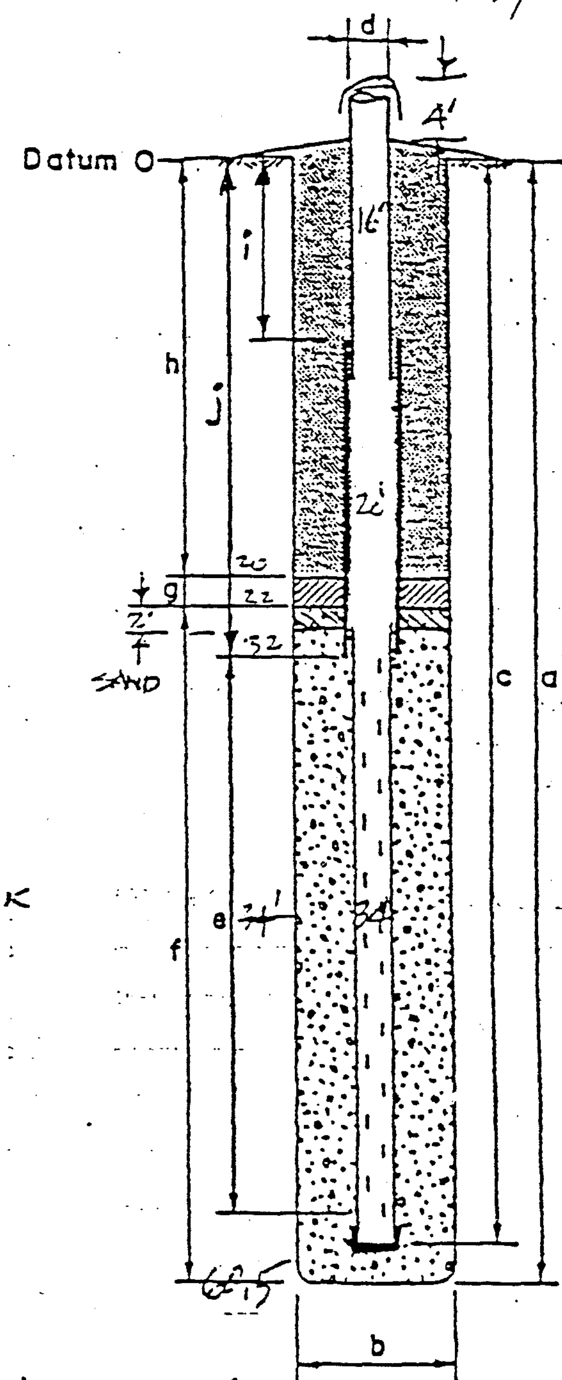
f. Permeable material interval 34'

g. Impermeable plug interval 2'

h. Backfill material interval 20'

i. Depth to Top of Slip/Settlement pipe 12'

j. " " Bottom " " " " 32



II. MATERIALS:

Permeable material 3/4" - 1 1/2" WASHED ROCK

Impermeable plug BENTONITE

Backfill material SAND

Casing material (incl. slip joints) 6" & 8" PVC

III. CONSTRUCTION:

Method of placing fill materials: RUBBER TIRE LOADER - CASE 580B

Method of placing casing: TRUCK MTD HYDRA CRANE

Problems encountered: ____

PMX # 55-1550-07(3)

GAS WELL DRILLING LOG

WELL No. 5 Coords. N 11,000 E 9385

Landfill name: MIDWAY LANDFILL GAS MIGRATION CONTROL Date 9-30-85/10-1-85

Time drilling 11:17 — 11:30 AM 9-30-85

7:15A 3:07 P 10-1-85

DESCRIPTION OF DRILLING SPOILS:

Cover soil depth: 4'

Description of Spoils

4'-23' PARTIALLY DECOMPOSED WOOD, CLOTH, PAPER, ETC., INCL TWO TIRES @ 40'

23'-25' GRAVEL

25'-64' PARTIALLY DECOMPOSED WOOD, CLOTHS, PAPER, ETC.

27' WET REFUSE AREA

40' TWO TIRES

64'-66' SANDY GRAVEL

66' CLAYEY SILT

Total depth of well 66' (Diam. 24")

DRILLING CONDITIONS

(Weather, obstructions, etc.) BROKE INNER KELLY BAR CABLE @ 11:30

Drilling company DBM CONTRACTORS, INC

Drilling equipment HENDERSON LL 100,000 lb TRUCK MTD DRILL; 6" KELLY BAR

Operators names CHUCK FENSTERMACKER, ~~MARVIN A OLNEY (OILER)~~ J. SEITZ

PMX#'5-1550-07(

GAS WELL CONSTRUCTION LOG

WELL No. 5 Coord's N 11,880 E 9385

Landfill name: MIDWAY GAS MIGRATION Date 10-1-85

I. DIMENSIONS:

a. Total depth of well 66'

b. Diameter of well 24"

c. Well casing interval 0-65'

d. Diameter of well casing 6"

e. Slotted interval of well casing 40'
from 25' to 65'

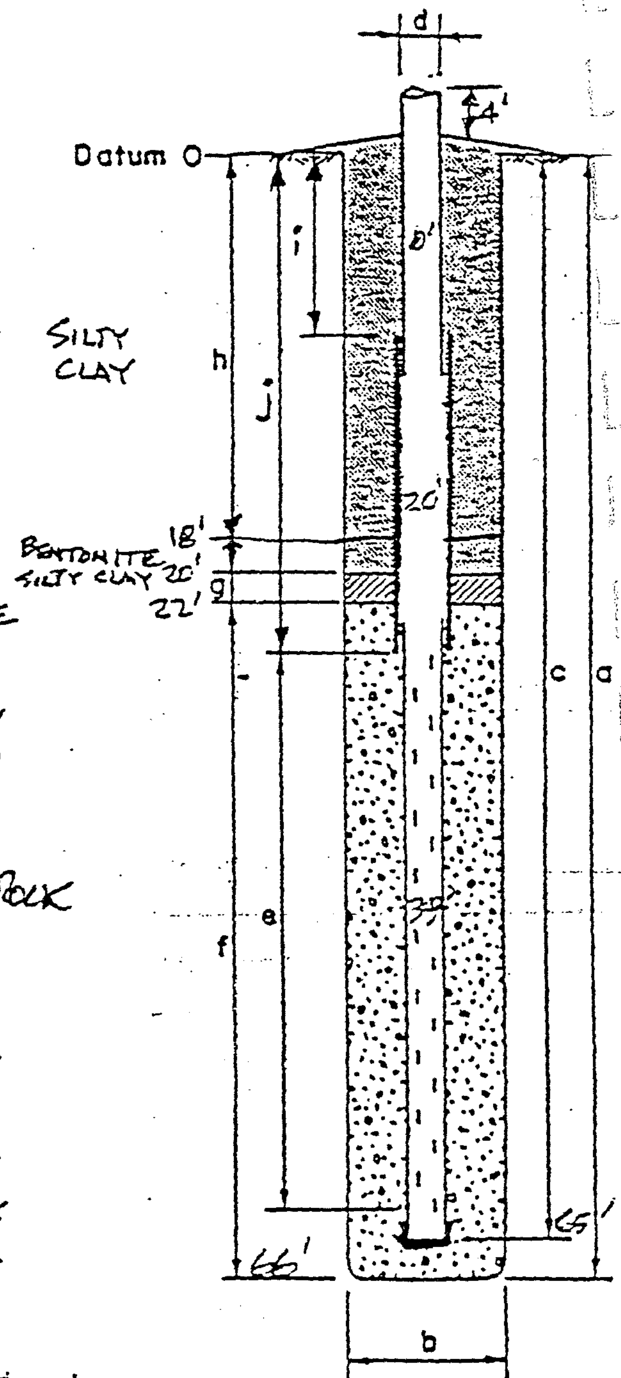
f. Permeable material interval 22'-66'

g. Impermeable plug interval 2' BENTONITE

h. Backfill material interval 18'

i. Depth to Top of Slip/Settlement pipe 5'

j. " " Bottom " " " " 25'



II. MATERIALS:

Permeable material 3/4" TO 1 1/2" WASHED ROCK

Impermeable plug BENTONITE

Backfill material SILTY CLAY

Casing material (incl. slip joints) 6" & 8" PVC

III. CONSTRUCTION: 7:45 AM -

Method of placing fill materials: RUBBER TIRE LOADER

Method of placing casing: TRUCK MTD HYDRA CRANE

Problems encountered:

FMX 77-1550-07(3)

GAS WELL DRILLING LOG

WELL No. 7 Coords. N 11,350 E 9723

Landfill name: MIDWAY LANDFILL GAS MIGRATION CONTROL Date 10-2 & 10-3-85

Time drilling 2:44 PM - 3:30 PM 10-2-85
7:00 AM - 3:27 PM 10-3-85

DESCRIPTION OF DRILLING SPOILS:

Cover soil depth: 1.0' Description of Spoils

1-19' PART. DECOMPOSED BLACK WOOD, PAPER, CLOTH, OCCA. TIRE
19-20 SANDY GRAVEL
20-69' PART. DECOMP. BLACK WOOD (TO 22' ON 10-2-85)
28' WET " " "
36' TIRE REMOVED
63' STEEL CABLE REMOVED
69'-70' SANDY CLAY

Total depth of well 70' (Diam. 24")

DRILLING CONDITIONS
(Weather, obstructions, etc.)

Drilling company DBM CONTRACTORS, INC

Drilling equipment HENDERSON LL 100,000 lb TRUCK MTD DRILL; 6" KELLY BAR

Operators names CHUCK FENSTERMACKER, MARVINA OLNEY (OILER)

PMX # 5-1550-07(3)

GAS WELL CONSTRUCTION LOG

WELL No. 7 Coord's N 11352 E 9725

Landfill name: MIDWAY GAS MIGRATION Date 10/4/85

I. DIMENSIONS:

a. Total depth of well 70'

b. Diameter of well 24"

c. Well casing interval 68'

d. Diameter of well casing 6"

e. Slotted interval of well casing from 26' to 68'

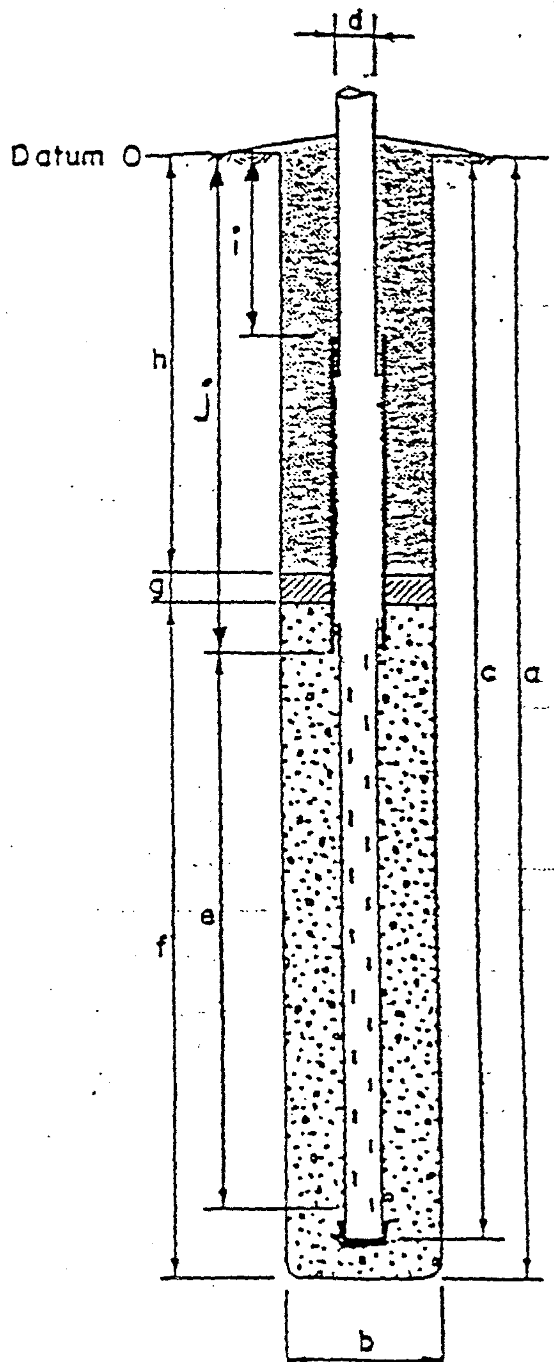
f. Permeable material interval 48'

g. Impermeable plug interval 2'

h. Backfill material interval 20'

i. Depth to Top of Slip/Settlement pipe 6'

j. " " Bottom " " " " 26'



II. MATERIALS:

Permeable material 1½" – 3/4" ROUN'D ROCK

Impermeable plug BENTONITE

Backfill material SILTY CLAY

Casing material (incl. slip joints) 6" & 8" PVC

III. CONSTRUCTION:

Method of placing fill materials: RUBBER TIRE LOADER (CASE 580 BACKHOE, END LOADER)

Method of placing casing: TRUCK MTD HYDRA CRANE

Problems encountered: NONE

TMX 77-1550-07(3)

GAS WELL DRILLING LOG

WELL No. 8 Coords. N 11,352 E 9815

Landfill name: MIDWAY LANDFILL GAS MIGRATION CONTROL Date 10-4-85

Time drilling 7:42 AM - 11:51 AM

DESCRIPTION OF DRILLING SPOILS:

Cover soil depth: 1' Description of Spoils

1'-52' PARTIALLY DECOMPOSED WOOD, PAPER, CLOTH, OCCATIONAL TIRE - HOT SPOT (STEAMING) AT 3'

52'-53' SILTY CLAY

53'-60' REFUSE - MOSTLY WOOD

60-63 SANDY GRAVEL

63-67.5 GRAVELLY SAND - BELLED OUT

MONITOR INDICATED EXCESS METHANE SEVERAL TIMES

MONITOR INDICATED ENOUGH METHANE TO SET UP BLOWER AT 10:30 AM

Total depth of well 67 1/2 FT (Diam. 24")

DRILLING CONDITIONS

(Weather, obstructions, etc.) SITE CONDITIONS WERE GOOD - NO OBSTRUCTIONS, AND THE WEATHER WAS GOOD

Drilling company DBM CONTRACTORS, INC

Drilling equipment HENDERSON LL 60,000 lb TRUCK MTD DRILL; 6" KELLY BAR

Operators names CHUCK FENSTERMACKER, ~~[illegible]~~ JOE SEITZ (OILER)

[signature] P.E.

PMX#'5-1550-07(3)

GAS WELL CONSTRUCTION LOG

WELL No. 6 Coord's N 11353 E 9815

Landfill name: MIDWAY GAS MIGRATION Date 6/4/85

I. DIMENSIONS:

a. Total depth of well 67.5'

b. Diameter of well 24"

c. Well casing interval 66'

d. Diameter of well casing 6"

e. Slotted interval of well casing from 66' to 26'

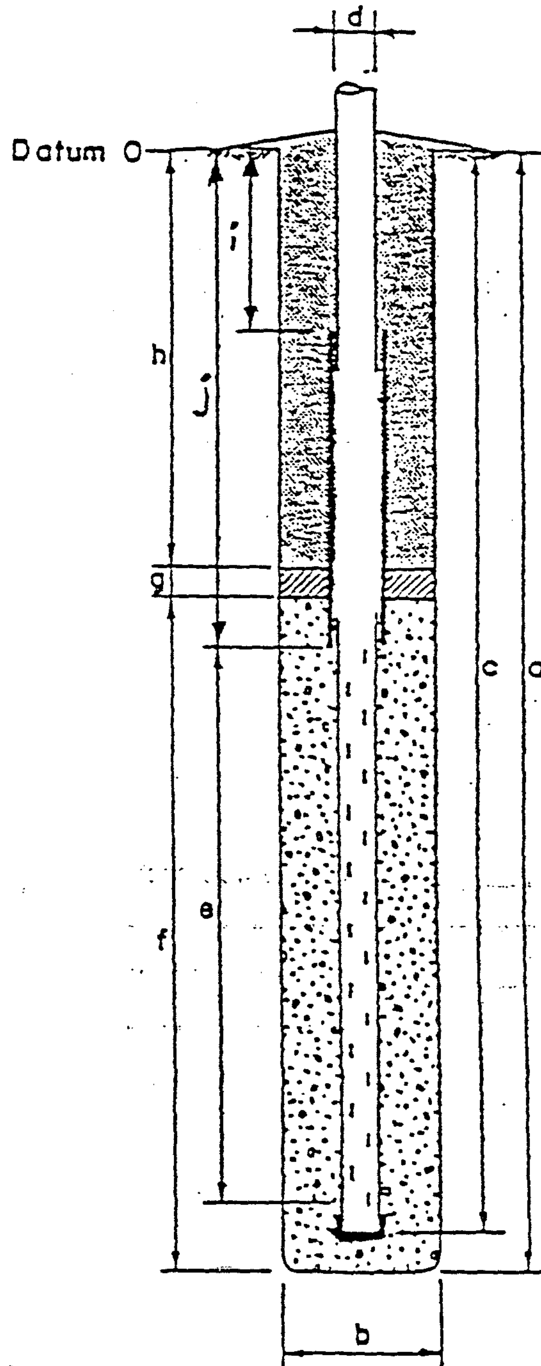
f. Permeable material interval 45 1/2'

g. Impermeable plug interval 2'

h. Backfill material interval 20'

i. Depth to Top of Slip/Settlement pipe 6'

j. " " Bottom " " " " 26'



II. MATERIALS:

Permeable material 3/4" to 1 1/2" Round Rock

Impermeable plug BENTONITE

Backfill material SILTY CLAY

Casing material (incl. slip joints) 6" & 8" PVC

III. CONSTRUCTION:

Method of placing fill materials: RUBBER TIRE LOADER

Method of placing casing: TRUCK MTD HYDRA CRANE

Problems encountered: NONE

IMX 77-1550-07(3)

GAS WELL DRILLING LOG

WELL No. 13 Coords. N 11830 E 9941

Landfill name: MIDWAY LANDFILL GAS MIGRATION CONTROL Date OCT 10, 1985

Time drilling 7:20 AM TO 1:32 PM ON 10/10/85

DESCRIPTION OF DRILLING SPOILS:

Cover soil depth: 1 FT Description of Spoils

1 - 20 FT - PARTIALLY DECOMPOSED WOOD WITH LOTS OF METAL SCRAPS, TIRES.

20 - 34 FT - PARTIALLY DECOMPOSED WOOD WITH MINOR AMOUNTS OF CLOTH - PLASTIC

34 - 34.5 FT - LAYER OF GREEN MATERIAL WITH HEAVY LACQUER SMELL - PROBABLY PAINT - MAYBE ZINC - CROMATE (BOEING) WITH KEYTONE THINNER

34.5 - 37 FT - PARTIALLY DECOMPOSED WOOD

37 - 43 FT - SILT AND GRAVEL

43 - 45 FT - WET PARTIALLY DECOMPOSED WOOD

45 - 58 FT - HAULED IN CLAY WITH GRAVEL, WIRE, PLASTIC PIECES EMBEDDED WATER ENCOUNTERED AT 46 FT

58 - 62 FT - BROWN CLAY

Total depth of well 62 FT. - CLAY SQUEEZED TO 54 FT (Diam. 24")

DRILLING CONDITIONS

(Weather, obstructions, etc.) PARTLY CLOUDY - BREEZY - GOOD CONSTRUCTION CONDITIONS

Drilling company DBM CONTRACTORS, INC

Drilling equipment HENDERSON LL 100,000 lb TRUCK MTD DRILL; 6" KELLY BAR

Operators names CHUCK FENSTERMACKER, ~~MARVIN OLNEY~~ LEE SEITZ, OILER (OILER)

[signature] P.E.

PMX # 5-1550-07 (3

GAS WELL CONSTRUCTION LOG

WELL No. 13 Coord's N 11830 E 9941

Landfill name: MIDWAY GAS MIGRATION Date 10/11/85

I. DIMENSIONS:

a. Total depth of well [1] 54 FT

b. Diameter of well 24"

c. Well casing interval 53'

d. Diameter of well casing 6"

e. Slotted interval of well casing
from 53' to 26'

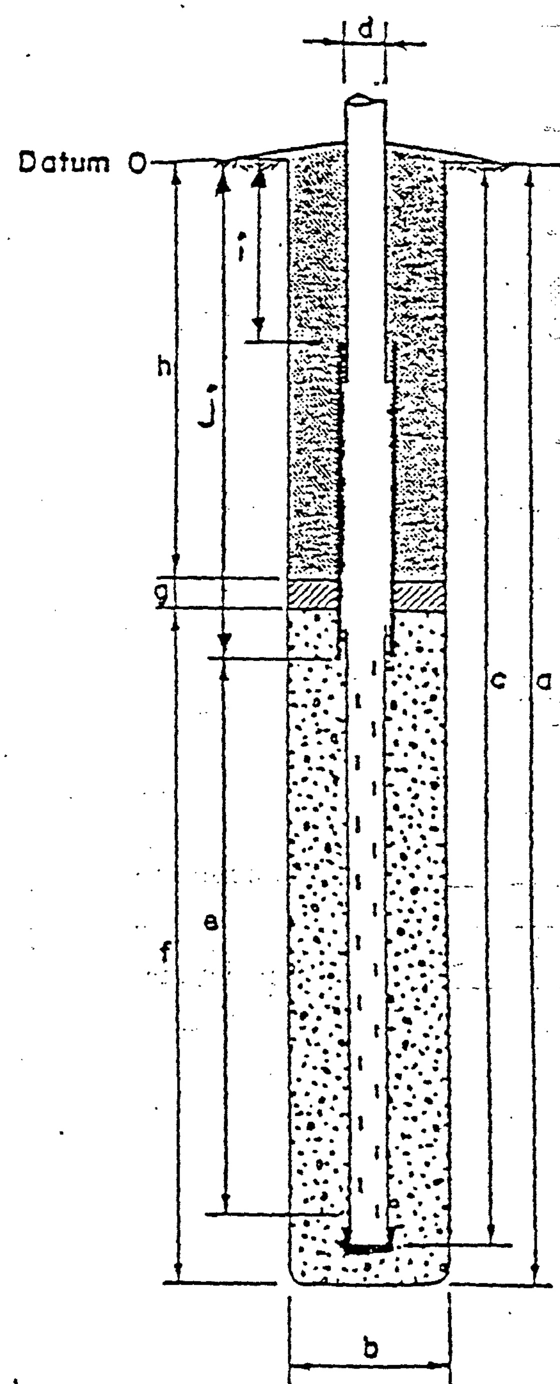
f. Permeable material interval 34'

g. Impermeable plug interval 2'

h. Backfill material interval 20'

i. Depth to Top of Slip/Settlement pipe 6.5'

j. " " Bottom " " " " 26.5'



II. MATERIALS:

Permeable material 3/4" TO 1 1/2" ROUN'D ROCK

Impermeable plug BENTONITE

Backfill material CLAY (BLUE)

Casing material (incl. slip joints) 6" & 8" PVC

III. CONSTRUCTION:

Method of placing fill materials: RUBBER TIRE LOADER

Method of placing casing: TRUCK MTD HYDRA CRANE

Problems encountered: [1] WELL DRILLED TO 62', DEPOSITED CLAY WITH BITS OF PLASTIC METAL AND GRAVEL TO 58, ORIGINAL [illegible]

FMX - 55-1550-07(3)

GAS WELL DRILLING LOG

WELL No. 14 Coords. N 11810 E 10061

Landfill name: MIDWAY LANDFILL GAS MIGRATION CONTROL Date

Time drilling BEGAN DRILLING AT 2:30 PM ON 10/10/85; COMPLETED 9:41 AM ON 10/14/85

DESCRIPTION OF DRILLING SPOILS:

Cover soil depth: 1 FT Description of Spoils

1 - 63 FT - PARTIALLY DECOMPOSED WOOD, LOTS OF TIRES, SOME PLASTIC PAPER, ETC.

WATER ENCOUNTERED AT 54 FT

63 - 65 FT - CLAY

25 LEL ALARMS WITH BREEZE BLOWING ON 10/14/85

Total depth of well 65 1/2 FT (Diam. 24")

DRILLING CONDITIONS

(Weather, obstructions, etc.) CLOUDY AND COOL - BREEZE

GOOD OPERATING CONDITIONS

Drilling company DBM CONTRACTORS, INC

Drilling equipment HENDERSON LL 100,000 lb TRUCK MTD DRILL; 6" KELLY BAR

Operators names CHUCK FENSTERMACKER, ~~MARVIN A OLNEY~~ JOE SEITZ (OILER)

[signature] P.E.

PMX#5-1550-07(3)

GAS WELL CONSTRUCTION LOG

WELL No. 14 Coord's N 11810 E 10061

Landfill name: MIDWAY GAS MIGRATION Date 10/14/85

I. DIMENSIONS:

a. Total depth of well 65.5 FT

b. Diameter of well 24"

c. Well casing interval 64 FT

d. Diameter of well casing 6"

e. Slotted interval of well casing from 26 FT to 64 F

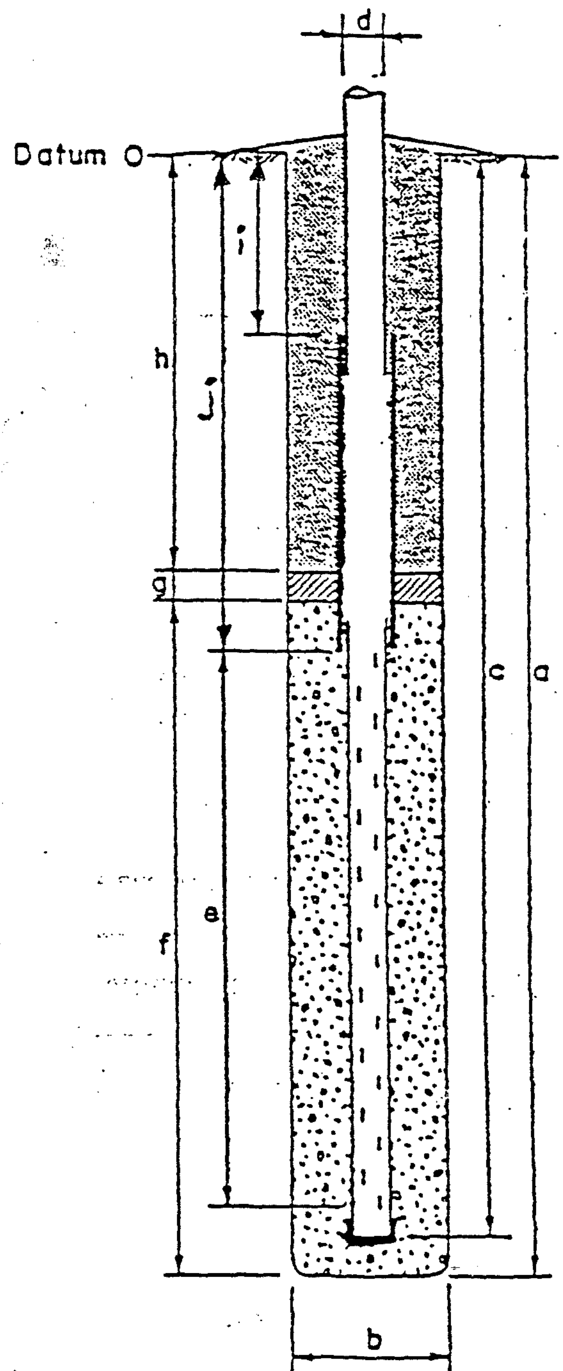
f. Permeable material interval 43.5 FT

g. Impermeable plug interval 2'

h. Backfill material interval 20 FT

i. Depth to Top of Slip/Settlement pipe 6 FT

j. " " Bottom " " " " 26 FT



II. MATERIALS:

Permeable material 3/4" TO 1 1/2" ROUN'D ROCK

Impermeable plug BENTONITE

Backfill material SILTY CLAY

Casing material (incl. slip joints) 6" & 8" PVC

III. CONSTRUCTION:

Method of placing fill materials: RUBBER TIRE LOADER

Method of placing casing: TRUCK MTD HYDRA CRANE

Problems encountered: NONE

TMX [illegible]-1550-01(5)

GAS WELL DRILLING LOG

WELL No. 16 Coords. N 11800 E 10375

Landfill name: MIDWAY LANDFILL GAS MIGRATION CONTROL Date 10/15, 16, 17/1985

Time drilling STARTED DRILLING 1:53 PM ON 10/15/85 AND COMPLETED 9:19 AM 10/17/85

DESCRIPTION OF DRILLING SPOILS:

Cover soil depth: 2.5 FT

Description of Spoils

2.5 FT TO 47 FT - PARTIALLY DECOMPOSED WOOD, PLASTIC, METAL, CLOTH, TIRES, IRON, ETC.

47 FT TO 50 FT - DAMP PARTIALLY DECOMPOSED WOOD

50 FT TO 52 FT - CLAY AND GRAVEL

52 FT TO 58 FT - WET PARTIALLY DECOMPOSED WOOD

58 FT TO 61 FT - CLAY WITH GRAVEL EMBEDDED

Total depth of well 61 FT (Diam. ~~24~~ 30")

DRILLING CONDITIONS

(Weather, obstructions, etc.) GOOD DRILLING CONDITIONS - NO OBSTRUCTIONS. INNER KELLY CABLE BROKE, OUTER KELLY WOULDN'T LOCK INNER KELLY BAR FOR A WHILE AFTER NEW CABLE WAS INSTALLED, BROKE 24-INCH BAILER BUCKET.

Drilling company DBM CONTRACTORS, INC

Drilling equipment HENDERSON LL 100,000 lb TRUCK MTD DRILL; 6" KELLY BAR

Operators names ~~CHUCK FENSTERMACKER~~ BOB WATSON, ~~MARVIN OLNEY~~ JOE SEITZ (OILER)

[illegible] P.E.

PMX#5-1550-07(3)

GAS WELL CONSTRUCTION LOG

WELL No. 16 Coord's N 11ECC E 10375

Landfill name: MIDWAY GAS MIGRATION ____ Date 10/17/85

I. DIMENSIONS:

a. Total depth of well 61 FT

b. Diameter of well ~~24"~~ 30"

c. Well casing interval 59 FT

d. Diameter of well casing 6"

e. Slotted interval of well casing from 24 FT to 59 FT

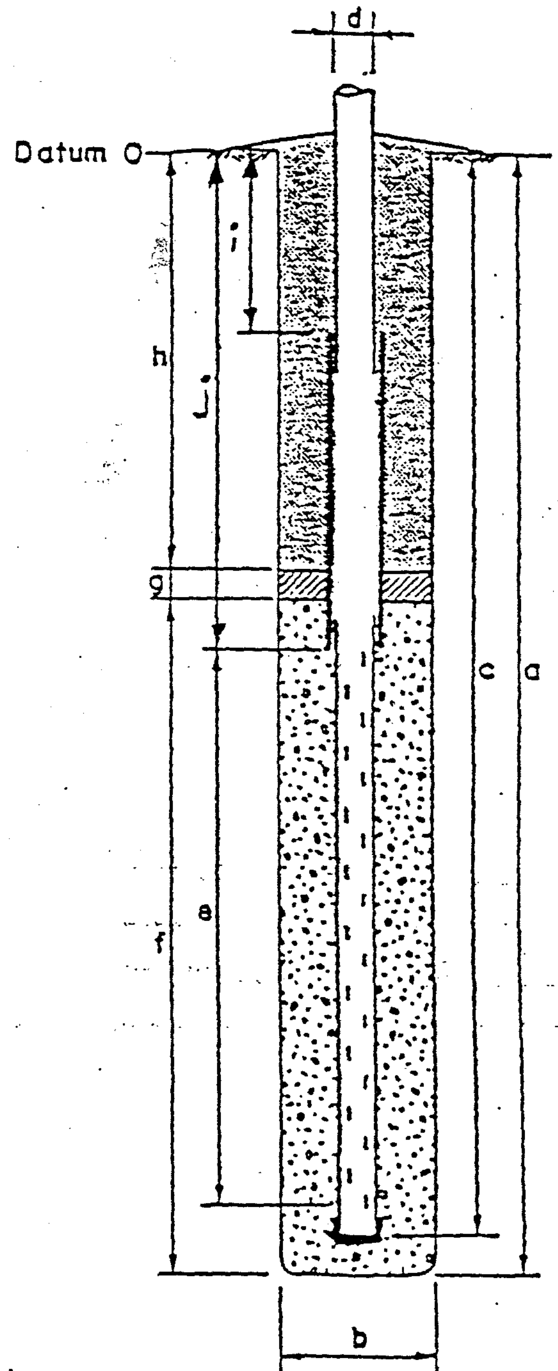
f. Permeable material interval 40 FT

g. Impermeable plug interval 2'

h. Backfill material interval 19 FT

i. Depth to Top of Slip/Settlement pipe 26 FT

j. " " Bottom " " " " 26 FT



II. MATERIALS:

Permeable material 3/4 TO 1 1/2 INCH ROUND ROCK

Impermeable plug BENTONITE

Backfill material SILTY CLAY

Casing material (incl. slip joints) 6" & 8" PVC

III. CONSTRUCTION:

Method of placing fill materials: RUBBER TIRE LOADER

Method of placing casing: TRUCK MTD HYDRA CRANE

Problems encountered: NONE

GAS WELL DRILLING LOG

WELL No. 17 Coords, N 16200 E 10150

Landfill name: MIDWAY LANDFILL GAS MIGRATION CONTROL Date 10/21/85

Time drilling STARTED DRILLING 10:01AM ON 10/17/85 AND COMPLETED 1:25PM ON 10/21/85

DESCRIPTION OF DRILLING SPOILS:

Cover soil depth: 2 FT. Description of Spoils

2-40 FT PARTIALLY DECOMPOSED WOOD, STEEL, TV WIRES, RUGS, TIRES, PLASTIC, ETC.
40-44 FT WOOD MIXED WITH SANDY CLAY.
44-48 FT LOTS OF CLOTH AND WOOD
48-49 FT SANDY GRAVEL
49-62 FT MOSTLY PARTIALLY DECOMPOSED WOOD WITH SOME TIRES, RAGS, PAPER, PLASTIC
62-63 FT GRAVEL
63-67 FT MOSTLY PARTIALLY DECOMPOSED WOOD WITH FISH NETS, TIRES, ETC. VERY LITTLE PLASTIC, PAPER OR CLOTH.
67-68 FT GRAVEL
68-79 FT PARTIALLY DECOMPOSED WOOD, FISH NETS, TIRES. - VERY WET AT 72 FT
79-80 FT GRAVEL & CLAY
80-84 FT PARTIALLY DECOMPOSED WOOD.
84-85 FT GRAVEL
85-90 FT. PARTIALLY DECOMPOSED WOOD
90-91 FT. SAND, GRAVEL & CLAY
91-95 FT PARTIALLY DECOMPOSED WOOD
95-97 FT SANDY GRAVEL BELLED OUT

Total depth of well 97 FT (Diam. ~~24~~ 30")

DRILLING CONDITIONS

(Weather, obstructions, etc.) PARTIALLY SUNNY WITH SOME SHOWERS. CONDITIONS GENERALLY GOOD.

Drilling company DBM CONTRACTORS, INC

Drilling equipment HENDERSON LL 100,000 lb TRUCK MTD DRILL; 6" KELLY BAR

Operators names CHUCK FENSTERMACKER, ~~MARVIN OLNEY~~ J. SEITZ (OILER)

[signature] P.E.

PMX # 5-1550-07(3)

GAS WELL CONSTRUCTION LOG

WELL No. 17 Coord's N 10200 E 11050

Landfill name: MIDWAY GAS MIGRATION ______ Date 10/21/85

I. DIMENSIONS:

a. Total depth of well 97 FT

b. Diameter of well ~~24"~~ 36"

c. Well casing interval 96 FT

d. Diameter of well casing 6"

e. Slotted interval of well casing from 26 FT to 96 FT

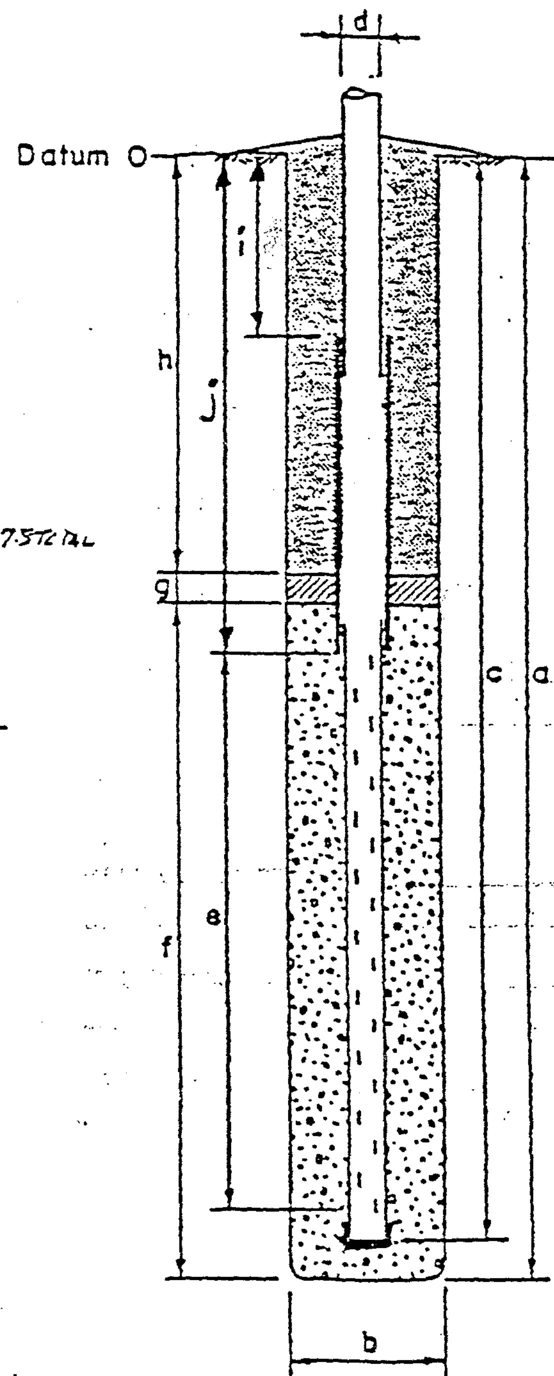
f. Permeable material interval 22 FT TO 97 FT - 75 TOTAL

g. Impermeable plug interval 2'

h. Backfill material interval 19 FT

i. Depth to Top of Slip/Settlement pipe 6.5 FT

j. " " Bottom " " " " 26.5



II. MATERIALS:

Permeable material 3/4" - 1 1/2" ROUND ROCK

Impermeable plug BENTONITE

Backfill material SILTY CLAY (TILL?)

Casing material (incl. slip joints) 6" & 8" PVC

III. CONSTRUCTION:

Method of placing fill materials: RUBBER TIRE LOADER

Method of placing casing: TRUCK MTD HYDRA CRANE

Problems encountered:

GAS WELL DRILLING LOG

WELL No. 20 Coords. N 10600 E 10295

Landfill name: MIDWAY LANDFILL GAS MIGRATION CONTROL Date 10/28/85

Time drilling STARTED DRILLING AT 7:55 AM ON 10/25/85 AND COMPLETED AT 1:40 PM ON 10/28/85

DESCRIPTION OF DRILLING SPOILS:

Cover soil depth: 2 FT

Description of Spoils

2-45 FT LOTS OF PARTIALLY DECOMPOSED WOOD, PAPER & PLASTIC WITH SOME TIRES, METAL, PIPES.
45-51 FT MOSTLY CLOTH WITH PARTIALLY DECOMPOSED WOOD
51-52 FT SANDY CLAY
52-58 FT PARTIALLY DECOMPOSED WOOD WITH SOME PLASTIC.
58-60 FT GRAVEL
60-63 FT PARTIALLY DECOMPOSED WOOD
63-64 FT CLAY/SAND/GRAVEL
64-72 FT WOOD (PARTIALLY DECOMPOSED) AND PAPER (WET TO WET)
72-77 FT WET PARTIALLY DECOMPOSED WOOD AND PAPER
77-78 FT SAND AND GRAVEL
78-88 FT MOSTLY PARTIALLY DECOMPOSED WOOD WITH SOME PAPER
88-90 FT PARTIALLY DECOMPOSED WOOD WITH LOTS OF PAPER
90-92.5 FT COARSE SAND THAT WAS BELLING OUT.

Total depth of well (Diam. 24")

DRILLING CONDITIONS

(Weather, obstructions, etc.)

Drilling company DBM CONTRACTORS, INC

Drilling equipment HENDERSON LL 100,000 lb TRUCK MTD DRILL; 6" KELLY BAR

Operators names CHUCK FENSTERMACKER, MARVINA OLNEY (OILER)

[signature] P.E.

PMX-93-1550-07(3)

GAS WELL CONSTRUCTION LOG

WELL No. 20 Coord's N 10600 E 10245

Landfill name: MIDWAY GAS MIGRATION Date 10/25/85

I. DIMENSIONS:

a. Total depth of well 92.5 FT

b. Diameter of well 24"

c. Well casing interval 91 FT

d. Diameter of well casing 6"

e. Slotted interval of well casing from 25 to 91 FT

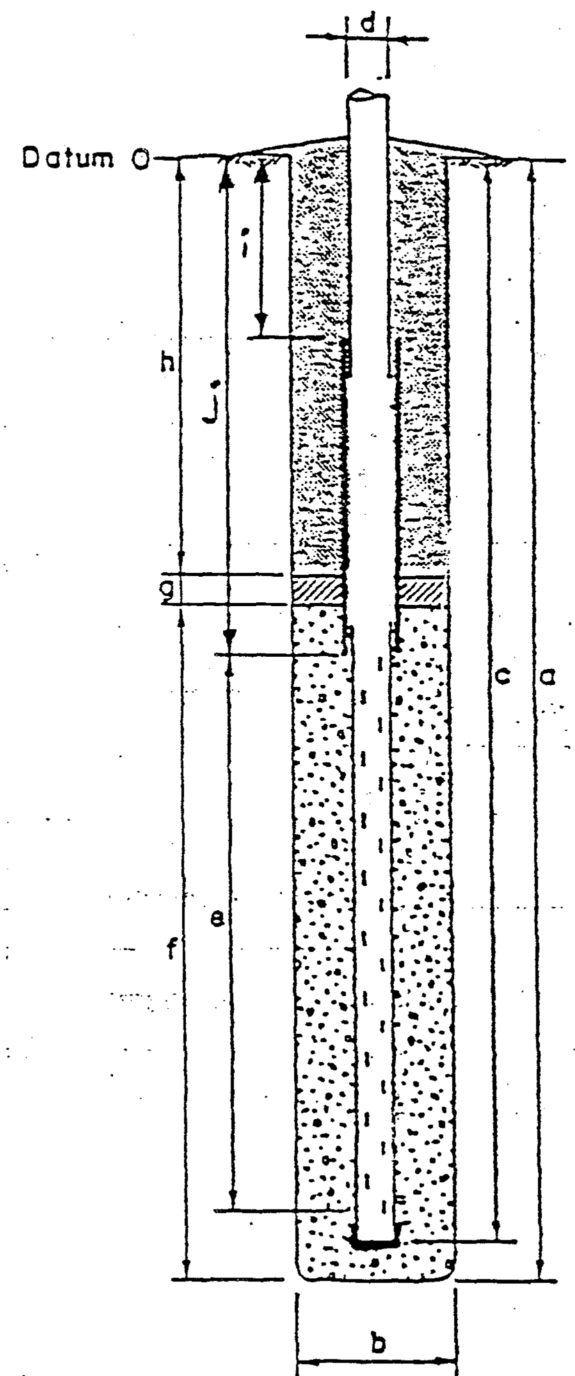
f. Permeable material interval 70.5 FT

g. Impermeable plug interval 2'

h. Backfill material interval 20 FT

i. Depth to Top of Slip/Settlement pipe 6

j. " " Bottom " " " " 26



II. MATERIALS:

Permeable material SILTY/CLAY (TILL?)

Impermeable plug BENTONITE

Backfill material 3/4 TO 1 1/2" ROUND ROCK

Casing material (incl. slip joints) 6" & 8" PVC

III. CONSTRUCTION:

Method of placing fill materials: RUBBER TIRE LOADER

Method of placing casing: TRUCK MTD HYDRA CRANE

Problems encountered: NONE

[illegible signature] PE

FMX 77-1550-01(5)

GAS WELL DRILLING LOG

WELL No. 21 Coords. N 10800 E 10340

Landfill name: MIDWAY LANDFILL GAS MIGRATION CONTROL Date 10/30/85

Time drilling STARTED DRILLING AT 3:25PM ON OCT 29, 1985 AND COMPLETED 3:35PM 10/30/85

DESCRIPTION OF DRILLING SPOILS:

Cover soil depth: 1FT

Description of Spoils

1-62 FT - MOSTLY PARTIALLY DECOMPOSED WOOD WITH SEVERAL TIRES, SOME PAPER, STEEL AND PLASTIC INTERMIXED - SOME ROCKS AND GRAVEL INTERMIXED

62-63 FT - SANDY GRAVEL

63-77 FT - [illegible] PARTIALLY DECOMPOSED WOOD WITH PAPER AND TIRES

72-95 FT WET PARTIALLY DECOMPOSED WOOD, PAPER, TIRES - PLASTK. METAL

95-97 FT SAND AND GRAVEL

97-101 FT CLAY (TILL?)

CONSIDERABLE AMOUNT OF METHANE ALARMS

Total depth of well 101 (Diam. ~~24"~~ 30")

DRILLING CONDITIONS

(Weather, obstructions, etc.) CLOUDY 10/29 AND SUNNY 10/30 - RAINED NIGHT 10/29 - EXTREMELY MUDDY CONDITIONS.

Drilling company DBM CONTRACTORS, INC

Drilling equipment HENDERSON LL 100,000 lb TRUCK MTD DRILL; 6" KELLY BAR

Operators names CHUCK FENSTERMACKER, ~~MARVIN OLNEY~~ JOE SEITZ (OILER)

PMX #55-1550-07 (3)

GAS WELL CONSTRUCTION LOG

WELL No. 21 Coord's N 10800 E 10340

Landfill name: MIDWAY GAS MIGRATION Date 10/31/85

I. DIMENSIONS:

a. Total depth of well 99 FT

b. Diameter of well 24"

c. Well casing interval 98 FT

d. Diameter of well casing 6"

e. Slotted interval of well casing from 25 FT to 98 FT

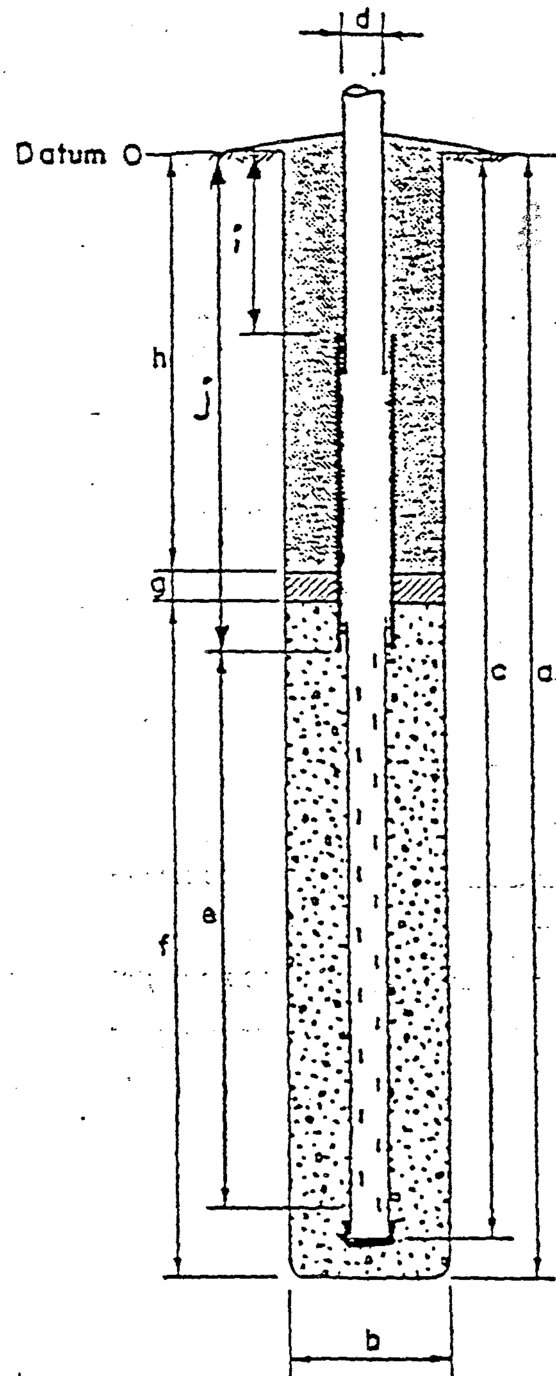
f. Permeable material interval 77 FT

g. Impermeable plug interval 2'

h. Backfill material interval 20 FT

i. Depth to Top of Slip/Settlement pipe 6 FT

j. " " Bottom " " " " 26 FT



II. MATERIALS:

Permeable material 3/4" to 1 1/2" ROUND ROCK

Impermeable plug BENTONITE

Backfill material SILTY/CLAY (TILL?)

Casing material (incl. slip joints) 6" & 8" PVC

III. CONSTRUCTION:

Method of placing fill materials: RUBBER TIRE LOADER

Method of placing casing: TRUCK MTD HYDRA CRANE

Problems encountered: NONE

GAS WELL DRILLING LOG

WELL No. 23 Coords. N 10150 E 9850

Landfill name: MIDWAY LANDFILL GAS MIGRATION CONTROL Date 11/4/85

Time drilling 3:15 PM ON 10/31/85 TO 8:25 AM 11/4/85

DESCRIPTION OF DRILLING SPOILS:

Cover soil depth: 2 FT

Description of Spoils

2 FT TO 21 FT - MOSTLY WOOD WITH SOME PAPER & PLASTIC

21 FT TO 48 FT - PARTIALLY DECOMPOSED WOOD WITH SOME TIRES PAPER & PLASTIC

48 FT TO 52 FT - VERY WET WITH SOME WATER - MOSTLY PARTIALLY DECOMPOSED WOOD

52 FT TO 62 FT - WET PARTIALLY DECOMPOSED WOOD WITH SOME PAPER & PLASTICS.

62 FT TO 72 FT - LARGE AMOUNT OF PARTIALLY DECOMPOSED PAPER AND WOOD

72 FT TO 79 FT - LARGE SIZED GRAVEL WITH SOME SAND.

79 FT - COULDN'T DRILL THOUGH AT THIS POINT - FINAL DEPTH

Total depth of well 79 FT (Diam. ~~24"~~ 30")

DRILLING CONDITIONS

(Weather, obstructions, etc.) MUDDY - WITH CLOUDS AND RAIN

Drilling company DBM CONTRACTORS, INC

Drilling equipment HENDERSON LL 100,000 lb TRUCK MTD DRILL; 6" KELLY BAR

Operators names CHUCK FENSTERMACKER, ~~MARVIN OLNEY~~ JOE SEITZ (OILER)

[illegible signature] PE

PMX #55-1550-07(3)

GAS WELL CONSTRUCTION LOG

WELL No. 23 Coord's N 10150 E 9850

Landfill name: MIDWAY GAS MIGRATION ________ Date 1/5/85

I. DIMENSIONS:

a. Total depth of well 78 FT

b. Diameter of well ~~24"~~ 30

c. Well casing interval 77 FT

d. Diameter of well casing 6"

e. Slotted interval of well casing from 19 FT to 77 FT

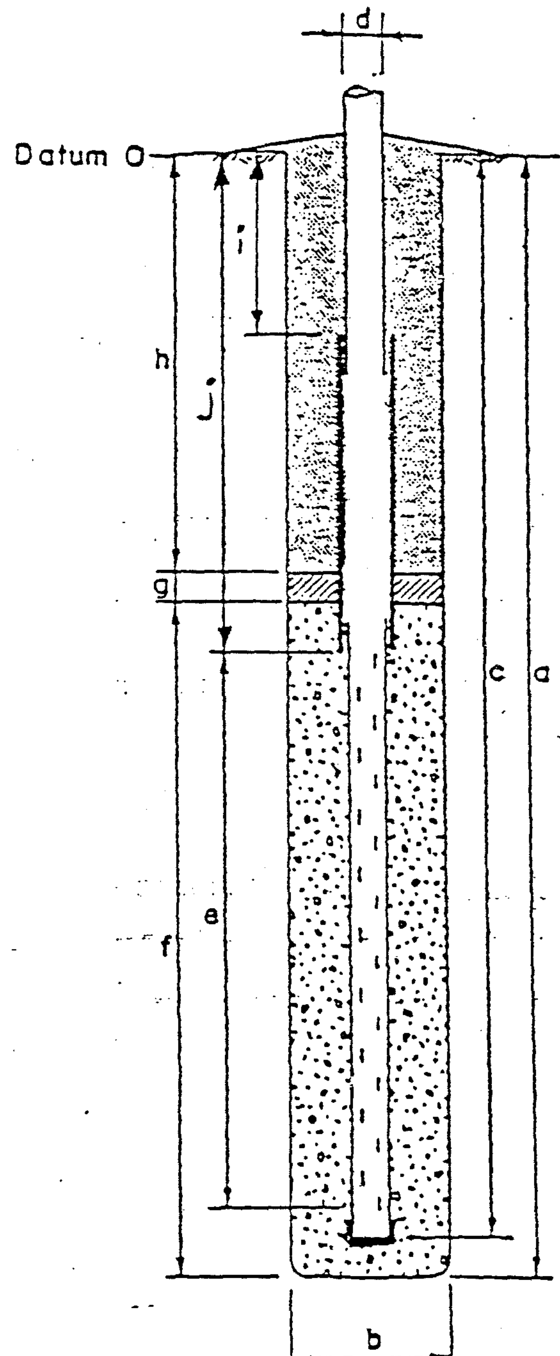
f. Permeable material interval 57 FT

g. Impermeable plug interval 2'

h. Backfill material interval 20 FT

i. Depth to Top of Slip/Settlement pipe 6 FT

j. " " Bottom " " " " 26 FT



II. MATERIALS:

Permeable material 1½" to ¾" ROUND ROCK

Impermeable plug BENTONITE

Backfill material SILTY CLAY

Casing material (incl. slip joints) 6" & 8" PVC

III. CONSTRUCTION:

Method of placing fill materials: RUBBER TIRE LOADER (CASE 580 BACKHOE)

Method of placing casing: TRUCK MTD HYDRA CRANE

Problems encountered: NONE.

IMX 11-1550-01(2)

GAS WELL DRILLING LOG

WELL No. 24 Coords. N 10150 E 9655

Landfill name: MIDWAY LANDFILL GAS MIGRATION CONTROL Date 11/4/85

Time drilling FROM 9:00 AM ON 11/4/85 TO 2:00 PM ON 11/4/85

DESCRIPTION OF DRILLING SPOILS:

Cover soil depth: 3 FT Description of Spoils

FROM 3 FT TO 57 - PARTIALLY DECOMPOSED WOOD, WIRE, PLASTIC & SOME PAPER.

57 FT TO 60.7 WET GRAVEL WITH WOOD INTERMIXED

VERY LITTLE METHANE SHOWING ON MONITOR.

Total depth of well 60.7 FT (Diam. 30" ~~24"~~)

DRILLING CONDITIONS

(Weather, obstructions, etc.) CLOUDY - AREA EXTREMELY WET AND MUDDY.

Drilling company DBM CONTRACTORS, INC

Drilling equipment HENDERSON LL 100,000 lb TRUCK MTD DRILL; 6" KELLY BAR

Operators names CHUCK FENSTERMACKER, JOE SEITZ ~~[illegible]~~ (OILER)

[signature] P.E.

PMX#55-1550-07(3)

GAS WELL CONSTRUCTION LOG

WELL No. 24 Coord's N 10150 E 9655

Landfill name: MIDWAY GAS MIGRATION Date 11/5/85

I. DIMENSIONS:

a. Total depth of well 58.5 FT

b. Diameter of well ~~24~~ 30

c. Well casing interval 57.5 FT

d. Diameter of well casing 6"

e. Slotted interval of well casing
from 23.5 FT to 57.5 FT

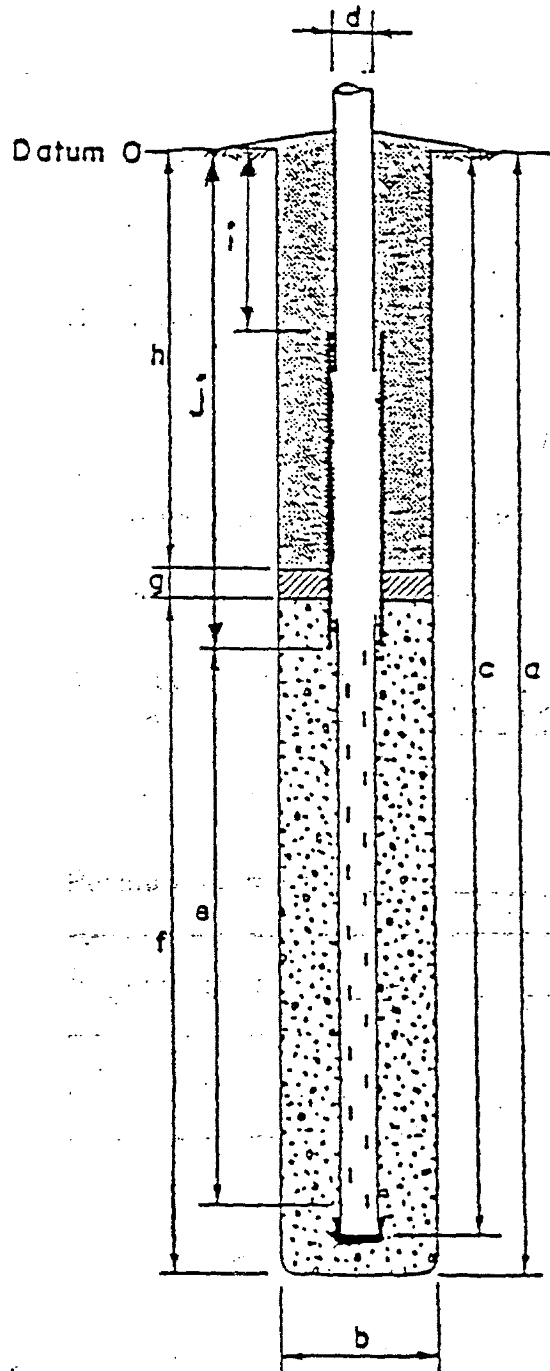
f. Permeable material interval 36.5 FT

g. Impermeable plug interval 2'

h. Backfill material interval 20 FT

i. Depth to Top of Slip/Settlement pipe 6 FT

j. " " Bottom " " " " 26 FT



II. MATERIALS:

Permeable material 3/4" to 1 1/2" ROUND Rock

Impermeable plug BENTONITE

Backfill material SILTY CLAY (TILL?)

Casing material (incl. slip joints) 6" & 8" PVC

III. CONSTRUCTION:

Method of placing fill materials: RUBBER TIRE LOADER

Method of placing casing: TRUCK MTD HYDRA CRANE

Problems encountered: NONE

MIA 77-1550-07(3)

GAS WELL DRILLING LOG

WELL No. 26 Coords. N 11500 E 10500

Landfill name: MIDWAY LANDFILL GAS MIGRATION CONTROL Date 11/6/85

Time drilling STARTED DRILLING AT 2:30PM 11/5/85 -- COMPLETED 1:38AM 11/6/85

DESCRIPTION OF DRILLING SPOILS:

Cover soil depth: 4 FT. Description of Spoils

4FT TO 42 FT PARTIALLY DECOMPOSED WOOD, SOME CABLE, WIRE, PLASTIC, PAPER ETC

42FT TO 43 FT GRAVEL/CLAY MIXTURE.

43FT TO 85 FT PARTIALLY DECOMPOSED WOOD WITH SOME PLASTIC, TIRES, PAPER ETC

85FT TO 87.5FT CLAY MATERIAL (TILL)

Total depth of well 87.5 FT. (Diam. ~~24~~ 30")

DRILLING CONDITIONS

(Weather, obstructions, etc.) COOL - MISTY TO RAIN - MUDDY.

Drilling company DBM CONTRACTORS, INC

illing equipment HENDERSON LL 100,000 lb TRUCK MTD DRILL; 6" KELLY BAR

Operators names CHUCK FENSTERMACKER, ~~MARVIN OLNEY~~ J. SEITZ (OILER)

[signature] PE

PMX #55-1550-07(3)

GAS WELL CONSTRUCTION LOG

WELL No. Z6 Coord's N 11500 E 10500

Landfill name: MIDWAY GAS MIGRATION — Date NOV 8, 1985

I. DIMENSIONS:

a. Total depth of well 80 FT

b. Diameter of well ~~24"~~ 30"

c. Well casing interval 79 FT

d. Diameter of well casing 6"

e. Slotted interval of well casing 55 FT
from 24 FT to 79 FT

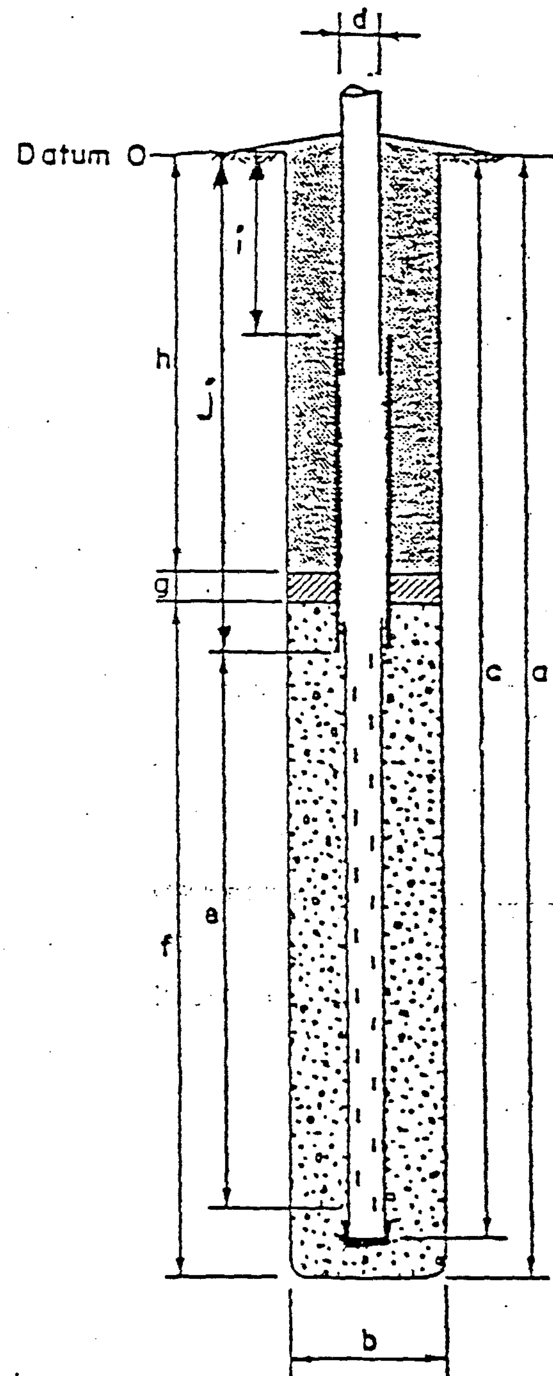
f. Permeable material interval 59

g. Impermeable plug interval 2'

h. Backfill material interval 19 FT

i. Depth to Top of Slip/Settlement pipe 6 FT

j. " " Bottom " " " " 26 F



II. MATERIALS:

Permeable material 3/4" to 1 1/2" Round Rock

Impermeable plug BENTONITE

Backfill material SILTY CLAY (TILL?)

Casing material (incl. slip joints) 6" & 8" PVC

III. CONSTRUCTION:

Method of placing fill materials: RUBBER TIRE LOADER

Method of placing casing: TRUCK MTD HYDRA CRANE

Problems encountered: NONE

TMX 1550-01(5)

GAS WELL DRILLING LOG

WELL No. 27 Coords. N 11650 E 10540

Landfill name: MIDWAY LANDFILL GAS MIGRATION CONTROL Date 11/7/85

Time drilling BEGAN DRILLING AT 2:10 PM 11/6/85 -- COMPLETED 1:30 PM 11/7/85

DESCRIPTION OF DRILLING SPOILS:

Cover soil depth: 2 FT

Description of Spoils

2 FT TO 78 FT -- MOSTLY PARTIALLY DECOMPOSED WOOD WITH PLASTIC, PAPER, METAL-ETC

78 FT TO 86 FT -- FROM HAULED IN CLAY LIKE MATERIAL TO NATURAL GROUND AT 86 FT

Total depth of well 86 FT (Diam: ~~24~~ 30")

DRILLING CONDITIONS

(Weather, obstructions, etc.) RAIN - EXTREMELY MUDDY

Drilling company DBM CONTRACTORS, INC

Drilling equipment HENDERSON LL 100,000 lb TRUCK MTD DRILL, 6" KELLY BAR

Operators names CHUCK FENSTERMACKER, ~~MARVIN OLNEY~~ JOE SEITZ (OILER)

PE

PMX #~~55~~-1550-07(3)

GAS WELL CONSTRUCTION LOG

WELL No. WELL #27 Coord's N 11650 E 10590

Landfill name: MIDWAY GAS MIGRATION Date NOV 5, 1985

I. DIMENSIONS:

a. Total depth of well 80 FT

b. Diameter of well ~~24"~~ 30"

c. Well casing interval 79 FT

d. Diameter of well casing 6"

e. Slotted interval of well casing 55 FT from 24 FT to 79 FT

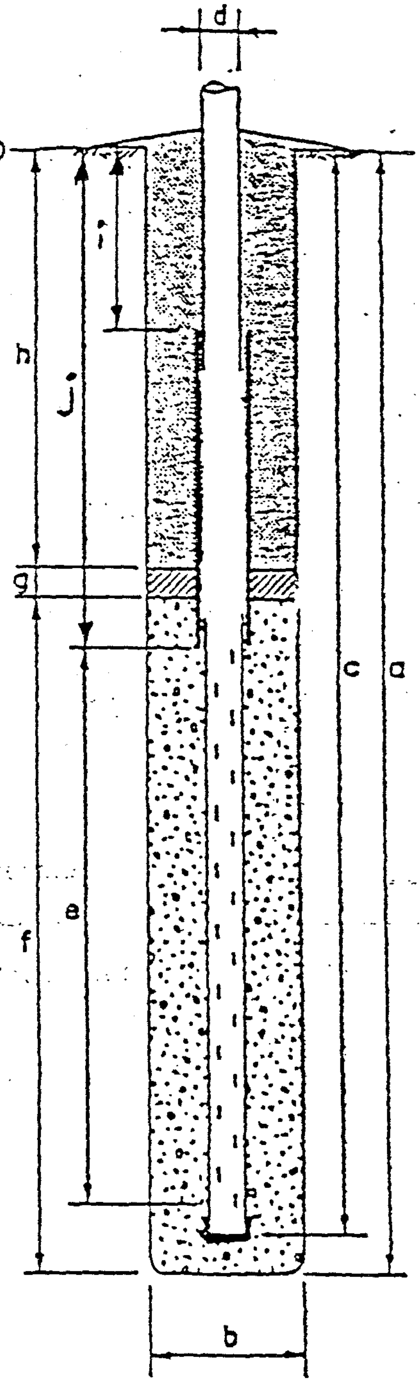
f. Permeable material interval 59 FT

g. Impermeable plug interval 2'

h. Backfill material interval 20 FT

i. Depth to Top of Slip/Settlement pipe 6 FT

j. " " Bottom " " " " 26 FT



II. MATERIALS:

Permeable material 1 1/2" to 3/4" ROUND ROCK

Impermeable plug BENTONITE

Backfill material SILTY-CLAY (TILL)

Casing material (incl. slip joints) 6" & 8" PVC

III. CONSTRUCTION:

Method of placing fill materials: RUBBER TIRE LOADER

Method of placing casing: TRUCK MTD HYDRA CRANE

Problems encountered: NONE

GAS WELL DRILLING LOG

WELL No. 29 Coords. N 10900 E 10380

Landfill name: MIDWAY LANDFILL GAS MIGRATION CONTROL Date 11/12/85

Time drilling FROM 1:55 PM 11/8/85 TO 12:00 C 11/11/85

DESCRIPTION OF DRILLING SPOILS:

Cover soil depth: 6 FT

Description of Spoils

6 FT TO 85 FT - WOOD, PAPER, PLASTIC, TIRES ~~METAL~~ -- MOSTLY PARTLY DECOMPOSED WOOD,

85 FT TO 87 FT - CLAY/GRAVEL

Total depth of well 87 FT (Diam. ~~24~~ 30")

DRILLING CONDITIONS

(Weather, obstructions, etc.) MUDDY - FROM CLOUDY TO CLEAR AND COLD - FREEZING

Drilling company DBM CONTRACTORS, INC

Drilling equipment HENDERSON LL 100,000 lb TRUCK MTD DRILL, 6" KELLY BAR

Operators names CHUCK FENSTERMACKER, ~~[illegible]~~ JOE SEITZ (OILER)

[illegible signature] P.E.

FMX-T??-1550-07(3)

GAS WELL CONSTRUCTION LOG

WELL No. 29 Coord's N 10900 E 10380

Landfill name: MIDWAY GAS MIGRATION ______ Date NOV 11, 1985

I. DIMENSIONS:

a. Total depth of well 87 FT

b. Diameter of well ~~24"~~ 30"

c. Well casing interval 86 FT

d. Diameter of well casing 6"

e. Slotted interval of well casing 63 FT
from 24 FT to 87 FT

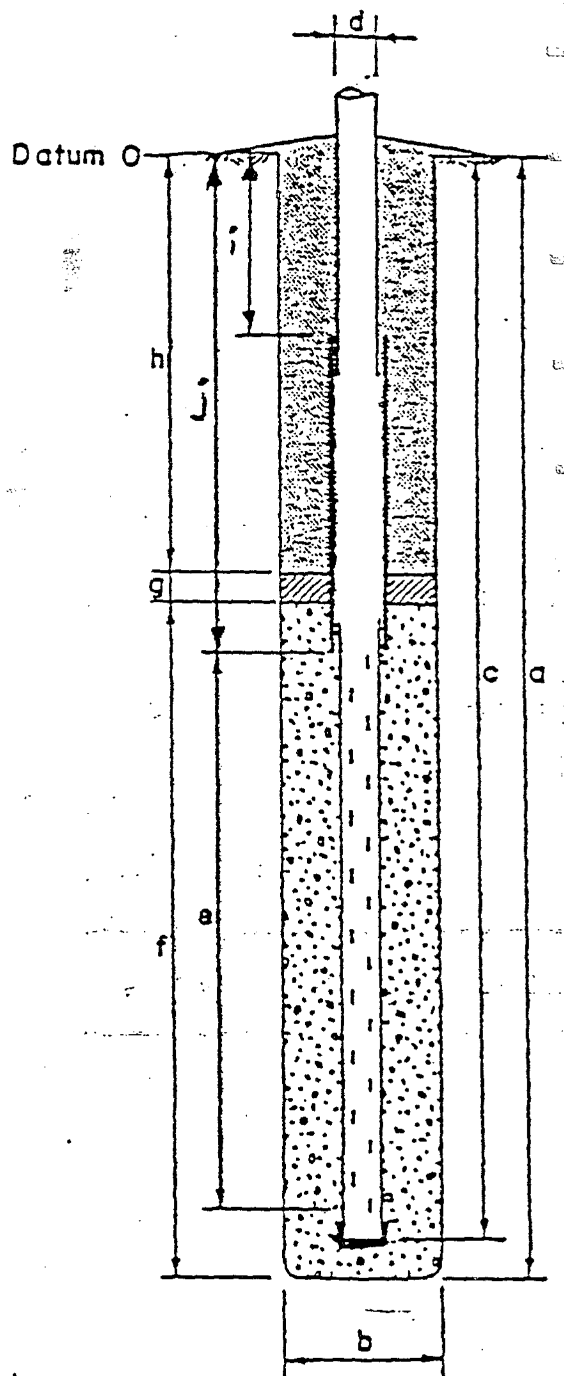
f. Permeable material interval 64 FT

g. Impermeable plug interval 2'

h. Backfill material interval 19 FT

i. Depth to Top of Slip/Settlement pipe 6 FT

j. " " Bottom " " " " 26 FT



II. MATERIALS:

Permeable material 3/4" to 1 1/2" ROUND ROCK

Impermeable plug BENTONITE

Backfill material SILTY CLAY (TILL?)

Casing material (incl. slip joints) 6" & 8" PVC

III. CONSTRUCTION:

Method of placing fill materials: RUBBER TIRE LOADER

Method of placing casing: TRUCK MTD HYDRA CRANE

Problems encountered: NONE

GAS WELL DRILLING LOG

WELL No. 30 Coords, N 10500 E 9550

Landfill name: MIDWAY LANDFILL GAS MIGRATION CONTROL Date 11/12/85

Time drilling FROM 1:00PM± TO 10:00 AM 11/12/85

DESCRIPTION OF DRILLING SPOILS:

Cover soil depth: 2 FT Description of Spoils

2 FT TO 50 FT - PARTIALLY DECOMPOSED WOOD, PAPER, PLASTIC, ETC. (DRY TO SOFT)

50 FT - - - - - - - - HIT SOMETHING VERY HARD - COULDN'T PENETRATE - - ANTICIPATED HITTING CLAY AT 53 FT ± - ACCEPTED SOFT.

Total depth of well 50 FT (Diam. ~~24~~ 30")

DRILLING CONDITIONS

(Weather, obstructions, etc.)

Drilling company DBM CONTRACTORS, INC

Drilling equipment HENDERSON LL 100,000 lb TRUCK MTD DRILL; 6" KELLY BAR

Operators names CHUCK FENSTERMACKER, ~~[illegible]~~ JOE SEITZ (OILER)

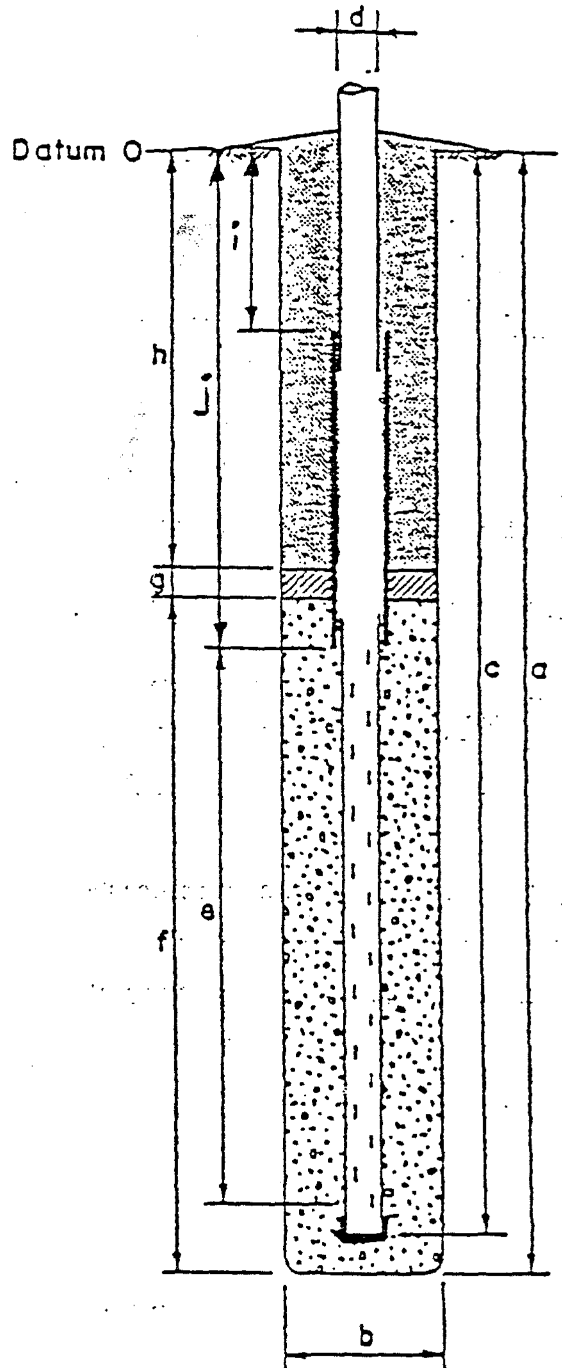
[signature] PE

PMX #~~55~~-1550-07(3)

GAS WELL CONSTRUCTION LOG

WELL. No. 30 Coord's N 10500 E 9550

Landfill name: MIDWAY GAS MIGRATION Date NOV 12, 1985



I. DIMENSIONS:

a. Total depth of well 50 FT

b. Diameter of well ~~24"~~ 30"

c. Well casing interval 49 FT

d. Diameter of well casing 6"

e. Slotted interval of well casing 26 FT
from 23 FT to 49 FT

f. Permeable material interval 27 FT

g. Impermeable plug interval 2'

h. Backfill material interval 21 FT

i. Depth to Top of Slip/Settlement pipe 6 FT

j. " " Bottom " " " " 26 FT

II. MATERIALS:

Permeable material 3/4" TO 1 1/2" ROUND ROCK

Impermeable plug BENTONITE

Backfill material SILTY CLAY

Casing material (incl. slip joints) 6" & 8" PVC

III. CONSTRUCTION:

Method of placing fill materials: RUBBER TIRE LOADER

Method of placing casing: TRUCK MTD HYDRA CRANE

Problems encountered: NONE

[illegible signature] P.E.

11-1250-07(3)

GAS WELL DRILLING LOG

WELL No. 31 Coords. N 10300 E 9605

Landfill name: MIDWAY LANDFILL GAS MIGRATION CONTROL Date 11/13/85

Time drilling FROM 10:25 AM 11/12/85 TO 1:55 PM 11/13/85

DESCRIPTION OF DRILLING SPOILS:

Cover soil depth: 2 FT Description of Spoils

2 FT TO 75 FT. PARTIALLY DECOMPOSED WOOD WITH SOME PAPER, TIRES, PLASTIC, ETC.

75 FT TO 76.4 FT SANDY GRAVEL

76.4 - SOMETHING EXTREMELY HARD.

Total depth of well (Diam. ~~24~~ 30")

DRILLING CONDITIONS

(Weather, obstructions, etc.)

Drilling company DBM CONTRACTORS, INC

Drilling equipment HENDERSON LL 100,000 lb TRUCK MTD DRILL; 6" KELLY BAR

Operators names CHUCK FENSTERMACKER, ~~MARVIN OLNEY~~ JOE SEITZ (OILER)

6-23 ... 85

PMX #55-1550-07(3)

GAS WELL CONSTRUCTION LOG

WELL No. 31 Coord's N 10300 E 9605

Landfill name: MIDWAY GAS MIGRATION Date NOV. 13, 1985

I. DIMENSIONS:

a. Total depth of well 76.4 FT

b. Diameter of well 24"

c. Well casing interval 75 1/2 FT

d. Diameter of well casing 6"

e. Slotted interval of well casing 50 FT
from 25 1/2 FT to 75 1/2 FT

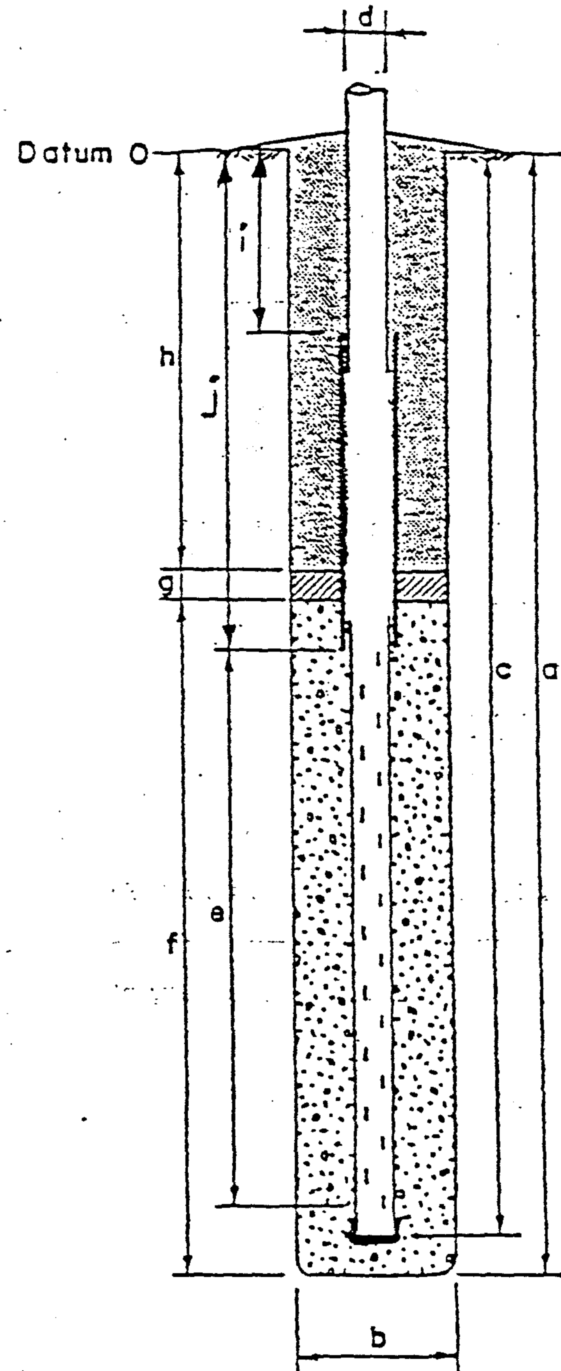
f. Permeable material interval 54 1/2 FT

g. Impermeable plug interval 2'

h. Backfill material interval 20 FT

i. Depth to Top of Slip/Settlement pipe 6 FT

j. " " Bottom " " " " 26 FT



II. MATERIALS:

Permeable material 3/4" to 1 1/2" ROUND ROCK

Impermeable plug BENTONITE

Backfill material SILTY CLAY (TILL?)

Casing material (incl. slip joints) 6" & 8" PVC

III. CONSTRUCTION:

Method of placing fill materials: RUBBER TIRE LOADER

Method of placing casing: TRUCK MTD HYDRA CRANE

Problems encountered: NONE

GHS WELL DRILLING LOG

WELL No. 32 Coords. N 10700 E 9525

Landfill name: MIDWAY LANDFILL GAS MIGRATION CONTROL Date 11/18/85

Time drilling BEGAN DRILLING 7:55 AM 11/18/85 -- COMPLETED 10:00 AM 11/18/85

DESCRIPTION OF DRILLING SPOILS:

Cover soil depth: 1 FT Description of Spoils

1 FT TO 14 FT - MOSTLY PARTIALLY DECOMPOSED CLOTH, PAPER & PLASTIC WITH SOME WOOD

14 FT TO 15 FT - CLAY/GRAVEL MIXTURE

15 FT TO 29 FT - PARTIALLY DECOMPOSED WOOD WITH SOME PAPER, PLASTIC, METAL, ETC.

29 FT - - WATER - PERCHED TABLE - DRY BELOW

29 FT - 38 FT - PARTIALLY DECOMPOSED WOOD WITH SOME PAPER, PLASTIC, METAL, ETC.

38 FT - 39 FT - CLAY/GRAVEL MIXTURE

39 FT - 79 FT - MOSTLY PARTIALLY DECOMPOSED WOOD

79 FT - 81 FT - MOSTLY TIRES

Total depth of well 81 FT (Diam. 30" ~~24"~~)

DRILLING CONDITIONS

(Weather, obstructions, etc.) CLEAR - SITE FROZEN & MUDDY UNDERNEATH.

Drilling company DBM CONTRACTORS, INC

Drilling equipment HENDERSON LL 100,000 lb TRUCK MTD DRILL; 6" KELLY BAR

Operators names CHUCK FENSTERMACKER, JOE SEITZ ~~[illegible]~~ (OILER)

[illegible] P.E.

PMX #55-1550-07(3)

GAS WELL CONSTRUCTION LOG

WELL No. 32 Coord's N 10700 E 9525

Landfill name: MIDWAY GAS MIGRATION Date NOV 18, 1955

I. DIMENSIONS:

a. Total depth of well 81 FT

b. Diameter of well ~~24"~~ 30"

c. Well casing interval 80 FT

d. Diameter of well casing 6"

e. Slotted interval of well casing 56 FT
from 24 FT to 80 FT

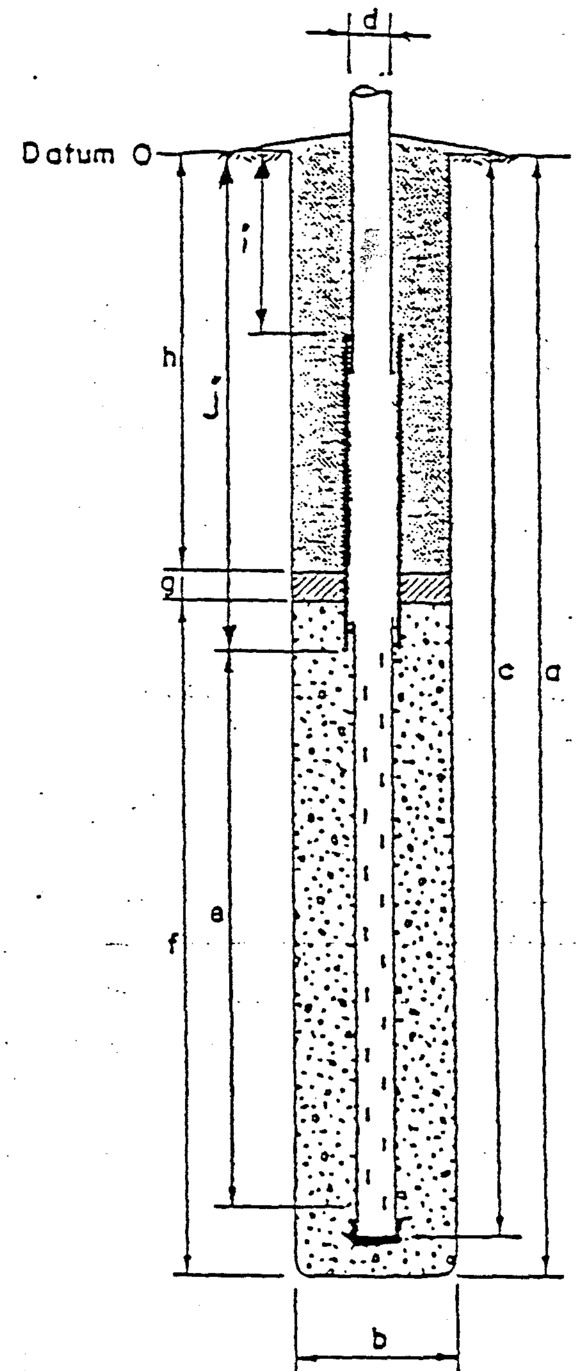
f. Permeable material interval 59 FT

g. Impermeable plug interval 2'

h. Backfill material interval 20 FT

i. Depth to Top of Slip/Settlement pipe 6 FT

j. " " Bottom " " " " 26 FT



II. MATERIALS:

Permeable material 3/4" TO 1 1/2" ROUND ROCK

Impermeable plug BENTONITE

Backfill material SILTY/CLAY (FILL?)

Casing material (incl. slip joints) 6" & 8" PVC

III. CONSTRUCTION:

Method of placing fill materials: RUBBER TIRE LOADER

Method of placing casing: TRUCK MTD HYDRA CRANE

Problems encountered: NONE

PMX # 55-1550-07(3)

GAS WELL DRILLING LOG

WELL No. 33 Coords. N 10900 E 9525

Landfill name: MIDWAY LANDFILL GAS MIGRATION CONTROL Date 11/19/85

Time drilling STARTED DRILLING 10:25 11/19/85 - - COMPLETED 2:30 PM 11/19/85

DESCRIPTION OF DRILLING SPOILS:

Cover soil depth: 1 FT

Description of Spoils

1 FT TO 35 FT MOSTLY RAGS, PLASTIC, WOOD WITH SOME CONCRETE AND TIRES

35 FT TO 36 FT CLAY (TILL?)

36 FT TO 80 FT MOSTLY PARTIALLY DECOMPOSED WOOD WITH SOME PAPER, CLOTH, PLASTIC, METAL ETC.

80 FT - CLAY (TILL?)

Total depth of well 80 FT (Diam. ~~24~~ 30")

DRILLING CONDITIONS

(Weather, obstructions, etc.) SNOW - COLD - MUDDY

Drilling company DBM CONTRACTORS, INC

Drilling equipment HENDERSON LL 100,000 lb TRUCK MTD DRILL, 6" KELLY BAR

Operators names CHUCK FENSTERMACKER, ~~[illegible]EY~~ JOE SEITZ (OILER)

[illegible signature] P.E.

PMX #55-1550-07(3)

GAS WELL CONSTRUCTION LOG

WELL No.: 53 Coord's N 10900 E 9525

Landfill name: MIDWAY GAS MIGRATION Date 12/4/55

I. DIMENSIONS:

a. Total depth of well 67 FT

b. Diameter of well ~~24"~~ 30"

c. Well casing interval 66 FT

d. Diameter of well casing 6"

e. Slotted interval of well casing 42 FT
from 24 FT to 66 FT

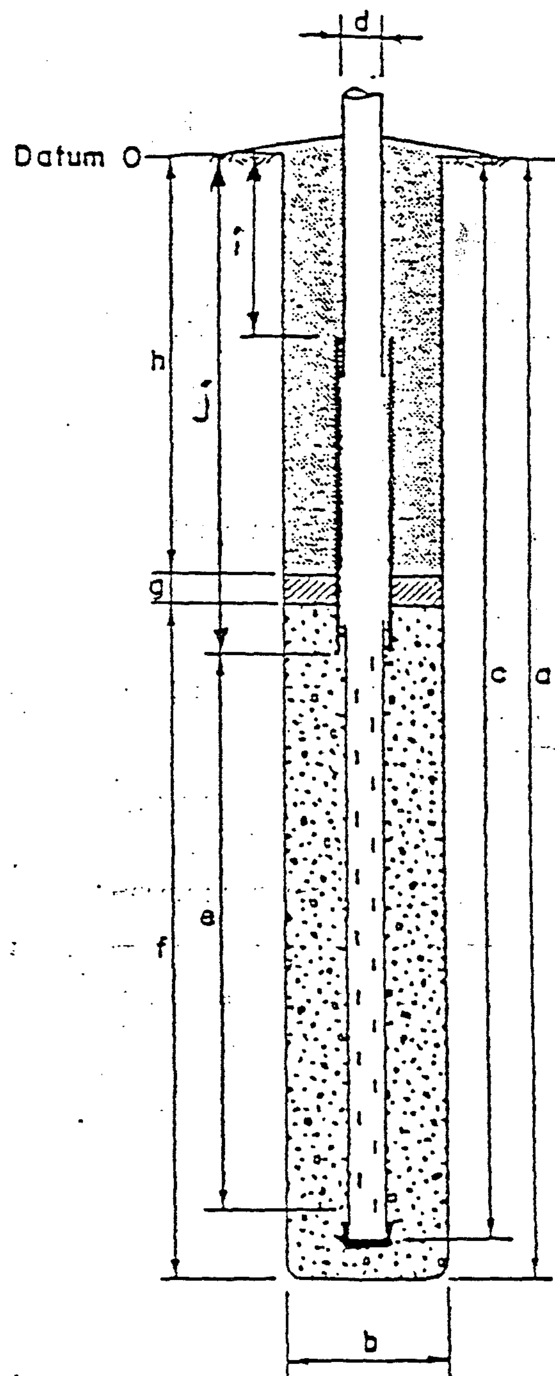
f. Permeable material interval 45 FT

g. Impermeable plug interval 2'

h. Backfill material interval 20 FT

i. Depth to Top of Slip/Settlement pipe 6 FT

j. " " Bottom " " " " 26 FT



II. MATERIALS:

Permeable material 3/4" to 1 1/2" ROUND ROCK

Impermeable plug BENTONITE

Backfill material SILTY CLAY (TILL?)

Casing material (incl. slip joints) 6" & 8" PVC

III. CONSTRUCTION:

Method of placing fill materials: RUBBER TIRE LOADER

Method of placing casing: TRUCK MTD HYDRA CRANE

Problems encountered: NONE

[signature] P.E.

PHX 31-1550-14 (18)

GAS WELL CONSTRUCTION LOG

WELL No. 38 Coords N10330.2 E. 9864.3

Landfill name: MIDWAY GAS MIGRATION - PHASE II Date ________

I. DIMENSIONS:

a. Total depth of well 112'

b. Diameter of well 24"
LOWER FROM 0 TO 110'
UPPER FROM 0 TO 56'

c. Well casing interval ________

d. Diameter of well casing 6" & 8"

e. Slotted interval of well casing ________
Lower from 68' to 110'
Upper from 26' to 56'

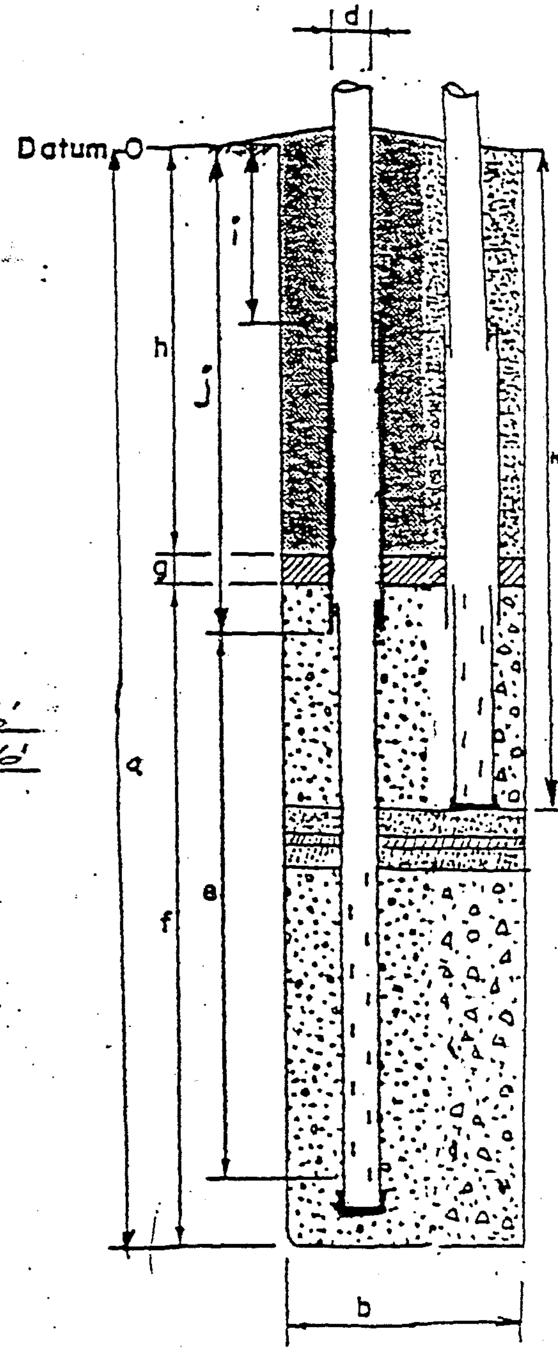
f. Permeable material interval ________
LOWER FROM 64' TO 112'
UPPER FROM 22' TO 58'

g. Impermeable plug interval 2'

h. Backfill material interval 19'

i. Depth to top of slip/settlement pipe 6'

j. " " bottom " " " 26'



II. MATERIALS:

Permeable material 1¼" WASHED ROCK

Impermeable plug BENTONITE

Backfill material SILTY CLAY

Casing material (incl. slip joints) SCH. 40 PVC (6" & 8" DIA.)

III. CONSTRUCTION:

Method of placing fill materials: CAT 931 B TRACK LOADER

Method of placing casing: 80 TON 'LIMA' CRANE W/ 130' TOWER

Problems encountered: ________

GAS WELL DRILLING LOG

WELL No. 38 COORDS N 10330.2 E 9864.3

Landfill name: MIDWAY GAS MIGRATION - PHASE II Date

Time drilling TWO (2) DAYS

DESCRIPTION OF DRILLING SPOILS:

Cover soil depth:	Description
0 - 3'	SILTY CLAY COVER MATERIAL
3' - 112'	REFUSE (WOOD, PLASTIC, PAPER, ETC.)
112'	GLACIAL TILL, FINE SILT

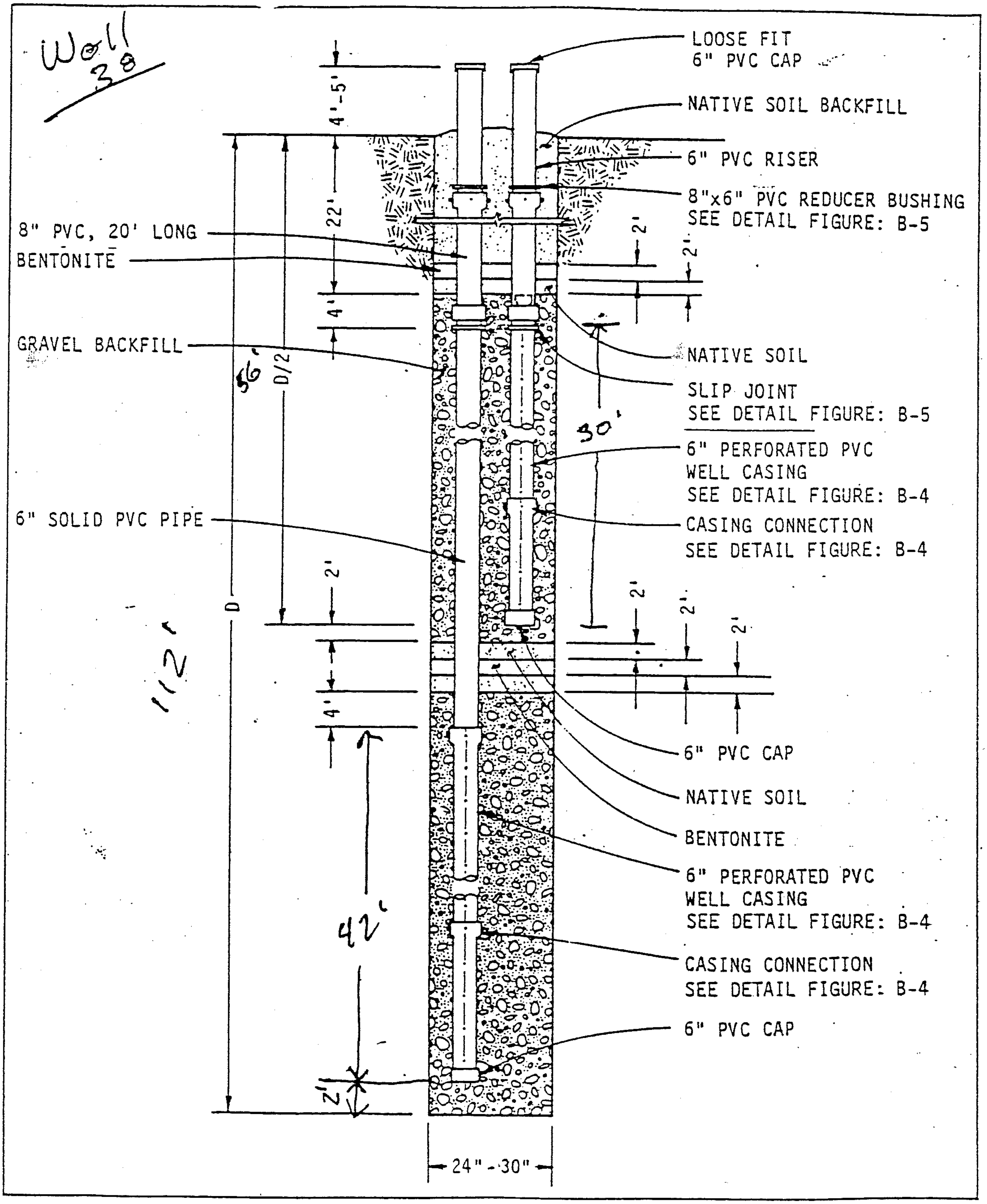
Total depth of well 112' (Diam. 24")

DRILLING CONDITIONS
(Weather, obstructions, etc.) WET & MUDDY

Drilling company DON H. MAHAFFEY DRILLING CO.

Drilling equipment 80 TON 'LIMA' CRANE W/5000 'WATSON' DRILL MOTOR

Operators names JON VIRDELL, DRILLER; RANDY VIRDELL, OILER



WELL 38

FIGURE B-3:
MIDWAY LANDFILL
PHASE II
VERTICAL WELL DETAIL

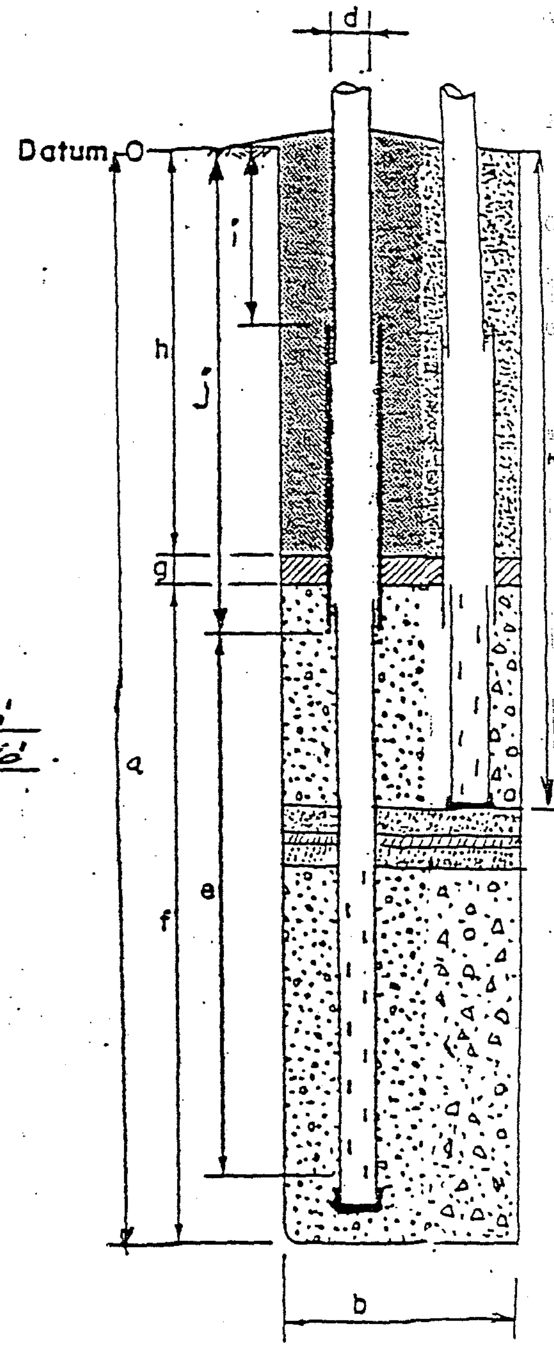
PHX 31-1550-14 (18)

GAS WELL CONSTRUCTION LOG

WELL No. 39 Coords N ~~10071~~ 10392.4 E ~~33~~ 10071.4

Landfill name: MIDWAY GAS MIGRATION - PHASE II Date 12-22-86

I. DIMENSIONS:



a. Total depth of well 128'

b. Diameter of well 24"

c. Well casing interval

d. Diameter of well casing 6" & 8"

e. Slotted interval of well casing
Lower from 76' to 126'
Upper from 26' to 64'

f. Permeable material interval 56'

g. Impermeable plug interval 2'

h. Backfill material interval 18'

i. Depth to top of slip/settlement pipe 6'

j. " " bottom " / " " 26'

II. MATERIALS:

Permeable material 1¼" WASHED ROCK

Impermeable plug BENTONITE

Backfill material SILTY CLAY

Casing material (incl. slip joints) SCH. 40 PVC (6" & 8" DIA.)

III. CONSTRUCTION:

Method of placing fill materials: CAT 931 B TRACK LOADER

Method of placing casing: 80 TON 'LIMA' CRANE w/130' TOWER

Problems encountered:

GAS WELL DRILLING LOG

WELL No. 39 COORDS N ~~[illegible]~~ 10392.4 E ~~[illegible]~~ 10071.4

Landfill name: MIDWAY LANDFILL GAS CONTROL Date 12-22-86

Time drilling & COMPLETION 1.5 DAYS

DESCRIPTION OF DRILLING SPOILS:

Cover soil depth:	Description
0 - 3'	SILTY CLAY COVER MATERIAL
3' - 47'	PARTIALY DECOMPOSED WOOD (80%), PLASTIC, PAPER, WIRE, TIN, ETC. (DRY MATERIAL)
47' - 128'	MOSTLY PARTIALY DECOMPOSED WOOD AND WATER.
128'	SILTY CLAY W/ COBLES AND GRAVEL

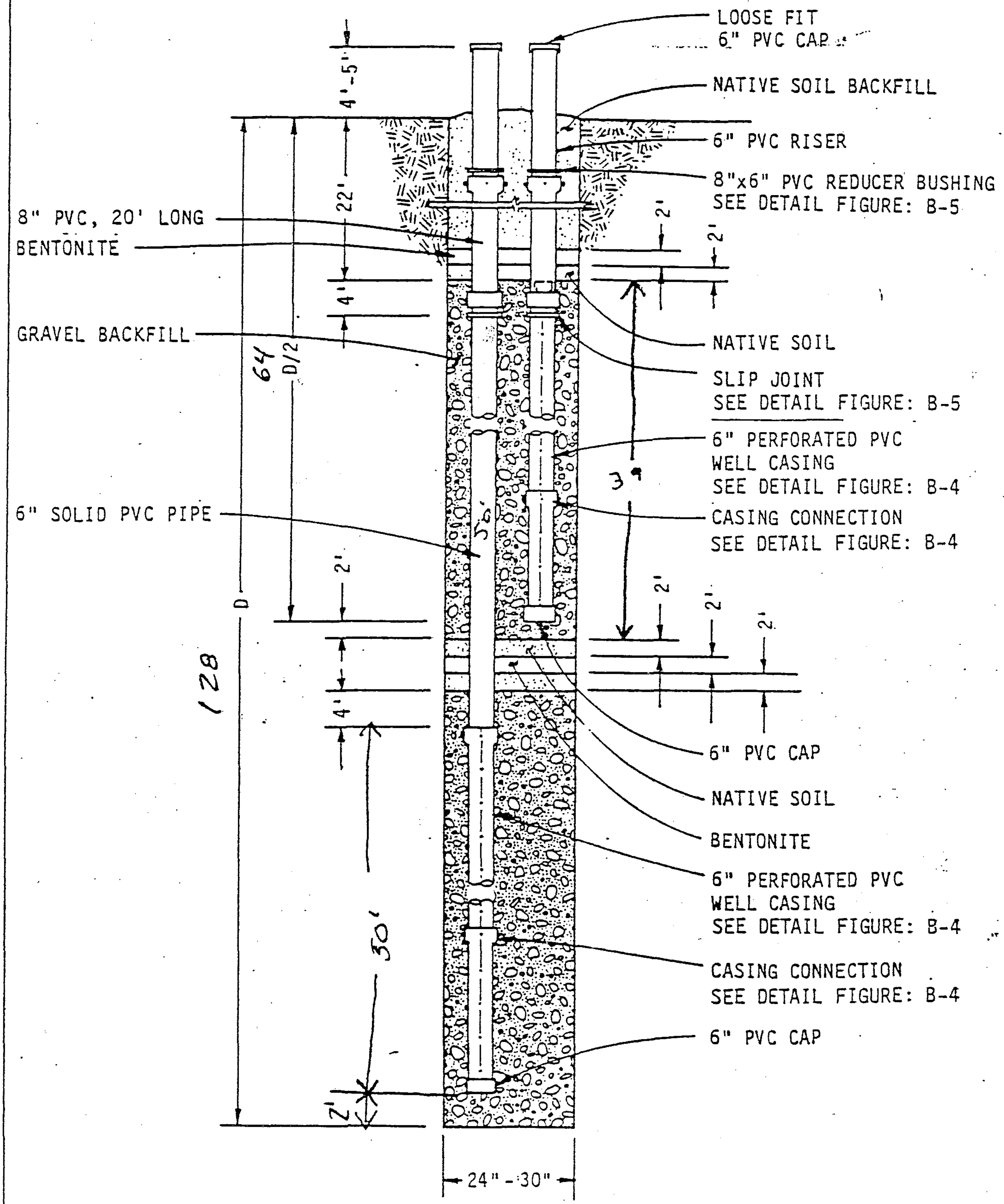
Total depth of well 128' (Diam. 24")

DRILLING CONDITIONS
(Weather, obstructions, etc.) WET & MUDDY, HEAVY RAIN

Drilling company DON H. MAHAFFEY DRILLING CO.

Drilling equipment 80 TON 'LIMA' CRANE W/ ~~120 TOWER~~ 5000 'WATSON' DRILL

Operators names JON VIRDELL, DRILLER; RANDY VIRDELL, OILER



WELL 39

FIGURE B-3:
MIDWAY LANDFILL
PHASE II
VERTICAL WELL DETAIL

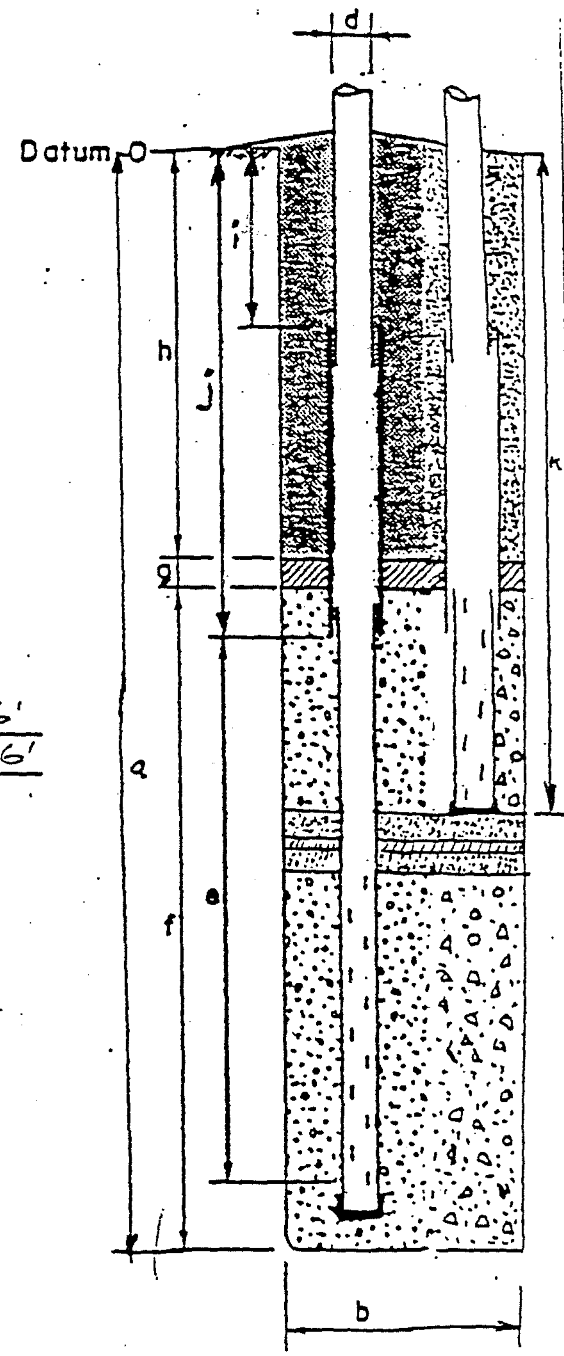
PHX 31-1550-14 (18)

GAS WELL CONSTRUCTION LOG

WELL No. 40 Coords N10588.3 E10043.0

Landfill name: MIDWAY GAS MIGRATION - PHASE II Date ______

I. DIMENSIONS:



a. Total depth of well 128'

b. Diameter of well 24"

LOWER FROM 0 TO 126'
UPPER FROM 0 TO 64'

c. Well casing interval ______

d. Diameter of well casing 24"

e. Slotted interval of well casing ______

Lower from 76' to 126'
Upper from 26' to 64'

f. Permeable material interval ______

LOWER FROM 72' TO 128'
UPPER FROM 22' TO 66'

g. Impermeable plug interval 2'

h. Backfill material interval 19'

i. Depth to top of slip/settlement pipe 6'

j. " " bottom " " " 26'

II. MATERIALS:

Permeable material 1¼" WASHED ROCK

Impermeable plug BENTONITE

Backfill material SILTY CLAY

Casing material (incl. slip joints) SCH. 40 PVC. (6" & 8" DIA.)

III. CONSTRUCTION:

Method of placing fill materials: CAT 931 B TRACK LOADER

Method of placing casing: 80 TON 'LIMA' CRANE W/ 130' TOWER

Problems encountered: ______

GAS WELL DRILLING LOG

WELL No. 40 COORDS N 10558.3 E 10043.0

Landfill name: MIDWAY GAS MIGRATION - PHASE II Date

Time drilling THREE (3) DAYS

DESCRIPTION OF DRILLING SPOILS:

Cover soil depth:	Description
0-3'	SILTY CLAY COVER MATERIAL
3' - 128'	REFUSE (WOOD, PLASTIC, PAPER, ETC.)
128'	GLACIAL TILL, FINE SILT

Total depth of well 128' (Diam. 24")

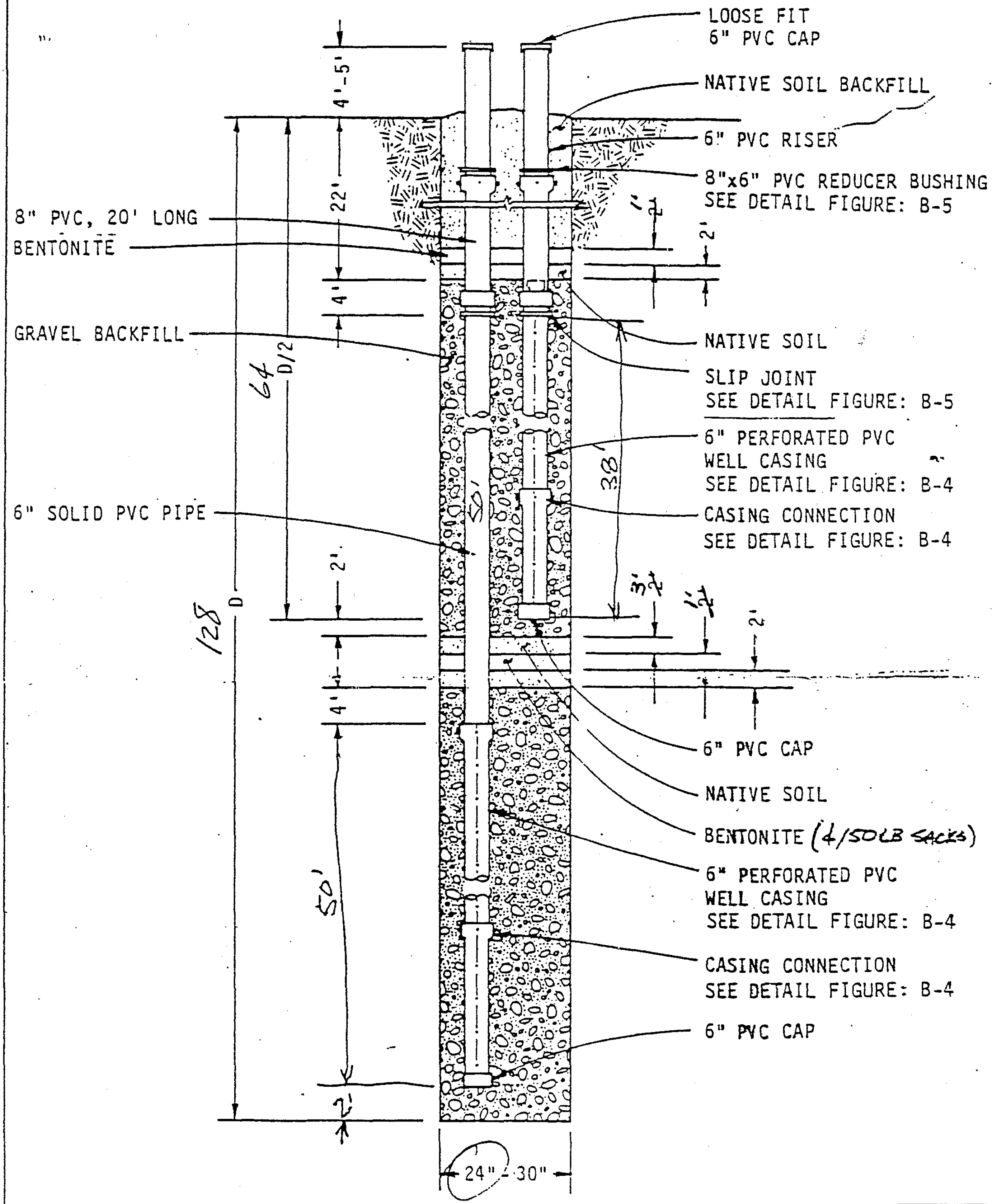
DRILLING CONDITIONS

(Weather, obstructions, etc.) WET & MUDDY

Drilling company DON H. MAHAFFEY DRILLING CO.

Drilling equipment 80 TON 'LIMA' CRANE w/5000 'WATSON' DRILL MOTOR

Operators names JON VIRDELL, DRILLER; RANDY VIRDELL, OILER



WELL 40

FIGURE B-3:
MIDWAY LANDFILL
PHASE II
VERTICAL WELL DETAIL

PHX 31-1550-14 (18)

GAS WELL CONSTRUCTION LOG

WELL No. 41 Coords N10540.4 E9767.3

Landfill name: MIDWAY GAS MIGRATION - PHASE II Date ____

I. DIMENSIONS:

a. Total depth of well 120'

b. Diameter of well 24"
LOWER FROM 0 TO 118'
UPPER FROM 0 TO 60'

c. Well casing interval ____

d. Diameter of well casing 6" & 8"

e. Slotted interval of well casing ____
Lower from 72' to 118'
Upper from 26' to 60'

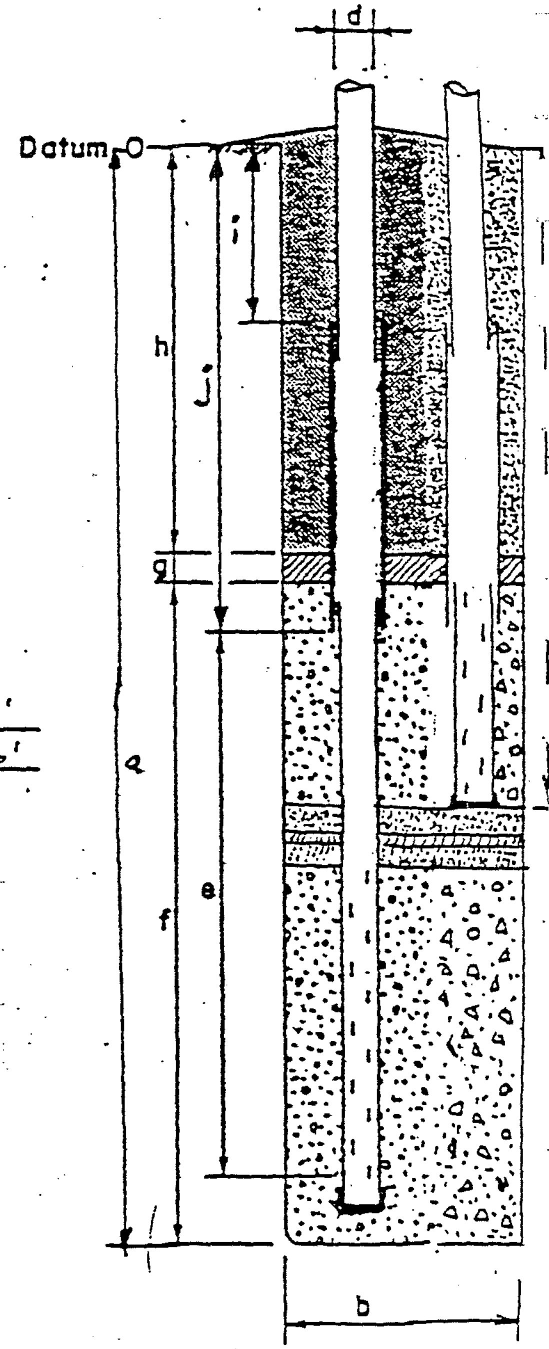
f. Permeable material interval ____
LOWER FROM 68' TO 120'
UPPER FROM 22' TO 62'

g. Impermeable plug interval 2'

h. Backfill material interval 19'

i. Depth to top of slip/settlement pipe 6'

j. " " bottom " " " 26'



II. MATERIALS:

Permeable material 1¼" WASHED ROCK

Impermeable plug BENTONITE

Backfill material SILTY CLAY

Casing material (incl. slip joints) SCH. 40 PVC. (6" & 8" DIA.)

III. CONSTRUCTION:

Method of placing fill materials: CAT 931 B TRACK LOADER

Method of placing casing: 30 TON 'LIMA' CRANE W/ 130' TOWER

Problems encountered: ____

GAS WELL DRILLING LOG

WELL No. 4 COORDS N 10540.4 E 9767.3

Landfill name: MIDWAY GAS MIGRATION – PHASE II Date

Time drilling TWO DAYS

DESCRIPTION OF DRILLING SPOILS:

Cover soil depth:	Description
0 - 3'	SILTY CLAY COVER MATERIAL
3' -- 120'	REFUSE (WOOD, PLASTIC, PAPER, ETC.)
120'	GLACIAL TILL, FINE SILT

Total depth of well 120' (Diam. 24")

DRILLING CONDITIONS

(Weather, obstructions, etc.) WET & MUDDY

Drilling company DON H. MAHAFFEY DRILLING CO.

Drilling equipment 80 TON 'LIMA' CRANE w/5000 'WATSON' DRILL MOTOR

Operators names JON VIRDELL, DRILLER; RANDY VIRDELL, OILER

FMX 31-1550-14 (18)

GAS WELL CONSTRUCTION LOG

WELL No. 42 Coords N11225.6 E9987.5

Landfill name: MIDWAY GAS MIGRATION - PHASE II Date

I. DIMENSIONS:

a. Total depth of well 64'

b. Diameter of well 24".
LOWER FROM 0 TO 62'
UPPER FROM 0 TO 32'

c. Well casing interval

d. Diameter of well casing 6" & 8"

e. Slotted interval of well casing
Lower from 44' to 62'
Upper from 26' to 32'

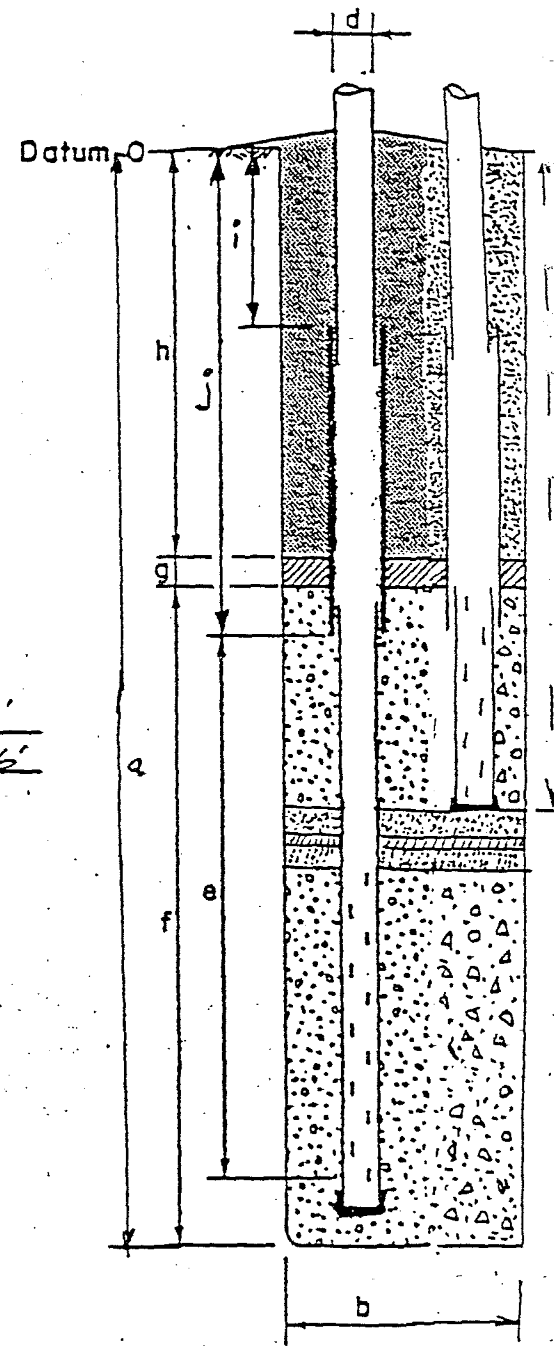
f. Permeable material interval
LOWER FROM ~~40~~' TO 64'
UPPER FROM 22' TO 34'

g. Impermeable plug interval 2'

h. Backfill material interval 19'

i. Depth to top of slip/settlement pipe 6'

j. " " bottom " / " " " 26'



II. MATERIALS:

Permeable material 1¼" WASHED ROCK

Impermeable plug BENTONITE

Backfill material SILTY CLAY

Casing material (incl. slip joints) SCH. 40 PVC. (6" & 8" DIA.)

III. CONSTRUCTION:

Method of placing fill materials: CAT 931 B TRACK LOADER

Method of placing casing: 80 TON 'LIMA' CRANE W/ 130' TOWER

Problems encountered:

GAS WELL DRILLING LOG

WELL No. 42 COORDS N 1225.6 E 9937.5

Landfill name: MIDWAY GAS MIGRATION - PHASE II Date

Time drilling TWO (2) DAYS

DESCRIPTION OF DRILLING SPOILS:

Cover soil depth:	Description
0 - 3'	SILTY CLAY COVER MATERIAL
3' - 64'	REFUSE (WOOD, PLASTIC, PAPER, ETC)
64'	GLACIAL TILL, FINE SILT

Total depth of well 64' (Diam. 24")

DRILLING CONDITIONS

(Weather, obstructions, etc.) WET & MUDDY

Drilling company DON H. MAHAFFEY DRILLING CO.

Drilling equipment 80 TON 'LIMA' CRANE W/5000 'WATSON' DRILL MOTOR

Operators names JON VIRDELL, DRILLER; RANDY VIRDELL, OILER

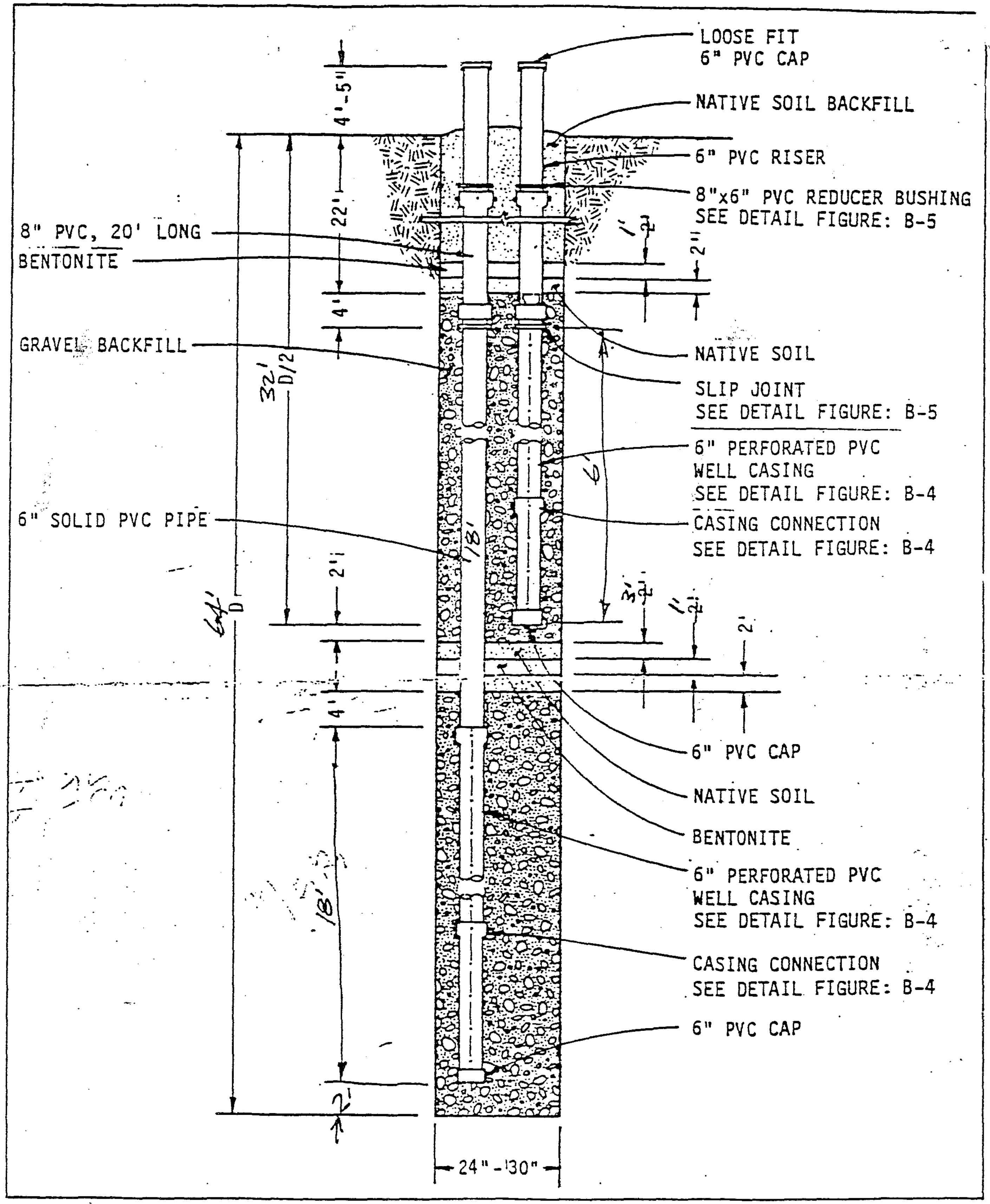


FIGURE B-3:
MIDWAY LANDFILL
PHASE II
VERTICAL WELL DETAIL

WELL 42

PHX 31-1550-14 (18)

GAS WELL CONSTRUCTION LOG

WELL No. 43 Coords N 11402.3 E 10070.2

Landfill name: MIDWAY GAS MIGRATION - PHASE II Date

I. DIMENSIONS:

a. Total depth of well 80'

b. Diameter of well 24"
LOWER FROM 0' TO 76'
UPPER FROM 0' TO 39'

c. Well casing interval

d. Diameter of well casing 6" & 8"

e. Slotted interval of well casing
Lower from 51' to 76'
Upper from 26' to 39'

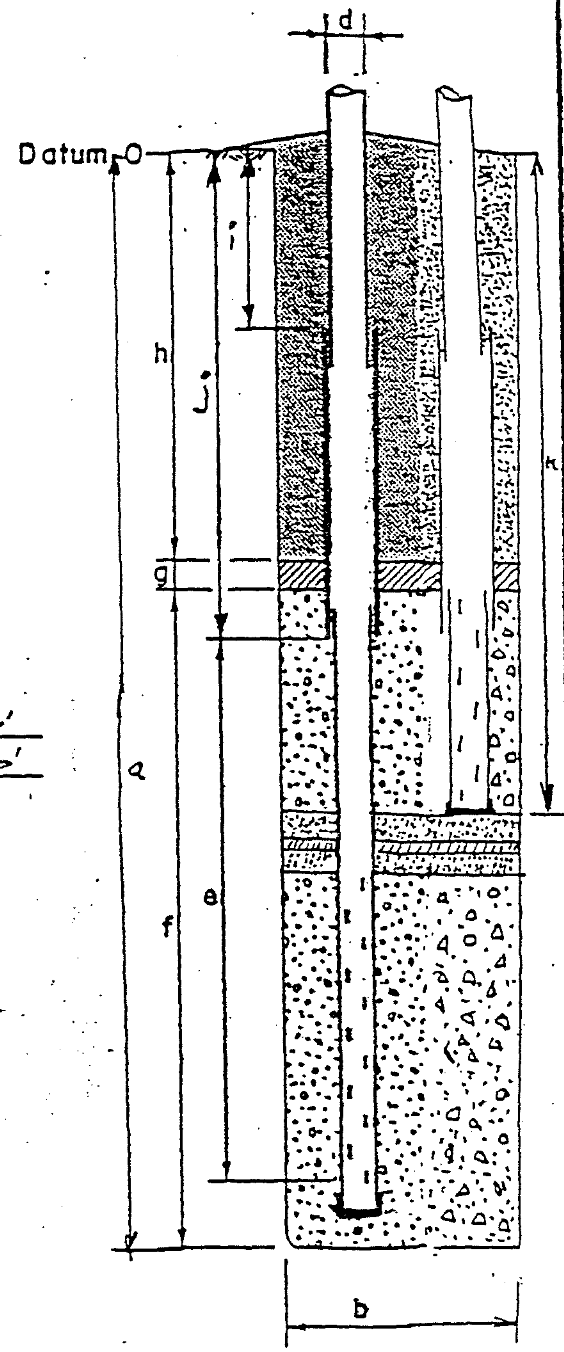
f. Permeable material interval
LOWER FROM 47' TO 80'
UPPER FROM 22' TO 41'

g. Impermeable plug interval 2'

h. Backfill material interval 19'

i. Depth to top of slip/settlement pipe 6'

j. " " bottom " " 26'



II. MATERIALS:

Permeable material 1¼" WASHED ROCK

Impermeable plug BENTONITE

Backfill material SILTY CLAY

Casing material (incl. slip joints) SCH. 40 PVC. (6" & 8" DIA.)

III. CONSTRUCTION:

Method of placing fill materials: CAT 931 B TRACK LOADER

Method of placing casing: 80 TON 'LIMA' CRANE W/ 130' TOWER

Problems encountered: HAD TO DRILL SECOND HOLE FOR SHALLOW WELL DUE TO OBSTRUCTION AT 40'±

GAS WELL DRILLING LOG

WELL No. 43 COORDS N 11401.3 E 10070.2

Landfill name: MIDWAY GAS MIGRATION - PHASE II Date

Time drilling TWO (2) DAYS

DESCRIPTION OF DRILLING SPOILS:

Cover soil depth:	Description
0 - 3'	SILTY CLAY COVER MATERIAL
3' - 80'	REFUSE (WOOD, PLASTIC, PAPER, ETC.)
80'	GLACIAL TILL, FINE SILT

Total depth of well 80' (Diam. 24")

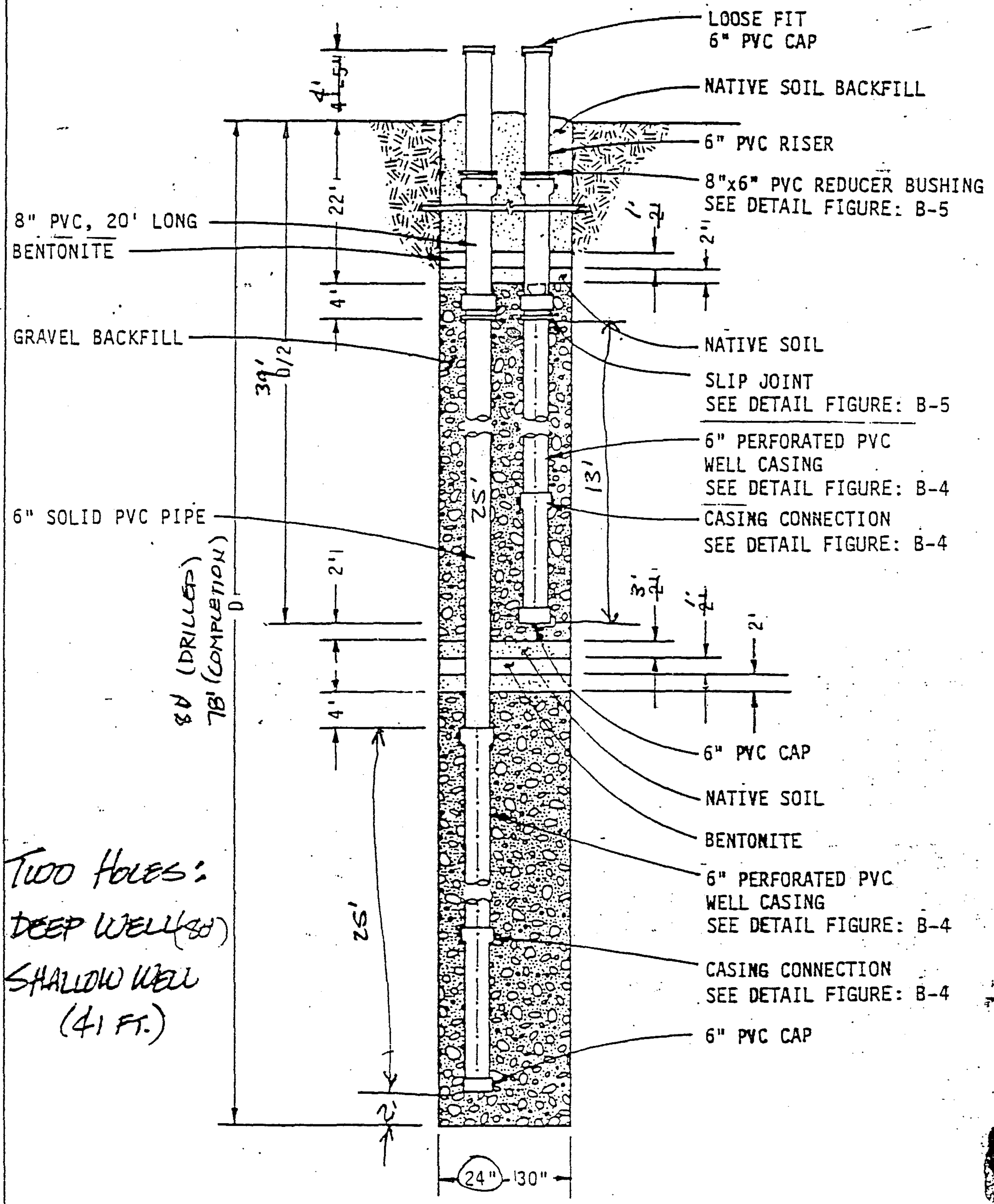
DRILLING CONDITIONS

(Weather, obstructions, etc.) ~~WET~~ WET & MUDDY

Drilling company DON H. MAHAFFEY DRILLING CO.

Drilling equipment 80 TON 'LIMA' CRANE W/ 5000 'WATSON' DRILL MOTOR

Operators names JON VIRDELL, DRILLER; RANDY VIRDELL, OILER



WELL 43

FIGURE B-3:
MIDWAY LANDFILL
PHASE II
VERTICAL WELL DETAIL

PHX 31-1550-14 (18)

GAS WELL CONSTRUCTION LOG

WELL No. 44 - Coords N11612.1 E10120.7

Landfill name: MIDWAY GAS MIGRATION - PHASE II Date ________

I. DIMENSIONS:

a. Total depth of well ~~83'~~ 81'

b. Diameter of well 24"

c. Well casing interval ________

d. Diameter of well casing 6"

e. Slotted interval of well casing ________
Lower from 26' to 76'
Upper from 26' to 39'

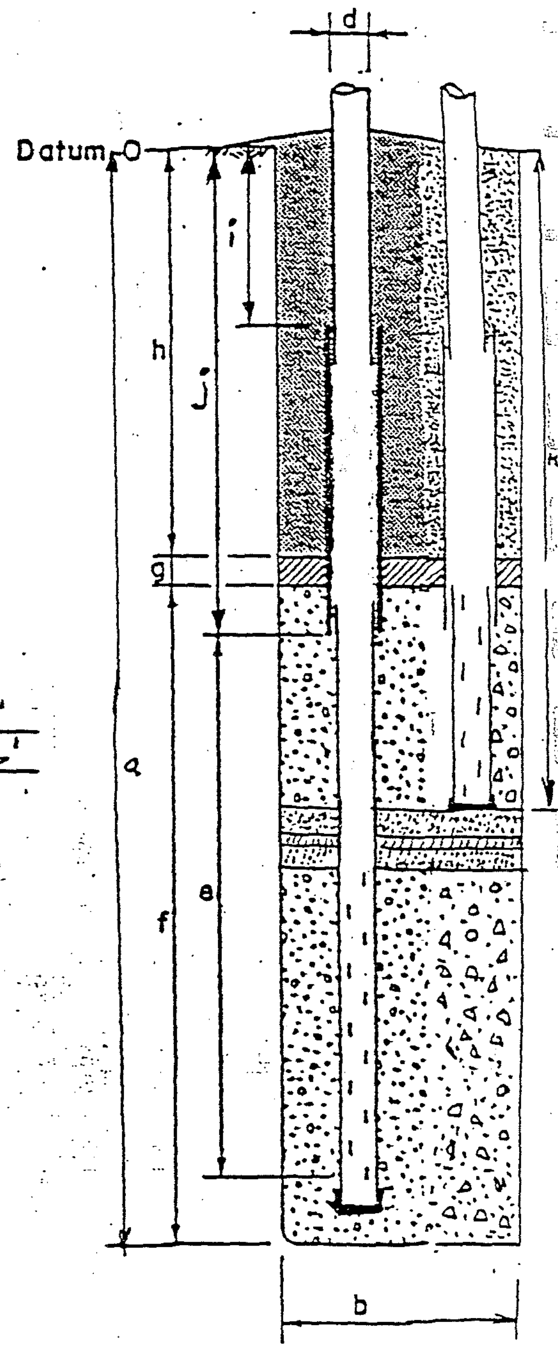
f. Permeable material interval 56'

g. Impermeable plug interval 4'

h. Backfill material interval 18'

i. Depth to top of slip/settlement pipe 6'

j. " " bottom " / " " 26'



II. MATERIALS:

Permeable material 1 1/4" WASHED ROCK

Impermeable plug BENTONITE

Backfill material SILTY CLAY

Casing material (incl. slip joints) SCH. 40 PVC. (6" & 8" DK.)

III. CONSTRUCTION:

Method of placing fill materials: CAT 931 CRAWLER LOADER

Method of placing casing: 80 TON 'LIMA' CRANE (130' TOWER)

Problems encountered: ________

GAS WELL DRILLING LOG

WELL No. 44 COORDS N 11612.1 E 10120.2

Landfill name: MIDWAY LANDFILL Date 12-8-86

Time drilling SIX (6) DAYS

DESCRIPTION OF DRILLING SPOILS:

Cover soil depth:	Description
0' - 3'	SILTY CLAY COVER MATERIAL
3' - 81'	REFUSE (WOOD, PLASTIC, PAPER, ETC.)
81'	GLACIAL TILL, FINE SILT

Total depth of well ~~78'~~ 81' (Diam. 24")

DRILLING CONDITIONS
(Weather, obstructions, etc.) CLEAR, COLD, WET & MUDDY

Drilling company DON H. MAHAFFEY DRILLING CO.

Drilling equipment 80 TON 'LIMA' CRANE W/ 5000 WATSON DRILL

Operators names JON VIRDELL, DRILLER

PHX 31-1550-14 (18)

GAS WELL CONSTRUCTION LOG

WELL No. 45 Coords N10317 E 373

Landfill name: MIDWAY GAS MIGRATION - PHASE II Date 12-11-86

I. DIMENSIONS:

a. Total depth of well 84'

b. Diameter of well 24"

c. Well casing interval

d. Diameter of well casing 6" (SHALLOW) 8" (DEEP)

e. Slotted interval of well casing
Lower from 26' to ~~42~~ 82'
Upper from 26' to 42'

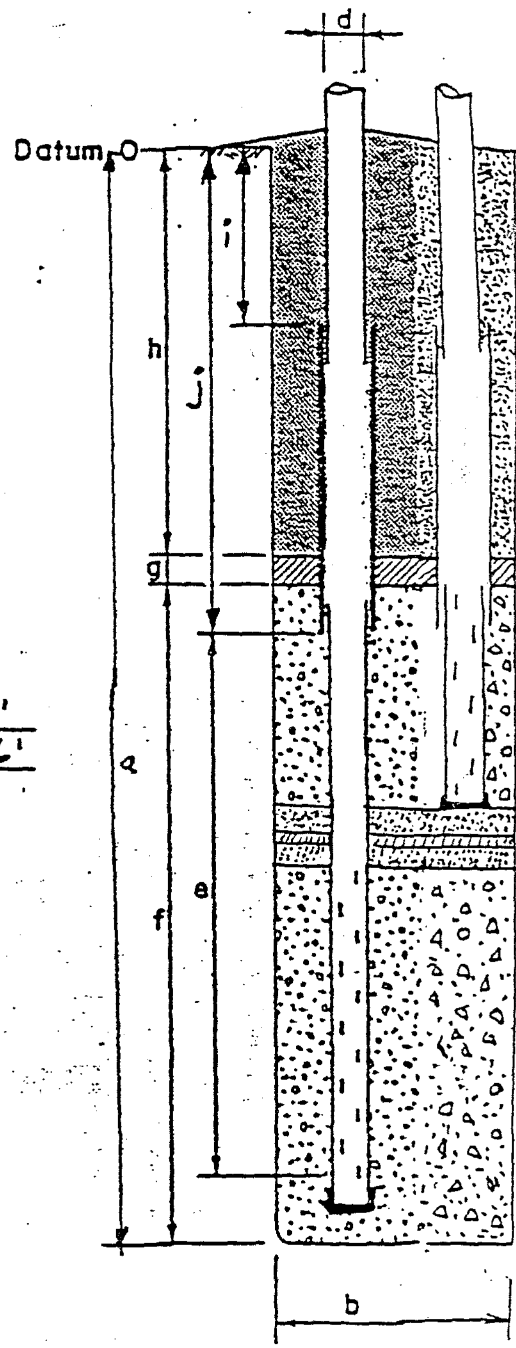
f. Permeable material interval 22'-84'

g. Impermeable plug interval 2 FT.

h. Backfill material interval 18 FT

i. Depth to top of slip/settlement pipe 6'

j. " " bottom " / " " 26'



II. MATERIALS:

Permeable material 1 1/4" WASHED ROCK

Impermeable plug BENTONITE

Backfill material SILTY CLAY

Casing material (incl. slip joints) SCH. 40 PVC. (6" & 8" DK.)

III. CONSTRUCTION:

Method of placing fill materials: CAT 931 B TRACK LOADER

Method of placing casing: 80 TON 'LIMA' CRANE w/ 130' TOWER

Problems encountered:

GAS WELL DRILLING LOG

WELL No. 45 COORDS N ______ E ______

Landfill name: MIDWAY LANDFILL Date 12-11-86

Time drilling TWO DAYS

DESCRIPTION OF DRILLING SPOILS:

Cover soil depth:	Description
0 - 3'	SILTY CLAY W/SOME ROCK, COVER MATERIAL
3' - 42'	PARTIALLY DECOMPOSED WOOD (75%), PAPER, PLASTIC, WIRE, PLASTIC BAGS, ETC. (VERY DRY MATERIAL)
42' - 45'	DIRT AND GRAVEL W/ ORGANICS
45' - 49'	PARTIALLY DECOMPOSED WOOD (80%), PLASTIC, ETC.
49' - 53'	" " ", INTO WATER
53' - 61'	" " " WITH SOME WATER
61' - 67'	" " ", CARPET, WIRE, ETC, VERY WET MATERIAL
67' - 77'	PARTIALLY DECOMPOSED WOOD, TIN, PAPER, ETC.
77' - 82'	SILTY CLAY W/ ORGANICS
82' - 84'	VERY FINE SILTY CLAY.

Total depth of well 84 FT. (Diam. 24")

DRILLING CONDITIONS

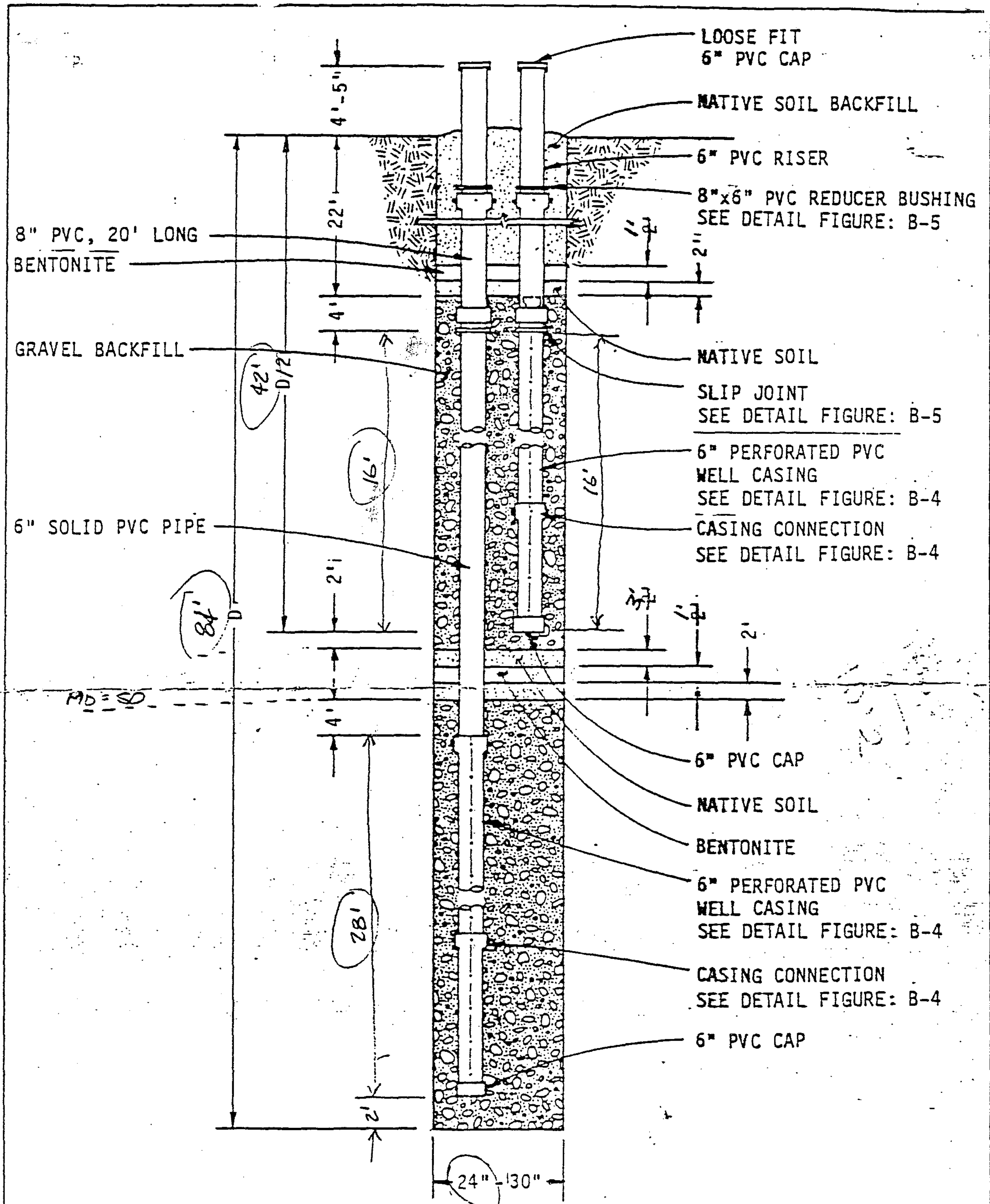
(Weather, obstructions, etc.) CLOUDY, COLD, WET & MUDDY

AVERAGE TEMP = 43°

Drilling company DON H. MAHAFFEY DRILLING CO.

Drilling equipment 80 TON 'LIMA' CRANE W/ 5000 WATSON DRILL

Operators names JON VIRDELL, DRILLER; RANDY VIRDELL, OILER.



WELL 45

FIGURE B-3:
MIDWAY LANDFILL
PHASE II
VERTICAL WELL DETAIL

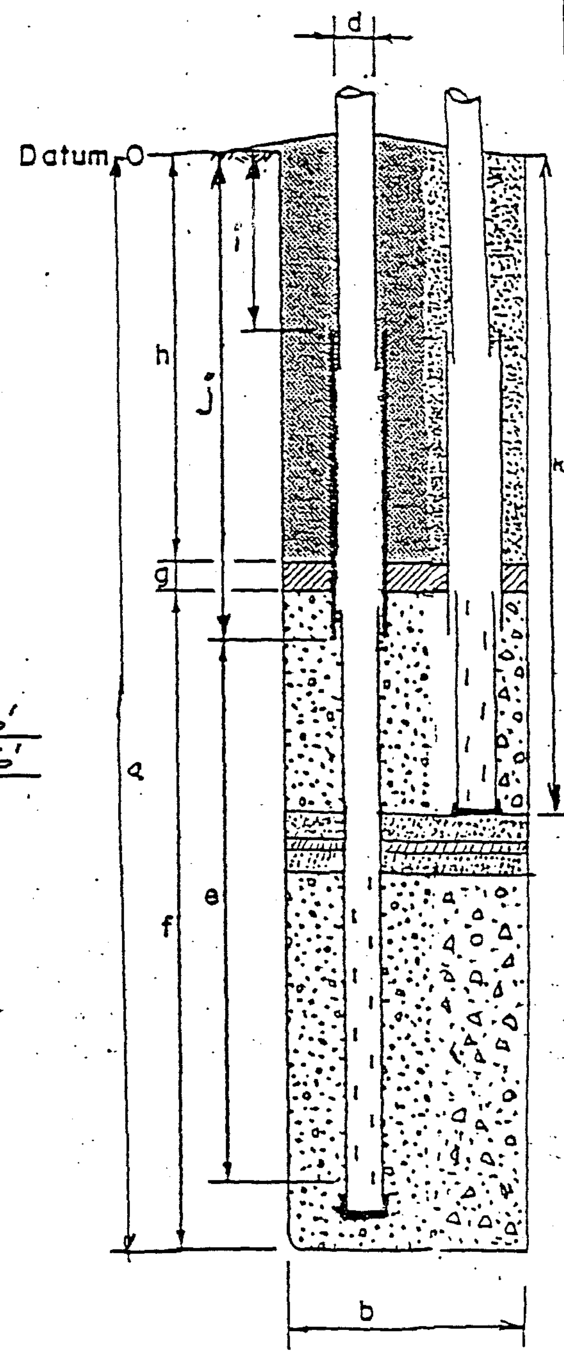
PHX 31-1550-14 (18)

GAS WELL CONSTRUCTION LOG

WELL No. 46 Coords N 11340.9 E 10270.1

Landfill name: MIDWAY GAS MIGRATION - PHASE II Date 12-18-86

I. DIMENSIONS:



a. Total depth of well 95'

b. Diameter of well 24"

c. Well casing interval ______

d. Diameter of well casing 6" (SHALLOW) 8" (DEEP)

e. Slotted interval of well casing ______
Lower from ______ to ______
Upper from 26' to 47.5'

f. Permeable material interval 22'-95'

g. Impermeable plug interval 2'

h. Backfill material interval 18'

i. Depth to top of slip/settlement pipe 6'

j. " " bottom " / " " 26'

II. MATERIALS:

Permeable material 1¼" WASHED ROCK

Impermeable plug BENTONITE

Backfill material SILTY CLAY

Casing material (incl. slip joints) SCH. 40 PVC. (6" & 8" DIA.)

III. CONSTRUCTION:

Method of placing fill materials: CAT 931B TRACK LOADER

Method of placing casing: 80 TON 'LIMA' CRANE w/130' TOWER

Problems encountered: ______

GAS WELL DRILLING LOG

WELL No. 46 COORDS N 11390.9 E 10270.1

Landfill name: MIDWAY Date 12-13-86

Time drilling TWO DAYS

DESCRIPTION OF DRILLING SPOILS:

Cover soil depth:	Description
0'-3'	SILTY CLAY COVER MATERIAL
3'-95'	REFUSE (WOOD, PLASTIC, PAPER, ETC.)
95'	GLACIAL TILL, FINE SILT

Total depth of well 95' (Diam. 24")

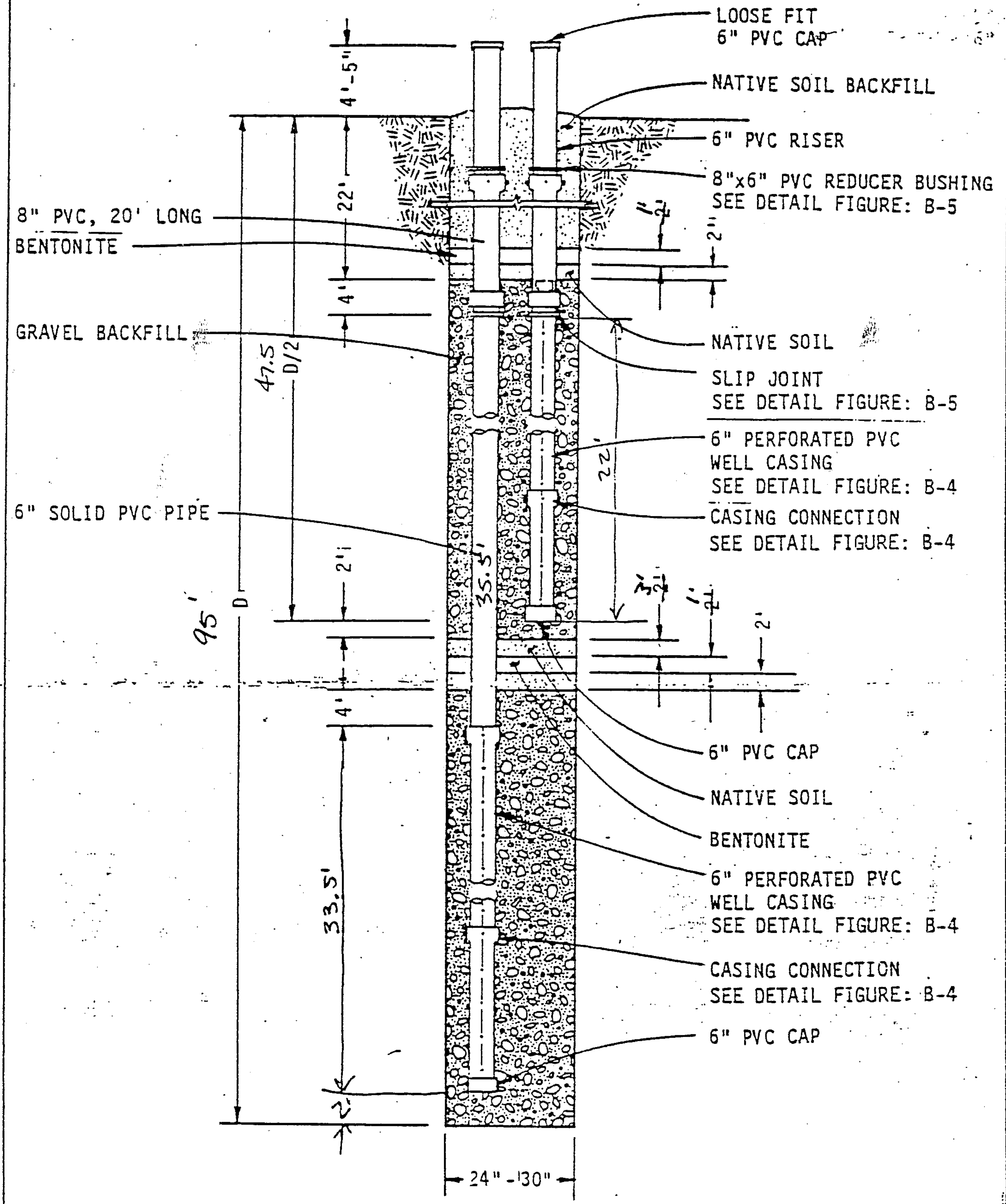
DRILLING CONDITIONS

(Weather, obstructions, etc.)

Drilling company DON H. MAHAFFEY DRILLING CO.

Drilling equipment 80 TON 'LIMA' CRANE W/ ~~[illegible]~~ 5000 'WATSON' DRILL

Operators names JON VIRDELL, DRILLER; RANDY VIRDELL, OILER



WELL 46

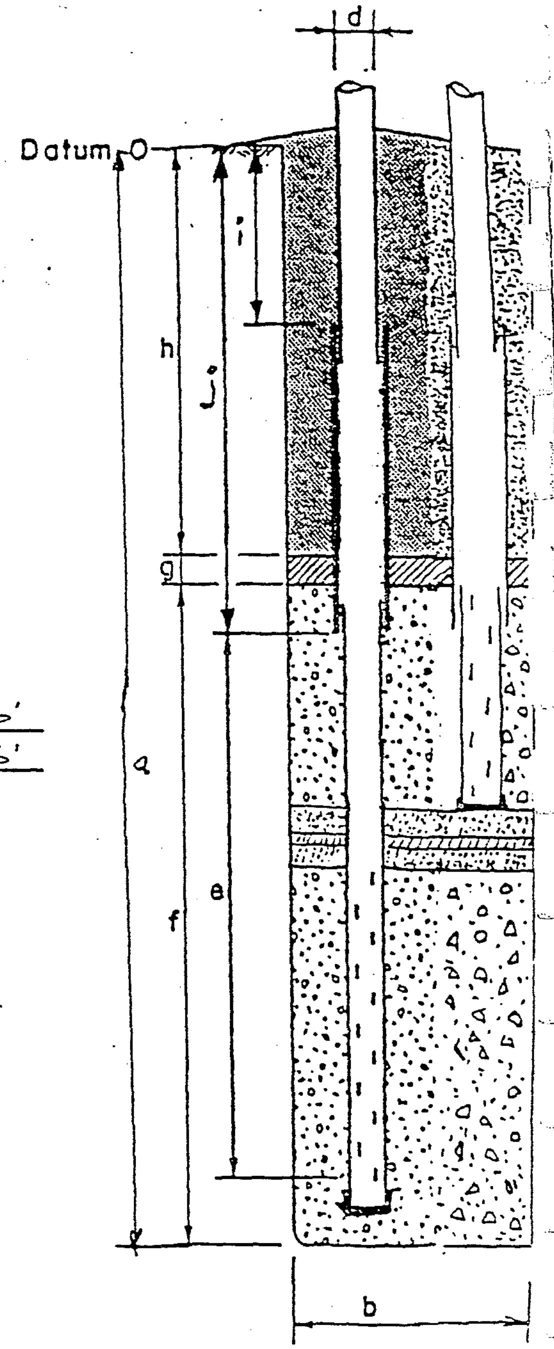
FIGURE B-3:
MIDWAY LANDFILL
PHASE II
VERTICAL WELL DETAIL

GHS WELL CONSTRUCTION LOG

WELL No. 47 Coords N 11195.3 E 10232.

Landfill name: MIDWAY GAS MIGRATION - PHASE II Date ______

I. DIMENSIONS:



a. Total depth of well 87'

b. Diameter of well 24"
LOWER FROM 0' TO 85'
UPPER FROM 0' TO 43.5'

c. Well casing interval ______

d. Diameter of well casing 6" & 8"

e. Slotted interval of well casing ______
Lower from 55' to 85'
Upper from 26' to 43.5'

f. Permeable material interval ______
LOWER FROM 51' TO 87'
UPPER FROM 22' TO 45'

g. Impermeable plug interval 2'

h. Backfill material interval 19'

i. Depth to top of slip/settlement pipe 6'

j. " " bottom " " " 26'

II. MATERIALS:

Permeable material 1¼" WASHED ROCK

Impermeable plug BENTONITE

Backfill material SILTY CLAY

Casing material (incl. slip joints) SCH. 40 PVC. (6" & 8" DIA.)

III. CONSTRUCTION:

Method of placing fill materials: CAT 931 B TRACK LOADER

Method of placing casing: 80 TON 'LIMA' CRANE w/130' TOWER

Problems encountered: ______

GAS WELL DRILLING LOG

WELL No. 47 COORDS N 11195.3 E 10232.5

Landfill name: MIDWAY GAS MIGRATION - PHASE II Date

Time drilling TWO DAYS

DESCRIPTION OF DRILLING SPOILS:

Cover soil depth:	Description
0' - 3'	SILTY CLAY COVER MATERIAL
3' — 87'	REFUSE, (WOOD, PLASTIC, PAPER, ETC.)
87'	GLACIAL TILL, FINE SILT

Total depth of well 87' (Diam. 24")

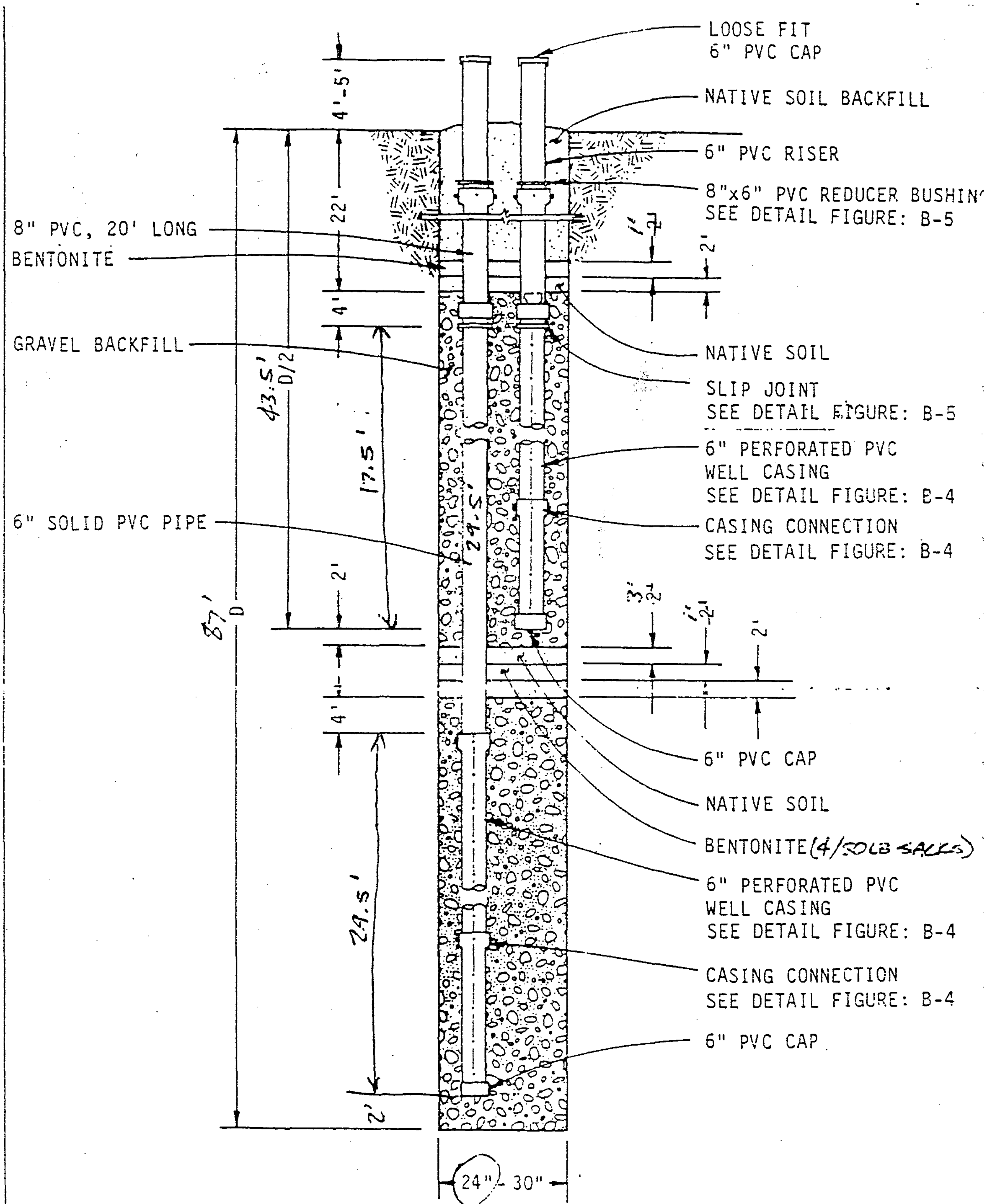
DRILLING CONDITIONS

(Weather, obstructions etc.) WET & MUDDY

Drilling company DON H. MAHAFFEY DRILLING CO.

Drilling equipment 30 TO 'LIMA' CRANE W/ 5000 'WATSON' DRILL MOTOR

Operators names JON VIRDELL, DRILLER; RANDY VIRDELL, OILER



WELL #7

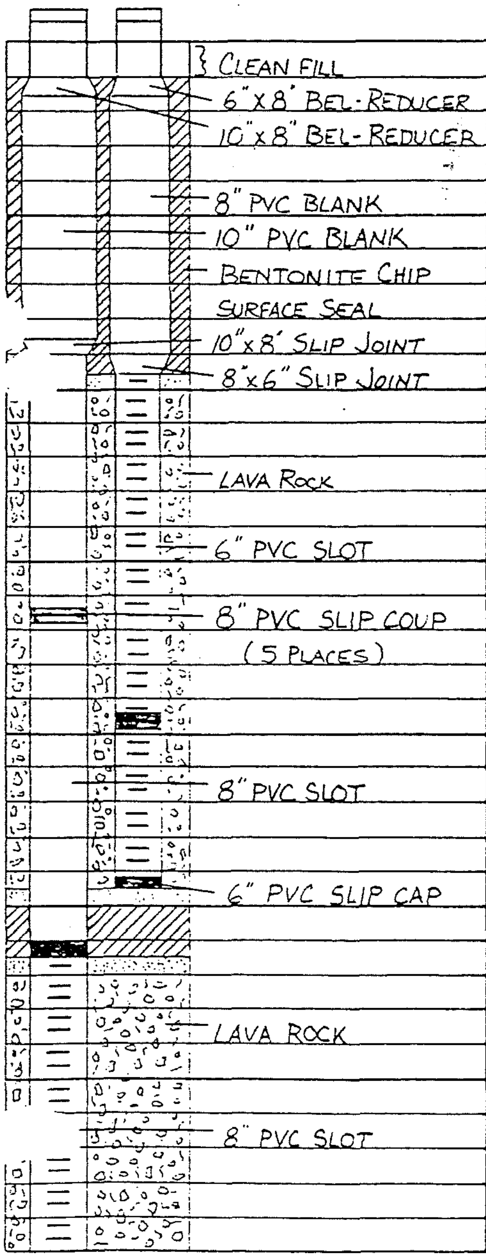
FIGURE B-3:
MIDWAY LANDFILL
PHASE II
VERTICAL WELL DETAIL

Well Installation Log

Job No. 55-1550-25 Client SEATTLE SWU Location MIDWAY LANDFILL

[illegible]NG TYPE SCH 80 PVC	DRILLING METHOD CABLE TOOL - 24" CASING		WELL NO. 48
LENGTH	SAMPLING METHOD		
JOINT TYPE PVC SLIP COUPLING - GLUED & SCREWED	HAMMER WT.	DROP	SHEET 1
SCREEN TYPE HORIZONTAL SLOT - 0.050"	DATE 10-2-89		
SLOT SIZE 0.050	BY J. HICKEY		OF 2
SEAL TYPE BENTONITE CHIP, PORTLAND CEMENT (BASE)	DRILLING CONTR. RAMLO WELL DRILLING		START / FINISH
INSTALL. METHOD BACKHOE / HOPPER / GROUT PUMP	WATER LEVEL		
FILTER VESICULAR LAVA ROCK	TIME		8-30 / 9-26
INSTALL	DATE		
GROUT			

WELL DETAILS



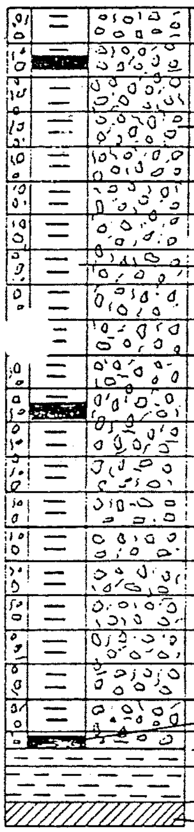
DEPTH	USCS	SOIL DESCRIPTION	INSTALLATION NOTES
		GROUND ELEVATION	
		SUBGRADE FILL - MED BROWN, SILTY SAND W/SOME GRAVEL, COBBLES	
10		GRAY CLAYEY SILT	
		REFUSE - NEWSPAPER, WOOD, CARDBOARD, PLASTIC, ROOFING,	
		REFUSE - WOOD, GRAVEL, METAL, PLASTIC, AUTO BATTERY, MED WASTE (I.V. DISP)	
20		HARDWARE, ELECT MOTOR	
		REFUSE - WOOD, PLASTIC, RAGS, GLASS, FOOD CONT'S, PILLS, COUGH SYRUP, PENCILS, BATTERYS, GRAVEL	
30		SYRINGE, MED. CLOTHING	
		SAME W/ MED DISPOSAL BAGS, SYRINGES, LOTS STYROFOAM	
40		REFUSE - WOOD, PLASTIC, METAL, HARDWARE, STRONG OIL SHEEN, POTATO BAGS, PIPE, BRICK, COBBLES	
50		REFUSE - WOOD, RUBBER HOSE, AUTO. HDWR, METAL, GLASS, BEER CANS, ELEC. RAZOR, TIRES, FOOD CONT'S	
60		REFUSE - WOOD, PLASTIC, HDWR, MED. TYPE BOTTLE, SAN. DIAPER, DISP. BAGS, TIRES, METAL, GRAVEL, GLASS	
70			

Well Installation Log

Job No. ______ Client ______ Location ______

NG TYPE	DRILLING METHOD					WELL NO. 48
LENGTH	SAMPLING METHOD					SHEET 2
JOINT TYPE	HAMMER WT.	DROP				OF 2
SCREEN TYPE	DATE					START / FINISH
SLOT SIZE	BY					
SEAL TYPE	DRILLING CONTR.					
INSTALL. METHOD	WATER LEVEL					
FILTER	TIME					
INSTALL	DATE					
GROUT						

WELL DETAILS

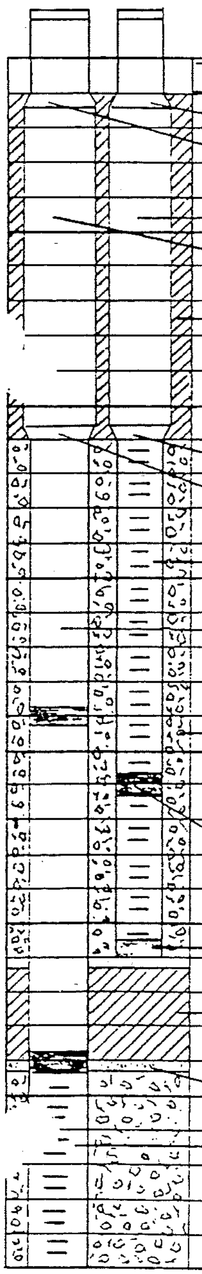


DEPTH	USCS	SOIL DESCRIPTION	INSTALLATION NOTES
		GROUND ELEVATION	
		REFUSE - WOOD, PLASTIC, METAL.	
		BRICK, SAND, GRAVEL	
		PLASTIC, TIRES, ELEC. MOTOR, HDWR	
		REFUSE - WOOD, SAND & GRAVEL,	
80		METAL, HARDWARE, PAPER, PLASTIC	
		REFUSE - WOOD, PLASTIC, METAL,	
		DOLL, NEWSPAPER (MAR 21, 1968)	
		BRICK, TILE, TRANS SPLINE	
90		BEV. CANS, GLASS, TIRES	
		REFUSE - WOOD, STACK, TAR PAPER,	
		FROZEN VEG BAGS, METAL, STACK	
		TV DINNER, SAND, GRAVEL, PAPER	
100			
		COARSE SAND W/COBBLES,	
		SOME REFUSE - WOOD, PLASTIC	
		~~GL~~ GLASS	
		REFUSE - WOOD, PLASTIC, METAL,	
110		GLASS, SHOES	
		BWN-GRAY TO BLUE-BWN SILTY CLAY (1 TO 2 FOOT)	
		SAND & GRAVEL	
120		END OF HOLE @ 117.5	

Well Installation Log

Job No. 55-1550-25 Client SEATTLE SOLID WASTE Location MIDWAY LANDFILL

NG TYPE 6" 8" + 10" SCH 80 PVC		DRILLING METHOD CABLE TOOL - 24" CASING	WELL NO. 49
LENGTH		SAMPLING METHOD	
JOINT TYPE SLIP COUPLING - GLUED + SCREWED		HAMMER WT. / DROP	SHEET 1
SCREEN TYPE HORIZONTAL SLOT		DATE 9-13-89	
SLOT SIZE .050"		BY J. HICKER	OF 2
SEAL TYPE BENTONITE CHIP - (ENVIROSEAL)		DRILLING CONTR. RAMCO WELL DRILLING	START / FINISH
INSTALL. METHOD BACKHOE / HOPPER		WATER LEVEL	
FILTER VESICULAR LAVA ROCK		TIME	6-2-89 / 7-5-89
INSTALL		DATE	
GROUT			



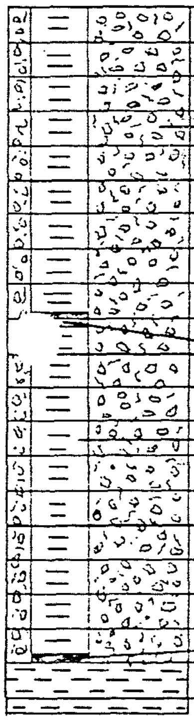
WELL DETAILS	DEPTH	USCS	SOIL DESCRIPTION	INSTALLATION NOTES
			GROUND ELEVATION	
CLEAN FILL			SUBGRADE FILL - GRAY-BROWN	
6" x 8" BEL-RED			GRAVELLY SAND W/SOME SILT	
8" x 10" BEL-RED				
8" PVC BLANK	10		GRAY CLAYEY SILT CAP	
10" PVC BLANK			REFUSE - GRAY, SILTY	
			W/WOOD	
BENTONITE CHIP				
SURFACE SEAL				
	20		REFUSE - BLACK, MOSTLY	
			DECOMPOSED WOOD	
6" x 8" SLIP JOINT			SLIGHT CREOSOTE ODOR	
8" x 10' SLIP JOINT				
			REFUSE - WOOD, PLASTIC, PAPER	
6" PVC SLOT	30		METAL, SOME GRAVEL, STYROFOAM	
8" PVC BLANK			REFUSE - SAME W/PIPE	
			REFUSE - PLASTIC, PAPER, RUBBER,	
VESICULAR LAVA	40		METAL, SOME WOOD	
ROCK FILTERPACK				
			REFUSE - MOSTLY WOOD, SOME	
6" PVC SLIP-COUP			PLASTIC METAL, GRAVEL, TIRES	
			BRICK, PORCELAIN	
	50			
6" PVC CAP (2 PL.)				
			REFUSE - MOSTLY WOOD, TIRES	
BENTONITE SEAL			METAL, PLASTIC, GRAVEL	
			HARDWARE; BRICK, PORCELAIN	
COLORADO SAND (3 PL.)	60		STYROFOAM	
8" PVC SLOT			REFUSE - LOTS PAPER, PLASTIC, CLOTH, METAL	
			REFUSE - MOSTLY WOOD, PLASTIC	
	70		RUBBER, METAL	

Well Installation Log

Job No. ______ Client ______ Location ______

[illegible]NG TYPE		DRILLING METHOD	WELL NO. 49
LENGTH		SAMPLING METHOD	
JOINT TYPE		HAMMER WT. / DROP	SHEET 2
SCREEN TYPE		DATE	OF 2
SLOT SIZE		BY	
SEAL TYPE		DRILLING CONTR.	START / FINISH
INSTALL. METHOD		WATER LEVEL	
FILTER		TIME	
INSTALL		DATE	
GROUT			

WELL DETAILS



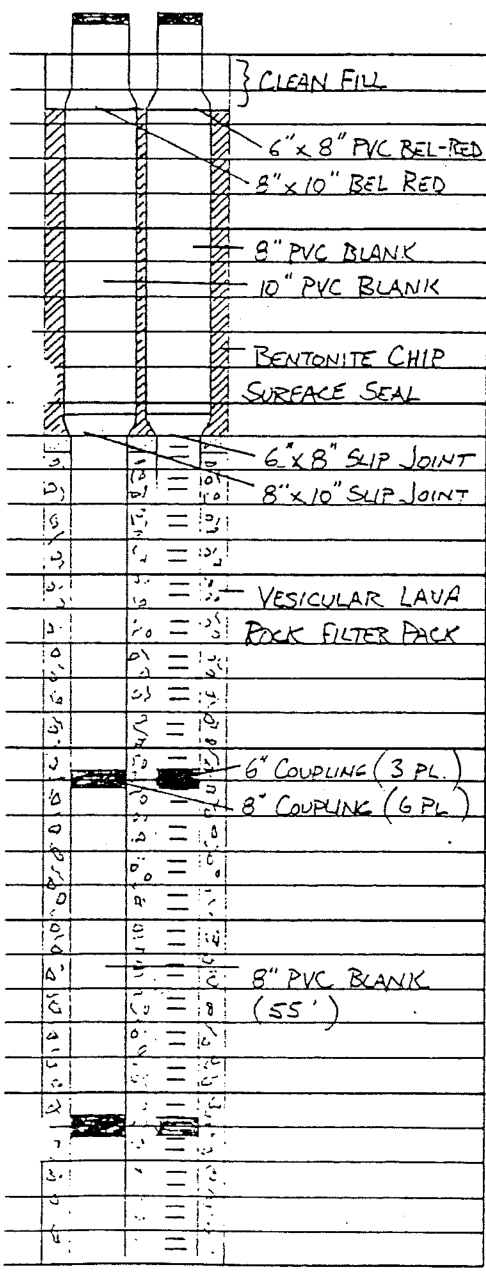
WELL DETAILS	DEPTH	USCS	SOIL DESCRIPTION GROUND ELEVATION	INSTALLATION NOTES
			REFUSE - MOSTLY WOOD, SOME	
			PLASTIC, METAL, GLASS, GRAVEL	
VESICULAR LAVA			REFUSE - WOOD, PLASTIC, TIRES	PCB ✓: POS
ROCK FILTERPACK	80		METAL, AUTO PARTS (SPARK PL, OIL FILTER)	
			REFUSE - LOTS OF METAL, WOOD	
			TIRES, PLASTIC, PAPER	
			INTERBEDDED GRAY BROWN SANDY GRAVEL	
8" SLIP. COUP (4 PL)	90		REFUSE - MOSTLY WOOD, SOME GRAVEL,	
			METAL, PLASTIC, PAPER	
8" PVC SLOT				
			INTERBEDDED COARSE SAND	
	100		w/GRAVEL, COBBLES + SOME REFUSE -	
			WOOD, PAPER, PLASTIC, METAL GLASS	
			INCREASING WOOD & OIL SHEEN	
			(SEPTIC ODOR)	
8" PVC CAP (2 PL)				
			GRAY - BLUE CLAYEY SILT	
	110		END OF HOLE @ 111.0 FT, CASING @ 106'	

Well Installation Log

Job No. 55-1550-25 Client SOLID WASTE UTILITY Location MIDWAY LANDFILL

NG TYPE SCHEDULE 80 PVC	DRILLING METHOD CABLE TOOL - 24" CASING		WELL NO. 50
LENGTH	SAMPLING METHOD		SHEET 1 OF 2
JOINT TYPE SLIP COUPLING - PVC (GLUE + SC.)	HAMMER WT.	DROP	
SCREEN TYPE HORIZONTAL SLOT	DATE		
SLOT SIZE .050"	BY J. HICKER		
SEAL TYPE BENTONITE CHIP	DRILLING CONTR. RAMCO WELL DRILLING		START / FINISH
INSTALL METHOD BACKHOE / HOPPER	WATER LEVEL		6-22
FILTER ½" - 5/8" LAVA ROCK	TIME		
INSTALL	DATE		
GROUT			

WELL DETAILS

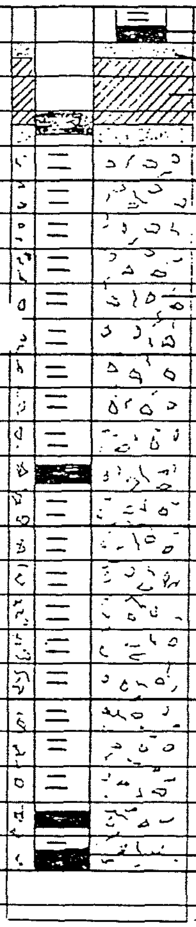


DEPTH	USCS	SOIL DESCRIPTION (GROUND ELEVATION)	INSTALLATION NOTES
		BROWN GRAVELLY SAND W/ SOME SILT (SUBGRADE FILL)	SPUD PIT EXCAVATED W/BACKHOE TO 11 FEET
10		REFUSE - WOOD, PLASTIC, TIRES, RAGS PAPER - DRY WITH DARK GRAY CLAYEY SILT	
20		REFUSE - WOOD, PLASTIC, METAL WITH DARK GRAY CLAYEY SILT, SOME SANDS, GRAVEL, SPOTTY OIL SHEEN, 84°	
30		DARK GRAY SANDY GRAVEL W/TRACE WOOD, METAL, PLASTIC 82°	
		REFUSE - MOSTLY WOOD, SOME PLASTIC, METAL, GLASS. 82°	
40		REFUSE - DENSE, BLACK SILTY, MOSTLY WOOD, SOME PAPER, METAL PLASTIC 85°	
50		REFUSE - BLACK SILTY, MOSTLY WOOD HARDWARE, METAL, GLASS, PLASTIC, SOME SAND + GRAVEL, SPOTTY OIL SHEEN, 105°	
60		REFUSE - DK GRAY SILTY MOSTLY WOOD, PLASTIC, SOME GRAVEL, COBBLES, 92°	

Well Installation Log

Job No. 55-1550-25 Client CITY OF SEATTLE Location MIDWAY LANDFILL

NG TYPE		DRILLING METHOD		WELL NO. 50
LENGTH		SAMPLING METHOD		
JOINT TYPE		HAMMER WT.	DROP	SHEET 2
SCREEN TYPE HORIZONTAL SLOT		DATE		OF 2
SLOT SIZE .051 - ½" SPACING		BY		
SEAL TYPE BENTONITE		DRILLING CONTR.		START / FINISH
INSTALL. METHOD		WATER LEVEL		
FILTER		TIME		
INSTALL		DATE		
GROUT				



WELL DETAILS	DEPTH	USCS	SOIL DESCRIPTION GROUND ELEVATION	INSTALLATION NOTES
6" PVC CAP (2 PL)	70		MOSTLY CLEAN WASH SAND, GRAVEL	
6" SAND (3 PL)			METAL, SOME WOOD PAPER 100°	
BENTONITE CHIPS				
			REFUSE - MOSTLY WOOD, SOME	
	80		METAL, PLASTIC 100°	
			REFUSE - WOOD, PLASTIC, METAL	
			HARDWARE, RUBBER, FABRIC,	
VESICULAR LAVA			FIBERGLASS, COPPER, STYROFOAM	
ROCK BACKFILL	90			
			REFUSE - MOSTLY WOOD	
			GRAVELLY SAND, TRACE PLASTIC	
			METAL	
			REFUSE - DK GRAY SILTY WOOD, PAPER	
	100		PLASTIC, METAL, GLASS, NEWSPAPER -	MAR '67
			SANDY GRAVEL w/COBBLES,	
			TRACE SILT, SOME WOOD,	
			CLEAN WASH, OIL SHEEN.	
	110			
			SANDY GRAVEL w/COBBLES,	
			1 PIECE RE-BAR, OIL SHEEN	
			SANDY GRAVEL w/COBBLES	
8" PVC CAP (2 PL)	120		TRACE COMPACTED SILT, OIL SH.	
CAVE IN - 3.3'				
			END OF HOLE @ 123.3 FEET	

Well Installation Log

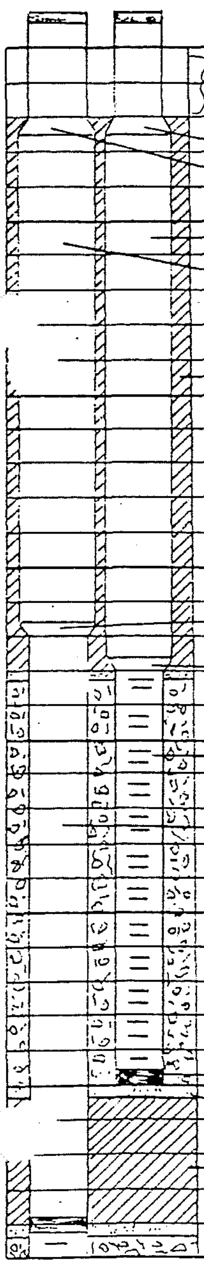
Job No. 55-1550-25 Client SEATTLE SOLID WASTE Location MIDWAY LANDFILL

CASING TYPE	6", 8' + 10" SCH 80 PVC
LENGTH	
JOINT TYPE	SLIP COUPLING - GLUED + SCREWED
SCREEN TYPE	HORIZONTAL SLOT
SLOT SIZE	.050"
SEAL TYPE	BENTONITE CHIPS (ENVIROPLUG)
INSTALL METHOD	BACKHOE/HOPPER
FILTER	VESICULAR LAVA ROCK
INSTALL	
GROUT	

DRILLING METHOD	24" CABLE TOOL
SAMPLING METHOD	
HAMMER WT.	DROP
DATE	8-22-89
BY	J. HICKER
DRILLING CONTR.	RAMLO WELL DRILLING
WATER LEVEL	
TIME	
DATE	

WELL NO.	52
SHEET	1
OF	2
START	FINISH
8-9-89	8-16-89

WELL DETAILS

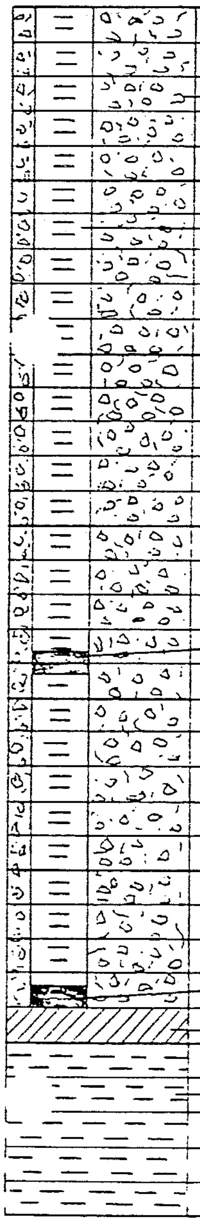


Well details	DEPTH	USCS	SOIL DESCRIPTION	INSTALLATION NOTES
			GROUND ELEVATION	
CLEAN FILL			GRAY-BROWN SILTY SAND W/GRAVEL (SUBGRADE FILL)	
6"x8" BEL-RED; 8"x10" BEL-RED			GRAY SANDY SILT W/REFUSE	
8" PVC BLANK; 10" PVC BLANK	5		REFUSE - WOOD, PLASTIC, TIRES, NEWSPAPER	>100 % LEL
BENTONITE CHIP SURFACE SEAL	10		REFUSE - WOOD, PLASTIC, METAL	
8"x10" SLIP JOINT; 6"x8" SLIP JOINT	15		REFUSE - BLACK, MULCHED WOOD, PLASTIC, METAL, HARDWARE, GRAVEL	
6" PVC SLOT	20		SAME W/SPOTTY OIL SHEEN	(PCB √ = NEG)
8" PVC BLANK			BLACK COARSE SAND W/GRAVEL, COBBLES AND SOME REFUSE	
	25		REFUSE - BLACK, MULCHED WOOD W/TRACE METAL, GRAVEL, PLASTIC	
6" PVC SLIP CAP (2 ft); COLORADO SAND (3 ft)	30			
BENTONITE SEAL			REFUSE - BLACK MULCHED WOOD, PLASTIC, TIRES, WIRE, METAL CORD, GRAVEL	
	35			

Well Installation Log

Job No. ____ Client ____ Location ____

[CASI]NG TYPE		DRILLING METHOD		WELL NO. 52
[LE]NGTH		SAMPLING METHOD		SHEET 2
JOINT TYPE		HAMMER WT.	DROP	OF 2
SCREEN TYPE		DATE		
SLOT SIZE		BY		
SEAL TYPE		DRILLING CONTR.		START / FINISH
INSTALL. METHOD		WATER LEVEL		
FILTER		TIME		
INSTALL		DATE		
GROUT				



WELL DETAILS	DEPTH	USCS	SOIL DESCRIPTION (GROUND ELEVATION)	INSTALLATION NOTES
LAVA ROCK FILTERPACK			INTERBEDDED COARSE SAND w/GRAVEL, COBBLES	
			REFUSE - WOOD w/METAL, TIRES ELEC. HARDWARE, GRAVEL, PLASTIC	
8" PVC SLOT	40		(SAME W/BLUISH OIL SHEEN - PCB √ = NEG)	
			REFUSE - WOOD PLASTIC, STEEL CONCRETE, FLOORING, PIPE,	
	45		REFUSE - WOOD, NEWSPAPER, PLASTIC, HARDWARE, COPPER WIRE SOME GRAVEL	
	50		REFUSE - WOOD, GRAVEL, WIRE GLASS	
8' SLIP COUP (3 PL)				
	55		REFUSE - WOOD, PLASTIC, BEVERAGE (DOMESTIC REFUSE) CANS, FOOD CONTAINERS, CLOTHING	
	60		BOOKS, TIRES, TOYS, MAR '72 NEWSPAPER	
8" SLIP CAP (2 PL)				
BENTONITE CHIPS	65			
PORTLAND CEMENT			GRAY SILTY SAND w/GRAVEL COBBLES, TRACE REFUSE - WOOD, WIRE (DECREASING REFUSE ↓)	* CASED HOLE TO 67.5' BAILED TO 72'
	70			

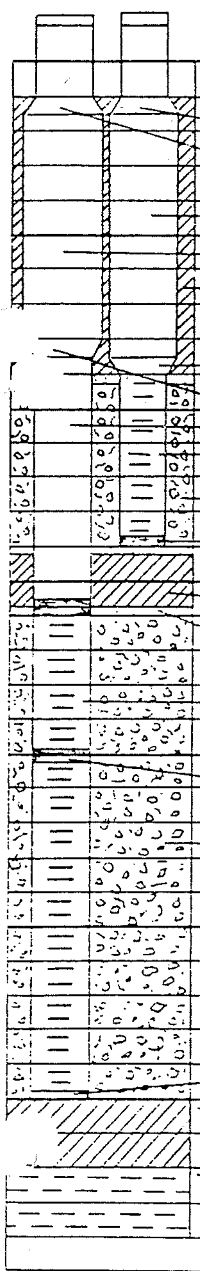
Well Installation Log

Job No. 55-1550-25 Client SEATTLE SOLID WASTE Location MIDWAY LANDFILL

NG TYPE	SCH 80 PVC - 6", 8" + 10"
LENGTH	
JOINT TYPE	PVC SLIP-COUPLING, GLUED + SCREWED
SCREEN TYPE	HORIZONTAL SLOT
SLOT SIZE	.050
SEAL TYPE	BENTONITE CHIP
INSTALL. METHOD	BACKHOE / HOPPER
FILTER	VESICULAR LAVA ROCK
INSTALL	
GROUT	

DRILLING METHOD	CABLE TOOL - 24" CASING
SAMPLING METHOD	
HAMMER WT.	DROP
DATE	9-19-89
BY	J. HICKER
DRILLING CONTR.	RAMCO WELL DRILLING
WATER LEVEL	
TIME	
DATE	

WELL NO.	53
SHEET	1
OF	1
START	FINISH
8-17	8-29



WELL DETAILS	DEPTH	USCS	SOIL DESCRIPTION	INSTALLATION NOTES
			GROUND ELEVATION	
CLEAN FILL			CLEAN FILL - BROWN SILTY SAND w/GRAVEL	
6" x 8" BEL-REDUCER			REFUSE - BOEING MYLAR'S, WOOD, METAL,	
8" x 10" BEL-REDUCER			BUILDING MATERIALS, OILY METAL	
			CUTTINGS	
8" PVC BLANK	10			
10" PVC BLANK			REFUSE - WOOD, PLASTIC, METAL	
BENTONITE CHIP			GRAVEL + COBBLES	
SURFACE SEAL				
6" x 8" SLIP JOINT			REFUSE - WOOD, PLASTIC, GRAVEL, CLOTH	
8" x 10" SLIP JOINT	20		STYROFOAM, HARDWARE, GLASS	
8" PVC BLANK			METALS - COPPER, BRASS, STEEL	
6" PVC SLOT				
LAVA ROCK			REFUSE - PAPER, WOOD, PLASTIC, TILE	
6" SLIP CAP (2 PL)			WIRE, BOOKS, HARDWARE	
	30			
BENTONITE SEAL			REFUSE - WOOD, GRAVEL, COBBLES,	
COLORADO SAND (3 PL)			METAL, PLASTIC, RAGS	
8" PVC SLOT			REFUSE - MOSTLY WOOD, METAL, PLASTIC	
	40		GRAVEL, STERILE MEDICAL WRAPPER	
8" PVC COUPLING				
			REFUSE - WOOD, TIRES, METAL, PLASTIC	
LAVA ROCK			GRAVEL, BOEING FILES, HOSE, WIRE	
			(VERY OILY)	
	50			
			REFUSE - WOOD, METAL, GRAVEL, COBBLES	
			INTERBEDDED SANDY GRAVEL w/ COBBLES	
			REFUSE - WOOD, METAL, GRAVEL	
3" SLIP CAP (2 PL)	60			
BENTONITE CHIP			REFUSE - PLASTIC, RAGS, BRICK, GRAVEL	
			WIRE, TIRES, PAPER, WOOD	
PORTLAND CEMENT				
			COARSE SAND w/ GRAVEL, COBBLES	
	70		REL. CLEAN WASH END OF HOLE @ 68.0 FEET	

Well Installation Log

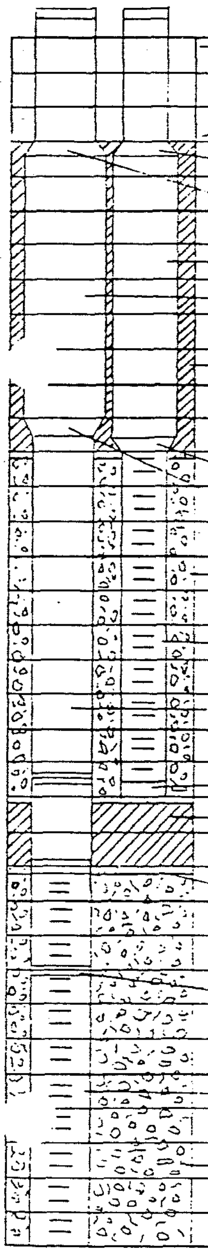
Job No. 55-1550-25 Client SEATTLE SWU Location MIDWAY LANDFILL

NG TYPE	SCH 80 PVC
LENGTH	
JOINT TYPE	PVC SLIP COUPLING - GLUED + SCREWED
SCREEN TYPE	HORIZONTAL SLOT
SLOT SIZE	0.050"
SEAL TYPE	BENTONITE CHIP / PORTLAND CEMENT
INSTALL. METHOD	BACKHOE / HOPPER / GROUT PUMP
FILTER	VESICULAR LAVA ROCK
INSTALL	
GROUT	

DRILLING METHOD	CABLE TOOL - 24" CASING
SAMPLING METHOD	
HAMMER WT.	DROP
DATE	10-5-89
BY	J. HICKER
DRILLING CONTR.	RAMLO WELL DRILLING
WATER LEVEL	
TIME	
DATE	

WELL NO.	54
SHEET	1
OF	2
START	FINISH
9-18	10-5

WELL DETAILS

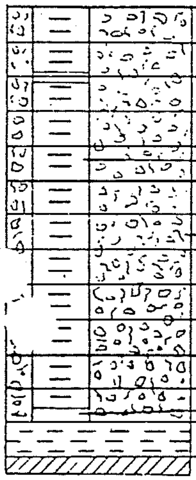


DEPTH	USCS	SOIL DESCRIPTION	INSTALLATION NOTES
		GROUND ELEVATION	
		STOCKPILE FILL	
		SUBGRADE FILL	
10		REFUSE - WOOD, PAPER, PLASTIC, GLASS, METAL	
		MOSTLY PLASTIC, VISQUEEN, BAGS	
		REFUSE - WOOD, PLASTIC, PAPER	
20		CONCRETE, METAL, HEAVY OIL SHEEN, TIRES, FOOD + BEV CONT.'S	
		GRAY PLASTIC, METAL FENCING	
		HARDWARE, ELEC. EQUIP	
30		CONCRETE, WOOD, GRAVEL + SAND	
		REFUSE - WOOD GRAVEL, COBBLES	
40		LOTS OF TIRES, PLASTIC PIPE, FOOD + BEV CONT'S FIBERGLASS	
		REFUSE - WHITE SHREADED PLASTIC	
		GRADING TO SAND, GRAVEL + COBBLES	
50		STRONG LAQUER ODOR, (>300 PPM HNU DOWN CASING)	
		REFUSE - WOOD, METAL, WIRE, TIRES	
		PLASTIC, FOOD + BEV CONT.S, NEWSPAPER (DEC. '72)	
		HARDWARE, AEROSOL CAN, GLASS, GRAVEL	
60		LOTS OF ENGINE PARTS	
		SILTY SANDY GRAVEL W/COBBLES	
		REFUSE - WOOD, PLASTIC, METAL, BRICK PIPE	
70			

Well Installation Log

Job No. 55-1550-25 Client ______ Location ______

NG TYPE		DRILLING METHOD	WELL NO. 54
LENGTH		SAMPLING METHOD	
JOINT TYPE		HAMMER WT. / DROP	SHEET 2
SCREEN TYPE		DATE	OF 2
SLOT SIZE		BY	
SEAL TYPE		DRILLING CONTR.	START / FINISH
INSTALL. METHOD		WATER LEVEL	
FILTER		TIME	
INSTALL		DATE	
GROUT			



WELL DETAILS	DEPTH	USCS	SOIL DESCRIPTION	INSTALLATION NOTES
	70		GROUND ELEVATION	
			REFUSE - WOOD, METAL, PLASTIC	
			GRAVEL, HARDWARE BR. CYLINDER	
			SILTY GRAVEL, (AMMONIA ODOR)	
8" PVC SLOT	80		REFUSE - CARDBOARD PLASTIC, PAPER	
			HARDWARE, CONCRETE, GLASS, WOOD	
LAVA ROCK			PIPE, JUL '68 NEWSPAPER	
			OIL SHEEN	
	90		REFUSE - MOSTLY WOOD W/SOME	
8" SLIP CAP (2 PL)			PLASTIC, METAL SHAVINGS	
			THIN LENSE GRAY CLAYEY SILT W/SOME SAND	
			COARSE SANDY GRAVEL W/COBBLES, CLEAN WASH	
			END OF HOLE @ 97'	

Well Installation Log

Job No. 55-1550-25 Client Seattle Solid Waste Location Midway Landfill

NG TYPE	Sch 80 PVC - 8" + 10"	DRILLING METHOD	Cable Tool - 24" Case
LENGTH		SAMPLING METHOD	
JOINT TYPE	Slip Coup - Glued + Screws	HAMMER WT. / DROP	
SCREEN TYPE	Horizontal Slot	DATE	7-27
SLOT SIZE	.050	BY	J. Hickey
SEAL TYPE	Bentonite Chip	DRILLING CONTR.	Ramco Well Drilling
INSTALL. METHOD	Backhoe / Hopper	WATER LEVEL	
FILTER	Vesicular Lava Rock	TIME	
INSTALL		DATE	
GROUT			

WELL NO. 55 — SHEET 1 OF 2 — START 7-17 FINISH 7-27

WELL DETAILS	DEPTH	USCS	SOIL DESCRIPTION (GROUND ELEVATION)	INSTALLATION NOTES
Clean Fill			Brown, gravelly sand w/some silt (subgrade)	
8"x10" Bel-Red	5			
10" PVC Blank			Light brown gravelly sand w/some silt grading to gray sandy silt (fill)	
Bentonite Chip Surface Seal	10		Gray silty sand w/gravel + refuse - plastic bags, wood, paper strong odor	
	15		Refuse - mostly wood + paper mulch, some sand, trace metal	
				Casing hung on chain link fence
8"x10" Slip Joint	20			
Colorado Sand				
8" PVC Slot			Coarse sand w/gravel, refuse - wood, paper, metal, plastic cloth	
Vesicular Lava Rock Filterpack	25		Refuse - mostly wood, metal, plastic, wire, motor windings some sand	
			Black pulpy refuse (decomp. wood?), rebar, hardware	
	30			
			Wood, tires, metal, plastic gravel + cobbles (trace spotty oil) PCB ✓ - Neg	
	35			

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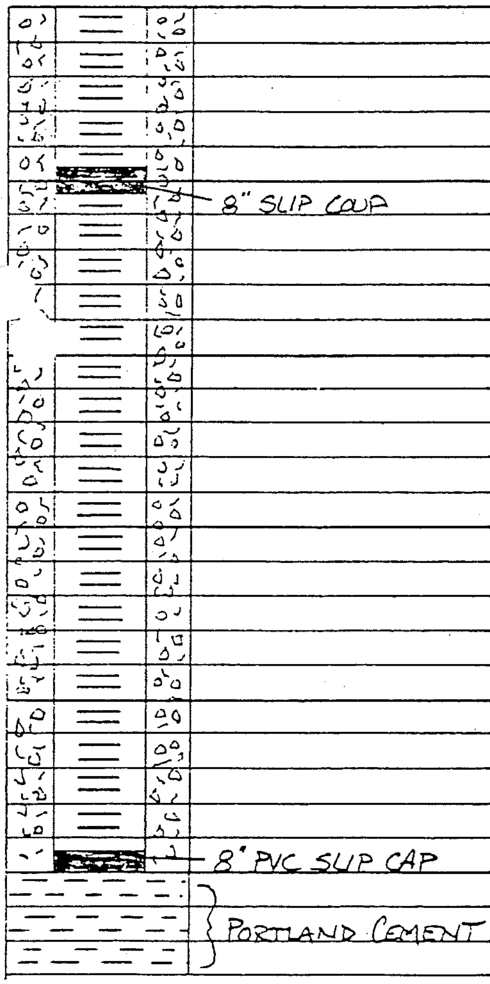
Well Installation Log

Job No. 55-1550-25 Client Seattle Solid Waste Location Midway Landfill

[illegible]NG TYPE		DRILLING METHOD	WELL NO. 55
L[illegible]NGTH		SAMPLING METHOD	
JOINT TYPE		HAMMER WT. / DROP	SHEET 2
SCREEN TYPE		DATE	OF 2
SLOT SIZE		BY	
SEAL TYPE		DRILLING CONTR.	START / FINISH
INSTALL. METHOD		WATER LEVEL	
FILTER		TIME	
INSTALL		DATE	
GROUT			

WELL DETAILS



DEPTH	USCS	SOIL DESCRIPTION	INSTALLATION NOTES
		GROUND ELEVATION	
		REFUSE - WOOD, TIRES, METAL PLASTIC, GRAVEL + COBBLES	
40		BLACK REFUSE - WOOD, PAPER, PLASTIC, METAL	
		REFUSE - WOOD, PLASTIC, GRAVEL, METAL, CARDBOARD	
45		MOSTLY TIRES + WOOD	EXTREMELY SLOW DRILLING
		MORE TIRES, WOOD, PLASTIC GLASS, METAL, SOME GRAVEL	
50		REFUSE - WOOD, PAPER, GRAVEL + COBBLES, PLASTIC BAGS, METAL, CIGS, BEER CANS	
55		REFUSE - WOOD, METAL, PLASTIC	
60			
		GRAY CLAYEY SILT w/ SAND GRAVELLY SAND w/ COBBLES	
		END OF HOLE @ 64'	
65			

Well Installation Log

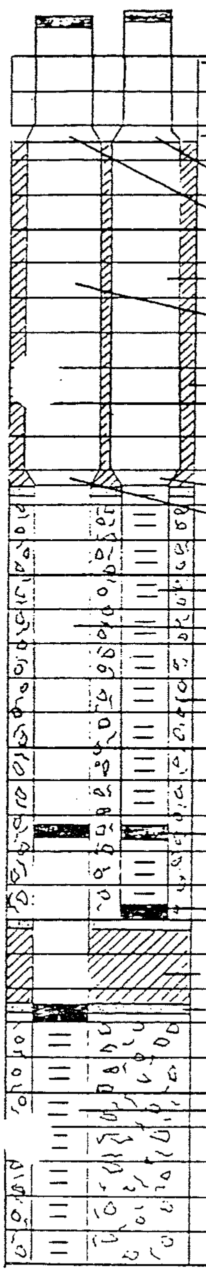
Job No. 55-1550-25 Client CITY OF SEATTLE Location MIDWAY LANDFILL

NG TYPE	6" + 8" SCH 80 PVC
LENGTH	
JOINT TYPE	PVC SLIP, GLUED w/ SCREWS
SCREEN TYPE	HORIZONTAL SLOT
SLOT SIZE	.051
SEAL TYPE	BENTONITE CHIPS
INSTALL. METHOD	BACKHOE / HOPPER
FILTER	LAVA ROCK
INSTALL	
GROUT	

DRILLING METHOD	CABLE TOOL - 24" CASING			
SAMPLING METHOD				
HAMMER WT.		DROP		
DATE	7-14-89			
BY	JOE HICKER			
DRILLING CONTR.	RAMLO WELL DRILLING			
WATER LEVEL				
TIME				
DATE				

WELL NO.	56
SHEET	1
OF	2
START	FINISH
7-8	

WELL DETAILS

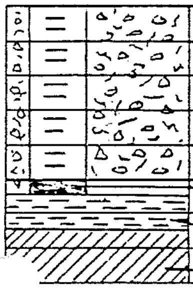


DEPTH	USCS	SOIL DESCRIPTION	INSTALLATION NOTES
		GROUND ELEVATION	
		BROWN SILTY SAND w/ GRAVEL (SUBGRADE FILL)	
		BLUE-GRAY CLAYEY SILT w/ SOME SAND	
10			
		GRAY CLAYEY SILT w/ SOME SAND, OCCASIONAL GRAVEL + COBBLES	
20		GRAY CLAYEY SILT w/ SOME GRAVEL + WOOD	
30		GRAY CLAYEY SILT w/ SOME GRAVEL, WOOD, METAL, TRACE OIL	
		GRAY CLAYEY SILT w/ REFUSE - WOOD, PLASTIC, METAL, CANS STYROFOAM HARDWARE	
40		INCREASING SAND + GRAVEL	
		CLEAN WASH, WELL SORTED + ROUNDED GRAVEL w/ REFUSE - WOOD, PLASTIC METAL, CANS, HARDWARE	
50		REFUSE - BLACK SILTY PULP OF WOOD, PLASTIC, STYROFOAM	
60		REFUSE - BLACK SILTY PULP OF WOOD, PLASTIC, METAL, TIRES PUTRICIBLE WASTES - FOOD CONTAINERS GARBAGE BAGS, PORK PAPER	

Well Installation Log

Job No. ____ Client ____ Location ____

IG TYPE		DRILLING METHOD					WELL NO. 56
LENGTH		SAMPLING METHOD					SHEET 2
JOINT TYPE		HAMMER WT.		DROP			OF 2
SCREEN TYPE		DATE					START / FINISH
SLOT SIZE		BY					
SEAL TYPE		DRILLING CONTR.					
INSTALL. METHOD		WATER LEVEL					
FILTER		TIME					
INSTALL		DATE					
GROUT							

WELL DETAILS	DEPTH	USCS	SOIL DESCRIPTION	INSTALLATION NOTES
	70		GROUND ELEVATION	
			REFUSE - BLACK, PULPY, - WOOD	
			PLASTIC, METAL, HARDWARE	
			PAPER, EVIDENCE OF MED. WASTE	
			- PLASTIC SAMPLE BOTTLE, SYRINGE	
			+ CAPS, RUBBER TUBING	
8" PVC CAP (2 PL)	80		INCREASING GRAVEL	
PORTLAND CEMENT				
BENTONITE CHIPS			GRAVEL W/ COBBLES, SOME	
			COARSE SAND	
			END OF HOLE AT 86.6	

Well Installation Log

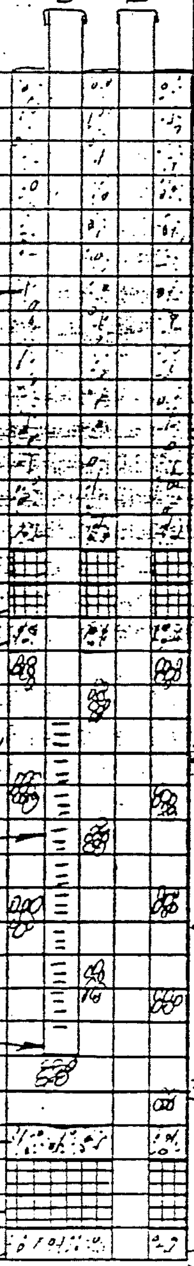
Job No. 31-1550-14-18C Client CITY OF SEATTLE Location MIDWAY LANDFI

CASING TYPE 4" SCH. 80 PVC	SHALLOW COMPLETION	DRILLING METHOD AIR ROTARY - 12"Ø		WELL NO. PA1
LENGTH 10' SCREEN 19' BLANK 29' TOTAL		SAMPLING METHOD GRAB		
JOINT TYPE FLUSH THREAD		HAMMER WT.	DROP	SHEET 1 OF 3
SCREEN TYPE HYDROPHYLLICS		DATE 12-16 12-17-86		
SLOT SIZE .100"		BY ALAN CAREY		
SEAL TYPE BENTONITE PELLET		DRILLING CONTR. RICHARDSON		START / FINISH
INSTALL. METHOD BUCKET THROUGH CASING		WATER LEVEL 22.0 / 56.5		1410 / 1430 12-16-86
FILTER PEA GRAVEL		TIME		
INSTALL BUCKET THROUGH CASING		DATE 2-20-87 / 2-20-87		
GROUT		SHALLOW / DEEP		

WELL DETAILS | DEPTH | USCS | SOIL DESCRIPTION | INSTALLATION NOTES

WELL PA1

S D



GROUND ELEVATION ±345

20'6" (D)

SHOT ROCK - 4-6"
BLACK RIVER QUARRY

NATIVE MATERIAL

5

GRAY, SILTY, M-F SAND WITH SOME GRAVEL, LOOSE, APPEARS TO BE FILL

10 SM

BENTONITE PELLET SEAL

NATIVE MATERIAL

15

END OF DAY 12-16-86
BLOWN-HYDRAULIC HOSE

SHALLOW COMPLETION
4" SCH. 80 PVC
.100" SLOT

20

200' (20'6")

25

COLOR CHANGE GRAY TO TAN

THREADED CAP

TAN, SILTY, M-F SAND WITH SOME GRAVEL, LOOSE, WEATHERED TILL?

SM

30

TIVE MATERIAL

BENTONITE PELLET SEAL

HARDER DRILLING, COLOR CHAN

NATIVE MATERIAL

35 SM

Well Installation Log

Job No. 31-1550-14-18A Client CITY OF SEATTLE Location MIDWAY LANDFILL

CASING TYPE 4" SCH 80 PVC	DEEP COMPLETION	DRILLING METHOD AIR ROTARY -12"ϕ	WELL NO. PA1
LENGTH 20' SCREEN 37' BLANK 67' TOTAL		SAMPLING METHOD GRAB	
JOINT TYPE FLUSH THREAD		HAMMER WT. DROP	SHEET 2 OF 3
SCREEN TYPE HYDROPHYLLICS		DATE 12-17-88	
SLOT SIZE .100"		BY ALAN CAREY - PMX	
SEAL TYPE N/A		DRILLING CONTR. RICHARDSON	START 1030 / FINISH 1500
INSTALL. METHOD N/A		WATER LEVEL	12-17-86
FILTER PEA GRAVEL		TIME	
INSTALL BUCKET THROUGH CASING		DATE	
GROUT			

WELL DETAILS WELL PA1	DEPTH	USCS	SOIL DESCRIPTION	INSTALLATION NOTES
D	35		GROUND ELEVATION ± 345	
DEEP COMPLETION 4" SCH 80 PVC .100 SLOT	40	SM	GRAY GRAVELLY SILTY M-F SAND VERY DENSE (TILL LIKE)	2.00" (40'6")
	45			COLOR CHANGE, ↑ GRAVEL %
	50			
PEA GRAVEL		GP \ GM	BROWNISH GRAY COARSE GRAVEL WITH SOME TO TRACE SAND, TRACE SILT, SOME COBBLES AND BOULDERS	
	55			
	60			2.00" (60'6")
THREADED END CAP	65			
CUTTINGS FLUSHED INTO WELL WHILE WITHDRAWING BIT	70			

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Well Installation Log

Job No. 31-1650-14-18A Client CITY OF SEATTLE Location MIDWAY LANDFILL

CASING TYPE		DRILLING METHOD AIR ROTARY -12"φ	WELL NO. PA1
LENGTH		SAMPLING METHOD GRAB	
JOINT TYPE		HAMMER WT. DROP	SHEET 3
SCREEN TYPE		DATE 12-17-88	OF 3
SLOT SIZE		BY ALAN CAREY -PMX	
SEAL TYPE		DRILLING CONTR. RICHARDSON	START / FINISH
INSTALL METHOD		WATER LEVEL	
FILTER		TIME	
INSTALL		DATE	
GROUT			

WELL DETAILS WELL PA1	DEPTH	USCS	SOIL DESCRIPTION	INSTALLATION NOTES
	70		GROUND ELEVATION	
CUTTINGS FLUSHED INTO WELL WHILE WITHDRAWING BIT		GP \ GM	GRAY FINE GRAVEL SOME SAND, TRACE SILT. WATER BEARING, LOOSE.	MAKING WATER EASER DRILLING
	75			
	80			

Well Installation Log

Job No. 31-1550-14-18A Client CITY OF SEATTLE Location MIDWAY LANDFILL

CASING TYPE 4" SCH. 80 PVC	SHALLOW COMPLETION	DRILLING METHOD CABLE TOOL - 12" ⌀
LENGTH 25' BLANK 10' SCREEN 35 FT TOTAL		SAMPLING METHOD GRAB
JOINT TYPE FLUSH THREAD		HAMMER WT. / DROP
SCREEN TYPE HYDROPHILLICS		DATE 11-24, 11-25-86
SLOT SIZE .100"		BY ALAN CAREY - PMX
SEAL TYPE BENTONITE PELLETS / NATIVE MATERIAL		DRILLING CONTR. RICHARDSON
INSTALL METHOD BUCKET THROUGH CASING		WATER LEVEL
FILTER PEA GRAVEL		TIME
INSTALL BUCKET THROUGH CASING		DATE
GROUT		

WELL NO. PAZ SHEET 1 OF 3

START 0800 FINISH 1615 11-24-86

WELL DETAILS PAZ

GROUND ELEVATION 340±

WELL DETAILS	DEPTH	USCS	SOIL DESCRIPTION	INSTALLATION NOTES
			SHOT ROCK - BLACK RIVER QUARRY	
	5			
NATIVE MATERIAL		SM	GRAY, SILTY, GRAVELLY F-M SAND, MOIST LOOSE, APPEARS TO BE FILL	
	10			
	15			
		GP	FINE GRAVEL, SPILLAGE FROM BATCH PLANT	
BENTONITE PELLETS				
NATIVE MATERIAL	20	SM	SILTY M-F SAND W SOME GRAVEL, VERY DENSE (TILL LIKE), SAND MOTTLED BROWN GRAY	
PEA GRAVEL				
	25			
SHALLOW COMPLETION 4" SCH 80 PVC .100 SLOT		GP \ GM	GRAY BROWN SANDY F-C GRAVEL TRACE SILT.	
	30			DRILLED TO 31.5' END OF 11-24-86
	35			

Well Installation Log

Job No. 31-1550-14-1RA Client CITY OF SEATTLE Location MIDWAY LANDFILL

CASING TYPE 4" SCH. 80 PVC	DEEP COMPLETION	DRILLING METHOD CABLE TOOL -170	WELL NO. PAZ
LENGTH 47' BLANK 20' SCREEN 67 TOTAL		SAMPLING METHOD GRAB	
JOINT TYPE FLUSH THREAD		HAMMER WT. - DROP -	SHEET 2 OF 3
SCREEN TYPE HYDROPHYLLICS		DATE 11-25, 12-1, 12-2-86	
SLOT SIZE .100"		BY ALAN CAREY -PMX	
SEAL TYPE BENTONITE PELLETS		DRILLING CONTR. RICHARDSON	START / FINISH
INSTALL. METHOD BUCKET THROUGH CASING		WATER LEVEL	0820-1630 11-25-86
FILTER PEA GRAVEL		TIME	
INSTALL BUCKET THROUGH CASING		DATE	0810-1400 12-1-86
GROUT			

WELL DETAILS PAZ	DEPTH	USCS	SOIL DESCRIPTION	INSTALLATION NOTES PAZ
"D"			GROUND ELEVATION ±340	
	35	GP \ GM	GRADING COARSER TO	DECREASE SAND HIT COBBLE
NATIVE MATERIAL				
BENTONITE PELLETS	40	GP \ GM	GRAY BROWN F-C GRAVEL, SOME SAND, TRACE SILT, OCCASIONAL COBBLES.	
NATIVE MATERIAL				
	45			END OF DAY 44.5' 11-25-88
				GRAVEL SIZE DECREASING
DEEP COMPLETION 4" SCH. 80 PVC .10 SLOT	50	GP \ GM	GRAY BROWN, FINE GRAVEL, SOME SAND, TRACE SILT	
	55			END OF DAY 12-1-86 DRILL RIG DOWN -57 GRAVEL SIZE INCREASING
PEA GRAVEL	60	GP \ GM	GRAY BROWN, F-C GRAVEL, SOME SAND, TRACE SILT, COBBLES FROM 62'-64'	HIT COBBLE
				GRADING FINER 64'
THREADED CAP	65	GP \ GM	GRAY BROWN, FINE GRAVEL, SOME SAND, TRACE SILT	
SPECIAL BENTONITE SEAL	70			

Well Installation Log

Job No. 31-1550-14-18A Client CITY OF SEATTLE Location MIDWAY LANDFILL

CASING TYPE		DRILLING METHOD	CABLE TOOL - 12" Ø
LENGTH		SAMPLING METHOD	GRAB
JOINT TYPE		HAMMER WT.	DROP
SCREEN TYPE		DATE	12-5, 12-6-86
SLOT SIZE		BY	ALAN CAREY
SEAL TYPE		DRILLING CONTR.	RICHARDSON
INSTALL METHOD		WATER LEVEL	
FILTER		TIME	
INSTALL		DATE	
GROUT			

WELL NO. PA2 — SHEET 3 OF 3

START	FINISH
12-5-86	
0800	1600

WELL DETAILS WELL PA2

WELL DETAILS	DEPTH	USCS	SOIL DESCRIPTION	INSTALLATION NOTES
	70		GROUND ELEVATION	
SPECIAL BENTONITE SEAL		GM	GRAY SILTY FINE GRAVEL WITH SOME SAND.	SILT % INCREASING
				END OF DAY 12-5-86
	75	GP	FINE GRAVEL, SOME SAND, WATER BEARING CLEAN	DRILLER NOTES FORMATION MAKING WATER
PEA GRAVEL BACKFILL	80			
	85	GP	F-C GRAVEL, SOME SAND OCCASIONAL COBBLES, WATER BEARING	GRADATION INCREASING, COARSE GRAVEL, COBBLES
	90			

Parametrix, Inc. 6/87

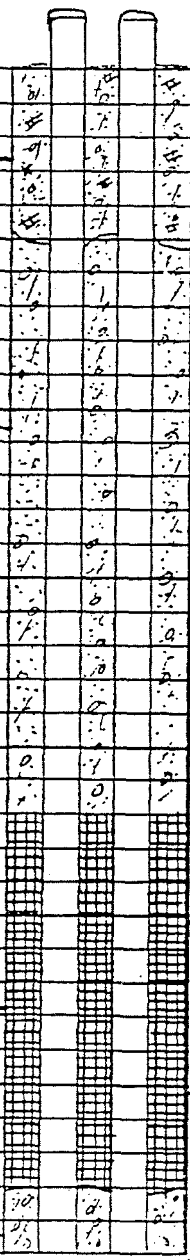
Well Installation Log

Job No. 31-1550-14-18A Client CITY OF SEATTLE Location MIDWAY LANDFILL

CASING TYPE 4" SCH. 80 PVC	SHALLOW COMPLETION	DRILLING METHOD AIR ROTARY - 12"ϕ
LENGTH 15' SCREEN 40' BLANK		SAMPLING METHOD GRAB
JOINT TYPE FLUSH THREAD		HAMMER WT. — DROP —
SCREEN TYPE HYDROPHYLLICS		DATE 2-10-87
SLOT SIZE .100"		BY ALAN CAREY - PMX
SEAL TYPE BENTONITE PELLETS		DRILLING CONTR. RICHARDSON
INSTALL METHOD BUCKET THROUGH CASING		WATER LEVEL
FILTER PEA GRAVEL		TIME
INSTALL BUCKET THROUGH CASING		DATE
GROUT		

WELL NO.	
PA 3	
SHEET 1	
OF 3	
START	FINISH
1130	1700
2-10	87

WELL DETAILS PA3 S D



WELL DETAILS	DEPTH	USCS	SOIL DESCRIPTION	INSTALLATION NOTES
			GROUND ELEVATION 352	
CUTTINGS/BENTONITE	0		SHOT ROCK	
	5	SP	GRAY, GRAVELLY SAND WITH PAPER, ASHES, LOOSE	
CAVED MATERIAL	10			
	15	GP	WASHED ROCK, COARSE CONCRETE AGGREGATE, FROM METHANE CURTAIN	
	20	GP	DARK GRAY SANDY GRAVEL, WATER BEARING, LOOSE, CLEAN	WATER IS COMING FROM SOUTH POND, MAY BE FOLLOWING CASING DOWN
"SPECIAL" BENTONITE PELLET SEAL	25			
	30	GP \ GM	BROWN F-C GRAVEL WITH SOME SAND, TRACE SILT, OCCASIONAL COBBLES	
CAVED MATERIAL	35			

Well Installation Log

Job No. 31-1550-14-18A Client CITY OF SEATTLE Location MIDWAY LANDFILL

CASING TYPE 4" SCH 80 PVC	DEEP COMPLETION	DRILLING METHOD AIR ROTARY	WELL NO. PA 3
LENGTH 25' SCREEN 68' BLANK 93' TOTAL		SAMPLING METHOD GRAB	
JOINT TYPE FLUSH THREAD		HAMMER WT. – DROP –	SHEET 2
SCREEN TYPE HYDRAULICS		DATE 2-10-87	OF 3
SLOT SIZE .100"		BY ALAN CAREY - PMX	
SEAL TYPE BENTONITE PELLETS		DRILLING CONTR. RICHARDSON	START / FINISH
INSTALL METHOD BUCKET THROUGH CASING		WATER LEVEL	1115 – 1145
FILTER PEA GRAVEL		TIME	
INSTALL BUCKET THROUGH CASING		DATE	2-11-87
GROUT			

WELL DETAILS PA 3

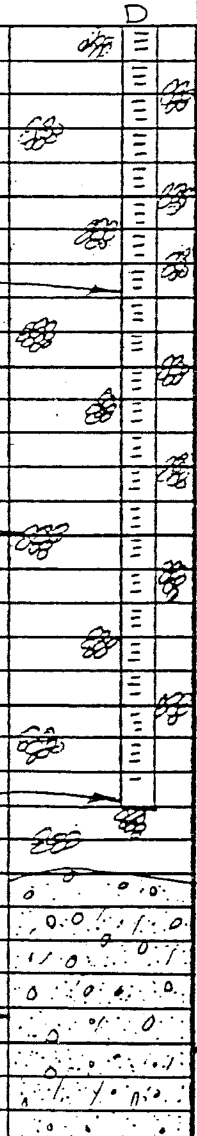
WELL DETAILS (S D)	DEPTH	USCS	SOIL DESCRIPTION	INSTALLATION NOTES
	35		GROUND ELEVATION 352	
CUTTINGS/BENTONITE				
	40	GP \ GM	BROWN F-C GRAVEL WITH SOME SAND, TRACE SILT, OCCASIONAL COBBLES FROM 30'-45', FREQUENT COBBLES FROM 45'-60'	
SHALLOW COMPLETION 4" SCH. 80 PVC ".1" SLOT				
	45			
PEA GRAVEL				
	50		SILT CONTENT INCREASING	
THREADED CAP				
CAVED MATERIAL	55			
PEA GRAVEL				
CUTTINGS/BENTONITE	60			
BENTONITE PELLETS		GM	BROWNISH GRAY SILTY C-F GRAVEL WITH FREQUENT COBBLES, TRACE SAND, VERY MOIST	
CUTTINGS/BENTONITE				
CAVED MATERIAL	65			
DEEP COMPLETION 4" SCH. 80 PVC .100" SLOT			GRAY, FINE GRAVEL WITH SOME SAND, TRACE SILT OCCASIONAL COBBLES	MUCH HARDER DRILLING
	70			

Well Installation Log

Job No. 31-1550-14-18A Client CITY OF SEATTLE Location MIDWAY LANDFILL

CASING TYPE		DRILLING METHOD AIR ROTARY - 12"Ø		WELL NO. PA3
LENGTH		SAMPLING METHOD GRAB		SHEET 3 OF 3
JOINT TYPE		HAMMER WT. —	DROP -	
SCREEN TYPE		DATE 2-10, 2-11-87		
SLOT SIZE		BY ALAN CAREY		
SEAL TYPE		DRILLING CONTR. RICHARDSON		START / FINISH
INSTALL. METHOD		WATER LEVEL		
FILTER		TIME		
INSTALL		DATE		
GROUT				

WELL DETAILS PA3



WELL DETAILS	DEPTH	USCS	SOIL DESCRIPTION	INSTALLATION NOTES
	70		GROUND ELEVATION 352	
		GP / GM	GRAY FINE GRAVEL WITH SOME SAND, TRACE SILT, OCCASIONAL COBBLE, VERY DENSE	
DEEP COMPLETION 4" SCH. 80 PVC .100" SLOT	75			TAKING AIR, COARSE GRAVEL CHATTING
	80			END OF DAY 2-10-87
PEA GRAVEL		GP / GM	GRAY, MOIST C-F GRAVEL WITH TRACE SAND, SILT, POROUS.	
	85			
	90			
THREADED CAP				
	95			PAY TO 95'
CUTTINGS (UNABLE TO CLEANOUT)	100			
	105			

Well Installation Log

Job No. 31-1550-14-19A Client CITY OF SEATTLE Location MIDWAY LANDFILL

CASING TYPE 4" SCH. 80	SHALLOW COMPLETION	DRILLING METHOD AIR ROTARY - 12"ϕ		WELL NO. PA4	
LENGTH 20' SCREEN 24' BLANK 44' TOTAL		SAMPLING METHOD GRAB			
JOINT TYPE FLUSH THREAD		HAMMER WT. -	DROP -	SHEET 1 OF 4	
SCREEN TYPE HYDROPHYLLICS		DATE 1-23-87			
SLOT SIZE .100"		BY ALAN CAREY - PMX			
SEAL TYPE BENTONITE PELLETS		DRILLING CONTR. RICHARDSON		START	FINISH
INSTALL METHOD BUCKET THROUGH CASING		WATER LEVEL		1-23-87	
FILTER PEA GRAVEL		TIME		1330	1545
INSTALL BUCKET THROUGH CASING		DATE			
GROUT					

WELL DETAILS PA4 (S D)	DEPTH	USCS	SOIL DESCRIPTION	INSTALLATION NOTES
			GROUND ELEVATION 360	
			SHOT ROCK - 4"-6" BLACK RIVER QUARRY	
CUTTINGS/BENTONITE	5	SM	DARK GRAY GRAVELLY SILTY SAND WITH ASHES (FILL)	
	10			
	15	SM	BROWNISH GRAY, SILTY M-F SAND WITH SOME GRAVEL, OCCASIONAL COBBLES, VERY DENSE (TILL LIKE)	
BENTONITE PELLETS				
CUTTINGS/BENTONITE	20			
CAVED MATERIAL		GP	GRAY BROWN, COARSE GRAVEL WITH FREQUENT COBBLES, SOME TO TRACE SAND	
SHALLOW COMPLETION 4" SCH. 80 PVC .100" SLOT	25			
	30	GP \ GM	BROWN, F-C GRAVEL WITH TRACE SAND, TRACE SILT.	
PEA GRAVEL	35			

Well Installation Log

Job No. 31-1550-14-18A Client CITY OF SEATTLE Location MIDWAY LANDFILL

CASING TYPE 4" SCH. 80 PVC	DEEP COMPLETION	DRILLING METHOD AIR ROTARY		WELL NO. PA4
LENGTH 40' SCREEN 58' BLANK 98' TOTAL		SAMPLING METHOD GRAB		
JOINT TYPE FLUSH THREAD		HAMMER WT. –	DROP –	SHEET 2
SCREEN TYPE HYDROPHYLLICS		DATE 1-26, 1-27-87		OF 4
SLOT SIZE .100"		BY ALAN CAREY-PMX		
SEAL TYPE BENTONITE PELLETS		DRILLING CONTR. RICHARDSON		START / FINISH
INSTALL. METHOD BUCKET THROUGH CASING		WATER LEVEL		0950 – 1030
FILTER PEA GRAVEL		TIME		
INSTALL BUCKET THROUGH CASING		DATE		
GROUT				

WELL DETAILS PA4 (S D)	DEPTH	USCS	SOIL DESCRIPTION	INSTALLATION NOTES
	35		GROUND ELEVATION 360	
SHALLOW COMPLETION 4" SCH. 80 PVC .100" SLOT				
			GRAY BROWN, C – F GRAVEL WITH	
	40	GP \ GM	SOME TO TRACE SAND, TRACE SILT	END OF DAY 1-26-87 CH_4 = 70% LEL AM OF 1-27-8
THREADED CAP				
	45		GRADING TO	
CAVED MATERIAL				
BENTONITE PELLETS				
	50			
CAVED MATERIAL		GP \ GM	BROWNISH GRAY, FINE GRAVEL WITH SOME SAND, TRACE SILT, OCCASIONAL COARSE GRAVEL/COBBLE LENSES	
	55			
DEEP COMPLETION 4" SCH. 80 PVC .100' SLOT				
	60			CH_4 = 25% LEL
	65			
PEA GRAVEL				
	70			

Well Installation Log

Job No. 31-1550-14-18A Client CITY OF SEATTLE Location MIDWAY LANDFILL

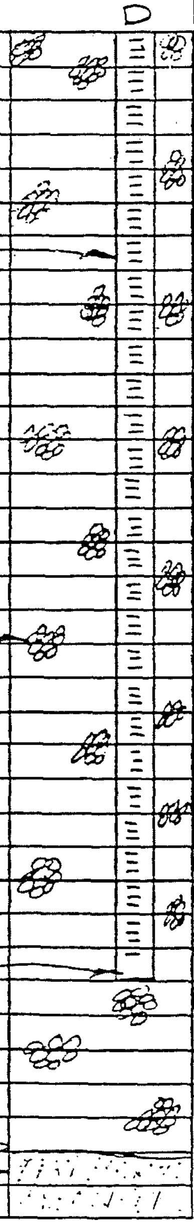
CASING TYPE	
LENGTH	
JOINT TYPE	
SCREEN TYPE	
SLOT SIZE	
SEAL TYPE	
INSTALL. METHOD	
FILTER	
INSTALL	
GROUT	

DRILLING METHOD AIR ROTARY					
SAMPLING METHOD GRAB					
HAMMER WT. -			DROP -		
DATE 1-27, 2-4-87					
BY ALAN CAREY					
DRILLING CONTR. RICHARDSON					
WATER LEVEL					
TIME					
DATE					

WELL NO. PA4
SHEET 3 OF 4

START	FINISH
1030	1330
1-27-87	

WELL DETAILS PA4



WELL DETAILS	DEPTH	USCS	SOIL DESCRIPTION	INSTALLATION NOTES
	70		GROUND ELEVATION 360	
		GP	BROWNISH GRAY FINE GRAVEL WITH	
			SOME SAND, TRACE	
DEEP COMPLETION		GM	SILT, OCCASIONAL COARSE	
4" SCH. 80 PVC	75		GRAVEL/COBBLE LENSES	GRADING SILTIER
.100" SLOT				
			— GRADING TO —	
	80	GM	GRAY, SILTY, FINE GRAVEL WITH	
			TRACE SAND, SLIGHTLY	
			MOIST	
	85			
PEA GRAVEL				
	90			
	95			
THREADED CAP		ML		
			TAN, SANDY SILT WITH	
			THIN LENSES OF FINE	
	100	GM	GRAVEL, SLIGHTLY	
			PLASTIC	
BACKFILLED CUTTINGS		ML		
(SANDY SILT)				
	105			

Well Installation Log

Job No. 31-1550-14-18A Client CITY OF SEATTLE Location MIDWAY LANDFILL

CASING TYPE		DRILLING METHOD	AIR ROTARY - 12" Ø	WELL NO.	PA4
LENGTH		SAMPLING METHOD	GRAB		
JOINT TYPE		HAMMER WT.	— DROP —	SHEET	4
SCREEN TYPE		DATE	2-4-87	OF	4
SLOT SIZE		BY	ALAN CAREY - PMX		
SEAL TYPE		DRILLING CONTR.	RICHARDSON	START	FINISH
INSTALL. METHOD		WATER LEVEL			
FILTER		TIME			
INSTALL		DATE			
GROUT					

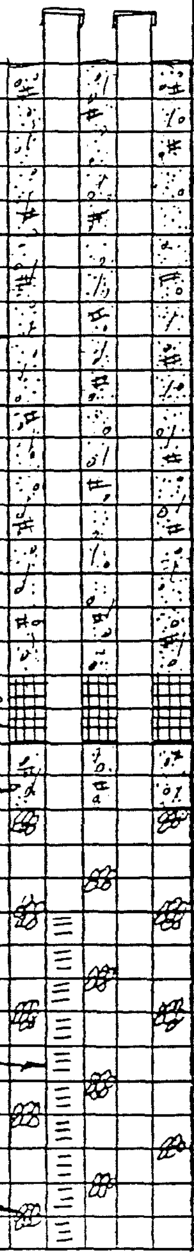
WELL DETAILS PA4	DEPTH	USCS	SOIL DESCRIPTION	INSTALLATION NOTES
	105		GROUND ELEVATION 360	
		ML		
BACKFILLED CUTTINGS (SANDY SILT)		GM		
	110		TAN, SANDY SILT WITH THIN LENSES OF FINE GRAVEL, SLIGHTLY PLASTIC	
		ML		
	115	GM		
		ML		
	120			

Well Installation Log

Job No. 31-1550-14-18A Client CITY OF SEATTLE Location MIDWAY LANDFILL

CASING TYPE 4" SCH 80 PVC	SHALLOW COMPLETION	DRILLING METHOD AIR ROTARY - 12"⌀	WELL NO. PA5
LENGTH 35' SCREEN 25' BLANK 60' TOTAL		SAMPLING METHOD GRAB	SHEET 1 OF 4
JOINT TYPE FLUSH THREAD		HAMMER WT. — DROP -	
SCREEN TYPE HYDROPHYLLICS		DATE 1-14 1-15-87	
SLOT SIZE .100"		BY ALAN CAZEN - PMX	START 1130 FINISH 1350
SEAL TYPE BENTONITE PELLETS		DRILLING CONTR. RICHARDSON	1-15-87
INSTALL. METHOD BUCKET THROUGH CASING		WATER LEVEL	
FILTER PEA GRAVEL		TIME	
INSTALL BUCKET THROUGH CASING		DATE	
GROUT			

WELL DETAILS PA5



Well details	Depth	USCS	Soil Description	Installation Notes
			GROUND ELEVATION 372	
			SHOT ROCK 4"-6"	
			BLACK RIVER QUARRY	
	5			
CUTTINGS/BENTONITE		SM	DARK GRAY, SILTY M-F SAND WITH SOME GRAVEL, LOOSE (FILL)	
	10			
				HARDER DRILLING, COLOR CHANGE
	15			
		SP	TAN, GRAVELLY, F-C-M SAND, CLEAN.	
BENTONITE PELLETS				
CUTTINGS/BENTONITE	20			
	25			END OF DAY 1-14-87 BOULDER, 25-27'
SHALLOW COMPLETION 4" SCH. 80 PVC .100" SLOT				
	30	GP	GRAY, COARSE GRAVEL WITH SOME SAND, OCCASIONAL COBBLES, CLEAN	
PEA GRAVEL				
	35			

Well Installation Log

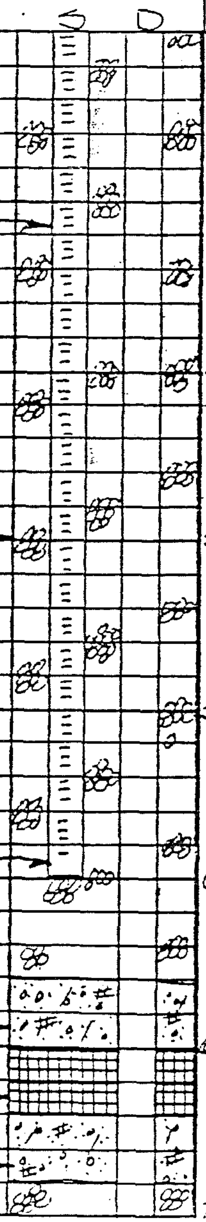
Job No. 31-1550-14-18A Client CITY OF SEATTLE Location MIDWAY LANDFILL

CASING TYPE 4" SCH. 80 PVC	DEEP COMPLETION	DRILLING METHOD AIR ROTARY-12"Ø
LENGTH 45' SCREEN 73' BLANK 118' TOTAL		SAMPLING METHOD GRAB
JOINT TYPE FLUSH THREAD		HAMMER WT. — DROP —
SCREEN TYPE HYDROPHYLLICS		DATE 1-15, 1-16-87
SLOT SIZE .100"		BY ALAN CAREY
SEAL TYPE BENTONITE PELLET		DRILLING CONTR. RICHARDSON
INSTALL. METHOD BUCKET THROUGH CASING		WATER LEVEL
FILTER PEA GRAVEL		TIME
INSTALL BUCKET THROUGH CASING		DATE
GROUT		

WELL NO.	SHEET	START	FINISH
PA5	2 OF 4	1550	1615
		1-15-87	

WELL DETAILS PA5

S D



SHALLOW COMPLETION 4" SCH. 80 PVC .100" SLOT

PEA GRAVEL

THREADED CAP

CUTTINGS/BENTONITE

NITE PELLETS

CUTTINGS/BENTONITE

DEPTH	USCS	SOIL DESCRIPTION	INSTALLATION NOTES
35		GROUND ELEVATION 372	
40			END OF DAY 1-15-87 CH_4 = 6% L.E.L.
	GP	GRAY COARSE GRAVEL WITH SOME SAND, OCCASIONAL COBBLES	
45			
50			
55			
	GP \ GM	BROWN SANDY, FINE GRAVEL WITH TRACE SILT.	
60			CH_4 = 6% L.E.L.
65			
	GP	BROWN F-C GRAVEL WITH FREQUENT COBBLES, TRACE SAND, CLEAN, SLIGHTLY POROUS	
70			

Well Installation Log

Job No. 31-1550-14-1BA   Client CITY OF SEATTLE   Location MIDWAY LANDFILL

CASING TYPE		
LENGTH		
JOINT TYPE		
SCREEN TYPE		
SLOT SIZE		
SEAL TYPE		
INSTALL METHOD		
FILTER		
INSTALL		
GROUT		

DRILLING METHOD AIR ROTARY-120	
SAMPLING METHOD GRAB	
HAMMER WT. -	DROP -
DATE 1-16-87	
BY ALAN CAREY	
DRILLING CONTR. RICHARDSON	
WATER LEVEL	
TIME	
DATE	

WELL NO. PA5	
SHEET 3 OF 4	
START	FINISH
0950-1530	
1-16-87	

WELL DETAILS PA5	DEPTH	USCS	SOIL DESCRIPTION	INSTALLATION NOTES
D	70		GROUND ELEVATION 372	
DEEP COMPLETION 4" SCH. 80 PVC .100" SLOT	75			
		GP	BROWN F-C GRAVEL WITH FREQUENT COBBLES, TRACE SAND, CLEAN, SLIGHTLY POROUS, VERY MOIST FROM 75-90	
	80			CH_4 = 5% L.E.L.
	85			
	90			EASIER, SMOOTHER DRILLING
PEA GRAVEL		ML	BROWNISH GRAY TO DARK GRAY OVER 100', SANDY SILT WITH THIN LENSES OF FINE GRAVEL, SLIGHTLY PLASTIC, VERY MOIST	
	95	GM		
		ML		
	100	GM		CH_4 = 9% LEL
		ML		
	105			

Well Installation Log

Job No. 31-1550-14-18A Client CITY OF SEATTLE Location MIDWAY LANDFILL

CASING TYPE	
LENGTH	
JOINT TYPE	
SCREEN TYPE	
SLOT SIZE	
SEAL TYPE	
INSTALL. METHOD	
FILTER	
INSTALL	
GROUT	

DRILLING METHOD AIR ROTARY-12"Ø					
SAMPLING METHOD GRAB					
HAMMER WT. -			DROP -		
DATE 1-16-87					
BY ALAN CAREY					
DRILLING CONTR. RICHARDSON					
WATER LEVEL					
TIME					
DATE					

WELL NO. PA5	
SHEET 4 OF 4	
START	FINISH

WELL DETAILS PA5	DEPTH	USCS	SOIL DESCRIPTION	INSTALLATION NOTES
	105		GROUND ELEVATION 372	
DEEP COMPLETION 4" SCH. 80 PVC .100" SLOT		ML		
		GM		
	110			
PEA GRAVEL		ML	DARK GRAY, SANDY SILT WITH THIN LENSES OF FINE GRAVEL, SLIGHTLY PLASTIC, VERY MOIST	
	115	GM		
THREADED CAP		ML		
	120			
	125			

Well Installation Log

Job No. 31-1550-14-18A Client CITY OF SEATTLE Location MIDWAY LANDFILL

CASING TYPE 4" SCH 80 P/C	SHALLOW COMPLETION	DRILLING METHOD AIR ROTARY - 12 ¼		WELL NO. PA6
LENGTH 35' SCREEN 28' BLANK 63' TOTAL		SAMPLING METHOD GRAB		
JOINT TYPE FLUSH THREAD		HAMMER WT.	DROP	SHEET 1
SCREEN TYPE HYDROPHYLLICS		DATE 1-8-87		OF 4
SLOT SIZE .100"		BY ALAN CAREY		
SEAL TYPE BENTONITE PELLETS		DRILLING CONTR. RICHARDSON		START / FINISH
INSTALL METHOD BUCKET THROUGH CASING		WATER LEVEL		1055 / 1635
FILTER PEA GRAVEL		TIME		
INSTALL BUCKET THROUGH CASING		DATE		1-8-87
GROUT				

WELL DETAILS PA6 — S D

Well details	Depth	USCS	Soil Description	Installation Notes
			GROUND ELEVATION 374	
			SHOT ROCK - 4-6"	
			BLACK RIVER QUARRY	
NATIVE SOIL	5			
	10	SM	GRAYISH BROWN, SILTY GRAVELLY FINE TO MEDIUM SAND, LOOSE (FILL)	
	15			
BENTONITE PELLETS				
CUTTINGS/BENTONITE	20			COLOR CHANGE
	25			
SHALLOW COMPLETION 4" SCH. 80 P/C .100" SLOT		SM	TAN: SILTY, GRAVELLY M-F SAND, LOOSE, APPEARS TO BE COLLUVIUM	
	30			HARDER DRILLING
PEA GRAVEL		SM	GRAY, SILTY, GRAVELLY, MEDIUM SAND WITH OCCASIONAL COBBLES, VERY DENSE (TILL LIKE)	
	35			

Well Installation Log

Job No. 31-1550-14-18A Client CITY OF SEATTLE Location MIDWAY LANDFILL

SING TYPE 4" SCH. 80 PVC	DEEP COMPLETION	DRILLING METHOD AIR ROTARY - 12"ϕ	WELL NO. PA6
LENGTH 45' SCREEN 75' BLANK 125' TOTAL		SAMPLING METHOD GRAB	
JOINT TYPE FLUSH THREAD		HAMMER WT. – DROP –	SHEET 2
SCREEN TYPE HYDROPHYLLIC		DATE 1-8-87	OF 4
SLOT SIZE .100"		BY ALAN CAREY - PMX	
SEAL TYPE BENTONITE PELLETS		DRILLING CONTR. RICHARDSON	START / FINISH
INSTALL METHOD BUCKET THROUGH CASING		WATER LEVEL	1015 — 1540
FILTER PEA GRAVEL		TIME	
INSTALL BUCKET THROUGH CASING		DATE	1-9-87
GROUT			

WELL DETAILS PA6 (S / D)	DEPTH	USCS	SOIL DESCRIPTION	INSTALLATION NOTES
	35		GROUND ELEVATION 374	
SHALLOW COMPLETION 4" SCH 80 PVC .100" SLOT	40	SM	GRAY, SILTY, GRAVELLY M-F SAND WITH OCCASIONAL COBBLES FROM 30-48, FREQUENT COBBLES FROM 48-52, VERY DENSE (TILL LIKE)	
	45			
PEA GRAVEL	50			
	55			
THREADED CAP	60	GM	BROWNISH GRAY, SILTY FINE GRAVEL WITH SOME SAND SATURATED FROM 68-72'	
CUTTINGS/BENTONITE	65			
BENTONITE PELLETS				
CUTTINGS/BENTONITE	70			

Well Installation Log

Job No. 31-1550-14-18A Client CITY OF SEATTLE Location MIDWAY LANDFILL

ING TYPE		DRILLING METHOD AIR ROTARY	WELL NO. PA6
LENGTH		SAMPLING METHOD GRAB	
JOINT TYPE		HAMMER WT. - DROP -	SHEET 3
SCREEN TYPE		DATE 1-8, 1-9-87	OF 4
SLOT SIZE		BY ALAN CAREY	
SEAL TYPE		DRILLING CONTR. RICHARDSON	START / FINISH
INSTALL. METHOD		WATER LEVEL	
FILTER		TIME	
INSTALL		DATE	
GROUT			

WELL DETAILS PA6

WELL DETAILS	DEPTH	USCS	SOIL DESCRIPTION	INSTALLATION NOTES
D	70		GROUND ELEVATION 374	
CUTTINGS/BENTONITE		GM	SEE PREVIOUS PAGE	
	75		DARK GRAY SILTY GRAVELLY, M-F SAND	
		SM	VERY DENSE (TILL LIKE)	
DEEP COMPLETION "SCH. 80 PVC 0" SLOT				
	80			END OF DAY 1-8-87
				BOULDER AT 82
	85			
	90	GM	LIGHT GRAY, SILTY COARSE GRAVEL WITH FREQUENT COBBLES, TRACE SAND, VERY MOIST, SLIGHTY POROUS	
PEA GRAVEL	95			
	100			
	105			

Well Installation Log

Job No. 31-1550-14-18A Client CITY OF SEATTLE Location MIDWAY LANDFIL

SING TYPE		DRILLING METHOD	AIR ROTARY - 12"ϕ
LENGTH		SAMPLING METHOD	GRAB
JOINT TYPE		HAMMER WT. —	DROP —
SCREEN TYPE		DATE	1-9-97
SLOT SIZE		BY	ALAN CAREY - PMX
SEAL TYPE		DRILLING CONTR.	RICHARDSON
INSTALL METHOD		WATER LEVEL	
FILTER		TIME	
INSTALL		DATE	
GROUT			

WELL NO. PA6
SHEET 4 OF 4

START	FINISH

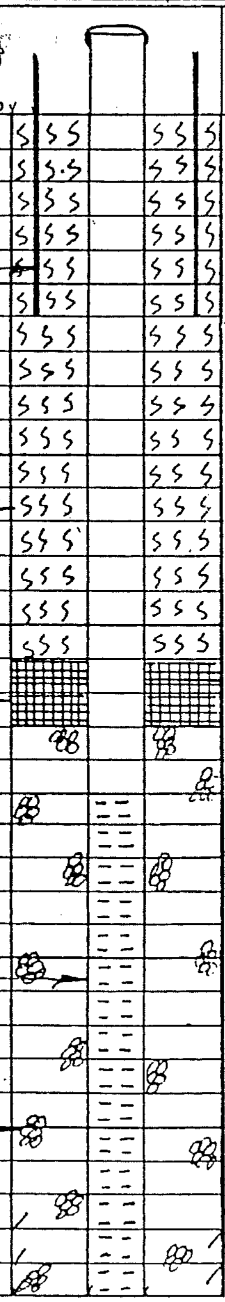
WELL DETAILS PA6	DEPTH	USCS	SOIL DESCRIPTION	INSTALLATION NOTES
	105		GROUND ELEVATION 374	
DEEP COMPLETION 4" SCH. 80 PVC .100" SLOT				
	110	GM	LIGHT GRAY, SILTY COARSE GRAVEL WITH FREQUENT COBBLES, TRACE SAND VERY MOIST, SLIGHTLY POROUS	
	115			
THREADED CAP	120			

Well Installation Log

Job No. 31-1550-20 Client CITY OF SEATTLE Location NORTH END OF MIDWAY LANDFILL

CASING TYPE 6" SCH. 80 PVC	DRILLING METHOD 16" ϕ AIR ROTARY		WELL NO. PC-4
LENGTH 20' SCREEN 20' WELL PIPE 5' EXT 25 TOTAL	SAMPLING METHOD		
JOINT TYPE FLUSH THREAD	HAMMER WT. —	DROP —	SHEET 1
SCREEN TYPE HYDROPHYLLICS	DATE 12-8		OF 2
SLOT SIZE .100	BY AL CAREY		
SEAL TYPE 3/8 BENTONITE PELLETS - 200 LBS	DRILLING CONTR. RICHARDSON WELL DRILLING		START / FINISH
INSTALL. METHOD BUCKET THRU CASING	WATER LEVEL	35.6 / 31.1	
FILTER PEA GRAVEL	TIME	1200 / 1200	1530 / 1610
INSTALL BUCKET THRU CASING	DATE	12-11-87 / 12-11-87	12-8-87
GROUT 450 LBS GRANULATED BENTONITE		T.O.P. / G.L.	

WELL DETAILS PC-4



Well details	Depth	USCS	Soil Description	Installation Notes
0			GROUND ELEVATION	1530 , 20'0" (0)-16"
			SHOT ROCK	
12" STEEL CASING		SM	GLACIAL DRIFT (FILL	
6	5			
			REFUSE - PRIMARILY V MOIST BROWN SILTY SAND W PAPER AND WOOD	
BENTONITE GROUT 450 LBS	10	REFUSE		
	15			
16				
BENTONITE PELLET SEAL - 200 LBS 18				
			REFUSE - PRIMARILY WOOD	
20	20			1600 , 19'1" (20'0")-16"
				0900
6" SCH 80 PVC .100 SLOT				
	25	REFUSE		POOR RETURN
				MOTHBALL SMELL
PEA GRAVEL	30			
	35			

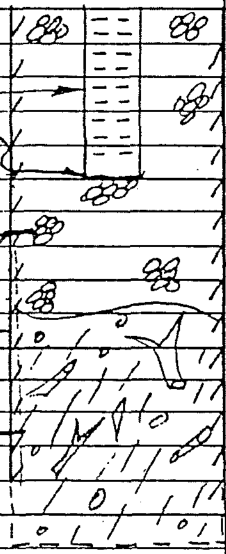
Well Installation Log

Job No. 31-1550-20 Client CITY OF SEATTLE Location

CASING TYPE		DRILLING METHOD	16"ϕ AIR ROTARY
LENGTH		SAMPLING METHOD	—
JOINT TYPE		HAMMER WT.	— DROP —
SCREEN TYPE		DATE	12-9-87
SLOT SIZE		BY	AL CAREY - PMX
SEAL TYPE		DRILLING CONTR.	RICHARDSON WELL DRILLING
INSTALL. METHOD		WATER LEVEL	
FILTER		TIME	
INSTALL		DATE	
GROUT			

WELL NO.	PC-4
SHEET	2
OF	2
START	12-9-87
FINISH	12-9-87

WELL DETAILS PC-4



DEPTH	USCS	SOIL DESCRIPTION	INSTALLATION NOTES
35		GROUND ELEVATION	
	REFUSE	REFUSE - PRIMARILY WOOD	
			1120 ↓ 10'0" (39'1")-16"
40			1510 ↓
45			
			1620 ↓ (49'1")-16"
50			
			MORE DIFFICULT DRILLING AT 51' POSSIBLY NATIVE SOIL

Well Installation Log

Job No. 31-1550-20 Client CITY OF SEATTLE Location NW CORNER OF MIDWAY LANDFILL

CASING TYPE	6" SCH. 80 PVC
LENGTH	30' SCREEN 11' WELL PIPE 5' EXT 16' TOTAL BLANK
JOINT TYPE	FLUSH THREAD
SCREEN TYPE	HYDROPHILLICS
SLOT SIZE	.100
SEAL TYPE	3/8" BENTONITE PELLETS - 200 LBS
INSTALL METHOD	BUCKET THRU CASING
FILTER	PEA GRAVEL
INSTALL	BUCKET THRU CASING
GROUT	250 LBS GRANULATED BENTONITE

DRILLING METHOD	AIR ROTARY - 16"
SAMPLING METHOD	GRAB
HAMMER WT.	-
DROP	-
DATE	12-21, 12-22-86
BY	AL CAREY - PMX
DRILLING CONTR.	RICHARDSON WELL DRILLING
WATER LEVEL	
TIME	
DATE	

WELL NO.	
PC-6	
SHEET 1	OF 2
START	FINISH
1355	1500
12-21	87

WELL DETAILS PC-6

+4
0
12" STEEL CASING
BENTONITE GROUT 260 LBS
BENTONITE PELLETS SEAL - 200 LBS
10
11
6" SCH. 80 PVC .100 SLOT
PEA GRAVEL

DEPTH	USCS	SOIL DESCRIPTION	INSTALLATION NOTES
		GROUND ELEVATION 344 ±	1355 19'0" (0)
	SM	SHOT ROCK GRAY SILTY, GRAVELLY SAND (COVER MATERIAL)	
5	REFUSE	REFUSE - PRIMARILY SILTY SANDY GRAVEL W PAPER	MUCH EASIER DRILLING - 5'
	REFUSE	REFUSE - PRIMARILY WOOD AND PAPER	
10			
15	REFUSE	REFUSE - PRIMARILY WOOD, PAPER WITH CONCRETE, TIRES	HARD DRILLING WOOD BLACK - LIKE CREOSOTE
20			1500 19'0" (18.8') - 0.65 CH₄ - 77% LEL 1330 12-21
25	REFUSE	REFUSE - PRIMARILY WOOD	
30			INCREASE IN MOISTURE
35		REFUSE - PRIMARILY WOOD W SOME SATURATED HIGHLY ORGANIC SOIL	

Parametrix, Inc.

Well Installation Log

Job No. 31-1550-20 Client CITY OF SEATTLE Location

CASING TYPE		DRILLING METHOD					WELL NO. PC-6S	
LENGTH		SAMPLING METHOD						
JOINT TYPE		HAMMER WT.		DROP			SHEET 2	
SCREEN TYPE		DATE					OF 2	
SLOT SIZE		BY						
SEAL TYPE		DRILLING CONTR.					START	FI[illegible]H
INSTALL. METHOD		WATER LEVEL	334				0925	10[illegible]
FILTER		TIME	1115					
INSTALL		DATE	12-22-81				12-22-	[illegible]
GROUT								

WELL DETAILS PC-6	DEPTH	USCS	SOIL DESCRIPTION GROUND ELEVATION	INSTALLATION NOTES
6"SCH. 80 PVC				INCREASE IN GRAVEL
.100 SLOT		REFUSE	REFUSE PRIMARILY	
			WOOD WITH SOME	1010 (3[illegible]
			SATURATED GRAVELLY	
THREADED CAP			SOIL	HARDER DRILLING AT 40'
41				PROBABLY NATIVE SOIL
		GM		
		(?)		

Well Installation Log

Job No. 31-1550-20 Client CITY OF SEATTLE Location NW CORNER OF MIDWAY LANDFILL

CASING TYPE 6" SCH. 80 PVC	DRILLING METHOD AIR ROTARY-16Ø		WELL NO. PC-7S
LENGTH 25 SCREEN 13' WELL PIPE 6' EXT BLANK 19' TOTAL	SAMPLING METHOD GRAB		
JOINT TYPE FLUSH THREAD	HAMMER WT. —	DROP —	SHEET 1
SCREEN TYPE HYDROPHYLLICS	DATE 12-23		OF 2
SLOT SIZE .100	BY AL CAREY - PMX		
SEAL TYPE 3/8 BENTONITE PELLETS - 200 LBS	DRILLING CONTR. RICHARDSON WELL DRILLING		START / FINISH
INSTALL. METHOD BUCKET THRU CASING	WATER LEVEL	23.6 / 18.0	
FILTER PEA GRAVEL	TIME	1200 / 1200	1310 / 1700
INSTALL BUCKET THRU CASING	DATE	12-28-87 / 12-28-87	12-23-87
GROUT 250 LBS GRANULATED BENTONITE		T.O.P / GL.	

WELL DETAILS PC-7	DEPTH	USCS	SOIL DESCRIPTION	INSTALLATION NOTES
+4				
0			GROUND ELEVATION	1310 19'0"(0)-16"
12"Ø STEEL CASING			SHOT ROCK	
			SILTY, GRAVELLY SAND	
		SM	COVER MATERIAL	
BENTONITE GROUT		REFUSE	REFUSE - MOIST, SILTY	
SEAL	5		GRAVELLY SAND	
6			W SOME STICKS, PAPER	
		REFUSE	REFUSE - MOSTLY	CUTTINGS MOSTLY WOOD
9			WOOD	
BENTONITE PELLET	10			STRONG, PUTRID, FARM SMELL
SEAL - 200 LBS 11			REFUSE - MOSTLY WOOD	(ANIMAL HIDES?)
		REFUSE	INSULATION, SOIL, ?	CUTTINGS, MOSTLY INSULATION
13				
	15			
6" SCH. 80 PVC			REFUSE - MOSTLY WOOD	STRONG H_2S SMELL
.100 SLOT			SOIL, ?	
				1355 18'8"(19'0")-16"
				1550
	20		REFUSE - MOSTLY WOOD	
			PAPER, PLASTIC	
		REFUSE		
PEA GRAVEL	25			INCREASE IN MOISTURE
				STRONG H_2S SMELL
	30			
			REFUSE - MOSTLY WOOD	CUTTINGS SATURATED
			AND SATURATED ORGANIC	
	35		RICH SOIL	

Well Installation Log

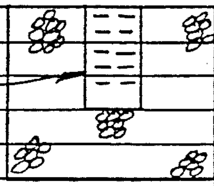
Job No. 31-1550-20 Client CITY OF SEATTLE Location

CASING TYPE	
LENGTH	
JOINT TYPE	
SCREEN TYPE	
SLOT SIZE	
SEAL TYPE	
INSTALL. METHOD	
FILTER	
INSTALL	
GROUT	

DRILLING METHOD	AIR ROTARY 16"Ø				
SAMPLING METHOD	—				
HAMMER WT.	—	DROP —			
DATE	12-23-87				
BY	AL CAREY - PMX				
DRILLING CONTR.					
WATER LEVEL	18.3				
TIME	0915				
DATE	12-24-87				

WELL NO.	
PC-7S	
SHEET 2	
OF 2	
START	FINISH

WELL DETAILS PC-7



WELL DETAILS	DEPTH	USCS	SOIL DESCRIPTION	INSTALLATION NOTES
	35		GROUND ELEVATION	
6" SCH 80 PVC		REFUSE	REFUSE - MOSTLY WOOD	
.100 SLOT			AND SATURATED ORGANIC	BLOW EXHAUST HOSE
38			RICH SOIL	1645 HARDER DRILLING 38' (37'8")
		GM		1655 MAKES H_2O ON
40	40		DENSE, SATURATED, GRAY	1700 START-UP
			SILTY, SANDY GRAVEL	

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SEATTLE ENGINEERING DEPARTMENT

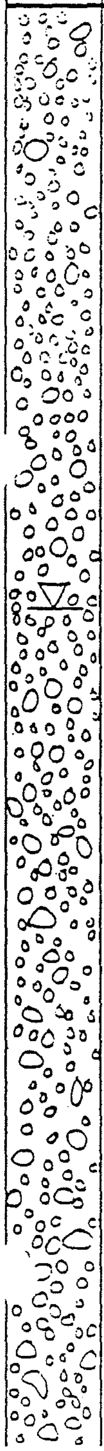
MATERIALS LABORATORY

LOG OF TEST BORING

DATE ____________________ HOLE NO. FD-11

PROJECT MIDWAY LANDFILL GAS CONTROL - GRD. ELEV. ________

LOCATION ____________________



STRATA	DEPTH	SAMPLE NO.	BLOW COUNT	STD. PEN.	DESCRIPTION OF MATERIAL: COMPOSITION	CONSISTENCY	MOISTURE	COLOR	WATER LEVEL
					65' - 103				
					medium GRAVEL, pea				
					size to 4 cm				
	80				80'-water				

INSPECTOR

CS 7.241

SEATTLE ENGINEERING DEPARTMENT

MATERIALS LABORATORY

LOG OF TEST BORING

DATE

HOLE NO. PD-11

PROJECT Midway Landfill Gas Control Phase II

GRD. ELEV.

LOCATION

STRATA	DEPTH	SAMPLE NO.	BLOW COUNT	STD. PEN.	DESCRIPTION OF MATERIAL: COMPOSITION	CONSISTENCY	MOISTURE	COLOR	WATER LEVEL
	103								
					TD = 103'				
					elevation = 253.7				

INSPECTOR

PHX 31-1550-14 (18)

GAS WELL CONSTRUCTION LOG

WELL No. PD-1 Coords N ? E ?

Landfill name: MIDWAY GAS MIGRATION - PHASE II Date 1-16-87

I. DIMENSIONS:

a. Total depth of well 132'

b. Diameter of well 12"

c. Well casing interval
LOWER from 130' to 0
UPPER from 65' to 0

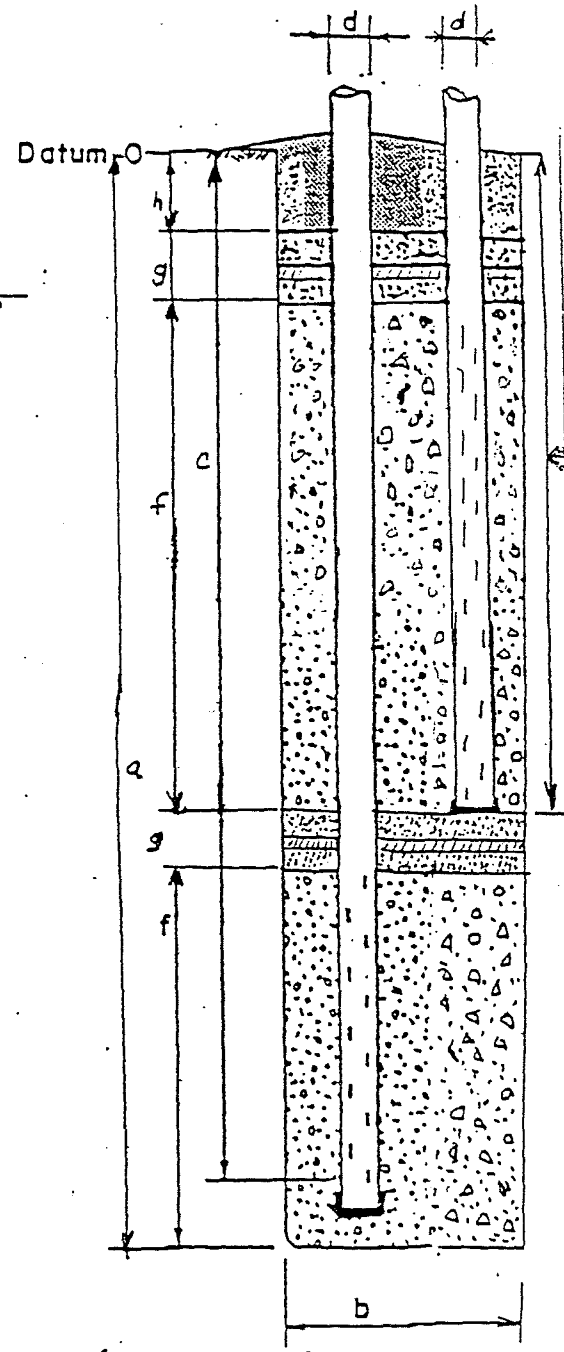
d. Diameter of well casing 4"

e. Slotted interval of well casing
Lower from 130' to 80'
Upper from 65' to 25'

f. Permeable material interval
Lower from 132 to 73
Upper from 67 to 22

g. Impermeable plug interval
Lower: 73 → 67
Upper: 22 → 0

h. Backfill material interval



II. MATERIALS:

Permeable material 9.5 yards washed + screened pea gravel

Impermeable plug 10 bags granulated Wyoming Bentonite (Enviro Gel)

Backfill material Cuttings mixed with 50% granulated bentonite

Casing material (incl. slip joints) 195' of 4" PVC (threaded couplings)

III. CONSTRUCTION:

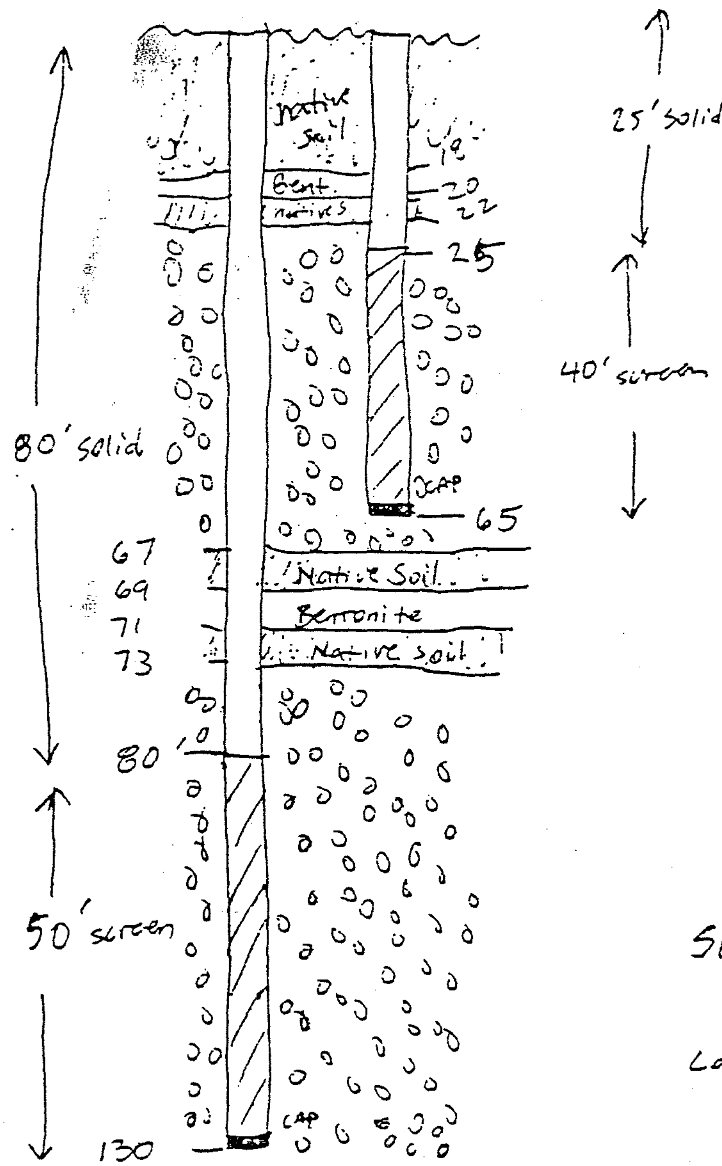
Method of placing fill materials: Backfilled with use of hand shovels

Method of placing casing: Lowered into hole by 20' sections using the sand line on the PortaDrill rig.

Problems encountered: none - well was completed in less than six hours

PD-1

TD = ~~[illegible]~~ (130)
TD/2 = 65



SHORT WELL: 25' SOLID PVC
40' SCREEN PVC

LONG WELL 80' SOLID PVC
50' SCREEN PVC

TOTALS: 105' SOLID
90' SCREEN

195' TOTAL

Memorandum

Date: 1-16-87 Job No. 31-1550-14(18)

To: Evan Skinner, Mahaffey Drill. Job Name: Midway Landfill

From: Mark Menard

Completion Resume' for Boring PD-1

① 1 set-up on PD-1

② 132' Drilling (12" diameter cased hole)

③ 197' Total Completion Footage

Shallow Well → 65'

Deep Well ⇒ 132'

a) 8 bags granulated bentonite used

b) 1) 90' slotted 4" PVC

2) 105' blank 4" PVC

Parametrix, Inc.

SEATTLE ENGINEERING DEPARTMENT

MATERIALS LABORATORY

CS 7.241

LOG OF TEST BORING

DATE 1/16/87 HOLE NO. PD-1

PROJECT Midway Landfill Gas Control Phase II GRD. ELEV. ~~[illegible]~~

LOCATION

STRATA	DEPTH	SAMPLE NO.	BLOW COUNT	STD. PEN.	DESCRIPTION OF MATERIAL: COMPOSITION	CONSISTENCY	MOISTURE	COLOR	WATER LEVEL
	1'				0-1' clay and organic rich SOIL				No water in this boring
					1'-9' SAND and GRAVEL fill.				
	9'				9'-20' fine to medium SAND				
	20'				20'-60' medium GRAVEL w/trace sand				
		Sample PD1-S1							

INSPECTOR

SEATTLE ENGINEERING DEPARTMENT

MATERIALS LABORATORY

CS 7.241

LOG OF TEST BORING

DATE ____________ HOLE NO. PD-1

PROJECT Midway Landfill Gas Control Phase II GRD. ELEV. ____________

LOCATION ____________

STRATA	DEPTH	SAMPLE NO.	BLOW COUNT	STD. PEN.	DESCRIPTION OF MATERIAL: COMPOSITION	CONSISTENCY	MOISTURE	COLOR	WATER LEVEL
					20'-60' medium GRAVEL w/trace sand				
	40'								
	46'	Sample PD1-S2							
	50'								
	60'								

INSPECTOR

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SEATTLE ENGINEERING DEPARTMENT

MATERIALS LABORATORY

LOG OF TEST BORING

DATE ______________________ HOLE NO. PD-1

PROJECT Midway Landfill Gas Control Phase II GRD. ELEV. ________

LOCATION ______________________

STRATA	DEPTH	SAMPLE NO.	BLOW COUNT	STD. PEN.	DESCRIPTION OF MATERIAL: COMPOSITION	CONSISTENCY	MOISTURE	COLOR	WATER LEVEL
					60' – 132' medium to coarse GRAVEL				
	70								
	77'	Sample PD1-S2							
	80'								
	90								

INSPECTOR

SEATTLE ENGINEERING DEPARTMENT

MATERIALS LABORATORY

CS 7.241

LOG OF TEST BORING

DATE ______________________ HOLE NO. PD-1

PROJECT Midway Landfill Gas Control Phase II GRD. ELEV. ______

LOCATION ______________________

STRATA	DEPTH	SAMPLE NO.	BLOW COUNT	STD. PEN.	DESCRIPTION OF MATERIAL: COMPOSITION	CONSISTENCY	MOISTURE	COLOR	WATER LEVEL
					60'-132' medium to coarse GRAVEL				
	100'								
	110'								
	120'								

INSPECTOR

SEATTLE ENGINEERING DEPARTMENT

MATERIALS LABORATORY

CS 7.241

LOG OF TEST BORING

DATE ______________________ HOLE NO. PD-1

PROJECT MIDWAY LANDFILL GAS CONTROL PHASE II GRD. ELEV. ________

LOCATION ______________________________________

STRATA	DEPTH	SAMPLE NO.	BLOW COUNT	STD. PEN.	DESCRIPTION OF MATERIAL				WATER LEVEL
					COMPOSITION	CONSISTENCY	MOISTURE	COLOR	
	132'								
					TD = 132'				

INSPECTOR

PHX 31-1550-14 (18)

GAS WELL CONSTRUCTION LOG

WELL No. PD-3 Coords N 10323.885 E 70427.104

Landfill name: MIDWAY GAS MIGRATION - PHASE II Date 1-15-87

I. DIMENSIONS:

a. Total depth of well 117'

b. Diameter of well 12"

c. Well casing interval
LOWER from 115 to 0
UPPER from 57 to 0

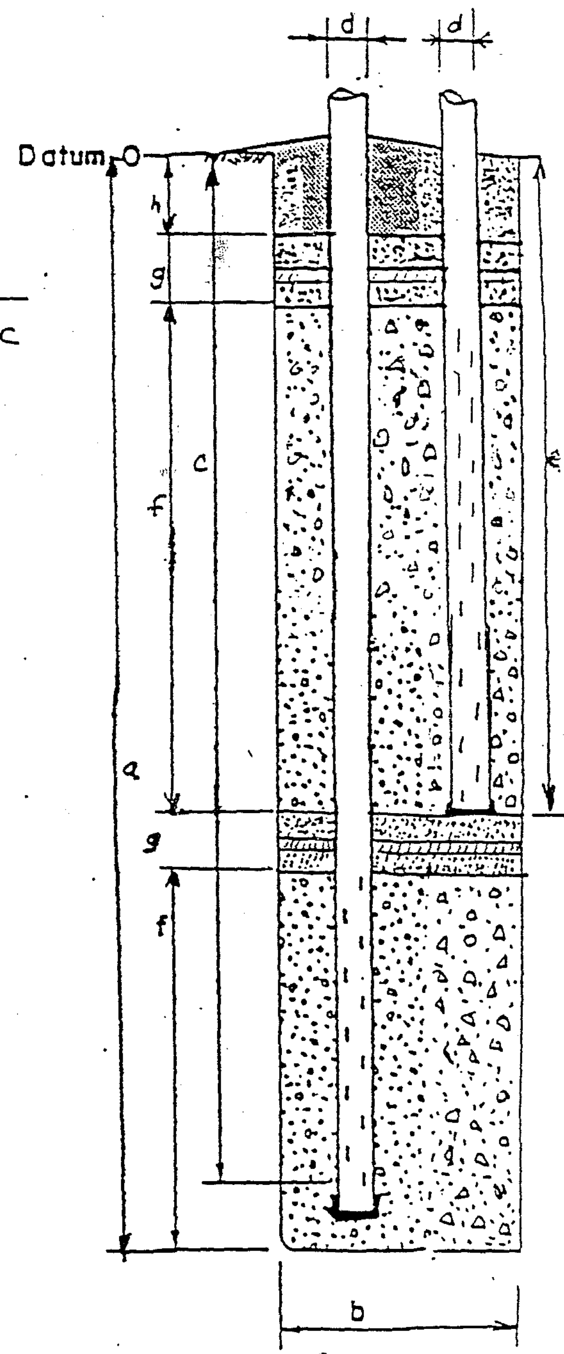
d. Diameter of well casing 4" Sch. 80 PVC

e. Slotted interval of well casing
Lower from 115 to 70
Upper from 57 to 27

f. Permeable material interval
Lower from 117 to 64
Upper from 58 to 22

g. Impermeable plug interval
Lower: 64 → 58
Upper: 22 → 0

h. Backfill material interval —



II. MATERIALS:

Permeable material ~8.75 yds washed pea gravel

Impermeable plug 8 bags granulated bentonite (Enviro Gel)

Backfill material Drill cuttings with 50% granulated bentonite

Casing material (incl. slip joints) 4" Sch. 80 PVC Pipe

III. CONSTRUCTION:

Method of placing fill materials: Backfilled with use of hand shovels

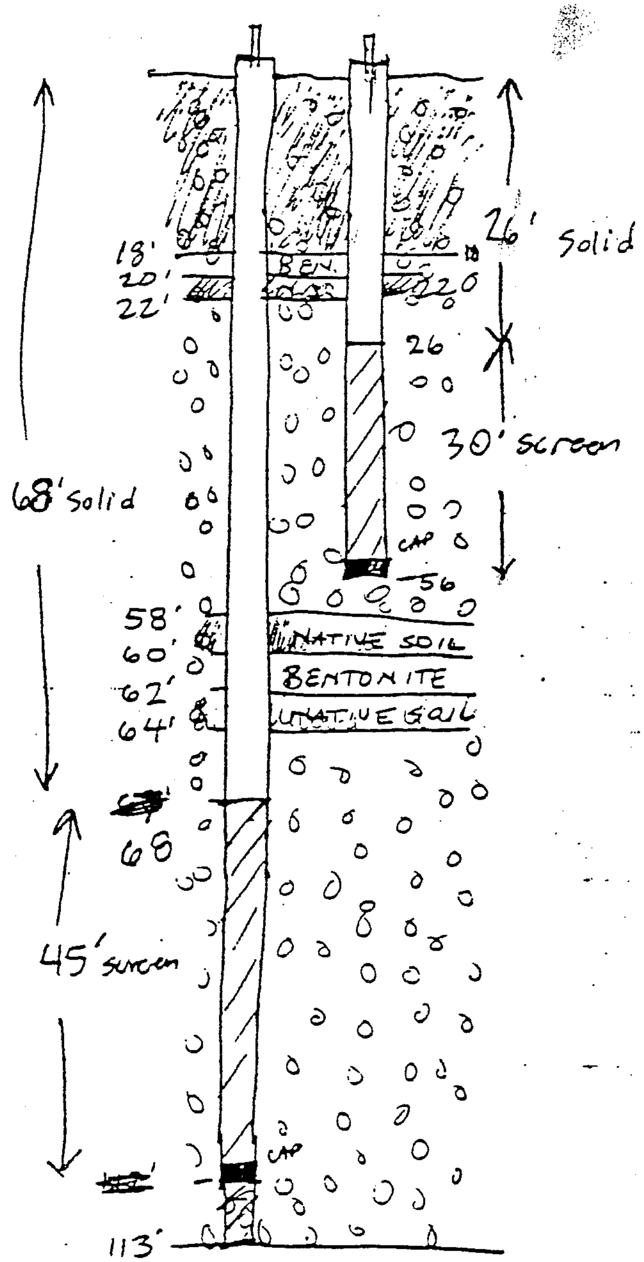
Method of placing casing: Lowered into hole by 20' sections using the sand line on the Porta Drill rig.

Problems encountered: none

PD-3

(Not as-built)

TD = 113
TD/2 = 56



Long well 68' solid
45' screen

Short well 26' solid
30' screen

Totals: 94' solid
75' screen

Memorandum

Date: 1-15-87 Job No. 31-1550-14 (18)

To: Evan Skinner, Mahaffey Drilling Job Name: Midway Landfill

From: Mark Menard, Beth Geiger

Completion Report, Well # PD-3

① Total Footage Drilled : 117'

② Total Completion : a) Deep well : 117'
Shallow well : 57'
TOTAL : 174'

③ One set-up on PD-3

a) 9 bags granulated bentonite used
b) 70' slotted 4" PVC, 104' solid 4" PVC used

CP 7000 rig used for drilling
Portadrill TLT rig used for completion

Evan D Skinner
Mark C. Menard
[illegible]

Parametrix, Inc.

CS 7.241

SEATTLE ENGINEERING DEPARTMENT

MATERIALS LABORATORY

LOG OF TEST BORING

DATE 1/15/87 HOLE NO. PD-3

PROJECT MIDWAY LANDFILL GAS CONTROL PHASE II GRD. ELEV. 375.8

LOCATION N 10323.885 E 10421.104

STRATA	DEPTH	SAMPLE NO.	BLOW COUNT	STD. PEN.	DESCRIPTION OF MATERIAL: COMPOSITION	CONSISTENCY	MOISTURE	COLOR	WATER LEVEL
					0'-7' sand and gravel fill				No water in the boring
	7'				7'-52' GRAVEL, well graded 2 mm - 5 cm, well rounded				
	20'								
		Sample PD3-S1							
	30'								

INSPECTOR

SEATTLE ENGINEERING DEPARTMENT

MATERIALS LABORATORY

CS 7.241

LOG OF TEST BORING

DATE ____________________ HOLE NO. FD-3

PROJECT ____________________ GRD. ELEV. ____________________

LOCATION ____________________

STRATA	DEPTH	SAMPLE NO.	BLOW COUNT	STD. PEN.	DESCRIPTION OF MATERIAL: COMPOSITION	CONSISTENCY	MOISTURE	COLOR	WATER LEVEL
	35'								
	45'								
	52'								
					52'-60'				
					sandy GRAVEL,				
					well graded 2mm-5cm				
	60'								

INSPECTOR

SEATTLE ENGINEERING DEPARTMENT

MATERIALS LABORATORY

CS 7.241

LOG OF TEST BORING

DATE ______________________ HOLE NO. PD-3

PROJECT ______________________ GRD. ELEV. ____________

LOCATION ______________________

STRATA	DEPTH	SAMPLE NO.	BLOW COUNT	STD. PEN.	DESCRIPTION OF MATERIAL: COMPOSITION	CONSISTENCY	MOISTURE	COLOR	WATER LEVEL
					60'-65'				
					medium GRAVEL				
					pea size to 3 cm				
	65'								
					65'-108'				
					very coarse GRAVEL				
					5-25 cm				
	90'								

INSPECTOR

SEATTLE ENGINEERING DEPARTMENT
MATERIALS LABORATORY

CS 7.241

LOG OF TEST BORING

DATE ______________________ HOLE NO. PD-3

PROJECT ______________________ GRD. ELEV. ______

LOCATION ______________________

STRATA	DEPTH	SAMPLE NO.	BLOW COUNT	STD. PEN.	DESCRIPTION OF MATERIAL: COMPOSITION	CONSISTENCY	MOISTURE	COLOR	WATER LEVEL
	100'								
	108'				108'–110'				
					medium GRAVEL with trace				
	110'				medium to coarse SAND				
					110'–113' very coarse				
					GRAVEL 5-25 cm				
	113'								
					TD of hole = 113'				
					elevation = 262.8				

INSPECTOR

PHX 31-1550-14 (18)

GAS WELL CONSTRUCTION LOG

WELL No. PD-4 Coords N 10491.961 E 10453.786

Landfill name: MIDWAY GAS MIGRATION - PHASE II Date 12-11-86

I. DIMENSIONS:

a. Total depth of well 132'

b. Diameter of well 12"

c. Well casing interval
LOWER from 130 to 0
UPPER from 68 to 0

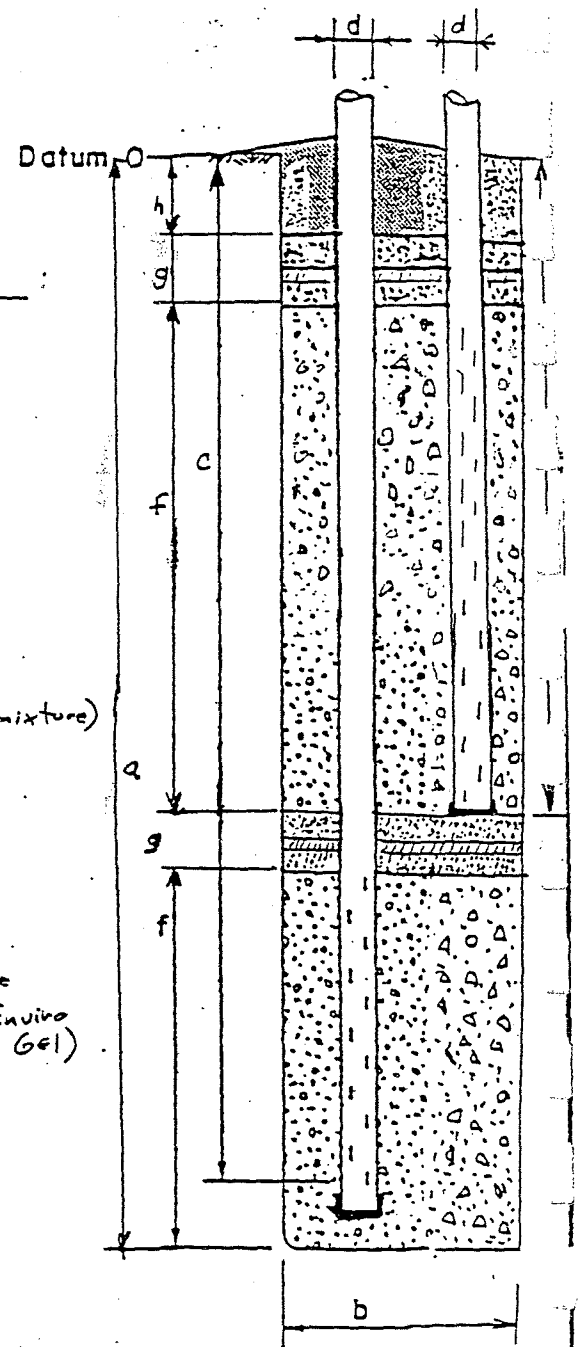
d. Diameter of well casing 4" Sch. 80 PVC

e. Slotted interval of well casing
Lower from 130 to 80
Upper from 68 to 28

f. Permeable material interval
Lower from 132 to 76
Upper from 70 to 22

g. Impermeable plug interval
Lower: 76 - 70
Upper: 22 - 0

h. Backfill material interval
(Back filled with cuttings/bentonite mixture)



II. MATERIALS:

Permeable material 6 yds. pea gravel

Impermeable plug 3 buckets 1/2" bentonite pellets, 9 bags granulated bentonite (Enviro Gel)

Backfill material drill cuttings with 50% granulated bentonite

Casing material (incl. slip joints) 4" Schedule 80 PVC Pipe

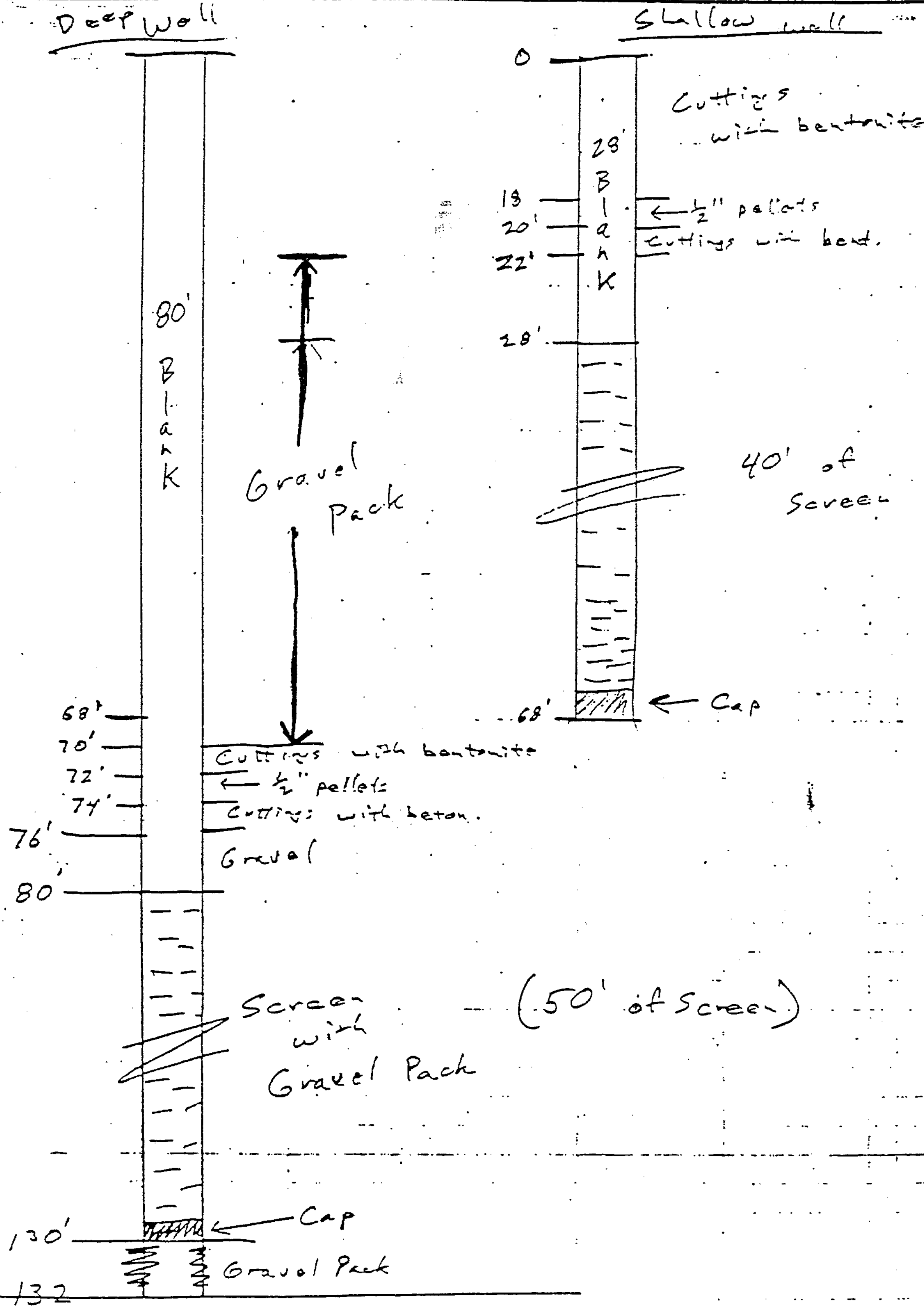
III. CONSTRUCTION:

Method of placing fill materials: Backfilled with use of hand shovels

Method of placing casing: lowered into hole by 20' sections using the sand line

Problems encountered: none

Boring P-D-4



Deep Well
Shallow well
0
Cuttings with bentonite
28'
Blank
18
20'
22'
← ½" pellets
Cuttings with bent.
28'
40' of Screen
68'
← Cap
80'
Blank
Gravel Pack
68'
70'
72'
74'
76'
80'
Cuttings with bentonite
← ½" pellets
Cuttings with beton.
Gravel
Screen with Gravel Pack
(50' of Screen)
Cap
130'
Gravel Pack
132

Memorandum

Date: 12/12/86 Job No. 31-1550-14(18)

To: EVAN SKINNER/MAHAFFEY DRILL. Job Name: MIDWAY LANDFILL GAS CONT UNIT "D"

From: MARK MENARD/BETH GEIGER

WELL COMPLETION: PD4

DRILLED & CASED TO 132'

DEEP WELL 131': 50' SCREEN PVC, ~~[illegible]~~, SOLID 81'

SHALLOW WELL 67.5' 40' SCREEN PVC 27½' SOLID

Well Drilling: 132'

One set-up on PD-4

[signature]

Parametrix, Inc.

SEATTLE ENGINEERING DEPARTMENT

MATERIALS LABORATORY

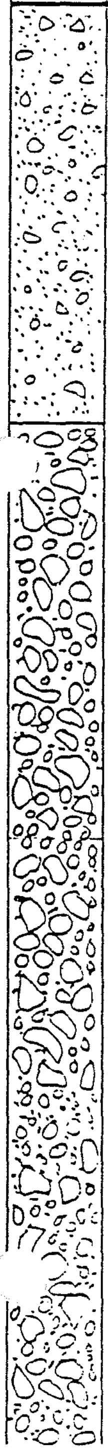
CS 7.241

LOG OF TEST BORING

DATE ~~[illegible]~~ 12/11/86 HOLE NO. PD-4

PROJECT MIDWAY LANDFILL GAS CONTROL PHASE II GRD. ELEV. 371.6

LOCATION N 10491.961 E10453.786

STRATA	DEPTH	SAMPLE NO.	BLOW COUNT	STD. PEN.	DESCRIPTION OF MATERIAL: COMPOSITION	CONSISTENCY	MOISTURE	COLOR	WATER LEVEL
					0'-9' SAND and GRAVEL fill				No water in this boring
	9'				9'-47' medium GRAVEL, minor sand, well graded				
	18'	Sample PD-4 S1							

INSPECTOR

SEATTLE ENGINEERING DEPARTMENT

MATERIALS LABORATORY

CS 7.241

LOG OF TEST BORING

DATE

HOLE NO. PD-4

PROJECT Midway Landfill Gas Control Phase II

GRD. ELEV.

LOCATION

STRATA	DEPTH	SAMPLE NO.	BLOW COUNT	STD. PEN.	COMPOSITION	CONSISTENCY	MOISTURE	COLOR	WATER LEVEL
					9'-47' medium GRAVEL minor sand.				
	40'								
	47'	Sample PD4 S3			47'-110' Sandy GRAVEL w/sand up to 45%, gravel is medium, well graded.				
	50'								
	60'								

INSPECTOR

SEATTLE ENGINEERING DEPARTMENT

MATERIALS LABORATORY

CS 7.241

LOG OF TEST BORING

DATE ______ HOLE NO. PD-4

PROJECT ______ GRD. ELEV. [illegible]

LOCATION ______

STRATA	DEPTH	SAMPLE NO.	BLOW COUNT	STD. PEN.	DESCRIPTION OF MATERIAL: COMPOSITION	CONSISTENCY	MOISTURE	COLOR	WATER LEVEL
	67'	Sample PD4-S4							
					47'-110' sandy GRAVEL w/sand up to 45%; gravel is medium, well graded.				
	80'								
	90'								
	94'	Sample PD4 S5							

INSPECTOR

CS 7.241

SEATTLE ENGINEERING DEPARTMENT

MATERIALS LABORATORY

LOG OF TEST BORING

DATE ____________ HOLE NO. PD 4

PROJECT Midway Landfill Gas Control Phase II GRD. ELEV. ____________

LOCATION ____________

STRATA	DEPTH	SAMPLE NO.	BLOW COUNT	STD. PEN.	COMPOSITION	CONSISTENCY	MOISTURE	COLOR	WATER LEVEL
	100'								
	110'				110'-124' gravelly SAND, with medium, well graded gravel up to 20%				
	118'	Sample PD4 S6							
	124'								
	125'	Sample PD4 S7							

INSPECTOR

PHX 31-1550-14 (18)

GAS WELL CONSTRUCTION LOG

WELL No. PD-7 Coords N11004 .006 E10552 .068

Landfill name: MIDWAY GAS MIGRATION - PHASE II Date 12-19-86

I. DIMENSIONS:

a. Total depth of well 119

b. Diameter of well 12"

c. Well casing interval
LOWER from 117.5 to ~~[illegible]~~ 0
UPPER from 58.5 to ~~[illegible]~~ 0

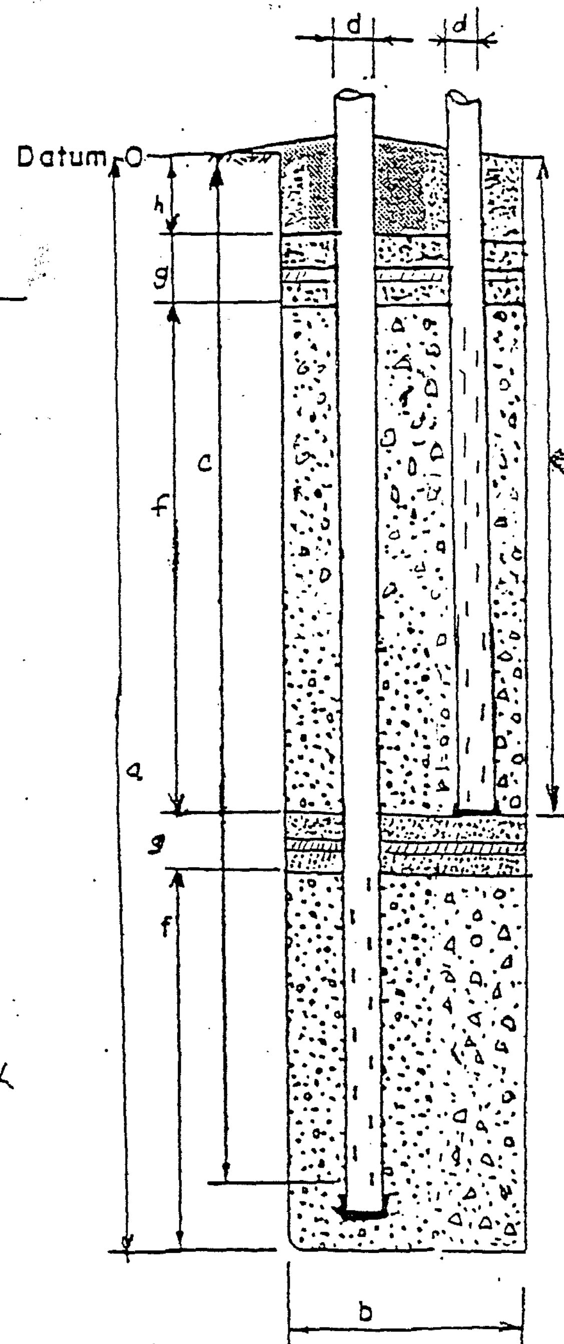
d. Diameter of well casing 4" PVC

e. Slotted interval of well casing
Lower from 117.5 to 77.5
Upper from 58.5 to 28.5

f. Permeable material interval
LOWER from 119 to 66.5
Upper from 60.5 to 22

g. Impermeable plug interval
66.5 – 60.5

h. Backfill material interval 22' → 0



II. MATERIALS:

Permeable material 5 yds washed Pea Gravel

Impermeable plug 1/4" bentonite Pellets

Backfill material Cuttings mixed with EnviroGel granulated bentonite

Casing material (incl. slip joints) 4" PVC Schedule 80

III. CONSTRUCTION:

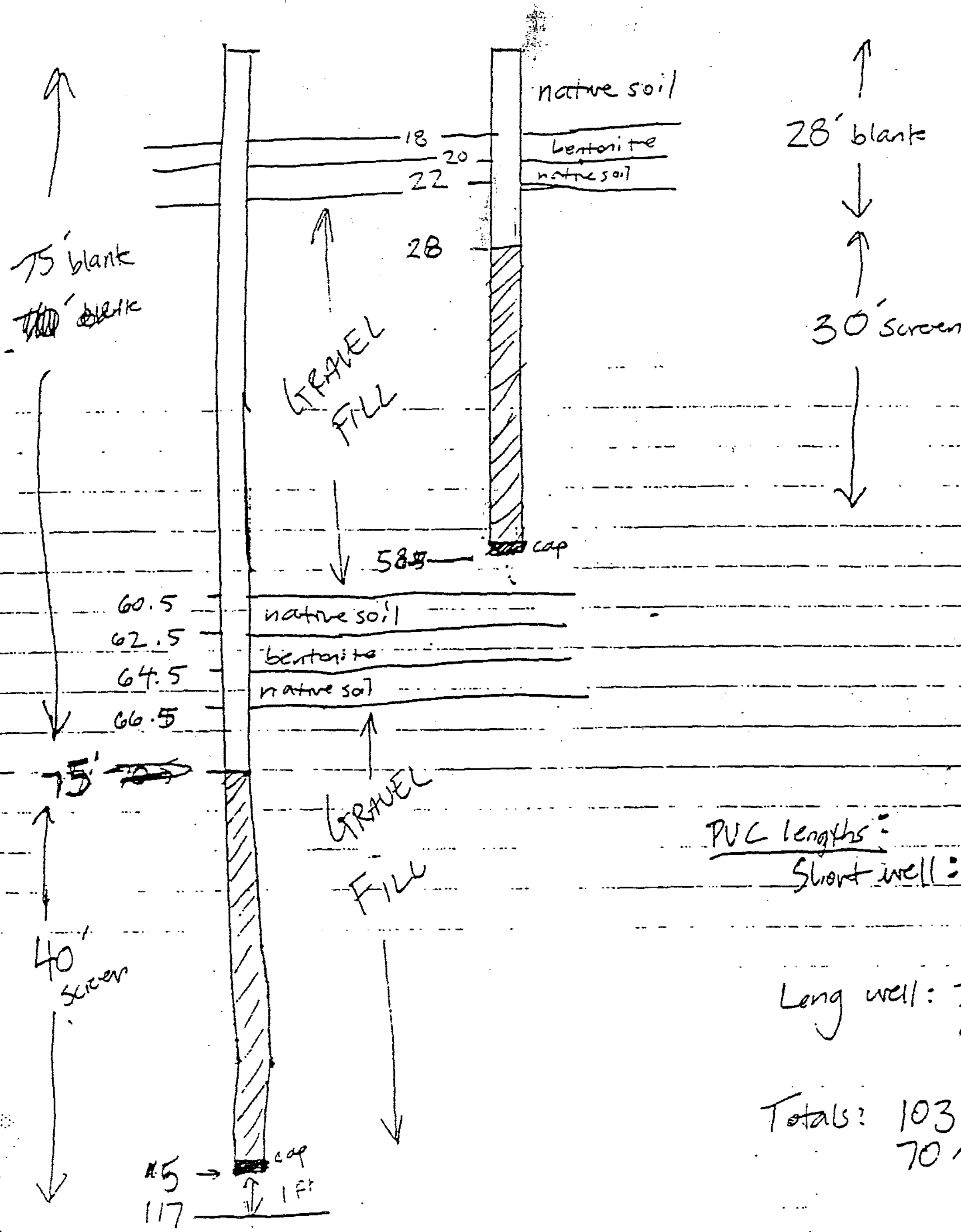
Method of placing fill materials: Hand shovelled into hole

Method of placing casing: lowered into hole by use of sand line

Problems encountered: none

PD-07

TD = 117'
D/2 = 58.5



PVC lengths:
Short well: 28' blank
30' screen

Long well: 75' blank
40' screen

Totals: 103' blank
70' screen

Memorandum

Date: 12-20-86 Job No. 31-1550-14(18)

To: Evan Skinner, Mahaffey Job Name: Midway Landfill

From: Mark Menard, Beth Geiger

Completion Memorandum for Well PD-7

① One Set-up on well PD-7

② Total Footage Drilled: 119'

③ Completion Footage: Deep Well: 117.5'

Shallow Well: 57'

Total Completion: 174.5'

Materials Used: 9 bags granulated bentonite

70' 4" PVC Screen

104.5' 4" PVC Solid

M. C. M

Evan D Skinner

Parametrix, Inc.

SEATTLE ENGINEERING DEPARTMENT

MATERIALS LABORATORY

CS 7.241

LOG OF TEST BORING

DATE 12-19-86 HOLE NO. PD-7

PROJECT Midway Landfill Gas Control Phase II GRD. ELEV. 360.1

LOCATION N 11004.006 E 10552.068

STRATA	DEPTH	SAMPLE NO.	BLOW COUNT	STD. PEN.	DESCRIPTION OF MATERIAL: COMPOSITION	CONSISTENCY	MOISTURE	COLOR	WATER LEVEL
					0'-5' SAND and GRAVEL fill				Water at 91'
	5'				5'-40' fine to medium SAND with minor medium GRAVEL				
		Sample PD7-S1							
	18'								

INSPECTOR

SEATTLE ENGINEERING DEPARTMENT

MATERIALS LABORATORY

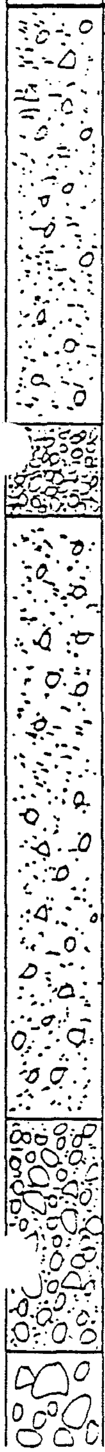
CS 7.241

LOG OF TEST BORING

DATE ______________________ HOLE NO. PD-7

PROJECT MIDWAY LANDFILL GAS CONTROL - PHASE II GRD. ELEV. ______

LOCATION ______________________



STRATA	DEPTH	SAMPLE NO.	BLOW COUNT	STD. PEN.	DESCRIPTION OF MATERIAL: COMPOSITION	CONSISTENCY	MOISTURE	COLOR	WATER LEVEL
					18'-40' fine to medium SAND w/minor gravel				
	40'				40'-42' sandy, pea size GRAVEL				
	42'	Sample PD7-S2							
					42'-55' fine to medium SAND w/minor gravel				
	55'				55'-60' sandy, medium GRAVEL				
	60'								

INSPECTOR ____

CS 7:241

SEATTLE ENGINEERING DEPARTMENT

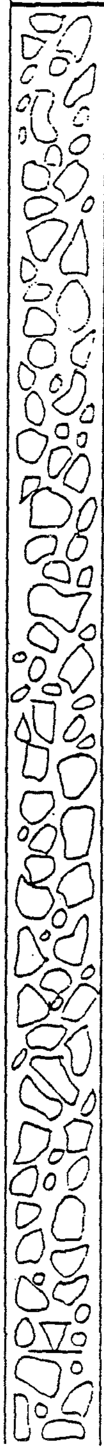
MATERIALS LABORATORY

LOG OF TEST BORING

DATE ____________________ HOLE NO. PD-7

PROJECT MIDWAY LANDFILL GAS CONTROL - PHASE II GRD. ELEV. ____________

LOCATION ____



STRATA	DEPTH	SAMPLE NO.	BLOW COUNT	STD. PEN.	DESCRIPTION OF MATERIAL: COMPOSITION	CONSISTENCY	MOISTURE	COLOR	WATER LEVEL
					60'-115' coarse GRAVEL				
					and BOULDERS				
	70'								
	80'								
	90'								
	91'				91'- WATER				

CS 7.241

SEATTLE ENGINEERING DEPARTMENT

MATERIALS LABORATORY

LOG OF TEST BORING

DATE ______________________ HOLE NO. PD-7

PROJECT Midway Landfill Gas Control Phase II GRD. ELEV. ______

LOCATION ______________________

STRATA	DEPTH	SAMPLE NO.	BLOW COUNT	STD. PEN.	COMPOSITION	CONSISTENCY	MOISTURE	COLOR	WATER LEVEL
					60' – 115' coarse GRAVEL and BOULDERS				
	100'								
	110'								
	115'	Sample PD7 S3			115'-119' interbedded coarse GRAVEL and SAND				
	119'				TD = 119'				
					elevation = 241.1				

PHX 31-1550-14 (18)

GAS WELL CONSTRUCTION LOG

WELL No. PD-10 Coords N11518.297 E10651.916

Landfill name: MIDWAY GAS MIGRATION - PHASE II Date 1/6/87

I. DIMENSIONS:

a. Total depth of well 102'

b. Diameter of well 12"

c. Well casing interval
LOWER from 101.5 to 0
UPPER from 51 to 0

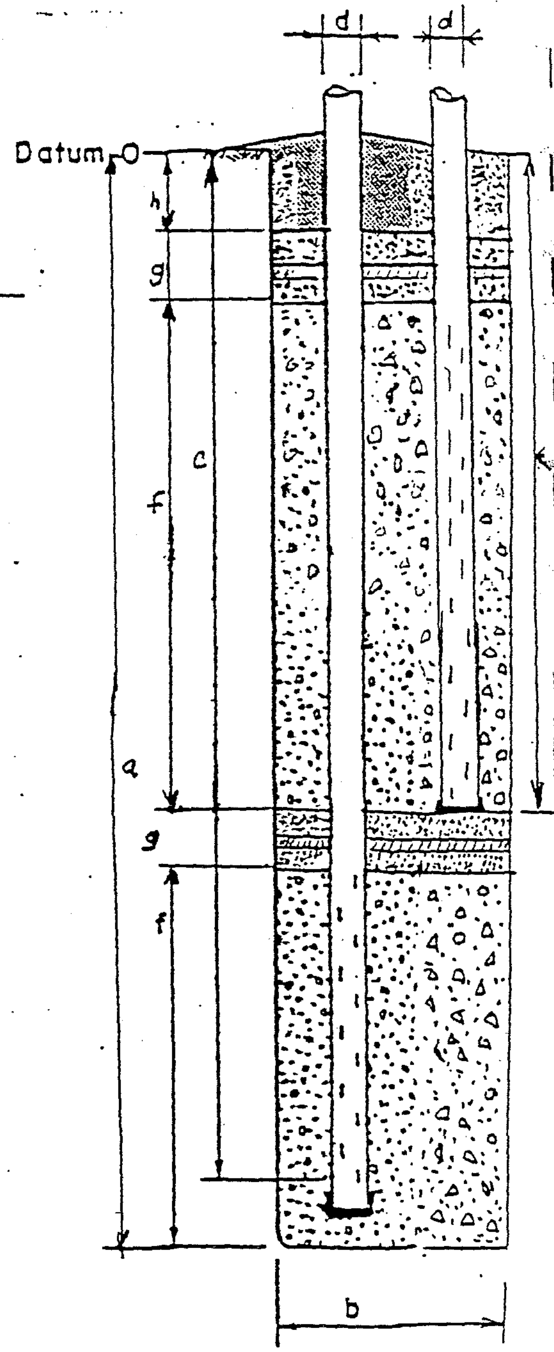
d. Diameter of well casing 4"

e. Slotted interval of well casing
Lower from 101.5 to 61.5
Upper from 51' to 26'

f. Permeable material interval
Lower from 102' to 59'
Upper from 53' to 22'

g. Impermeable plug interval 22' - 18'
59' - 53'

h. Backfill material interval 18' - 0'



II. MATERIALS:

Permeable material Washed pea gravel

Impermeable plug 10 Bags bentonite (granulated bentonite - Enviro Gel)

Backfill material cuttings mixed w/ 50% bentonite

Casing material (incl. slip joints) 152.5'

III. CONSTRUCTION:

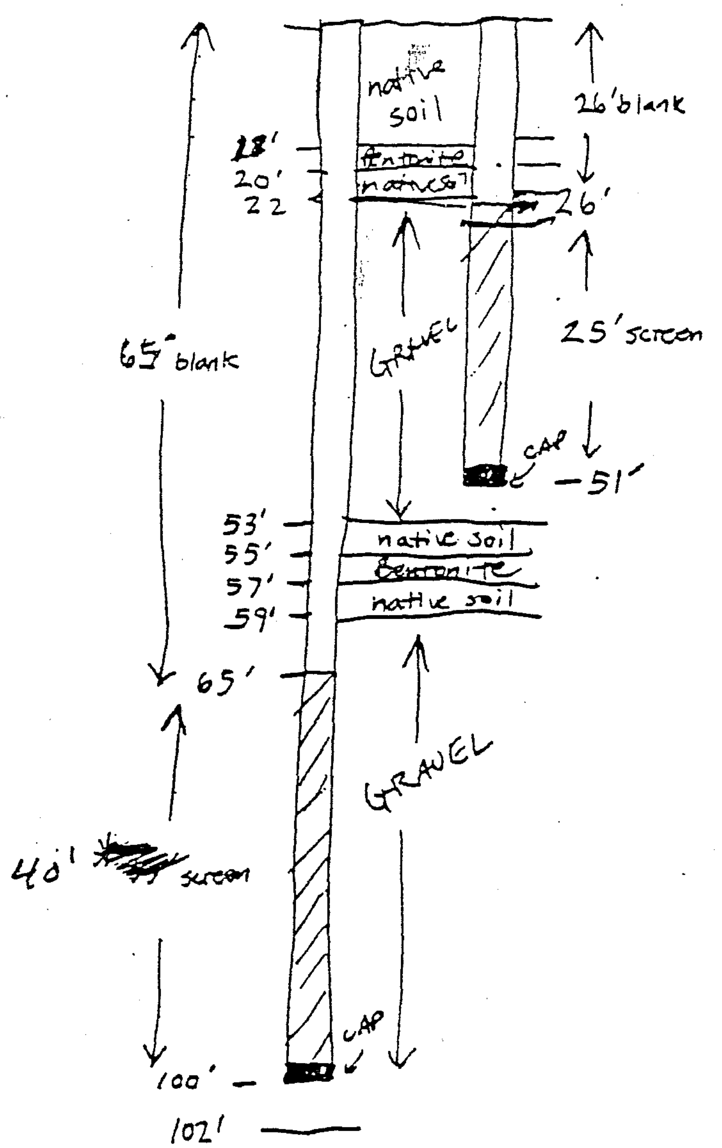
Method of placing fill materials: Backfilled w/ hand shovels

Method of placing casing: Lowered into hole (20' sections) using sand line on rig

Problems encountered: none

D-10

TD = 102'
TD/2 = 51'



PD-10 PVC Totals:

Long well: 65' blank PVC
35' screen "
Short well: 26' blank "
25' screen "

Totals: 101' blank PVC
60' screen PVC
161' All together

* ~~If hole drops 2' while pulling casing, screen length should be increased to 40' on long well, blank decreased to 62'.~~

this won't work, Beth!
LCM

Memorandum

Date: 1-7-87 Job No. 31-1550-14 (18)

To: Evan Skinner / Mahaffey Drilling Job Name: Midway Landfill Unit "D"

From: Mark Menard

Completion Report on Well PD-10:

Short Well : 51 feet

Deep Well : 101.5 feet

① Total Completion : 154.5'

② Total Footage Drilled : 104'

③ One set-up on PD-10

(9 1/2 bags of 1/4" Bentonite used in well)

Mark C. Menard

Evan D Skinner

Parametrix, Inc.

CS 7.241

SEATTLE ENGINEERING DEPARTMENT
MATERIALS LABORATORY

LOG OF TEST BORING

DATE 1/6/87 HOLE NO. PD-10

PROJECT MIDWAY LANDFILL GAS CONTROL PHASE II GRD. ELEV. 356.1

LOCATION N 11518.297 E 10651.916

STRATA	DEPTH	SAMPLE NO.	BLOW COUNT	STD. PEN.	DESCRIPTION OF MATERIAL: COMPOSITION	CONSISTENCY	MOISTURE	COLOR	WATER LEVEL
					0'-7' SAND and GRAVEL fill				water at 81' in this boring (elev. 275.1
	7'				7'-14' Gravelly SAND				
	14'				14'-40' medium GRAVEL minor SAND, trace silt				

INSPECTOR

CS 7.241

SEATTLE ENGINEERING DEPARTMENT

MATERIALS LABORATORY

LOG OF TEST BORING

DATE ____________________ HOLE NO. PD-10

PROJECT ____________________ GRD. ELEV. ____

LOCATION ____________________

STRATA	DEPTH	SAMPLE NO.	BLOW COUNT	STD. PEN.	DESCRIPTION OF MATERIAL: COMPOSITION	CONSISTENCY	MOISTURE	COLOR	WATER LEVEL
	40'				40'-60'				
					Interbedded SAND				
					and medium GRAVEL,				
					w/intermittent WOOD				
	45'	Sample	PD10 S1						
	60'								

INSPECTOR

SEATTLE ENGINEERING DEPARTMENT

MATERIALS LABORATORY

CS 7.241

LOG OF TEST BORING

DATE ____________ HOLE NO. PD-10

PROJECT ____________ GRD. ELEV. ____________

LOCATION ____________

STRATA	DEPTH	SAMPLE NO.	BLOW COUNT	STD. PEN.	DESCRIPTION OF MATERIAL: COMPOSITION	CONSISTENCY	MOISTURE	COLOR	WATER LEVEL
					60'-90'				
					medium GRAVEL,				
					trace sand				
	80'								
	90	Sample PD 10 S2							

INSPECTOR

SEATTLE ENGINEERING DEPARTMENT

MATERIALS LABORATORY

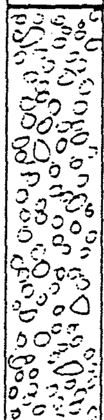
CS 7.241

LOG OF TEST BORING

DATE ______________________ HOLE NO. PD-10

PROJECT ______________________ GRD. ELEV. ______

LOCATION ______________________

STRATA	DEPTH	SAMPLE NO.	BLOW COUNT	STD. PEN.	DESCRIPTION OF MATERIAL: COMPOSITION	CONSISTENCY	MOISTURE	COLOR	WATER LEVEL
					90'-102'				
					medium GRAVEL, mostly				
					pea size, up to 6 cm.				
	102								
					TD = 102'				
					elevation = 254.1'				

INSPECTOR

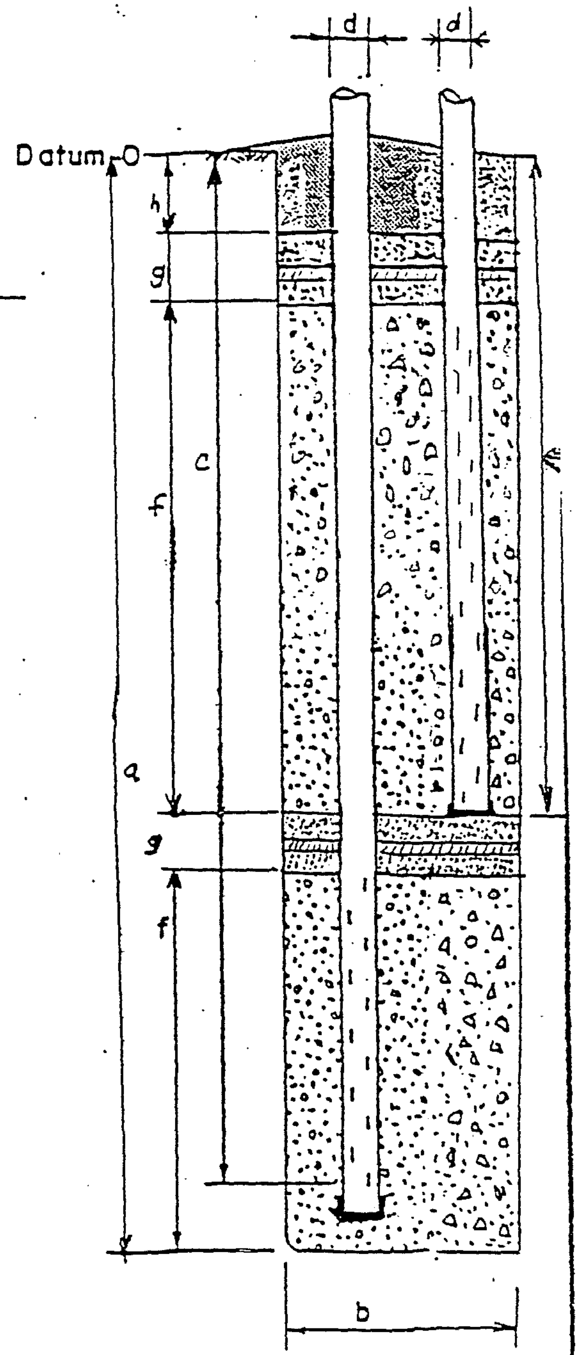
PHX 31-1550-14 (18)

GAS WELL CONSTRUCTION LOG

WELL No. ~~[illegible]~~ PD-11 Coords N 11690 171 E 10694 406

Landfill name: MIDWAY GAS MIGRATION - PHASE II Date 1/9/87

I. DIMENSIONS:



a. Total depth of well 103'

b. Diameter of well 12"

c. Well casing interval ~~[illegible]~~
LOWER from 101 to 0
UPPER from 51 to 0

d. Diameter of well casing 4"

e. Slotted interval of well casing
Lower from 101 to 61
Upper from 51 to 26

f. Permeable material interval
Lower from 103 to 59
Upper from 53 to 22

g. Impermeable plug interval 22-18'
59-53

h. Backfill material interval 18'-0'

II. MATERIALS:

Permeable material washed pea gravel

Impermeable plug 9 bags granulated bentonite (EnviroGel)

Backfill material cuttings mixed w/ 50% bentonite

Casing material (incl. slip joints) 152' 4" sch 80 PVC

III. CONSTRUCTION:

Method of placing fill materials: Backfilled w/ hand shovels

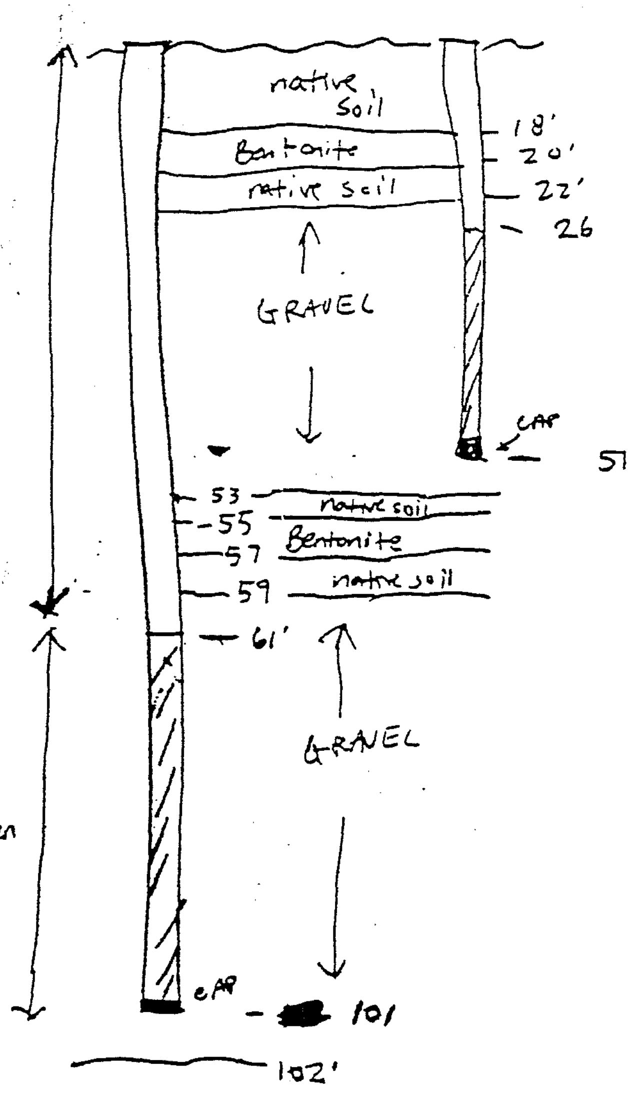
Method of placing casing: lowered into hole in 20' sections using sand line on drill rig

Problems encountered: none

PD-11

TD = 102'

TD/2 = 51



Memorandum

Date: 1-9-87 Job No. 31-1550-14 (18)

To: Evan Skinner Job Name: Midway Landfill

From: Mark Menard, Beth Geiger

Completion Report: PD-11

① One set-up on PD-11

② Total Depth Drilled: 103'

③ Completion: Short Well: 51'

Deep Well: 101'

Total Completion: 154'

Used 9 bags of granulated bentonite.

Mark C. Menard

Evan D Skinner

Parametrix, Inc.

SEATTLE ENGINEERING DEPARTMENT

MATERIALS LABORATORY

CS 7.241

LOG OF TEST BORING

DATE 1/9/87 HOLE NO. PD-11

PROJECT Midway Landfill Gas Control Phase II GRD. ELEV. 356.7

LOCATION N 11690.171 E 10684.406

STRATA	DEPTH	SAMPLE NO.	BLOW COUNT	STD. PEN.	DESCRIPTION OF MATERIAL: COMPOSITION	CONSISTENCY	MOISTURE	COLOR	WATER LEVEL
					0'-7' SAND and GRAVEL fill				water at 80' in this boring
	7'				7'-12' medium GRAVEL, mostly pea size, with trace sand				(elev 276.7
	12'				12'-65' Sandy GRAVEL, pea size to 6 cm, with trace sand, trace silt.				

INSPECTOR

SEATTLE ENGINEERING DEPARTMENT

MATERIALS LABORATORY

CS 7.241

LOG OF TEST BORING

DATE ____________________ HOLE NO. PD-11

PROJECT Midway Landfill Gas Control Phase II GRD. ELEV. ________

LOCATION ____________________

STRATA	DEPTH	SAMPLE NO.	BLOW COUNT	STD. PEN.	DESCRIPTION OF MATERIAL: COMPOSITION	CONSISTENCY	MOISTURE	COLOR	WATER LEVEL
	35								
					sandy GRAVEL pea size to 2" w/ minor sand				
	50								
	60								

INSPECTOR

SEATTLE ENGINEERING DEPARTMENT

MATERIALS LABORATORY

CS 7.241

LOG OF TEST BORING

DATE

HOLE NO. FD-11

PROJECT Midway Landfill Gas Control

GRD. ELEV.

LOCATION

STRATA	DEPTH	SAMPLE NO.	BLOW COUNT	STD. PEN.	DESCRIPTION OF MATERIAL: COMPOSITION	CONSISTENCY	MOISTURE	COLOR	WATER LEVEL
					65' - 103				
					medium GRAVEL, pea				
					size to 4 cm				
	80								
					80' - water				

INSPECTOR

CS 7.241

SEATTLE ENGINEERING DEPARTMENT

MATERIALS LABORATORY

LOG OF TEST BORING

DATE ____________ HOLE NO. PD-11

PROJECT MIDWAY LANDFILL GAS CONTROL PHASE II GRD. ELEV. ____________

LOCATION ____________

STRATA	DEPTH	SAMPLE NO.	BLOW COUNT	STD. PEN.	COMPOSITION	CONSISTENCY	MOISTURE	COLOR	WATER LEVEL
	103				TD = 103'				
					elevation = 253.7				

INSPECTOR

Applied Geotechnology Inc.
FIELD LOG OF EXPLORATION

PRELIMINARY

BORING/TEST PIT NO. LW 1
TOTAL DEPTH 173
SHEET 1 OF 13

LOCATION

SURFACE ELEVATION: ~ 372 - 375
DATUM: MSL

PROJECT: Midway	
PROJ. MGR: PF	
JOB NO: 14169.104	LOGGED BY: PF
	EDITED BY:
DRILLING CONTRACTOR: HOLT	
DRILL RIG TYPE BUCYRUS 22W	
DRILLERS NAME: HOLT	
SAMPLING METHODS: D+M, BAIL	
HAMMER WT.:	DROP:
STARTED, TIME: 1500	DATE: 12/19/86
COMPLETED, TIME: 1530	DATE: 12-19-86
BACKFILLED, TIME:	DATE:

DATE:				
TIME:				
BORING DEPTH (ft.)				
CASING DEPTH (ft.)				
WATER DEPTH (ft.)				

SURFACE CONDITIONS:

SAMPLE DEPTH	SAMPLER TYPE	BLOWS/0.5 foot	FEET DRIVEN	FEET RECOVERED	SAMPLE CONDITION	DRILLING RATE (min/ft)			DEPTH IN FEET	GRAPHIC LOG	DESCRIPTION
									0		Cobble-sized gravel drill pad
									1		
									2		Cover material - gray and brown silt (?)
									3		
									4		
									5		

Applied Geotechnology Inc.
FIELD LOG OF EXPLORATION – CONTINUED

SHEET 2 OF 13 BORING/TEST PIT NO. CW1

PROJECT:

JOB NO: 14169.104 BY: KF

DEPTH	TYPE	BLOWS	DRIVEN	REC'V'D	COND.	D.RATE			DEPTH	GRAPHIC LOG	
									5		
									6		Landfill Debris LOL >100%
									7		
									8		
									9		
									0		
									1		
									2		
									3		
									4		

Applied Geotechnology Inc.

FIELD LOG OF EXPLORATION – CONTINUED

SHEET 3 OF 13 BORING/TEST PIT NO. 1

PROJECT: MIDWAY

JOB NO: 14169 104

BY: AFM

DEPTH	TYPE	BLOWS	DRIVEN	REC'V'D	COND.	D.RATE	HW	GAS	DEPTH	GRAPHIC LOG	
									65		
							600	909	66		LARGE GRAVEL IN BAILER - MAKING H.
											DTW @ 11:46 – 53.5
											11.48 – 62.8
											11:49 – 61.31
									67		PLACE PACKER IN CASING
											WELD ON 11'0"
											1228 DTW 55.12'
									68		
									69		
									70		
									71		
									72		
											STOP FOR DAY
											[illegible] – 72'
									73		0750 DTW 64.65' FROM G.L WITH
											PLUG IN CASING
									74		

Applied Geotechnology Inc.

FIELD LOG OF EXPLORATION – CONTINUED

SHEET 4 OF 13 BORING/TEST PIT NO. LW-1

PROJECT: MIDWAY

JOB NO: 14169.104

BY: AEM

DEPTH	TYPE	BLOWS	DRIVEN	REC'V'D	COND.	D.RATE			DEPTH	GRAPHIC LOG	
									75		
									76		[illegible] DTW 74.00' 9:40
											73.90' 9:45 Little seepage
											LANDFILL DEBRIS
									77		
									78		
									79		
									80		
									81		
									82		82' CHECK FOR SEEPAGE - LITTLE IF ANY
									83		
									84		

Applied Geotechnology Inc.

FIELD LOG OF EXPLORATION – CONTINUED

SHEET 5 OF 13 BORING/TEST PIT NO. 20

PROJECT: MIDWAY

JOB NO: 14169.104 BY: AEM

DEPTH	TYPE	BLOWS	DRIVEN	REC'V'D	COND.	D.RATE	H_2S	GAS	DEPTH	GRAPHIC LOG	DESCRIPTION
									85		@ 85.5 - EASY TO DRIVE CASING
86	Bail	—	—	—	—				86		BROWN + GRAY CLAY (CL) SOFT TO STIFF MOIST TO WET MOD TO HIGH PLASTICITY (CH)? FILL
							000	000	87		
									88		
									89		
		6	6"						90		
		7	6"								
91	D+M	16	6"						91	CL	MOTTLED GREEN GRAY CLAY (CL) (CH)? STIFF MOIST TO WET WITH SOME LANDFILL DEBRIS FILL
									92		
									93		
									94		

Applied Geotechnology Inc.
FIELD LOG OF EXPLORATION – CONTINUED

SHEET 6 OF 13 BORING/TEST PIT NO. LW-1

PROJECT: MIDWAY
JOB NO: 14169.104 BY: AFM

DEPTH	TYPE	BLOWS	DRIVEN	REC'V'D	COND.	D.RATE	H_2S	GAS	DEPTH	GRAPHIC LOG	DESCRIPTION
									95		
		2	6								
		6	6								
									6	ML	BROWN CLAYEY SILT (ML)
	DHM	7	12								SOFT TO STIFF, MOIST
										CL	WITH ROOTLETS AND METAL FRAGMENTS
									7		at ~96.5 - CHANGE TO GRAY AND GREEN GRAY CLAY WITH WIRE AND WOOD FRAGMENTS. (CH)? (FILL)
							000	035	98		WELDED ON 9'10"
									9		
									100		
		23	6"								MOTTLED GRAY AND GRAY GREEN SILTY SAND (SM) VERY DENSE,
100.5	DHM	50	4"	4"	D					SM	MOIST; WITH SOME SUBROUNDED TO SUBANGULAR GRAVEL
									101		AND SOME WOOD FRAGMENTS, TRACE CLAY (FILL)
									102		
									103		
									104	GM	

Applied Geotechnology Inc.
FIELD LOG OF EXPLORATION – CONTINUED

SHEET 7 OF 13 BORING/TEST PIT NO. 4

PROJECT: MIDWAY
JOB NO: 14169.104 BY: AEM

DEPTH	TYPE	BLOWS	DRIVEN	REC'V'D	COND.	D.RATE	WJ	Gm	DEPTH	GRAPHIC LOG	DESCRIPTION
105	DM	50	5½"	3"	D				105	GM	GRAY SILTY SANDY GRAVEL (GM) VERY DENSE, MOIST; (FILL)
									106		WELD ON 10' 2"
							000	007	107		DRILLING RATE INCREASE STRIKING LINE BETWEEN 107 TO 108
									108		
									109		DRILLER NOTES MAKING WATER AT ~109½'
[illegible]	DM	50	3"	1	D						1150 DTW 101.51
											1151 DTW 100.75 ↑
									110		BROWN AND GRAY CLAY MIXED WITH SILTY GRAVEL WITH SOME SAND WITH SOME METAL FRAGMENTS (FILL)
							006	006		GM	
									111		WELD ON 10' 0"
											INCREASE IN SILT @ about 111 observ in BROWN
									112		LESS SILT IN SAND & GRAVEL AT ABOUT 112
											CONTINUES TO CLEAN UP (LESS SILT WITH DEPTH
									113		
113	Grab									GP	COLOR CHANGE @ about 113' TO BROWN FROM GRAY
											DRILLER SAMPLE AT 113
									114		BROWN SANDY GRAVEL (GP)
											(FILL) DENSE [illegible]
											WITH METAL FRAGMENTS
											DTW 107.35 1451
											DTW [illegible] [illegible]

DTW 107.25' [illegible] ↑

Applied Geotechnology Inc.

FIELD LOG OF EXPLORATION – CONTINUED

SHEET 8 OF 13 BORING/TEST PIT NO. EW-1

PROJECT: MIDWAY

JOB NO: 14169.104

BY: AEM

DEPTH	TYPE	BLOWS	DRIVEN	REC'V'D	COND.	D.RATE	HU	GAS	DEPTH	GRAPHIC LOG	
									115		DROVE CASING TO 117'
											BAILED. 3' FOOT HEAVE
									116		
									117		12-17-86 - at 8:00
											DTW 98.00' FROM G.L.
											WATER SAMPLE TAKEN
							600	003	118	GP	
									119		
									120		
									121		
									122		
									123		
									124		
											Drilling [illegible] at 124.5
										GM	

Applied Geotechnology Inc.
FIELD LOG OF EXPLORATION – CONTINUED

SHEET 9 OF 13 BORING/TEST PIT NO. [illegible]

PROJECT: MIDWAY
JOB NO: 19169.104
BY: AFM

DEPTH	TYPE	BLOWS	DRIVEN	REC'V'D	COND.	D.RATE	HW	GW	DEPTH	GRAPHIC LOG	DESCRIPTION
									125		
									126		
									127		12:17
											DTW 124.65' From G.L
											12:23 DTW 124.65' From G.L.
									128		
129	Bailer								129	GM	GRAY BROWN SILTY GRAVEL (GM)
											VERY DENSE WITH SOME SAND.
											NOT MAKING WATER
							000	002	130		
									131		Driller notes water in casing at 131
									132		
									133	GM	
									134		DTW 131.00 1510
											130.71' 1511
											130.42' 1512
											130.10 1513
											129.84 1515

Applied Geotechnology Inc.
FIELD LOG OF EXPLORATION – CONTINUED

SHEET 10 OF 13 BORING/TEST PIT NO. 4

PROJECT: MIDWAY
JOB NO: 14169.104 BY: AAM

DEPTH	TYPE	BLOWS	DRIVEN	REC'V'D	COND.	D.RATE	H2	GAS	DEPTH	GRAPHIC LOG	
									135		
									6		
137	Bails								137	GW	GRAY SANDY GRAVEL (GW) VERY DENSE SATURATED WATER BEARING SAND IS MEDIUM TO COARSE GRAIN LARGE SUBROUNDED ~~TO SUB~~ ANGULAR GRAVEL – TRACE SILT WITH SOME 8" Cobble GRAVEL 1-3"
									8		12-18-# DTW 96.43' FROM G.L.
							000	001	9		
140									140		
									1		ABLE TO DRIVE AND BAIL
									2		
143	Bails								143	GW	GRAY SANDY GRAVEL (GW) WATER BEARING – WITH SOME Cobbles TRACE SILT 1-3" GRAVEL SAND IS COARSE GRAIN
									144		

Applied Geotechnology Inc.

FIELD LOG OF EXPLORATION – CONTINUED

SHEET 11 OF 13 BORING/TEST PIT NO. AW 1

PROJECT: MIDWAY

JOB NO: 14169.104 BY: AEM

DEPTH	TYPE	BLOWS	DRIVEN	REC'V'D	COND.	D.RATE	HnU	GAS	DEPTH	GRAPHIC LOG	DESCRIPTION
									145		
									146		DRIVE & BAIL
									147		
148	Bailer						.000	.001	148	GW	GRAY SANDY GRAVEL. (GW) SATURATED SAND IS COARSE GRAIN
									149		WELD ON 10' 11"
									150		
									151		
									152		
									153		
									154		

Applied Geotechnology Inc.

FIELD LOG OF EXPLORATION – CONTINUED

SHEET 12 OF 13 BORING/TEST PIT NO. 1

PROJECT: MIDWAY

JOB NO: 14169.104 BY: AEM

DEPTH	TYPE	BLOWS	DRIVEN	REC'V'D	COND.	D.RATE	H_2S	GAS	DEPTH	GRAPHIC LOG	
155	BAIL								155	GW	GRAY SANDY GRAVEL (GW) SATURATED TRACE SILT 1 - 4" GRAVEL MED TO COARSE SAND.
									156		
									157		
									158		
							000	000	159		WELD ON 10'6" 990 DTW 104.32 FROM GL. WITH PLUG IN CASING
									160		
									161		
162	Bail								162	GM	GRAY SILTY GRAVEL (GM) [illegible] WET, WITH SOME COARSE SAND) - - : ORANGE BROWN SILT SILT BALLS - MOIST TO WET
									163		
									164		

Applied Geotechnology Inc.

FIELD LOG OF EXPLORATION – CONTINUED

SHEET 13 OF 13 BORING/TEST PIT NO. LW 1

PROJECT: MIDWAY

JOB NO: 19169.104 BY: AEM

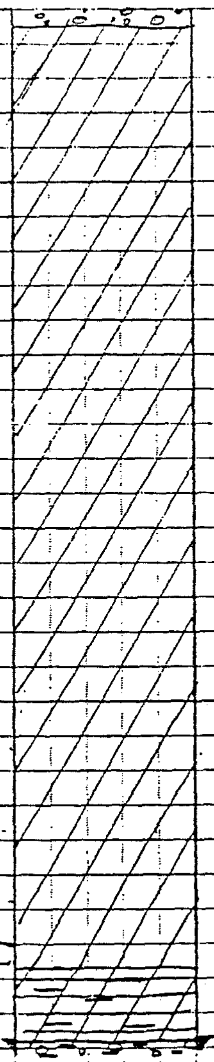
DEPTH	TYPE	BLOWS	DRIVEN	REC'V'D	COND.	D.RATE			DEPTH	GRAPHIC LOG	
									165		
									166		
167	Bail								167	GM/ML	GRAY BROWN GRAVELLY SILT, SILTY GRAVEL (ML/GM) D MOIST TO WET
									168		
169	Bailer								169	ML	SAMPLE TAKEN FROM DRILL BIT MOTTLED BROWN + GRAY SILT (ML MOIST TO WET WITH SOME PEA GRAVEL
									170		
									171		
172	D&M	18	6"						172		
		50	5"								
									173	ML	GRAY SILT (ML) HARD - DRY TO MOIST
											BORING LW1 TERMINATED AT APPROXIMATE DEPTH 173' ON 12-19-86
									174		

PRELIMINARY

Applied Geotechnology Inc.
Geotechnical Engineering, Geology, & Hydrogeology

SHEET 1 OF 1
JOB NO. 14169.104
DATE 1/6/87
COMPUTED BY JF
CHECKED BY

PROJECT Midway
SUBJECT LW-2 SUMMARY LOG



0 — ROCK DRILL PAD

20

40 — LANDFILL DEBRIS

60

80

100

110.5 — GRAY CLAYEY SILT AND REFUSE

119 / 120 — SILTY GRAVEL @ ~119'

TD 120'

Well Installation Log

Job No. 35-1550-20 Client CITY OF SEATTLE Location

CASING TYPE ½" SCH. 80 PVC, .020 SLOT	"5" PROBE	
LENGTH 10' SCREEN 22' SOLID (PAY 25) 32' TOTAL		
JOINT TYPE FLUSH SCREW		
SCREEN TYPE HYDROPHYLLICS		
SLOT SIZE .020		
SEAL TYPE BENTONITE PELLET / GRANULATED BENT.		
INSTALL METHOD BUCKET / SACK		
FILTER PEA GRAVEL		
INSTALL BUCKET		
GROUT —		

DRILLING METHOD	AIR ROTARY			
SAMPLING METHOD	GRAB			
HAMMER WT.	—	DROP —		
DATE	8-26-87			
BY	A. CAREY - PMX			
DRILLING CONTR.	TACOMA PUMP			
WATER LEVEL	56.7	19.8		
TIME	1030	1030		
DATE	9-8	9.8		
	"W"	I		

WELL NO.	AN
SHEET 1	OF 3
START	FINISH
1115	1535
8-26-87	

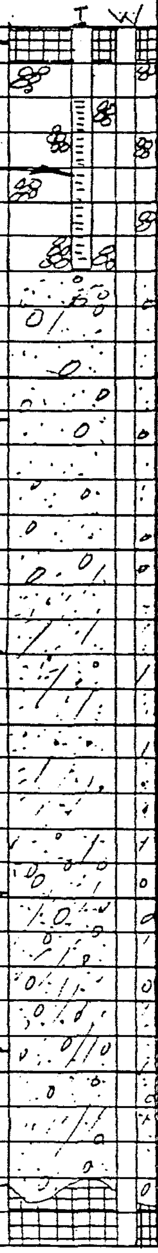
WELL DETAILS WELL AN	DEPTH	USCS	SOIL DESCRIPTION	INSTALLATION NOTES
M I W	0		GROUND ELEVATION 361	1115 18'11" (0')
1		SM	LOOSE-MED DENSE, RED BROWN, DRY, SILTY GRAVELLY M-F SAND W OCCASIONAL COBBLES ROOTS	
BENTONITE PELLET SEAL - 200 LBS				
5	5		"BECOMING" MED DENSE GRAY, SLIGHTLY MOIST W/O ROOTS	
PEPCER GRANULATED BENTONITE - 600 LBS				ADD H2O
	10	GP \ GM	DENSE, BROWN, MOIST? SLIGHTLY SILTY F-C GRAVEL W SOME SAND	STOP H2O
	15			
17				
BENTONITE PELLET SEAL - 150 LBS		SM	MED DENSE, GRAY, MOIST SILTY M-F SAND W SOME F GRAVEL - UNIT SATURATED FROM 14'-16'	1200 21.6 (18'11")
	20			1345
21				
22				EASY DRILLING
½" SCH. 80 PVC .020 SLOT				
ATTEMPT TO PUMP SHALLOW PROBE GRAVEL PACK - CASING REMOVED - APPEARS TO BE MAKING WATER. STATIC AT 22'	25			
32	30			
33				% SILT DECREASING, % GRAVEL INCREASING
BENTONITE PELLET SEAL - 300 LBS	35			

Well Installation Log

Job No. 35-1550-20 Client CITY OF SEATTLE Location

CASING TYPE 3/4" SCH. 80 PVC	"M" PROBE	DRILLING METHOD AIR ROTARY	WELL NO. AN
LENGTH 5' SCREEN 37' (PAY 40) SOLID 42' TOTAL		SAMPLING METHOD GRAB	
JOINT TYPE FLUSH SCREW		HAMMER WT. — DROP —	SHEET 2 OF 3
SCREEN TYPE HYDROPHYLLICS		DATE 8-26, 8-27 1987	
SLOT SIZE .020		BY AL CAREY PMX	
SEAL TYPE BENTONITE PELLET - 300 LBS		DRILLING CONTR. TACOMA PUMP	START / FINISH
INSTALL. METHOD BUCKET		WATER LEVEL 28.0' / 20.0'	0900 / 1200
FILTER PEA GRAVEL		TIME 0845 / 0830	
INSTALL BUCKET		DATE 8-27-87 / 8-31-87	8-27-87
GROUT			

WELL DETAILS WELL AN



WELL DETAILS	DEPTH	USCS	SOIL DESCRIPTION	INSTALLATION NOTES
			GROUND ELEVATION	
BENTONITE PELLET SEAL - 300 LBS	35	3 GP \ GM	MED DENSE, GRAY, MOIST SLIGHTLY SILTY, SANDY FINE GRAVEL - SILT AND FINE SAND FORMS COATING ON GRAVEL	
37				
3/4 SCH. 80 PVC .020 SLOT				
	40			1415 ↓ 19'3" (40'5")
				1505 ↓ MAKES H_2O ON START UP
42		GP	MED DENSE, BROWNISH GRAY, WATER BEARING F-C GRAVEL WITH SOME SAND - WATER CARRIES SILT	GRAVEL WET, EXHAUST NOT MAKING H_2O. FORMATION WOULD PROBABLY MAKE SMALL AMOUNT OF H_2O IF DEVELOPED AS WATER WELL
CAVED MATERIAL	45	4		
SAND HEAVES INTO CASING PREVENTING BENTONITE GROUT SLURRY SEAL FROM SETTING	50			
	55	SM	LOOSE, GRAY, SATURATED, SILTY M-F SAND W TRACE TO SOME F GRAVEL	
SAND HEAVE INTO CASING CAUSING BENT. PELLET PLUG TO FORM IN SHOE		5 SP \ SM	MED. DENSE, GRAY, V. MOIST, SLIGHTLY SILTY M-F SAND w SOME F. GRAVEL	END OF DAY 8-26 PAY 58'
ATTEMPT TO BLOW OUT WITH AIR	60			1535 ↓ 21'0" (59'8")
				0900 ↓ BIT PLUGGED, SAND HEAVED INTO CASING
CAVED MATERIAL		GP \ GM	MED DENSE, BROWNISH GRAY WATER BEARING, SLIGHTLY SILTY F-C GRAVEL W SOME SAND	
	65			MAKING SMALL AMOUNT OF H_2O INTERMITTANTLY THROUGHOUT UNIT
GROUND CAVES BEHIND CASING CAUSING PLUG TO FORM IN SHOE 69		6		
BLOW OUT PLUG WITH AIR	70			

Well Installation Log

Job No. 35-1550-20 Client CITY OF SEATTLE Location

CASING TYPE	3/4" SCH 80 PVC	'W' PROBE
LENGTH	10' SCREEN - 75 SOLID (PAY 80)	85 TOTAL
JOINT TYPE	FLUSH SCREW	
SCREEN TYPE	HYDROPHYLLICS	
SLOT SIZE	.020	
SEAL TYPE	1/2" BENTONITE PELLETS	
INSTALL METHOD	BUCKET	
FILTER	PEA GRAVEL	
INSTALL	BUCKET	
GROUT		

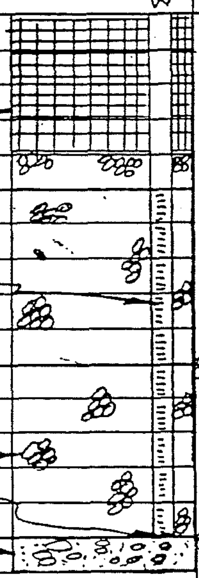
DRILLING METHOD	AIR ROTARY			
SAMPLING METHOD	GRAB			
HAMMER WT.	—	DROP —		
DATE				
BY				
DRILLING CONTR.				
WATER LEVEL	56'	56.7	19.8	19.7
TIME	1300	1030	1030	1030
DATE	8-27	9-8	9-8	9-8
		W	I	M

WELL NO. AN

SHEET 3 OF 3

START	FINISH

WELL DETAILS WELL AN



BENTONITE PELLET SEAL - 200 LBS

74

75

3/4" SCH. 80 PVC .020 SLOT

PEA GRAVEL FILTER

SCREW ON CAP

85

NATIVE GRAVEL

BOTTOM OF WELL WITH PROBE HEAVE 1' END OF DAY 8-27

DEPTH	USCS	SOIL DESCRIPTION	INSTALLATION NOTES
70		GROUND ELEVATION	DRILLING NOTABLY EASIER
	SM / ML	MED DENSE, GRAY, SATURATED	AT 70'
	SM / ML	SILTY SAND W A TRACE	
		FINE GRAVEL, WITH	
		LAYERS OF SOFT, SLIGHTLY	MAKING H_2O AT 74'
75		PLASTIC, TAN, MOIST	
		SANDY SILT	MAKING APPROX 35 GPM
	GP		H_2O OF LOW TURBIDITY
		MED DENSE, WATER	
		BEARING, CLEAN	
		C-F GRAVEL W/	0950 6'9" (79'8")
80		SOME COARSE SAND	1140
			MAKING 100 GAL/MIN - WATER
85	—		V CLEAR
		BOTTOM OF BORING - 86'	1200 (86'5")

Well Installation Log

Job No. 31-1550-14-0045 Client CITY OF SEATTLE Location

CASING TYPE 3/4" SCH. 80 PVC "M" PROBE	DRILLING METHOD AIR ROTARY		WELL NO. AO
LENGTH 30' SCREEN 21' (PAY 25') SOLID 51' TOTAL	SAMPLING METHOD GRAB		
JOINT TYPE FLUSH SCREW	HAMMER WT. —	DROP —	SHEET 1 OF 3
SCREEN TYPE HYDROPHILLICS	DATE 8-13		
SLOT SIZE .020	BY AL CAREY		
SEAL TYPE CEMENT-BENT. GROUT/BENT PELLET	DRILLING CONTR. TACOMA PUMP		START 1600 / FINISH 1620
INSTALL METHOD BERKELEY GROUT PUMP	WATER LEVEL 12.7' / 49.8'		
FILTER PEA GRAVEL	TIME 1200 / 0900		
INSTALL BUCKET	DATE 8-20 / 8-26		8-13-87
GROUT 4 BAGS CEMENT - 1 BAG BENTONITE	"S" / "W"		

WELL DETAILS WELL AO	DEPTH	USCS	SOIL DESCRIPTION	INSTALLATION NOTES
M W	0		GROUND ELEVATION 358	1600 19'0" (0')
		SM	MED DENSE, RED BROWN, SL. MOIST SILTY M-F SAND W SOME GRAVEL, ROOTS	ADD H2O - DUST CONTROL
CEMENT-BENTONITE GROUT SLURRY	5	SM	SIMILAR TO ABOVE, NO ORGANICS, GRAY	
			BOULDER - 8'	1620 STOP DRILLING
				0945 BIT TOO WORN
	10	SM	DENSE, LT GRAY SL MOIST, SILTY GRAVELLY M-F SAND W OCCASIONAL COBBLES - TILL LIKE	ADD H_2O
	15			
18				
BENTONITE PELLET SEAL - 150 LBS 20				1005 19'7" (19'0")
21	20			1235 MAKES H_2O ON START-UP
3/4" SCH 80 PVC .020 SLOT	25			
PEA GRAVEL FILTER	30	GP	LOOSE - MED DENSE GRAY WATER BEARING, SL.	MAKING H_2O - DENSITY CHANGE 31'
		GM	SILTY RED COARSE GRAVEL W SOME SAND	
	35			

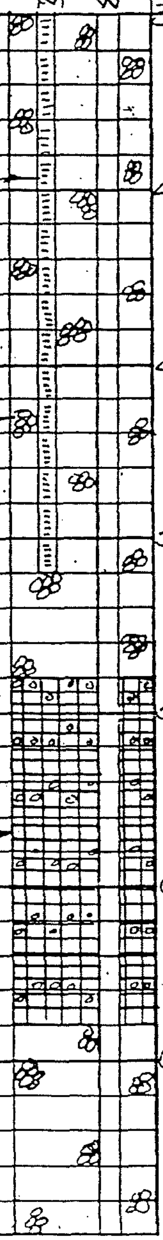
Well Installation Log

Job No. 31-1550-14-0045 Client CITY OF SEATTLE Location

CASING TYPE	SEE SHEET #1, PROBE "S" FOR DETAILS	DRILLING METHOD AIR ROTARY	WELL NO. AO
LENGTH		SAMPLING METHOD GRAB	
JOINT TYPE		HAMMER WT. / DROP	SHEET 2
SCREEN TYPE		DATE	OF 3
SLOT SIZE		BY	
SEAL TYPE 400 LBS 1/4" BENTONITE PELLETS		DRILLING CONTR.	START / FINISH
INSTALL. METHOD		WATER LEVEL: 16.0 / 51.0 / 15.0	
FILTER		TIME: 0830 / 0830 / 0900	0945 / 1640
INSTALL		DATE: 8-17 / 8-18 / 8-20	8-14-87
GROUT			

WELL DETAILS WELL AO

M W



Well details	Depth	USCS	Soil description	Installation notes
			GROUND ELEVATION	
	35	SP	LOOSE, GRAY SATURATED GRAVELLY C-M SAND	
3/4" SCH 80 PVC .020 SLOT		GP		1320 ↓ 21'4" (38'7")
	40		LOOSE, BROWNISH GRAY WATER BEARING F-C GRAVEL W SOME SAND	1610 ↓ DRILLER ESTIMATES THIS WOULD PRODUCE A MIN. 15 GAL/MIN
				INCREASE SAND %. DECREASE
PEA GRAVEL FILTER	45	GP GM		GRAVEL SIZE, LESS H_2O PRODUCTION, SILT % INCREA W DEPTH
	50	GM		
51				
				INCREASE % SAND, DECREASE
54	55	SM	LOOSE, GRAY, SATURATED SILTY, M-F SAND W SOME GRAVEL	GRAVEL (POSSIBLY WATER BEARING SP WITH LAYERS OF ML, SIMILAR TO A7 - AL CAREY 11-10-87)
BENTONITE PELLET - PEA GRAVEL SEAL (4:1 RATIO BY VOL) 400 LBS BENTONITE PELLETS				DECREASE IN MOISTURE
	60	SM	MED DENSE, GRAY MOIST SILTY GRAVELLY M-F SAND GRADING TO:	1640 ↓ 3'3" (59'11") 1030 ↓ SAND HEAVING UP CASING 1035 ↓ 19'10" (63'2") 1340 ↓
64				
	65	GM	MED. DENSE, GRAY SATURATED, SILTY SANDY FINE GRAVEL	
	70			

Parametrix, Inc. 6/87

Well Installation Log

Job No. 31-1550-14-0045 Client CITY OF SEATTLE Location

CASING TYPE 3/4" SCH 80 PVC	W/ PROBE	DRILLING METHOD AIR ROTARY					WELL NO. AO	
LENGTH 25' SCREEN 73' SOLID (PAY 75)	98 TOTAL	SAMPLING METHOD GRAB						
JOINT TYPE FLUSH SCREEN		HAMMER WT.			DROP		SHEET 3	
SCREEN TYPE HYDROPHYLLICS		DATE 8-17-87					OF 3	
SLOT SIZE .020		BY AL CAREY						
SEAL TYPE		DRILLING CONTR. TACOMA PUMP					START	FINISH
INSTALL. METHOD		WATER LEVEL	48.7	16.7				
FILTER		TIME	1100	1100			1030	1715
INSTALL		DATE	9-8	9-8			8-17-87	
GROUT			W	M				

WELL DETAILS WELL AO

WELL DETAILS	DEPTH	USCS	SOIL DESCRIPTION	INSTALLATION NOTES
W	70		GROUND ELEVATION	MAKING H_2O, DECREASE IN SILT, HEAVING SLIGHT
73		GP	MED DENSE, WATER BEARING, CLEAN SANDY C-F GRAVEL	MAKING APPROX 30 GPM
PEA GRAVEL FILTER	75		GRAVEL IS SUB ANGULAR TO SUB ROUNDED, 3/8-1"	MAKING 50-60 GPM
			SAND IS M-C, PRED SUB ANGULAR, WATER A LT. BROWN COLOR	
	80			1455 ↓ STOP TO RE-FUEL
				1515 ↓
3/4" SCH 80 PVC.				1535 ↓ 19'8" (83'0")
.020 SLOT				1610 ↓ MAKING - 30 GPM
	85			INCREASING SAND CONTENT GRAVEL SIZE DECREASING
		SP	LAYERING OF WATER BEARING, CLEAN	
	90	GP	GRAVELLY M-C SAND	
		SP		WATER HAS GREATER TURBIDITY AFTER 91'
		GP		
		SP		
	95	GP		
98				BOTTOM OF BORING - 98
	100			
				1715 ↓ (102'8")
	105			

Well Installation Log

Job No. 31-1550-20-0034 Client CITY OF SEATTLE Location

CASING TYPE 3/4" SCH 80 PVC	PROBE "M"	DRILLING METHOD AIR ROTARY	WELL NO. AR
LENGTH 25' SCREEN 20' BLANK 25 TOTAL		SAMPLING METHOD GRAB	
JOINT TYPE FLUSH SCREW		HAMMER WT. DROP	SHEET 1
SCREEN TYPE HYDROPHYLLICS		DATE 9-15-87	OF 3
SLOT SIZE .020		BY AL CAREY	
SEAL TYPE 1/4 BENTONITE PELLET - CEMENT/BENT GROUT		DRILLING CONTR. TACOMA PUMP	START / FINISH
INSTALL METHOD BUCKET / BERKELY GROUT PUMP		WATER LEVEL 9.3 / 53.3 / 75.1	
FILTER PEA GRAVEL		TIME 1030 / 1030 / 1030	1325 - 1435
INSTALL BUCKET		DATE 9-22 / 9-22 / 9-22	
GROUT 2 BAGS CEMENT - 1 BAG BENTONITE		M / I / D	9-15-87

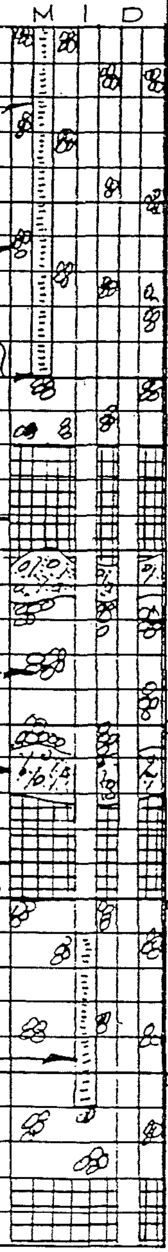
WELL DETAILS WELL AR	DEPTH	USCS	SOIL DESCRIPTION	INSTALLATION NOTES
M I D	0		GROUND ELEVATION 352 ±	1325 210' (0')
1		SM	LOOSE, BELOW 1/2 MED DENSE W DEPTH, RED BROWN TO BROWN DRY TO SLIGHTLY MOIST SILTY GRAVELLY SAND WITH COBBLES, BOULDERS	BOULDER AT 1'
CEMENT/BENTONITE GROUT				COLOR CHANGE 335 ADJUST RIG 350
	5	SM		
				MOISTURE CHANGE HARDER DRILLING - 8'
	10	GM	MED DENSE, TAN, V MOIST SANDY, SILTY C-F GRAVEL	MOISTURE COLOR CHANGE - 11'
14		GP	MED DENSE, GRAY, MOIST SLIGHTLY SILTY, SANDY F-C GRAVEL	
BENTONITE PELLET SEAL - 100 LBS	15	GM		
17				MOISTURE SAND, SILT GRAVEL
CAVED MATERIAL				HARDER DRILLING - 15
19		GP	DENSE BROWNISH GRAY SLIGHTLY MOIST C-F GRAVEL W SOME SAND MAX SIZE 1 1/2", PREC 3/8 - 3/4	
20	20			1435 19'4" (210')
3/4" SCH 80 PVC .020 SLOT				1015 MAKES ABOUT 40 GALS H2O ON START EASIER DRILLING 24'
	25	GM	MED DENSE, GRAY, MOIST SILTY, SANDY C-F GRAVEL	
PEA GRAVEL FILTER	30			
	35			

Well Installation Log

Job No. 31-1550-20-0034 Client CITY OF SEATTLE Location

CASING TYPE 3/4 SCH 80 PVC	1 PROBE	DRILLING METHOD AIR ROTARY				WELL NO. AR
LENGTH 5' SCREEN 61 (PAY 65) FEET PLAIN 66 TOTAL		SAMPLING METHOD GRAB				
JOINT TYPE FLUSH SCREW		HAMMER WT. —		DROP —		SHEET 2
SCREEN TYPE HYDROPHYLLICS		DATE 9-16-87				OF 3
SLOT SIZE .020		BY A. CAREY				
SEAL TYPE 2 EA 1/4" BENTONITE PELLET SEALS 250 LBS TOTAL		DRILLING CONTR. TACOMA PUMP				START / FINISH
INSTALL METHOD BUCKET		WATER LEVEL	NO H_2O	9.5'		1015 / 1620
FILTER PEA GRAVEL		TIME	1400	0900		
INSTALL BUCKET		DATE	9-16-87	9-21-87		9-16-87
GROUT						

WELL DETAILS	DEPTH	USCS	SOIL DESCRIPTION	INSTALLATION NOTES
M I D	35		GROUND ELEVATION 352±	
3/4" SCH. 80 PVC .020 SLOT		GM		EASIER DRILLING, SATURATED CUTTING (LIKE CAKE MIX -37' CHUNKS OF A DRY, SANDY SILT IN CUTTINGS UNIT MAY BE LAYER
		SP	LOOSE, GRAY, WATER BEARING, M-F SAND WITH TRACE GRAVEL	1050 ↓ 70'0" (40'4")
PEA GRAVEL FILTER	40	ML	INTERLAYERED WITH	1140 ↓ W.B. SP AND ML
	3 4	SP	A. DENSE GRAY, NONPLASTIC SANDY SILT AND A	MAKING 5 GPM ON SAT-IX
SLIP ON CAP 45	45	ML	MED DENSE, TAN, SL. PLASTIC SILT WITH SOME SAND	
47		SP		
BENTONITE PELLET SEAL -125 LBS 50	50	GP \ GM	DENSE, GRAY, WATER BEARING SLIGHTLY SILTY SANDY C-F GRAVEL	HARDER DRILLING, MAKING MORE H_2O -48'
	5	ML	WITH OCCASIONAL LAYERS OF TAN SL. PLASTIC SILT	
PEA GRAVEL				↑ COARSE GRAVEL, LESS H_2O 53-54'
	55 6	GP \ GM	DENSE GRAY, V MOIST SLIGHTLY SILTY F-C GRAVEL W SOME FINE SAND PRED GRAVEL SIZE 3/8-1" F. SAND SILT COATS GRAVEL	
CAVED MATERIAL 57				1235 ↓ BROKEN PULL DOWN
BENTONITE PELLET SEAL - 125 LBS 60	60			1300 ↓ CHAIN 1310 ↓ 19'9" (60'4")
61		GM	DENSE BROWNISH GRAY V MOIST SILTY SANDY C-F GRAVEL	1500 ↓ NO H_2O ON STARTUP
3/4" SCH 80 PVC .020 SLOT	65			
66				GRAVEL ½" → 3" OUT OF EXHAUST
68	7			
	70	SM		

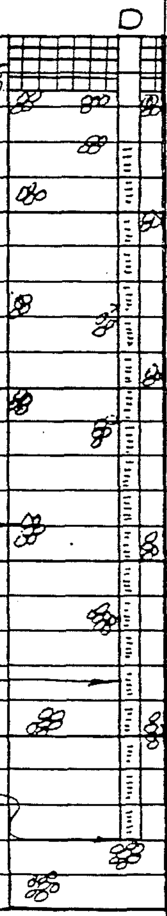


Well Installation Log

Job No. 3-1550-14-0034 Client CITY OF SEATTLE Location

ASING TYPE 3/4" SCH. 80 PVC	"D" PROBE	DRILLING METHOD AIR ROTARY				WELL NO. AR	
LENGTH 20' SCREEN 73' (PAY 75) SOLID	93' TOTAL	SAMPLING METHOD GRAB					
JOINT TYPE FLUSH SCREW		HAMMER WT. —		DROP —		SHEET 3	
SCREEN TYPE HYDROPHYLLICS		DATE 9-16, 19-17-87				OF 3	
SLOT SIZE .020		BY AL CAREY					
SEAL TYPE 1/4" BENTONITE PELLETS - 125 LBS		DRILLING CONTR. TACOMA PUMP				START	FINISH
INSTALL METHOD BUCKET		WATER LEVEL	79.5			1040	1210
FILTER PEA GRAVEL		TIME	1500				
INSTALL BUCKET		DATE	9-17-87			9-17-87	
GROUT							

WELL DETAILS	DEPTH	USCS	SOIL DESCRIPTION GROUND ELEVATION	INSTALLATION NOTES
BENTONITE PELLET SEAL - 125 LBS 71.5	70	8 SM	MED DENSE, TAN, V. MOIST SILTY M-F SAND W SOME F. GRAVEL	COLOR CHANGE HARDER DRILLING 72'
73				
	75	GM	MED DENSE DARK GRAY V. MOIST, SANDY, SILTY FINE GRAVEL	
				INCREASE MOISTURE GRAVEL SIZE 79'
	80			1620 ⊻ 18' 11" (80' 1")
				1060 ⊻
PEA GRAVEL FILTER		9 GM	MED DENSE, DARK GRAY SATURATED SILTY C-F GRAVEL W SOME SAND	
	85			
3/4" SCH. 80 PVC .020 SLOT				
	90			COARSE GRAVEL 2" IN CUTTINGS EASIER DRILLING 91
SLIP ON CAP 93		SM	LOOSE GRAY WATER BEARING, SILTY FINE SAND W SOME FINE GRAVEL	1130 ⊻ REPAIR HAMMER
95	95			1150 ⊻ MAKING 2 IN STRIP
				1210 ⊻ MAKING 5-10 GPM H₂O VERY SILTY
				(99')
	100			
	105			



35' SOUTH OF X-OF 20TH AVE S, S.E. EAST ROW

Well Installation Log

Job No. 31-1550-20 Client CITY OF SEATTLE Location

CASING TYPE	1/2" SCH. 80 PVC
LENGTH	24' SCREEN 21' (PA1 7.5) BLANK. 45' TOTAL
JOINT TYPE	FLUSH SCREW
SCREEN TYPE	HYDROPHYLLICS
SLOT SIZE	.020
SEAL TYPE	BENT. PELLET, FOR - CONC. / BENT SLURRY
INSTALL METHOD	BUCKET - BERKELY GROUT PUMP
FILTER	PEA GRAVEL
INSTALL	BUCKET
GROUT	4 BAGS CEMENT 1/2 BAG BENT.

DRILLING METHOD	AIR ROTARY			
SAMPLING METHOD	GRAB			
HAMMER WT.	—	DROP	—	
DATE	9-29-87			
BY	AL CAREY			
DRILLING CONTR.	TACOMA PUMP			
WATER LEVEL	149.15			
TIME	1000			
DATE	10-7-87			
	"W"			

WELL NO.	AV
SHEET	1
OF	5
START	FINISH
1135	1505
9-29-87	

WELL DETAILS WELL AV

S M D W

WELL DETAILS	DEPTH	USCS	SOIL DESCRIPTION	INSTALLATION NOTES
			GROUND ELEVATION 392 ±	1135 ADD H2O 20'1" (0)
		GP \ GM	MED DENSE GRAY MOIST ? SLIGHTLY SILTY, SANDY C-F GRAVEL	HAMMER FUNCTIONING POORLY
CEMENT/BENTONITE GROUT SLURRY SEAL	5			
	10	SM	DENSE GRAY MOIST ? GRAVELLY, SILTY, M-F SAND	H2O OFF
14.5				VERSE GRAVEL % ... DIFFICULTY
BENTONITE PELLET SEAL - 150 LBS	15	GP \ GM	V DENSE TO DENSE, GRAY SLIGHTLY MOIST SLIGHTLY SILTY SANDY F-C GRAVEL	
19	20			1320 19'9" (20'1")
21				1430 HAMMER FUNCTION... NORMALLY
1/2" SCH 80 PVC .020 SLOT	25	SP \ SM	DENSE, GRAY, MOIST SILTY TO SLIGHTLY SILTY GRAVELLY SAND WITH LAYERS OF SLIGHTLY SILTY C-F GRAVEL	EASIER DRILLING, ↑ % SAND
		GP GM		
PEA GRAVEL FILTER	30	SP \ SM		DRILLS HARD (LIKE GRAVEL) INTERMITTANTLY
		GP GM		
		SP SM		
	35			

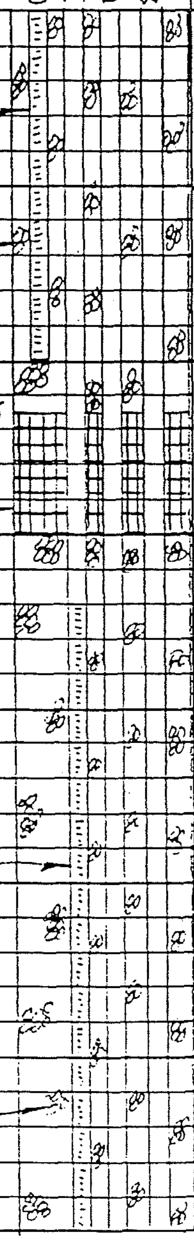
Well Installation Log

Job No. 31-1550-20 Client CITY OF SEATTLE Location

CASING TYPE ½" SCH. 80 P/C	M PROBE	DRILLING METHOD AIR ROTARY	WELL NO. AV
LENGTH 30' SCREEN 52' (PAY 55') BLANK 82' DTH		SAMPLING METHOD GRAB	
JOINT TYPE FLUSH SCREW		HAMMER WT. — DROP —	SHEET 2
SCREEN TYPE HYDROPHYLLICS		DATE 9-29, 9-30-87	OF 5
SLOT SIZE .020		BY AL CAREY P-MX	
SEAL TYPE ½" BENTONITE PELLET - 400 LBS		DRILLING CONTR. TACOMA PUMP	START / FINISH
INSTALL METHOD BUCKET		WATER LEVEL 149.15	
FILTER PEA GRAVEL		TIME	1005 / 1605
INSTALL BUCKET		DATE	
GROUT			9-30-87

WELL DETAILS WELL AV

S M D W



WELL DETAILS	DEPTH	USCS	SOIL DESCRIPTION (GROUND ELEVATION)	INSTALLATION NOTES
½" SCH.80 P/C				
.020 SLOT				
		GP	DENSE, BROWNISH GRAY	END OF DAY 9-29 38'
			MOIST, SLIGHTLY	
		\	SILTY C-F GRAVEL	1005 ↓ 19'2" (39'10")
PEA GRAVEL FILTER	40	GM	WITH SOME SAND	1025 ↓ CUTTINGS WET ??
			SILT + FINE SAND	??? PROBABLY
			ADHERE TO GRAVEL	FROM ???
			PRED GRAVEL SIZE	???
45	45		½"-1"	
46.5				
BENTONITE PELLET				
SEAL - 400 LBS				
50	50			
			DENSE, BROWNISH GRAY	GRAVEL GRADING COARSER
52			MOIST, SLIGHTLY SILTY	LARGER MAX SIZE ABOUT
		3	F-C GRAVEL WITH	DRILLING -51'
		GP	SOME SAND SILT + FINE	
	55	\	SAND ADHERE TO	
		GM	GRAVEL, PRED GRAVEL	
			SIZE 1"-1½"	
½" SCH. 80 P/C				
.020 SLOT		4 SP	MED. DENSE, BROWNISH GRAY	1040 ↓ 20'10" (59'0")
	60	\ SM	V. MOIST SLIGHTLY SILTY	1230 ↓
			GRAVELLY F-M-C SAND	
		GP	COARSE SAND PRED SUB-ANGULAR	CUTTINGS V MOIST
		\		
			MED DENSE, BROWNISH GRAY	
	65	GM	MOIST SLIGHTLY SILTY SANDY	
PEA GRAVEL FILTER			FINE GRAVEL	1255 ↓ ???
				1305 ↓ ???
		GP	SEE NEXT PAGE	EXHAUST ???
		\		??? -UP
	70	GM		

Parametrix, Inc. 6/87

Well Installation Log

Job No. 71-1550-20 :0488 Client CITY OF SEATTLE Location

CASING TYPE		DRILLING METHOD AIR ROTARY	WELL NO. AV
LENGTH		SAMPLING METHOD GRAB	
JOINT TYPE		HAMMER WT. DROP	SHEET 3
SCREEN TYPE		DATE 9-30-87	OF 5
SLOT SIZE		BY A. CAREY	
SEAL TYPE 1/4" BENTONITE PELLETS		DRILLING CONTR. TACOMA PUMP	START / FINISH
INSTALL METHOD BUCKET		WATER LEVEL No H_2O	
FILTER PEA GRAVEL		TIME 0900	1020 / 1630
INSTALL BUCKET		DATE 10-1-87	10-1-87
GROUT			

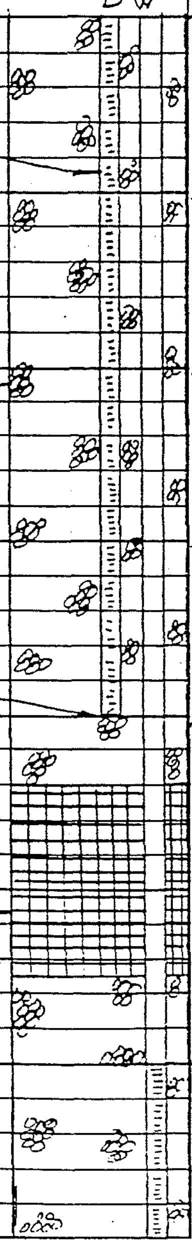
WELL DETAILS	DEPTH	USCS	SOIL DESCRIPTION (GROUND ELEVATION)	INSTALLATION NOTES
M D W				
1/2" SCH. 80 PVC, .020 SLOT		GP \ GM	MED DENSE, BROWNISH GRAY V MOIST SL. SILTY F-C GRAVEL W SOME SAND	
	5	GM	V MOIST SILTY SANDY F GRAVEL	INCREASE % SILT, SAND ≈2 FT LAYER
PEA GRAVEL FILTER	75			
	6	GP \ GM	DENSE, BROWNISH GRAY V MOIST, SLIGHTLY SILTY F-C GRAVEL WITH SOME SAND AND OCCASIONAL COBBLES BELOW 86'	1335 ↓ 19'7' (79'10") 1450 ↓
SCREW ON CAP — 82	80			
CAVED MATERIAL (HOLE DRY) 84				
BENTONITE PELLET SEAL - 150 LBS 89	85	GP \ GM		HARDER DRILLING COBBLE
CAVED MATERIAL (HOLE DRY)	90	SM?		LARGE COBBLE ADD H_2O V EASY DRILLING 91-92 SILTY SAND?
END OF DAY 10-5-87 92.5				
95	95 7	GP \ GM	MED DENSE, BROWNISH GRAY V MOIST, SLIGHTLY SILTY SANDY FINE GRAVEL	GRAVEL SIZE → FINE
1/2" SCH 80 PVC .020 SLOT				END OF DAY 9-30-87
				1405 ↓ 18'0" (99'5") 1020 ↓
PEA GRAVEL FILTER	100			
				HARDER DRILLING - 103'
	105			

Well Installation Log

Job No. 31-1552-20 Client CITY OF SEATTLE Location

CASING TYPE ½" SCH 80 PVC	1" PROBE	DRILLING METHOD AIR ROTARY	WELL NO. AV
LENGTH 30' SCREEN 95' (PA: 100) BLANK - 150 TOTAL		SAMPLING METHOD GRAB	
JOINT TYPE FLUSH SCREEN		HAMMER WT. — DROP —	SHEET 4 OF 5
SCREEN TYPE HYDROPHILLIC		DATE	
SLOT SIZE .020		BY	
SEAL TYPE ¼" BENTONITE PELLETS 200 LBS		DRILLING CONTR.	START 1135 FINISH 1205
INSTALL METHOD BUCKET		WATER LEVEL	
FILTER PEA GRAVEL		TIME	
INSTALL BUCKET		DATE	10-2-87
GROUT			

WELL DETAILS



D W

½" SCH 80 PVC

.020 SLOT

PEA GRAVEL FILTER

SCREW ON CAP

125

127

BENTONITE PELLET SEAL - 200 LBS

132.5

135

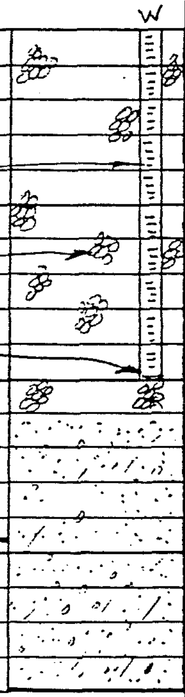
DEPTH	USCS	SOIL DESCRIPTION	INSTALLATION NOTES
105		GROUND ELEVATION	CUTTINGS MOSTLY GRAVEL CHIPS WITH SILT COATING, LITTLE SAND. POOR RETURN - TAKING AIR
	GP \ GM	DENSE POROUS, BROWNISH GRAY, V. MOIST SLIGHTLY SILTY COARSE GRAVEL WITH SOME TO TRACE SAND - WITH THIN LENSES OF - LOOSE TO MED DENSE SLIGHTLY SILTY FINE GRAVEL - ALSO POROUS (REDATE 1100, 1150 HAMMER)	
110	GM		
	GM		TAKING LESS AIR ↑ % SILT FINE 113'
115	GM		1240 CLEAN HAMMER AIR ASSEMBLY; 1345 USE FOAM 19'7" (118.5'); 1410; 1455 TO CLEAR HOLE; COLOR CHANGE TO BROWN; ADD H_2O FROM 118'
120	GP	MED DENSE, BROWN, SLIGHTLY SILTY TO CLEAN SANDY F-C GRAVEL	
125			
130			EASIER DRILLING 133'
135	SP \ SM	LOOSE, BROWN SLIGHTLY SILTY M-F SAND	CAN'T DRILL OPEN HOLE; END OF DAY 10-1 137'; 1630 143 (137'10"); 1135
140			

Well Installation Log

Job No. 31-1550-14 Client CITY OF SEATTLE Location

CASING TYPE 3/4" SCH 80 PVC	"W" PROBE	DRILLING METHOD AIR ROTARY		WELL NO. AV
LENGTH 15' SCREEN 135' (BY 140) SOLID		SAMPLING METHOD GRAB		SHEET 5
JOINT TYPE FLUSH SCREW		HAMMER WT. —	DROP —	OF 5
SCREEN TYPE HYDROPHYLLICS		DATE 10-7-87		
SLOT SIZE .020		BY AL CAREY		
SEAL TYPE N/A		DRILLING CONTR. TACOMA PUMP		START / FINISH
INSTALL. METHOD N/A		WATER LEVEL 144.5		
FILTER PEA GRAVEL		TIME 0900		
INSTALL		DATE 10-5-87		
GROUT				

WELL DETAILS WELL AV



WELL DETAILS	DEPTH	USCS	SOIL DESCRIPTION	INSTALLATION NOTES
	140		GROUND ELEVATION	W SOME GRAVEL (BIG REACTION)
3/4" SCH. 80 PVC				
.020 SLOT		SP	LOOSE, TAN, SLIGHTLY SILTY, M-F SAND	
PEA GRAVEL FILTER	145	SM	W SOME GRAVEL	
SCREW ON CAP				
150	150			
151				CREDIT WELL DEPTH -151' (152.1')
CAVED MATERIAL				APPEARS TO BE MAKING H_2O -154'
	155			HARDER DRILLING -156'
		GP	DENSE, GRAY, WATER BEARING FINE GRAVEL W SOME COARSE SAND	
159				160' DRILLED OPEN HOLE UNABLE TO TELL IF MAKING H_2O
	160			

WELL AV - TESTED 10-7-87 1450 HR

PROBE	PRESS	O_2	CH_4
S	+0.3	13.0	8.0 % VOL
M	-1.4	11.5	14.0 % VOL
D	-1.5	19.0	5000 PPM
W	-0.8	17.0	9.0 % VOL

MIDWAY LANDFILL
25' NORTH OF

Well Installation Log

Job No. 31-1550-14-0045 Client CITY OF SEATTLE Location MW-11

CASING TYPE 3/4" SCH. 80 PVC	PROBE "S"	DRILLING METHOD AIR ROTARY				WELL NO. AM	
LENGTH 15' SCREEN 25' SOLID 40' TOTAL		SAMPLING METHOD GRAB					
JOINT TYPE FLUSH SCREW		HAMMER WT. —		DROP —		SHEET 1	
SCREEN TYPE HYDROPHYLLICS		DATE 8-4-87				OF 4	
SLOT SIZE .020		BY AL CAREY- PMX					
SEAL TYPE CONCRETE/BENT SLURRY – BENT PELLET		DRILLING CONTR. TACOMA PUMP				START	FINISH
INSTALL METHOD BERKELY GROUT PUMP	150LBS	WATER LEVEL	26.5	58.4	90.2		
FILTER PEA GRAVEL		TIME	0930	0935	0940	1140	1715
INSTALL BUCKET		DATE	8-11	8-11	8-11	8-4-87	
GROUT 4 BAGS CEMENT 1 BAG BENT. POWDER			"S"	"M"	"D"		

WELL DETAILS WELL AM	DEPTH	USCS	SOIL DESCRIPTION	INSTALLATION NOTES
S M D	0		GROUND ELEVATION 370 ±	1140 20'3" (0)
			SHOT ROCK 4"-6"	ADD H₂O -DUST CONTROL
				EASY DRILLING - HAMMER NOT WORKING
	5		LOOSE, DARK BROWN, MOIST, SILTY SAND WITH SOME FINE GRAVEL, NUMEROUS WOOD FRAGMENTS, DECAYED VEGETATION ODOR (FILL)	
CONCRETE/BENTONITE SLURRY SEAL	10	SM (FILL)		
	15		COLOR CHANGE, INCREASE % GRAVEL, DECREASE SAND, SILT	1155 STOP TO REPAIR HAMMER 1200
		ML	MED DENSE, BROWNISH GRAY SANDY GRAVEL WITH A SANDY SILT NODULES AND OCCASIONAL WOOD FRAGMENTS	
BENTONITE PELLET SEAL - 150 LBS.	20	GP		1205 19'10" (20'3") 1330
23		ML		
25	25	SM	DENSE, GRAY, SLIGHTLY MOIST SILTY GRAVELLY C-F-M SAND - TILL LIKE	
PEA GRAVEL FILTER				
	30		INCREASE GRAVEL, DECREASE SILT	
SCH 80 PVC .020 SLOT		GP	DENSE BROWNISH GRAY SLIGHTLY SILTY SANDY	
END OF DAY 8-7-87-34		GM	C-F GRAVEL	
34	35			

Well Installation Log

Job No. 31-1550-14-0015 Client CITY OF SEATTLE Location

SING TYPE 3/4" SCH. 80 PVC	PROBE "M"	DRILLING METHOD AIR ROTARY		WELL NO.	AM
LENGTH 20 SCREEN 53 SOLID (PAY 55) 73 TOTAL		SAMPLING METHOD GRAB			
JOINT TYPE FLUSH SCREW		HAMMER WT. —	DROP —	SHEET 2	
SCREEN TYPE HYDROPHYLLICS		DATE 8-4		OF 4	
SLOT SIZE .020		BY AL CAREY PMX			
SEAL TYPE 1/2" BENTONITE PELLET - 100 LBS		DRILLING CONTR. TACOMA PUMP		START	FINISH
INSTALL. METHOD BUCKET		WATER LEVEL			
FILTER PEA GRAVEL		TIME			
INSTALL BUCKET		DATE			
GROUT					

WELL DETAILS WELL AM

S M P

WELL DETAILS	DEPTH	USCS	SOIL DESCRIPTION	INSTALLATION NOTES
	35		GROUND ELEVATION	
				SUDDEN INCREASE IN MOIST AT 37'
40		GP \ GM	MED DENSE, WATER BEARING, BROWN SLIGHTLY SILTY C-F GRAVEL WITH A TRACE TO SOME SAND. MOST OF SILT CARRIED IN H_2O	1405 19'9" (40'3")
CAVED MATERIAL	40			1450 MAKING H_2O ON START-UP AND INTERMITTANTLY THE UNIT
PEA GRAVEL				
44				
BENTONITE PELLET SEAL - 100 LBS	45			
48				
CAVED MATERIAL		SM	DENSE, BROWN SILTY SAND WITH TRACE TO SOME FINE GRAVEL	
50	50			
52.5			GRADATIONAL CONTACT DECREASE SAND, INCREASE GRAVEL.	
	55	SM \ GM	SILTY GRAVELLY SAND TO SILTY SANDY GRAVEL	
PEA GRAVEL FILTER				DRILLING MUCH HARDER AT 5'
	60			1530 19'10" (60'0") 1615 ADD H_2O
SCH 80 PVC .020 SLOT		GP \ GM	DENSE, BROWNISH GRAY MOIST? SLIGHTLY SILTY C-F GRAVEL W/ TRACE TO SOME SAND	TAKING AIR-WATER
	65			STOP H_2O
	70			

Well Installation Log

Job No. 31-1550-14-0045 Client CITY OF SEATTLE Location

CASING TYPE 3/4" SCH. 80 P/C	PROBE "D"	DRILLING METHOD AIR ROTARY					WELL NO. AM	
LENGTH 35' SCREEN 83' SOLID (PAY 85) 118' TOTAL		SAMPLING METHOD GRAB						
JOINT TYPE FLUSH SCREW		HAMMER WT. —		DROP —			SHEET 3	
SCREEN TYPE HYDROPHYLLICS		DATE 8-4 AND 8-5-87					OF 4	
SLOT SIZE .020		BY AL CAREY - PMX						
SEAL TYPE 1/2" BENTONITE PELLETS - 150 LBS		DRILLING CONTR. TACOMA PUMP					START	FINISH
INSTALL METHOD BUCKET		WATER LEVEL	70.5'	89.5'				
FILTER PEA GRAVEL		TIME	0840	0830			1000	1430
INSTALL BUCKET		DATE	8-5-87	8-6-87			8-5-87	
GROUT								

WELL DETAILS WELL AM

WELL DETAILS	DEPTH	USCS	SOIL DESCRIPTION	INSTALLATION NOTES
M D	70		GROUND ELEVATION	
		GP		SAMPLE 4 MOIST, INCREASE
SCREW ON CAP		\		IN SILT
72.5		GM		
				EASY DRILLING
74.5			MED DENSE BROWN	
	75	5 ML	SANDY SILT W/	
BENTONITE PELLET			SOME - TRACE FINE	
SEAL - 150 LBS			GRAVEL - MODERATE	END OF DAY 8-4-87 - 78'
79			PLASTICITY - PROBABLE	DRILLING MORE DIFFICULT
	80		AQUITARD	1715 ↓ 71'6" (79'10")
				1000 ↓ MAKING H_2O ON
				START-UP
83			DENSE - MED DENSE, GRAY	
			SATURATED SANDY SILT/	
	85	GM	FINE GRAVEL	
PEA GRAVEL FILTER				
		6		
	90			
3/4" SCH 80 P/C				DECREASE IN MOIST SAME
.020 SLOT	95			UNIT (GM)
				COLOR CHANGE TO BROWN
			LOOSE, BROWN MOIST	
		7 GP	CLEAN SANDY FINE	DRILLING W/O DOWN PRESSURE
			GRAVEL GRAVEL 1/4-1/2	
	100		WELL TO SUB ROUNDED	MAKING H_2O AT 100'
				1100 ↓ 19'2" (101'4")
		SP	LOOSE, DARK GRAY, WATER BEARING	1150 ↓
			M-F SAND - CUTTINGS	
			APPEAR LT BROWN FROM	MAKING SMALL AMOUNT H_2O
	105		SILT WHICH IS BEING	2-3 GPM
			CARRIED IN H_2O	

Well Installation Log

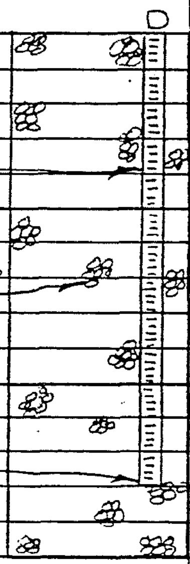
Job No. 31-1550-14-0045 Client CITY OF SEATTLE Location

SING TYPE	SEE SHEET 3	DRILLING METHOD	AIR ROTARY
LENGTH	"D"	SAMPLING METHOD	GRAB
JOINT TYPE	FOR	HAMMER WT. -	DROP -
SCREEN TYPE	PROBE	DATE	8-5-87
SLOT SIZE	DETAILS	BY	AL CAREY - PMX
SEAL TYPE		DRILLING CONTR.	TACOMA PUMP
INSTALL METHOD		WATER LEVEL	
FILTER		TIME	
INSTALL		DATE	
GROUT			

WELL NO. AM
SHEET 4 OF 4

START	FINISH

WELL DETAILS WELL AM



3/4" SCH 80 PVC
.020 SLOT
PEA GRAVEL FILTER
SCREW ON CAP
118
120

DEPTH	USCS	SOIL DESCRIPTION	INSTALLATION NOTES
105		GROUND ELEVATION	
			APPEARS NOT MAKING H_2O
			STILL V MOIST - SATURATED
		LOOSE, DARK GRAY, WATER	1200 STOP DRILLING - PLUG
		BEARING M-F SAND	1210 BIT
110	SP	WITH SOME F GRAVEL AND	
		COARSE SAND BELOW 111'	INCREASE IN COARSE
			SAND - FINE GRAVEL
			CONTENT
115	SP		
			APPEARS TO BE A PETROLEUM
			CONTAMINANT SEPARATING
			OUT OF H_2O
120		BOTTOM OF BORING 8-7-87	
			1235 (120'6")
			1330 STARTED COMPRESSOR
			MADE ABOUT 15 GALLONS
			OF LIQUEFIED SAND
125			1410 CLEANING OUT HOLE
			FORMATION MAKING ABOUT
			10 GAL/MIN
130			

Figure A-1

RECORD OF BOREHOLE MW-1

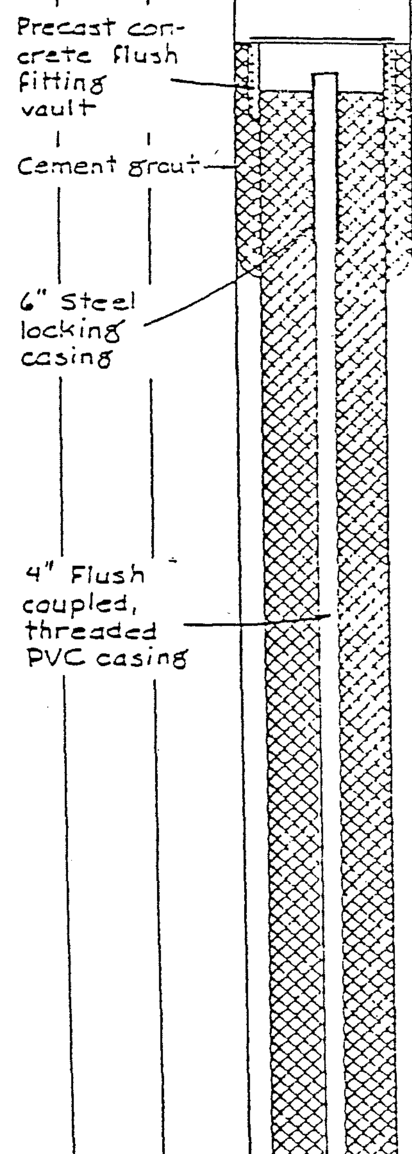
LOCATION See Figure
DATUM 375 ft. (approx.)
DATE 3-25-85
SAMPLER HAMMER WEIGHT 140 LB., DROP 30 IN.
BORING METHOD Air Rotary Drill

SOIL PROFILE: ELEVN / DEPTH	SOIL PROFILE: DESCRIPTION	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/FT.	ELEVATION
375 / 0.0	Dark brown; sandy, fine to coarse GRAVEL, trace silt.	1	AR		375
370 / 5.0	Medium to dark brown; silty, fine to medium SAND, trace gravel.	2	AR		370
		3	AR		365
360 / 15.0	Medium to dark brown; fine to coarse GRAVEL, to gravelly, fine to coarse SAND to sandy, fine to coarse GRAVEL, trace silt.	4	AR		360
		5	AR		355
		6	AR		350
345 / 30.0		7	AR		345

STANDARD PENETRATION TEST ▲"N" BLOWS PER FOOT

WATER CONTENT, PERCENT
Wp Wn WL

GROUNDWATER WELL INSTALLATION



REMARKS: AR - Air rotary drill

VERTICAL SCALE
1 IN. TO 5 FT.

Golder Associates

JOB # 853-1007

Figure A-1

RECORD OF BOREHOLE MW-1

LOCATION See Figure   DATUM 375 ft. (approx.)   DATE 3-25-85

SAMPLER HAMMER WEIGHT 140 LB., DROP 30 IN.   BORING METHOD Air Rotary Drill

ELEVN / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	BLOWS/FT.	ELEVATION
	Gray-brown to brown; Fine to coarse SAND, some gravel, trace silt.	7	AR		
		8	AR		340
335 / 40.0	Gray-brown to brown; Fine to coarse SAND and Fine to coarse GRAVEL, some to trace silt.	9	AR		335
		10	AR		330
	50.0-55.0: Grades to fine to coarse SAND, some gravel, some silt.	11	AR		325
		12	AR		320
315 / 60.0	Gray-brown to brown; silty, fine to coarse SAND, some gravel.	13	AR		315
310 / 65.0		14	AR		310

STANDARD PENETRATION TEST ▲ "N" BLOWS PER FOOT

WATER CONTENT, PERCENT: Wp Wn WL

GROUNDWATER WELL INSTALLATION:

- 4" Flush coupled, threaded PVC casing
- Cement grout
- Bentonite seal
- Pea gravel

REMARKS:

VERTICAL SCALE 1 IN TO 5 FT.

Golder Associates

JOB # 853-1007

Figure A-1

RECORD OF BOREHOLE MW-1

LOCATION See Figure — DATUM 375 Ft. (approx) — DATE 3-25-85

SAMPLER HAMMER WEIGHT 140 LB., DROP 30 IN. — BORING METHOD Air Rotary Drill

ELEVN. / DEPTH	SOIL PROFILE: DESCRIPTION	STRAT. PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/FT.	ELEVATION	STANDARD PENETRATION TEST ▲"N" BLOWS PER FOOT / WATER CONTENT, PERCENT (Wp, Wn, WL)	GROUNDWATER WELL INSTALLATION
	Medium-brown; silty, fine to coarse SAND and fine to coarse GRAVEL.		14	AR				
						305		
			15	AR				
						300		
299 / 76.0	Gray-green to medium brown; fine to coarse GRAVEL and fine to coarse SAND, some to trace silt.		16	AR				
						295		4" Flush coupled, threaded PVC casing
			17	AR				
	85.0-115.0 : Local lenses of silt.					290		
			18	AR				Pea gravel
						285		
			19	AR				0.020 Slotted 4" PVC Screen
						280		
			20	AR				
						275		
			21	AR				

REMARKS.

VERTICAL SCALE 1 IN. TO 5 FT.

Golder Associates

JOB # 853-1007

Figure A-1

RECORD OF BOREHOLE MW-1

LOCATION See Figure — DATUM 375 ft. (approx.) — DATE 3-25-85

SAMPLER HAMMER WEIGHT 140 LB., DROP 30 IN. — BORING METHOD Air Rotary Drill

SOIL PROFILE			SAMPLES			ELEVATION	STANDARD PENETRATION TEST ▲ "N" BLOWS PER FOOT / WATER CONTENT, PERCENT (Wp ● Wn WL)	GROUNDWATER WELL INSTALLATION
ELEVN / DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FT.			
	Gray-green to medium brown; fine to coarse GRAVEL and fine to coarse SAND, some to trace silt.					270		
						265		
						260		
						255		0.020 slotted 4" PVC screen
								Pea gravel
250						250		Bentonite seal
240 / 126.0	Dark gray; CLAY, some silt, trace sand, trace gravel. End of Hole at 126.0 ft.							
						245		

REMARKS:

VERTICAL SCALE 1 IN TO 5 FT.

Golder Associates

JOB = 853-1C03

RECORD OF BOREHOLE MW-2A

Figure A-2

LOCATION See Figure DATUM 382 Ft. DATE 4-29-85

SAMPLER HAMMER WEIGHT 140 LB., DROP 30 IN. BORING METHOD Air Rotary Drill

ELEVN. / DEPTH	SOIL PROFILE: DESCRIPTION	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/FT.	ELEVATION
382 / 0.0	Brown to grayish brown; fine to coarse GRAVEL, some fine to coarse sand, trace silt.	1	AR		380
		2	AR		375
372 / 10.0	Grayish-brown; silty, fine to coarse SAND and fine to coarse GRAVEL.	3	AR		370
		4	AR		365
		5	AR		360
357 / 25.0	Light olive-gray; fine to coarse GRAVEL, trace fine to coarse sand and silt.	6	AR		355

STANDARD PENETRATION TEST ▲ "N" BLOWS PER FOOT

WATER CONTENT, PERCENT Wp Wn WL

PIEZOMETER INSTALLATION

4" Flush coupled, threaded PVC casing

Cement grout

REMARKS AR - Air rotary drill.

VERTICAL SCALE 1 IN TO 5 FT.

Golder Associates

JOB # 853-1007

Figure A-2

RECORD OF BOREHOLE MW-2A

LOCATION See Figure DATUM 382 Ft. DATE 4-29-85

SAMPLER HAMMER WEIGHT 140 LB., DROP 30 IN. BORING METHOD Air Rotary Drill

ELEVN / DEPTH	SOIL PROFILE: DESCRIPTION	STRAT. PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/FT.	ELEVATION
352 / 30.0	Light olive-gray; fine to coarse SAND and fine to coarse GRAVEL, trace silt and clay.		7	AR		350
347 / 35.0	Grayish-brown; fine to coarse SAND, trace fine to medium gravel, and clay.		8	AR		345
342 / 40.0	Grayish-brown to dark gray; fine to coarse GRAVEL, trace fine to coarse sand and clay.		9	AR		340
337 / 45.0	Grayish-tan; silty, fine to coarse SAND and fine to coarse GRAVEL, trace clay.		10	AR		335
332 / 50.0	Gray-brown; fine to coarse SAND, some silt, trace gravel.		11	AR		330
327 / 55.0	Gray-brown; fine to coarse sandy SILT and fine to coarse GRAVEL to silty, fine to coarse SAND and fine to coarse GRAVEL.		12	AR		325
			13	AR		320

STANDARD PENETRATION TEST ▲"N" BLOWS PER FOOT

WATER CONTENT, PERCENT Wp Wn WL

PIEZOMETER INSTALLATION

4" Flush coupled, threaded PVC casing

Cement grout

REMARKS

VERTICAL SCALE 1 IN TO 5 FT.

Golder Associates

JOB # 853-1007

Figure A-2

RECORD OF BOREHOLE MW-2A

LOCATION See Figure — DATUM 382 Ft. — DATE 4-29-85

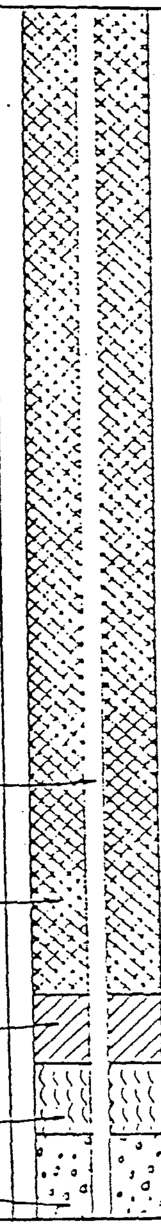
SAMPLER HAMMER WEIGHT 140 LB.. DROP 30 IN. — BORING METHOD Air Rotary Drill

ELEV. DEPTH	SOIL PROFILE: DESCRIPTION	SAMPLES: NUMBER	TYPE	BLOWS/FT.	ELEVATION
		14	AR		315
	70.0-75.0: Grades to fine to coarse SAND and fine to coarse GRAVEL, some silt.	15	AR		310
307 / 75.0	Grayish-brown to dark brown; fine to coarse GRAVEL, some to trace fine to coarse sand, trace silt.	16	AR		305
		17	AR		300
		18	AR		295
		19	AR		290
		20	AR		285

STANDARD PENETRATION TEST ▲ "N" BLOWS PER FOOT

WATER CONTENT, PERCENT — Wp Wn WL

PIEZOMETER INSTALLATION



REMARKS.

VERTICAL SCALE 1 IN TO 5 FT.

Golder Associates

JOB # 853-1007

Figure A-2

RECORD OF BOREHOLE MW-2A

LOCATION See Figure — DATUM 382 Ft. — DATE 4-29-85

SAMPLER HAMMER WEIGHT 140 LB., DROP 30 IN. — BORING METHOD Air Rotary Drill

SOIL PROFILE			SAMPLES				STANDARD PENETRATION TEST ▲ "N" BLOWS PER FOOT / WATER CONTENT, PERCENT (Wp – Wn – WL)	PIEZOMETER INSTALLATION
ELEVN / DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FT.	ELEVATION		
	Grayish-brown to dark brown; fine to coarse GRAVEL, some to trace fine to coarse sand, trace silt.		21	AR		280		
277 / 105.0	Light olive-gray; SILT, some fine to coarse sand, trace fine to medium gravel.		22	AR		275		
			23	AR		270		
			24	AR		265		4" Flush coupled, threaded PVC casing
262 / 120.0	Light olive-gray; fine to coarse SAND, trace fine to medium gravel, trace silt.		25	AR		260		Pea gravel
257 / 125.0	Light olive-gray to dark gray; fine to coarse GRAVEL, some to trace fine to coarse sand, trace silt.		26	AR		255		0.020" Well screen.
			27	AR		250		

REMARKS.

VERTICAL SCALE 1 IN TO 5 FT.

Golder Associates

JOB # 853-1007

Figure [illegible]

RECORD OF BOREHOLE MW-2A

LOCATION See Figure DATUM 382 Ft. DATE 4-29-85

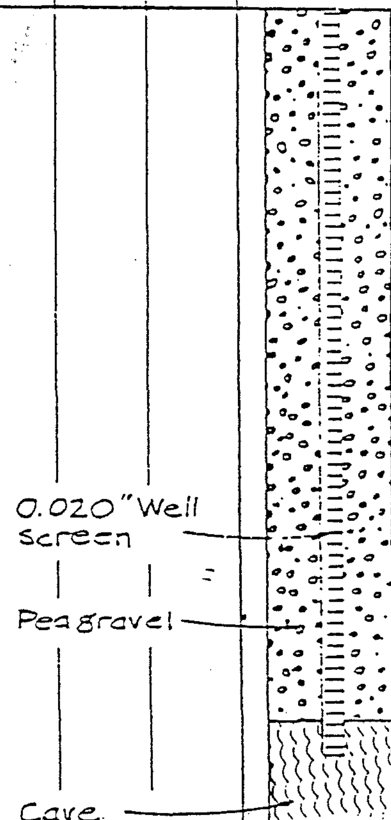
SAMPLER HAMMER WEIGHT 140 LB.. DROP 30 IN. BORING METHOD Air Rotary Drill

ELEVN. / DEPTH	SOIL PROFILE: DESCRIPTION	SAMPLES: NUMBER	TYPE	BLOWS/FT.	ELEVATION
	Light olive-gray to dark grey; Fine to coarse GRAVEL, some to trace fine to coarse sand, trace silt.	28	AR		245
		29	AR		240
		30	AR		235
		31	AR		230
227 / 155.0	End of Hole at 155.0 ft.				225

STANDARD PENETRATION TEST ▲ "N" BLOWS PER FOOT

WATER CONTENT, PERCENT — Wp Wn WL

PIEZOMETER INSTALLATION



REMARKS.

VERTICAL SCALE 1 IN TO 5 FT.

Golder Associates

JOB # 853-1007

Figure A-3

RECORD OF BOREHOLE MW-3

LOCATION See Figure
DATUM 412 ft.
DATE 3-5-85

SAMPLER HAMMER WEIGHT 140 LB., DROP 30 IN.
BORING METHOD Air Rotary Drill

SOIL PROFILE: ELEVN / DEPTH	SOIL PROFILE: DESCRIPTION	SAMPLES: NUMBER	SAMPLES: TYPE	ELEVATION
	Medium-brown; silty, gravelly, fine to very coarse SAND to silty, fine to very coarse SAND; some gravel.	7	AR	380
		8	AR	375
		9	AR	370
		10	AR	365
361 / 51.0	Medium-brown; fine to very coarse SAND and fine to very coarse GRAVEL, some silt.	11	AR	360
		12	AR	355
		13	AR	350

STANDARD PENETRATION TEST ▲"N" BLOWS PER FOOT

WATER CONTENT, PERCENT (Wp, Wn, WL)

PIEZOMETER INSTALLATION

Cement grout

4" Flush coupled, threaded PVC casing

REMARKS:

VERTICAL SCALE 1 IN TO 5 FT.

Golder Associates

JOB # 853-1007

Figure A-3

RECORD OF BOREHOLE MW-3

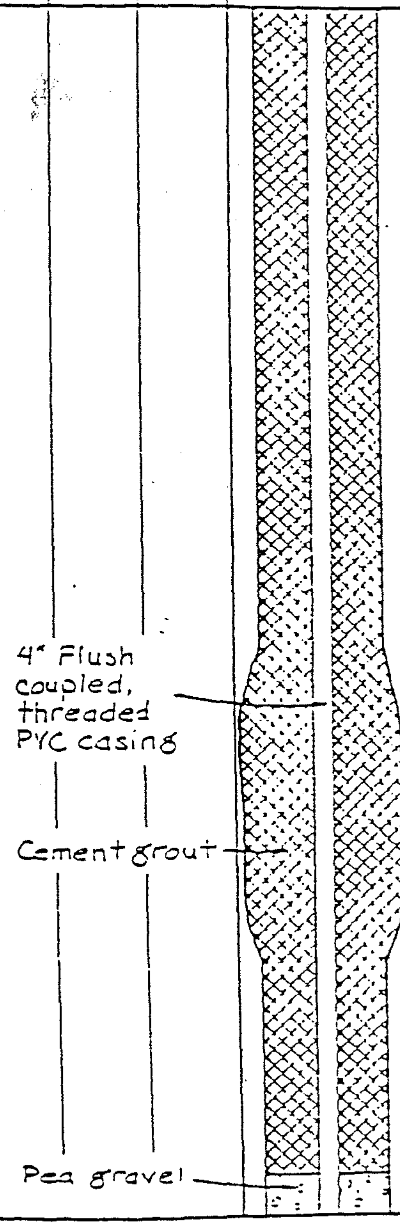
LOCATION See Figure
DATUM 412 Ft.
DATE 3-5-85
SAMPLER HAMMER WEIGHT 140 LB., DROP 30 IN.
BORING METHOD Air Rotary Drill

ELEVN / DEPTH	SOIL PROFILE: DESCRIPTION	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/FT.	ELEVATION
344		14	AR		345
68.0	Medium brown; Fine to coarse GRAVEL, some fine to very coarse sand, trace silt.	15	AR		340
		16	AR		335
		17	AR		330
		18	AR		325
		19	AR		320
317 / 95.0	Dark gray; Fine to coarse GRAVEL, some fine to very coarse sand, trace to some silt.	20	AR		315

STANDARD PENETRATION TEST
▲ "N" BLOWS PER FOOT

WATER CONTENT, PERCENT
Wp Wn WL

PIEZOMETER INSTALLATION



REMARKS:

VERTICAL SCALE
1 IN. TO 5 FT.

Golder Associates

JOB # 853-1007

Figure A-3

RECORD OF BOREHOLE MW-3

LOCATION See Figure

DATUM 412 ft.

DATE 3-5-85

SAMPLER HAMMER WEIGHT 140 LB., DROP 30 IN.

BORING METHOD Air Rotary Drill

SOIL PROFILE: ELEVN / DEPTH	SOIL PROFILE: DESCRIPTION	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/FT.	ELEVATION
	Dark gray; fine to coarse GRAVEL, some fine to very coarse sand, trace to some silt.	21	AR		310
		22	AR		305
300 / 112.0	Medium-brown; fine to coarse GRAVEL and fine to very coarse SAND, some silt.	23	AR		300
		24	AR		295
		25	AR		290
287 / 125.0	Medium-brown; silty, fine to coarse SAND, trace gravel.	26	AR		285
		27	AR		280

STANDARD PENETRATION TEST ▲"N" BLOWS PER FOOT

WATER CONTENT, PERCENT

Wp Wn WL

PIEZOMETER INSTALLATION

Pea gravel

Bentonite seal

4" Flush coupled, threaded PVC casing

Pea gravel

REMARKS.

VERTICAL SCALE 1 IN TO 5 FT.

Golder Associates

JOB = 853-1007

Figure A-3

RECORD OF BOREHOLE MW-3

LOCATION See Figure
DATUM 412 ft.
DATE 3-5-85
SAMPLER HAMMER WEIGHT 140 LB., DROP 30 IN.
BORING METHOD Air Rotary Drill

ELEVN / DEPTH	SOIL PROFILE DESCRIPTION	STRAT. PLOT	SAMPLES NUMBER	TYPE	BLOWS/FT.	ELEVATION	STANDARD PENETRATION TEST ▲"N" BLOWS PER FOOT / WATER CONTENT, PERCENT Wp Wn WL	PIEZOMETER INSTALLATION
	Medium brown; silty Fine to coarse SAND, trace gravel.		28	AR		275		
			29	AR		270		4" Flush coupled, threaded PVC casing
			30	AR		265		
			31	AR		260		Pea gravel
			32	AR		255		0.020" Well screen
248			33	AR		250		
164.0	Medium red-brown; gravelly, Fine to very coarse SAND, some silt.		34	AR		245		

REMARKS.

VERTICAL SCALE
1 IN TO 5 FT.

Golder Associates

JOB # 853-1007

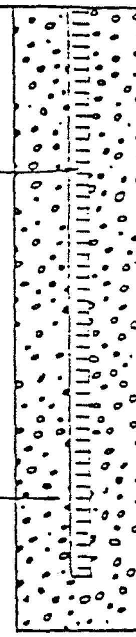
Figure A-3

RECORD OF BOREHOLE MW-3

LOCATION See Figure
DATUM 412 Ft.
DATE 3-5-85

SAMPLER HAMMER WEIGHT 140 LB., DROP 30 IN.
BORING METHOD Air Rotary Drill

SOIL PROFILE			SAMPLES				STANDARD PENETRATION TEST ▲ "N" BLOWS PER FOOT / WATER CONTENT, PERCENT (Wp, Wn, WL)	PIEZOMETER INSTALLATION
ELEVN. / DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FT.	ELEVATION		
	Medium red-brown; gravelly, fine to very coarse SAND, some silt.		35	AR		240		
			37	AR		235		
234 / 178.0	Dark gray-green; medium to coarse SAND and fine to medium GRAVEL.		38	AR		230		
225 / 187.0	End of Hole at 187.0 Ft.					225		



REMARKS.

VERTICAL SCALE
1 IN TO 5 FT.

Golder Associates

JOB # 853-1007

Figure A-4

RECORD OF BOREHOLE MW-4

LOCATION See Figure
DATUM 375 Ft. (approx.)
DATE 3-27-85, 3-28-85
SAMPLER HAMMER WEIGHT 140 LB., DROP 30 IN.
BORING METHOD Air Rotar, Drill

ELEVN / DEPTH	SOIL PROFILE: DESCRIPTION	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/FT.	ELEVATION
375 / 0.0	Dark brown; fine to coarse SAND, some silt, some gravel.	1	AR		375
370 / 5.0	Dark brown to gray-brown to medium brown; fine to coarse SAND and fine to coarse GRAVEL, some to trace silt (trace cobbles and organic between 5.0 - 10.0 Ft.).	2	AR		370
		3	AR		365
		4	AR		360
	20.0-25.0: Grades to fine to coarse SAND, some gravel, some silt.	5	AR		355
		6	AR		350
		7	AR		345

STANDARD PENETRATION TEST ▲"N" BLOWS PER FOOT

WATER CONTENT, PERCENT: Wp, Wn, WL

GROUNDWATER WELL INSTALLATION:

- Precast concrete flush fitting vault
- 6" Steel locking casing
- 4" Flush coupled, threaded PVC casing
- Cement grout

REMARKS: AR- Air rotary drill

VERTICAL SCALE 1 IN TO 5 FT.

Golder Associates

JOB # 853-1007

Figure A-4

RECORD OF BOREHOLE MW-4

LOCATION See Figure
SAMPLER HAMMER WEIGHT 140 LB., DROP 30 IN.
DATUM 375 Ft. (approx.)
DATE 3-27-85, 3-28-85
BORING METHOD Air Rotary Drill

SOIL PROFILE			SAMPLES				STANDARD PENETRATION TEST "N" BLOWS PER FOOT / WATER CONTENT, PERCENT Wp Wn WL	GROUNDWATER WELL INSTALLATION
ELEVN DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FT.	ELEVATION		
	Dark brown to gray-brown to medium brown; fine to coarse SAND and fine to coarse GRAVEL, some to trace silt.		7	AR		340		
			8	AR		335		
			9	AR		330		Cement grout
			10	AR		325		4" Flush coupled, threaded PVC casing
			11	AR		320		
			12	AR		315		
			13	AR		310		
			14	AR				

REMARKS:

VERTICAL SCALE
1 IN. TO 5 FT.

Golder Associates

JOB # 853-1007

Figure A-4

RECORD OF BOREHOLE MW-4

LOCATION See Figure — DATUM 375 Ft. (approx.) — DATE 3-27-85, 3-28-85

SAMPLER HAMMER WEIGHT 140 LB., DROP 30 IN. — BORING METHOD Air Rotary Drill

ELEVN / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	BLOWS/FT.	ELEVATION	GROUNDWATER WELL INSTALLATION
	Dark brown to gray-brown to medium brown; fine to coarse SAND and fine to coarse GRAVEL, some to trace silt.	14	AR		305	Cement grout; Bentonite seal
		15	AR		300	Pea gravel
		16	AR		295	
295 / 80.0	Dark grey to medium brown; fine to coarse GRAVEL, some sand to sandy, fine to coarse GRAVEL.	17	AR		290	4" Flush coupled, threaded PVC casing
		18	AR		285	
	90.0-100.0: Trace silt	19	AR		280	
		20	AR		275	
275 / 100.0		21	AR			

STANDARD PENETRATION TEST ▲"N" BLOWS PER FOOT

WATER CONTENT, PERCENT (Wp, Wn, WL)

REMARKS.

VERTICAL SCALE 1 IN TO 5 FT.

Golder Associates

JOB # 853-1007

Figure 4-4

RECORD OF BOREHOLE MW-4

LOCATION See Figure
DATUM 375 Ft. (approx.)
DATE 3-27-85, 3-28-85
SAMPLER HAMMER WEIGHT 140 LB., DROP 30 IN.
BORING METHOD Air Rotary Drill

SOIL PROFILE · SAMPLES · ELEVATION · STANDARD PENETRATION TEST ▲"N" BLOWS PER FOOT · WATER CONTENT, PERCENT (Wp, Wn, WL) · GROUNDWATER WELL INSTALLATION

ELEVN. / DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FT.	ELEVATION
275 / 100.0	Gray-brown to brown; fine to coarse SAND and fine to coarse GRAVEL, trace silt.		21	AR		
						270
			22	AR		
						265
			23	AR		
	115.0-120.0: Grades to sandy, fine to coarse GRAVEL.					260
			24	AR		
						255
			25	AR		
						250
			26	AR		
245 / 130.0	Gray-green to brown; fine to coarse GRAVEL, trace sand.					245
			27	AR		
						240
			28	AR		

Groundwater well installation: Pea gravel; 4" Flush coupled, threaded PVC casing; 0.020" Well screen

REMARKS:

VERTICAL SCALE
1 IN. TO 5 FT.

Golder Associates

JOB # 853-1007

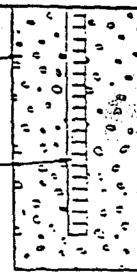
Figure A-4

RECORD OF BOREHOLE MW-4

LOCATION See Figure DATUM 375 Ft. (approx.) DATE 3-27-85, 3-28-85

SAMPLER HAMMER WEIGHT 140 LB., DROP 30 IN. BORING METHOD Air Rotary Drill

SOIL PROFILE: ELEVN / DEPTH	SOIL PROFILE: DESCRIPTION	SOIL PROFILE: STRAT. PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/FT.	ELEVATION	STANDARD PENETRATION TEST ▲ "N" BLOWS PER FOOT / WATER CONTENT, PERCENT (Wp Wn WL)	GROUNDWATER WELL INSTALLATION
	Gray-green to brown; fine to coarse GRAVEL, trace sand.		28	AR			Pea gravel	
						235		
			29	AR			0.020" Well screen	
230 45.0	End of Hole at 145.0 ft.					230		



MARKS:

VERTICAL SCALE
1 IN TO 5 FT.

Golder Associates

JOB # 853-1007

Figure A-18

RECORD OF BOREHOLE MW-5

LOCATION See Figure   DATUM 325 ft. (approx.)   DATE 6-18-85

SAMPLER HAMMER WEIGHT 140 LB., DROP 30 IN.   BORING METHOD Air Rotary Drill

ELEVN. / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	BLOWS/FT.	ELEVATION	WELL INSTALLATION
		7	AR			
290 / 35.0	Medium brown; fine to coarse GRAVEL, some to trace sand, some to trace silt.				290	
		8	AR			4" dia. Flush coupled, threaded PVC casing
	38.0-40.0: Boulder.				285	
		9	AR			
					280	Pea gravel
		10	AR			
					275	
		11	AR			
	53.0: Boulder.					4" dia. PVC Sch. 40, 0.020 well screen.
270 / 55.0	Medium brown; fine to coarse GRAVEL, trace sand and silt.				270	
		12	AR			
					265	
		13	AR			
					260	
		14	AR			6-26-85

STANDARD PENETRATION TEST ▲ "N" BLOWS PER FOOT

WATER CONTENT, PERCENT: Wp Wn WL

REMARKS:

VERTICAL SCALE 1 IN. TO 5 FT.

Golder Associates

JOB # 853-1007

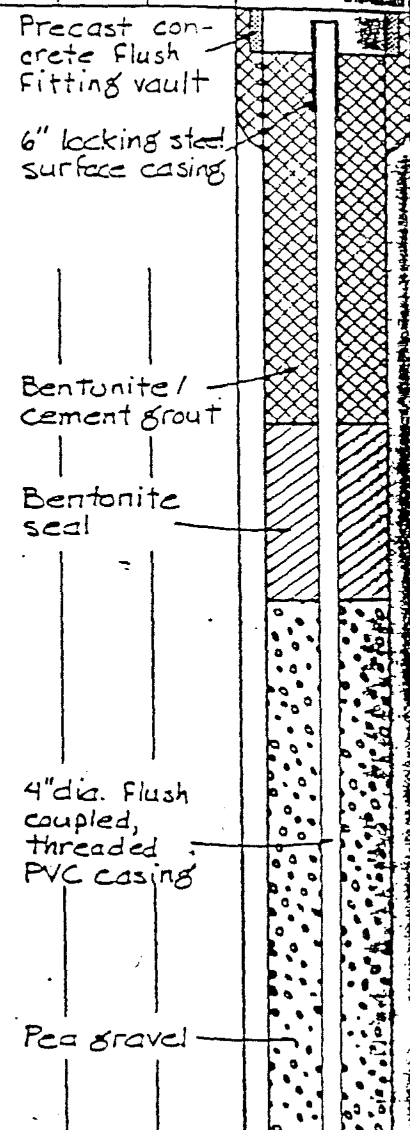
Figure A-1a

RECORD OF BOREHOLE MW-5

LOCATION See Figure DATUM 325 ft. (approx.) DATE 6-18-85

SAMPLER HAMMER WEIGHT 140 LB., DROP 30 IN. BORING METHOD Air Rotary Drill

SOIL PROFILE			SAMPLES				STANDARD PENETRATION TEST ▲"N" BLOWS PER FOOT / WATER CONTENT, PERCENT Wp ● Wn WL	WELL INSTALLATION
ELEVN. / DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FT.	ELEVATION		
325 / 0.0	Medium brown to gray; sandy fine to medium GRAVEL and SILT to CLAY and fine to very coarse SAND, some to trace gravel.		1	AR		325		
			2	AR		320		
			3	AR		315		
310 / 15.0	Medium brown; clayey fine to very coarse SAND and fine to coarse GRAVEL to medium to very coarse SAND, trace gravel, some clay.		4	AR		310		
			5	AR		305		
			6	AR		300		
			7	AR		295		



REMARKS: AR - Air rotary drill.

VERTICAL SCALE 1 IN. TO 5 FT.

Golder Associates

JOB # 853-1007

Figure A-

RECORD OF BOREHOLE MW-5

LOCATION See Figure | DATUM 325 Ft. (approx.) | DATE 6-18-85

SAMPLER HAMMER WEIGHT 140 LB., DROP 30 IN. | BORING METHOD Air Rotary Dri

ELEVN. / DEPTH	DESCRIPTION (SOIL PROFILE)	STRAT. PLOT	NUMBER (SAMPLES)	TYPE (SAMPLES)	BLOWS/FT. (SAMPLES)	ELEVATION	STANDARD PENETRATION TEST ▲ "N" BLOWS PER FOOT / WATER CONTENT, PERCENT (Wp, Wn, WL)	WELL INSTALLAT
	Medium brown; fine to coarse GRAVEL, trace sand and silt.		14	AR				
						255	4" dia. PVC Sch. 40, 0.020 well screen	
			15	AR				
						250	Pea gravel	
247			16	AR				
78.0	Gray to medium brown; silty, gravelly CLAY, trace sand.						Bentonite seal	
						245		
			17	AR				
240							Sluff	
85.0	End of Hole at 85.0 Ft.					240		

REMARKS:

VERTICAL SCALE 1 IN. TO 5 FT.

Golder Associates

JOB # 853-100

Figure A-14

RECORD OF BOREHOLE MW-6

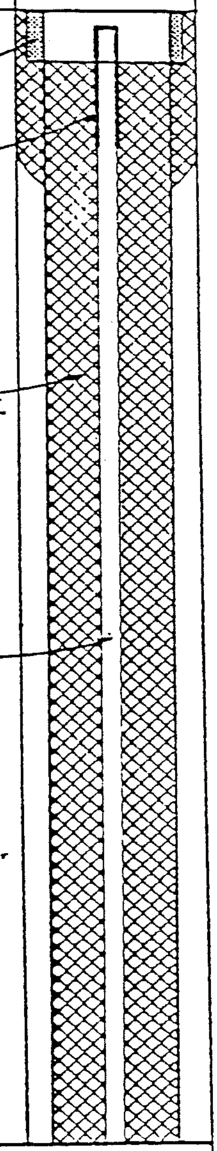
LOCATION See Figure
DATUM 280 Ft.
DATE 6-21-85
SAMPLER HAMMER WEIGHT 140 LB., DROP 30 IN.
BORING METHOD Air Rotary Drill

ELEVN. / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLES – NUMBER	SAMPLES – TYPE	SAMPLES – BLOWS/FT.	ELEVATION
280 / 0.0	Light to medium brown; silty, fine to coarse SAND, trace to some gravel.	1	AR		280
		2	AR		275
	10.0-15.0: No gravel. 10.0-20.0: Trace organic matter.	3	AR		270
		4	AR		265
260 / 20.0	Medium to dark brown; silty fine to coarse GRAVEL and fine to coarse SAND. 20.0-25.0: Grades to silty SAND and GRAVEL. 25.0-30.0: Grades to GRAVEL, some to trace sand, trace silt.	5	AR		260
		6	AR		255
		7	AR		250

STANDARD PENETRATION TEST ▲ "N" BLOWS PER FOOT

WATER CONTENT, PERCENT Wp Wn WL

WELL INSTALLATION



REMARKS: AR- Air rotary drill.

VERTICAL SCALE 1 IN. TO 5 FT.

Golder Associates

JOB # 853-1007

Figure A-[illegible]

RECORD OF BOREHOLE MW-6

LOCATION See Figure | DATUM 280 Ft. (approx.) | DATE 6-21-85

SAMPLER HAMMER WEIGHT 140 LB., DROP 30 IN. | BORING METHOD Air Rotary Drill

SOIL PROFILE: ELEVN. / DEPTH	SOIL PROFILE: DESCRIPTION	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/FT.	ELEVATION	STANDARD PENETRATION TEST ▲ "N" BLOWS PER FOOT / WATER CONTENT, PERCENT (Wp, Wn, WL)	WELL INSTALLATION
247							
33.0	Dark brown to gray; silty CLAY, some sand and gravel.	8	AR		245		
243 / 37.0	Dark brownish-gray; fine to very coarse GRAVEL, trace sand and silt.	9	AR		240	Bentonite/cement grout	
235 / 45.0	Medium to light brown; fine to very coarse SAND and fine to coarse GRAVEL, some silt.	10	AR		235	4" dia. flush coupled threaded PVC casing	
		11	AR		230		
					225		
222.5 / 57.5	Medium brown; fine to very coarse SAND, some to trace gravel, some silt.	12	AR				
		13	AR		220		
215 / 65.0		14	AR		215		

REMARKS:

VERTICAL SCALE
1 IN. TO 5 FT.

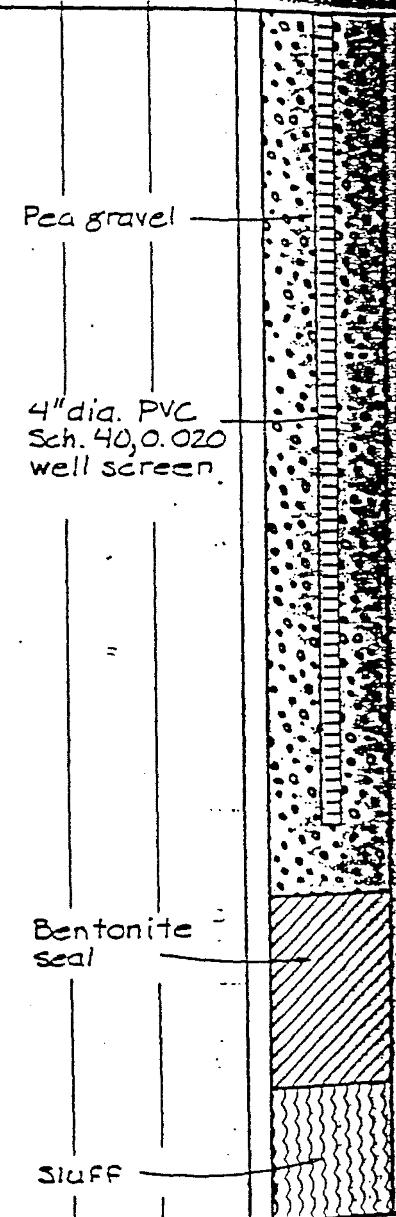
Golder Associates

JOB # 853-1007

RECORD OF BOREHOLE MW-6

LOCATION See Figure
DATUM 280 ft. (approx.)
DATE 6-21-85
SAMPLER HAMMER WEIGHT 140 LB., DROP 30 IN.
BORING METHOD Air Rotary D...

SOIL PROFILE			SAMPLES				STANDARD PENETRATION TEST ▲ "N" BLOWS PER FOOT / WATER CONTENT, PERCENT (Wp, Wn, WL)	WELL INSTALLATION
ELEVN. / DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FT.	ELEVATION		
	Gray-brown; sandy fine to coarse GRAVEL, some to trace silt to fine to coarse SAND and fine to coarse GRAVEL.		21	AR				
						175		
			22	AR				
						170		
			23	AR				
	115.0 - 120.0: Grades to fine to coarse GRAVEL.					165		
			24	AR				
						160		
			25	AR				
155 / 125.0	Gray; silty CLAY, trace sand to sandy, silty CLAY.					155		
			26	AR				
						150		
			27	AR				
						145		
142	End of Hole at 138.0 ft.							

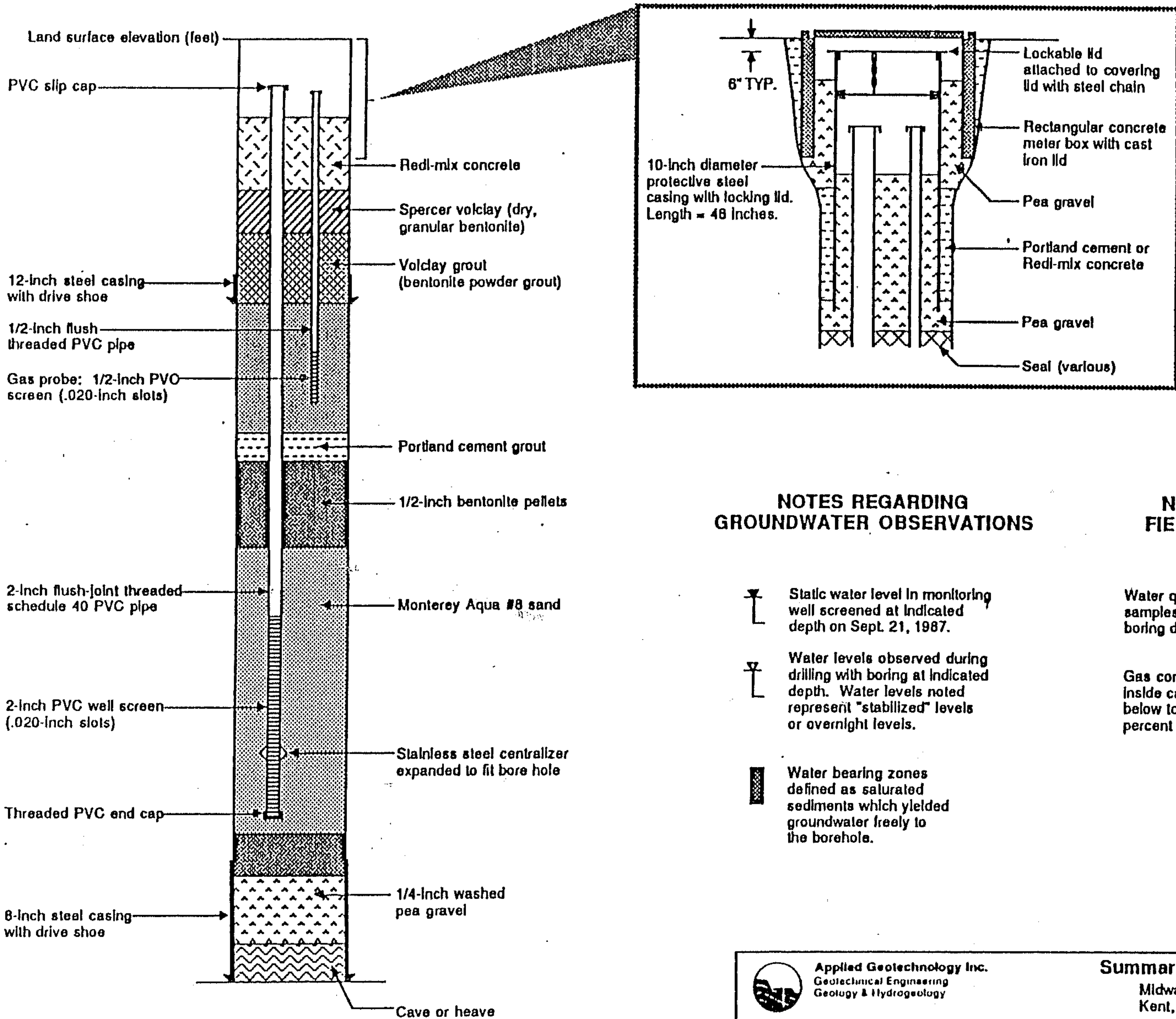


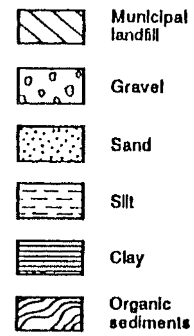
REMARKS:

VERTICAL SCALE 1 IN. TO 5 FT.

Golder Associates

JOB # 853-1007





NOTE: Detailed geologic logs follow the summary logs.

NOTES REGARDING GROUNDWATER OBSERVATIONS

Static water level in monitoring well screened at indicated depth on Sept. 21, 1987.

Water levels observed during drilling with boring at indicated depth. Water levels noted represent "stabilized" levels or overnight levels.

Water bearing zones defined as saturated sediments which yielded groundwater freely to the borehole.

NOTES REGARDING FIELD MEASUREMENTS

Water quality measurements made on samples of groundwater bailed from well boring during drilling.

Gas concentration measurements taken inside casing approximately 2 to 3 feet below top of casing. Measurements in percent lower explosive limit (% LEL).

Applied Geotechnology Inc.
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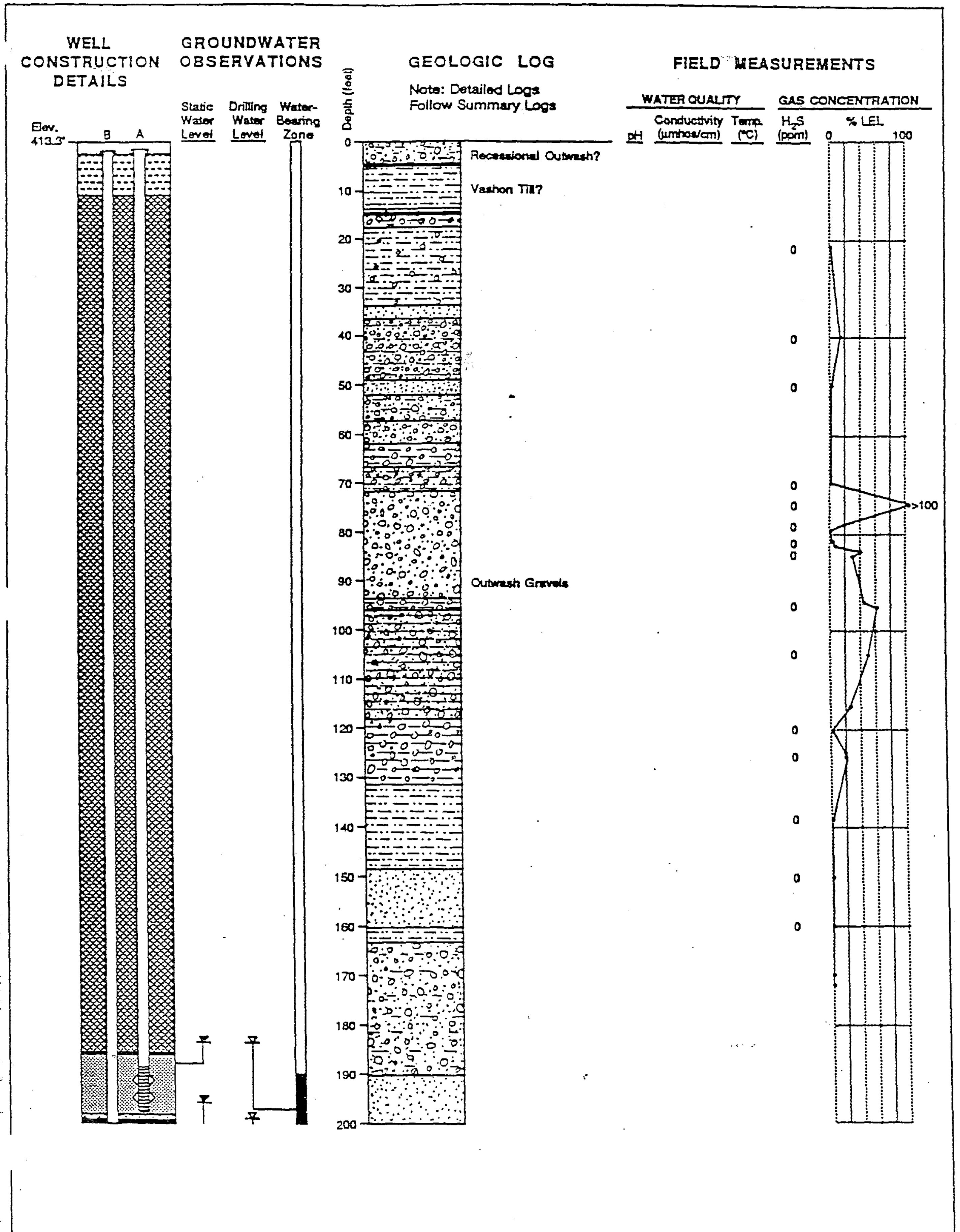
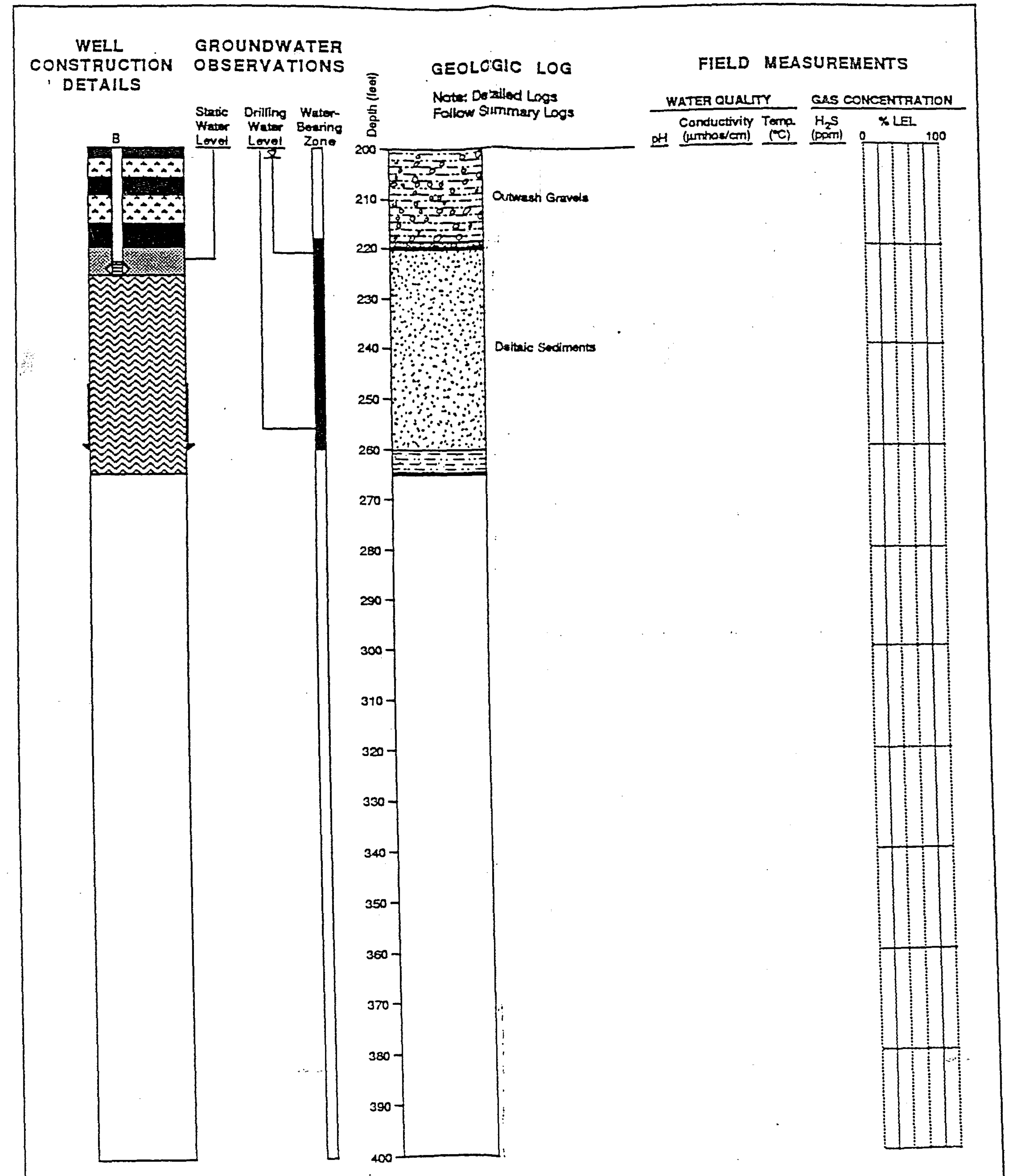
Summary Log Legend
Midway Landfill
Kent, Washington

PLATE **B1**

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
14,169.102	KER	MAA	7 Nov 87		





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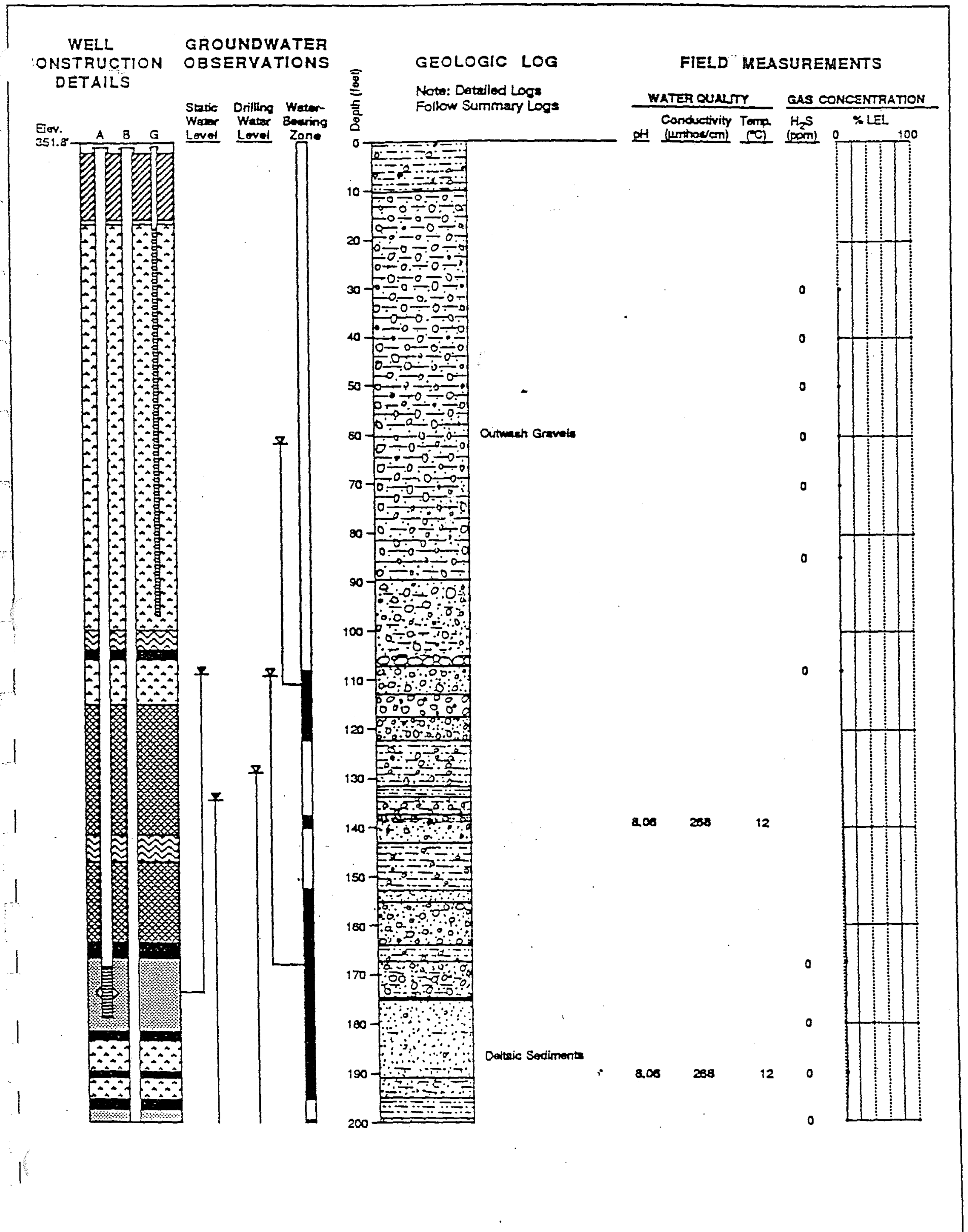
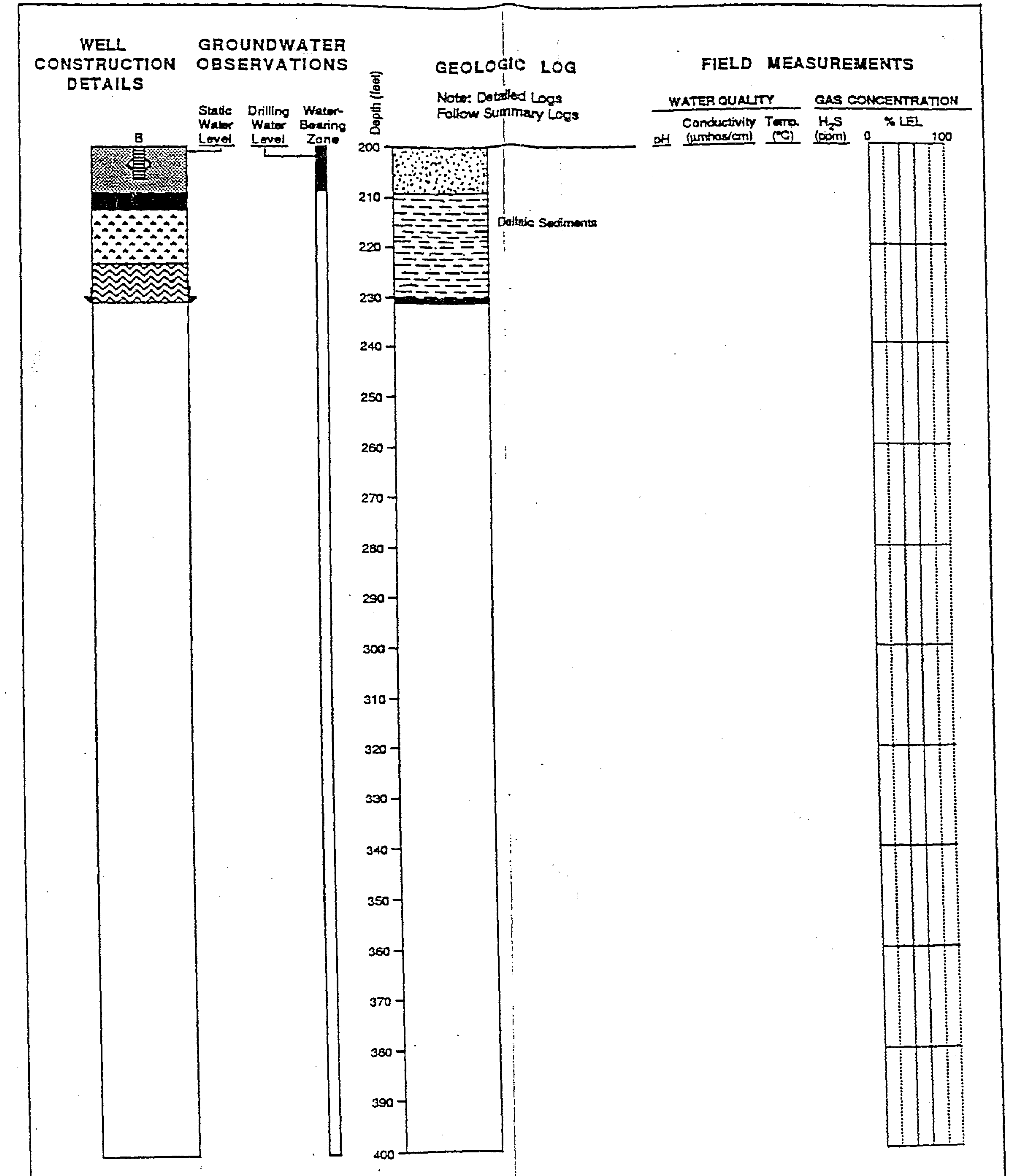
Summary Log MW-7
Midway Landfill
Kent, Washington

PLATE **B2**

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
14,169.102	KER	MAA	7 Nov 87		





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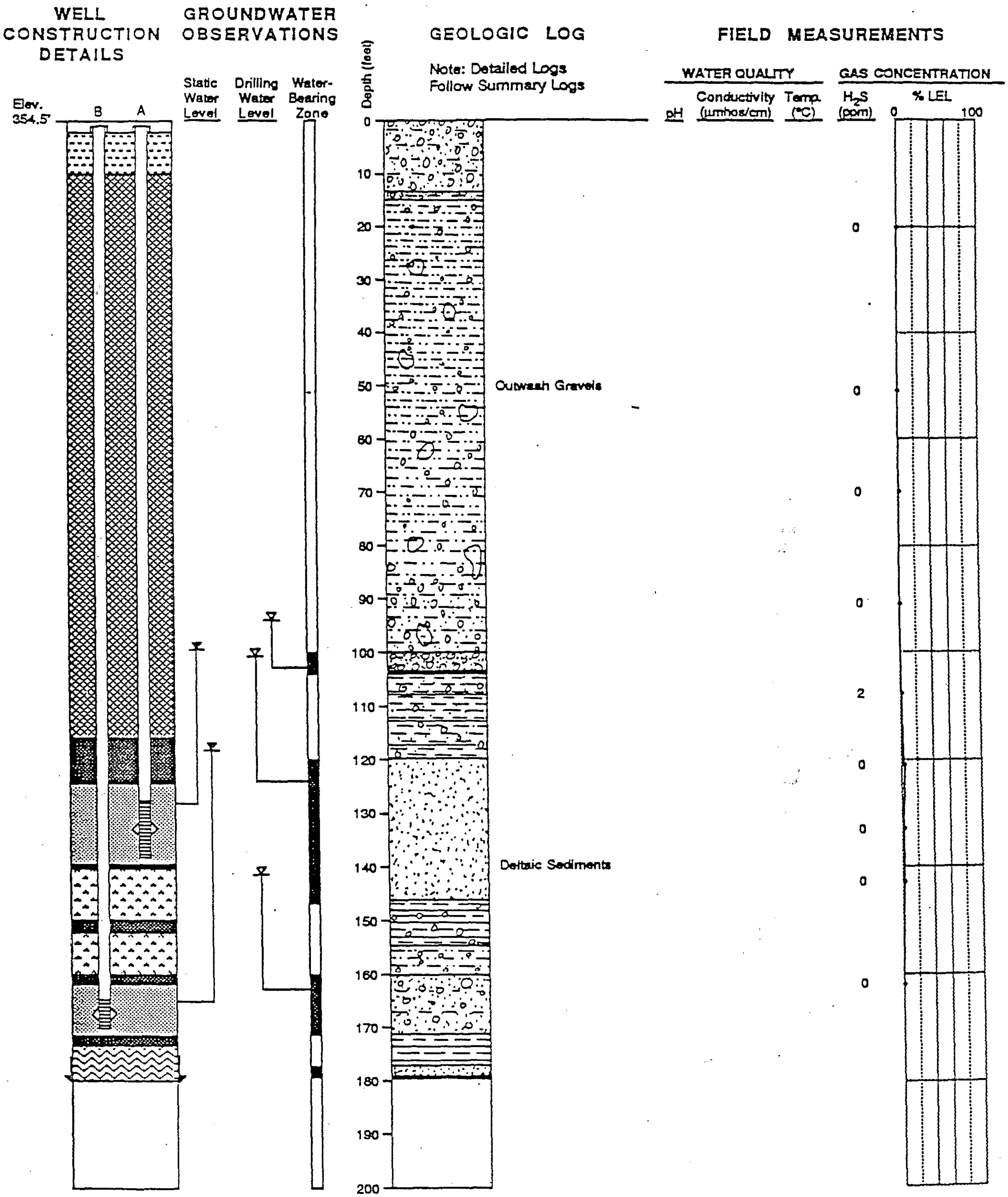
Summary Log MW-8
Midway Landfill
Kent, Washington

PLATE **B3**

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
14,169.102	KER	MAB	7 Nov 87		



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Summary Log MW-9
Midway Landfill
Kent, Washington

PLATE B4

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
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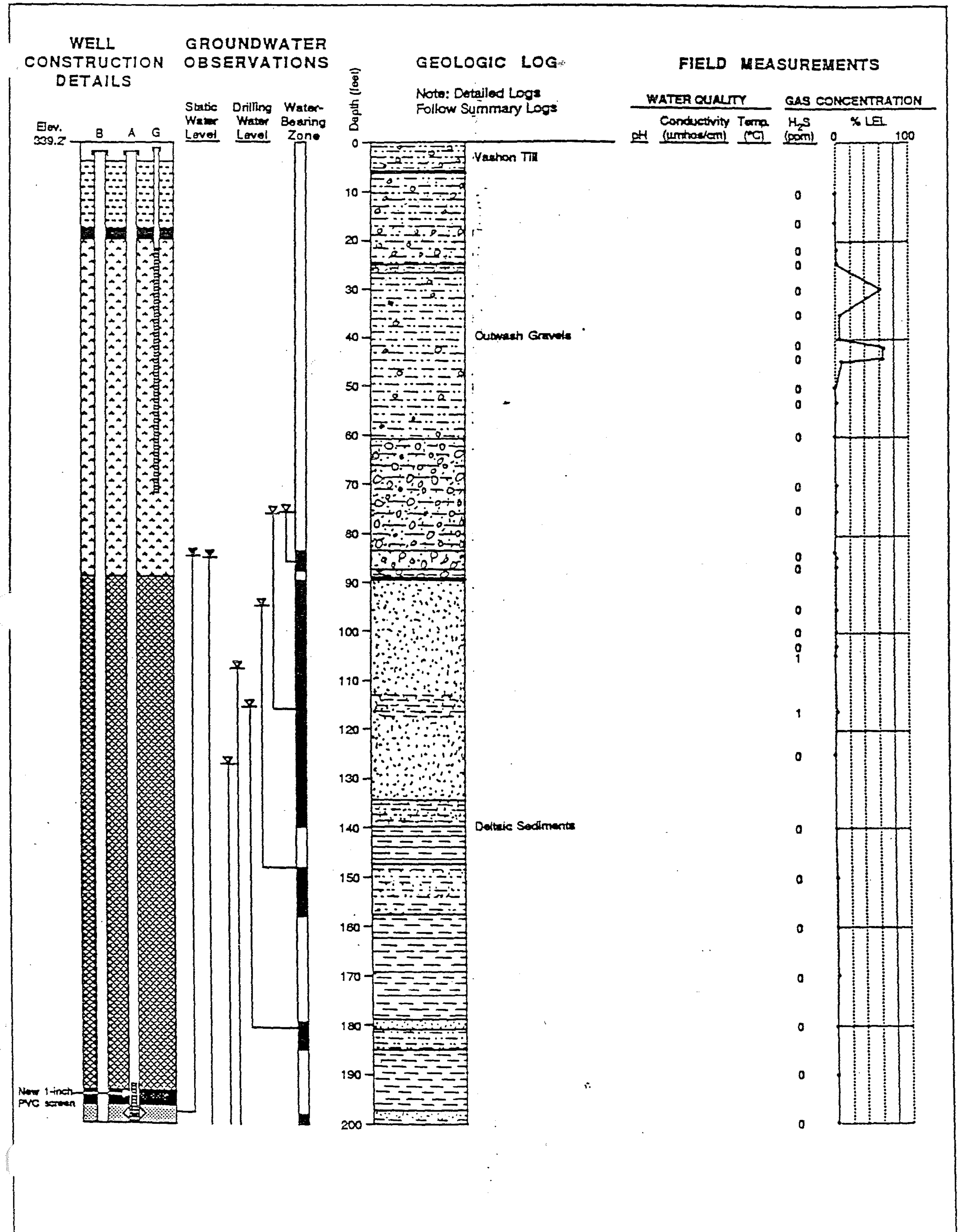

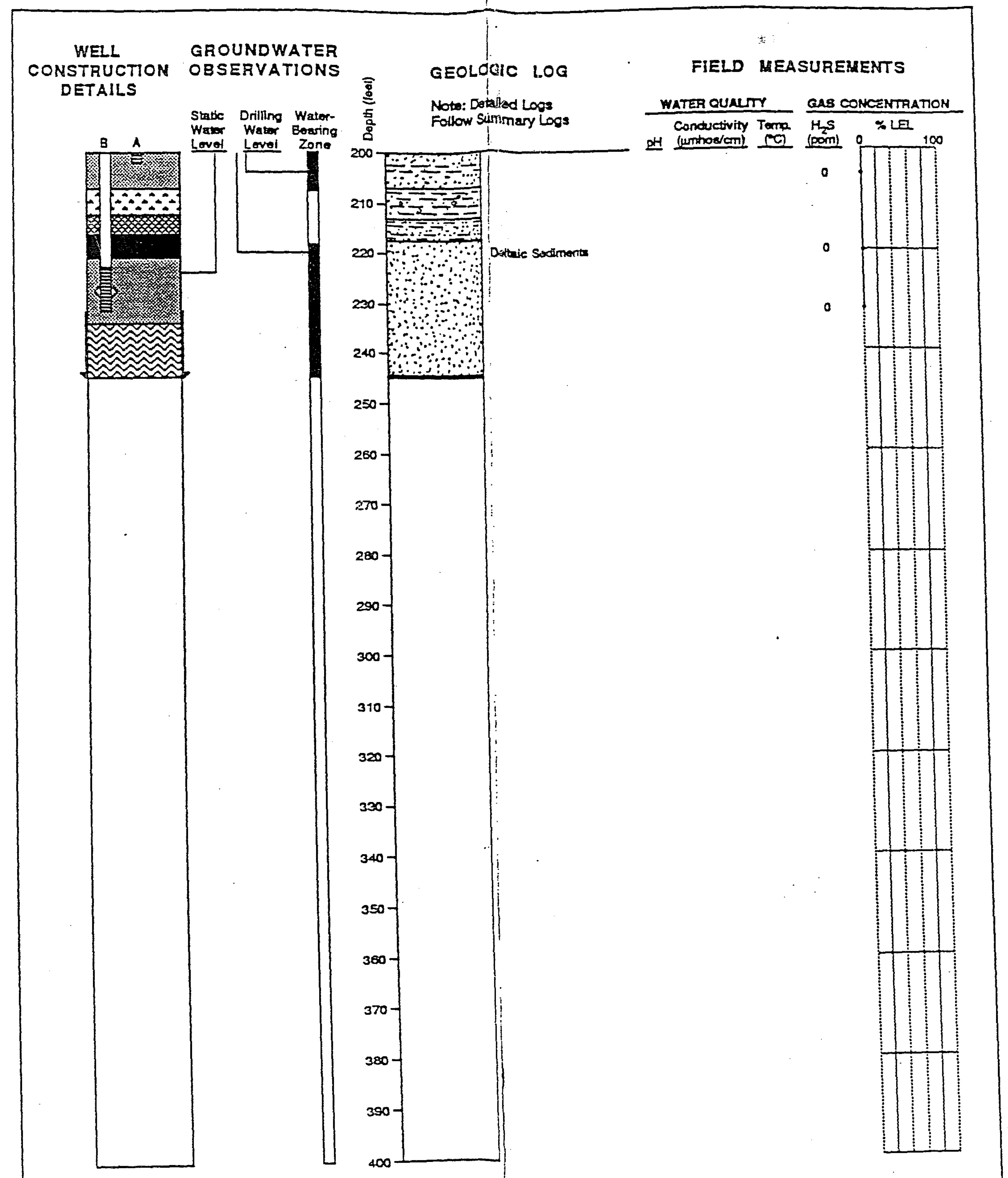

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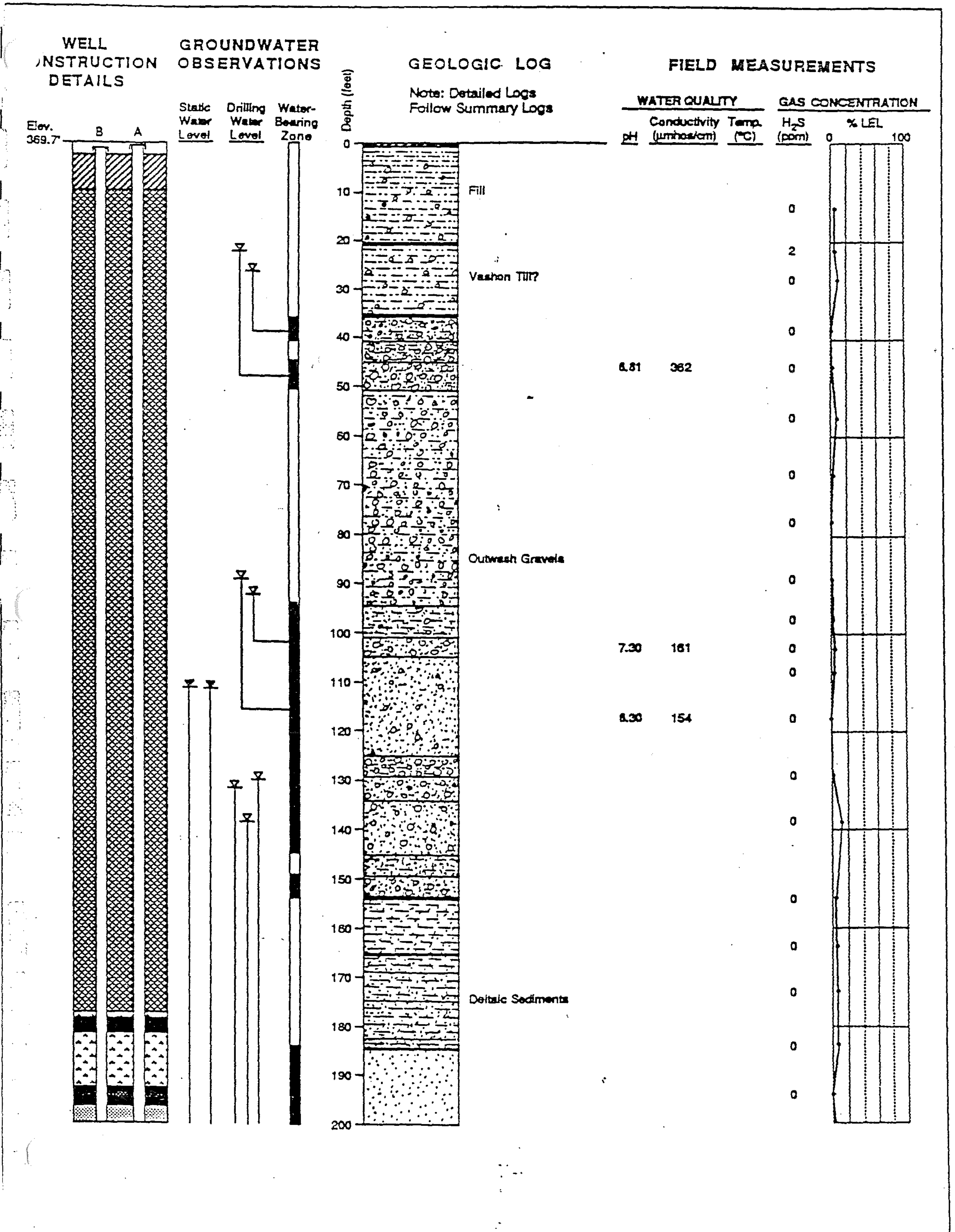
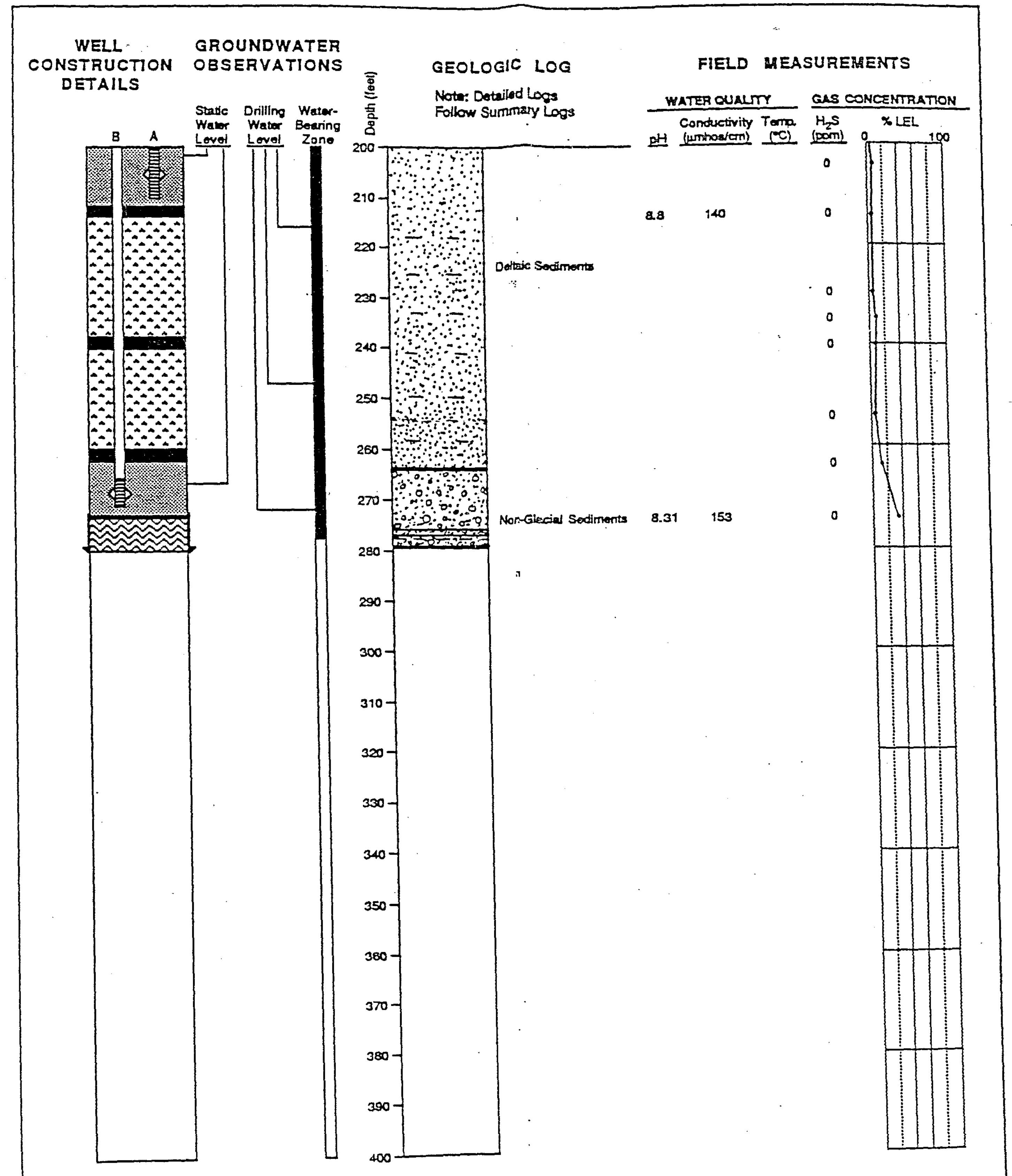
Summary Log MW-10
Midway Landfill
Kent, Washington

PLATE **B5**

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
14,169.102	KER	MAA	7 Nov 87		





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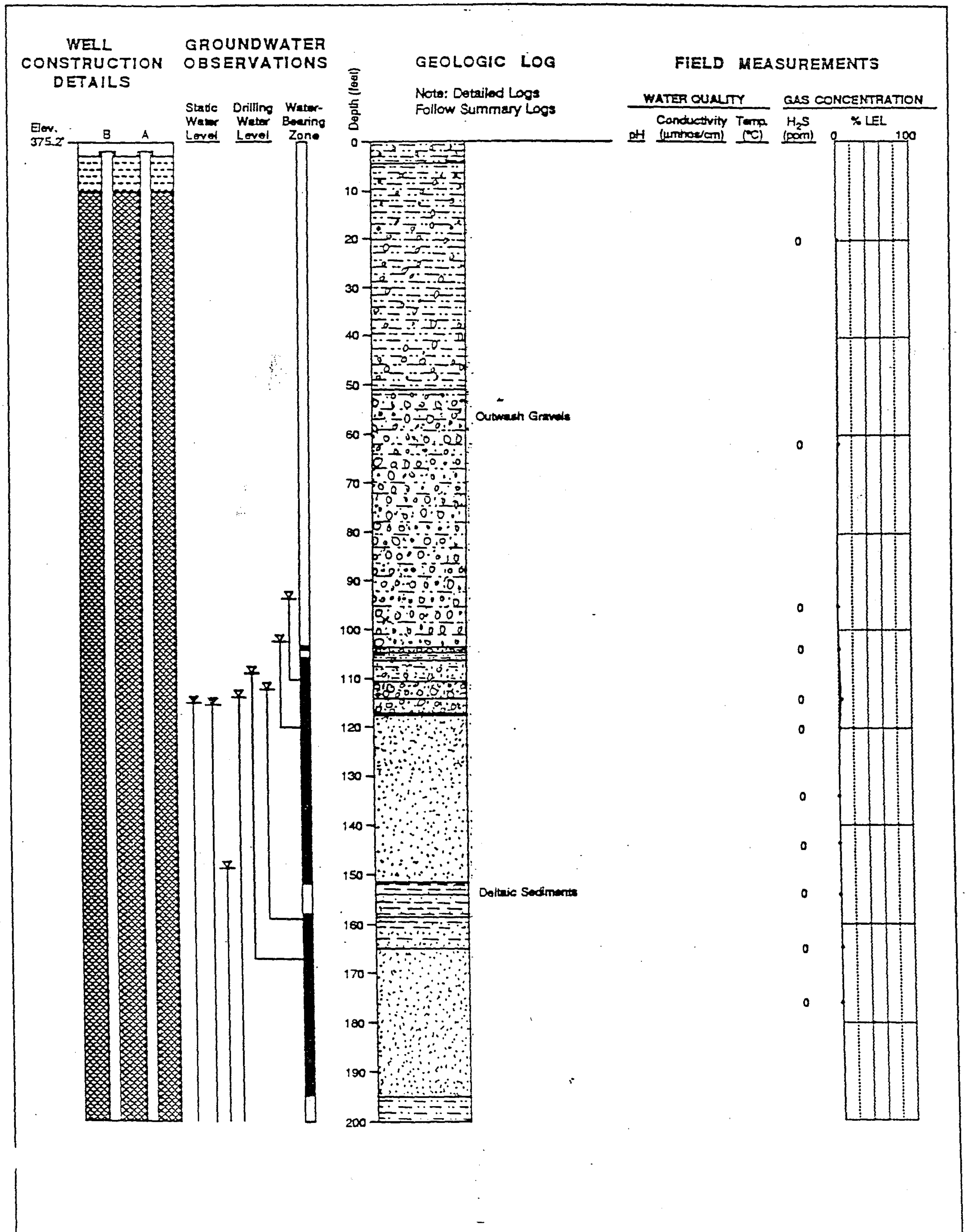
Summary Log MW-11
Midway Landfill
Kent, Washington

PLATE **B6**

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
14,159.102	KER	MAA	7 Nov 87		



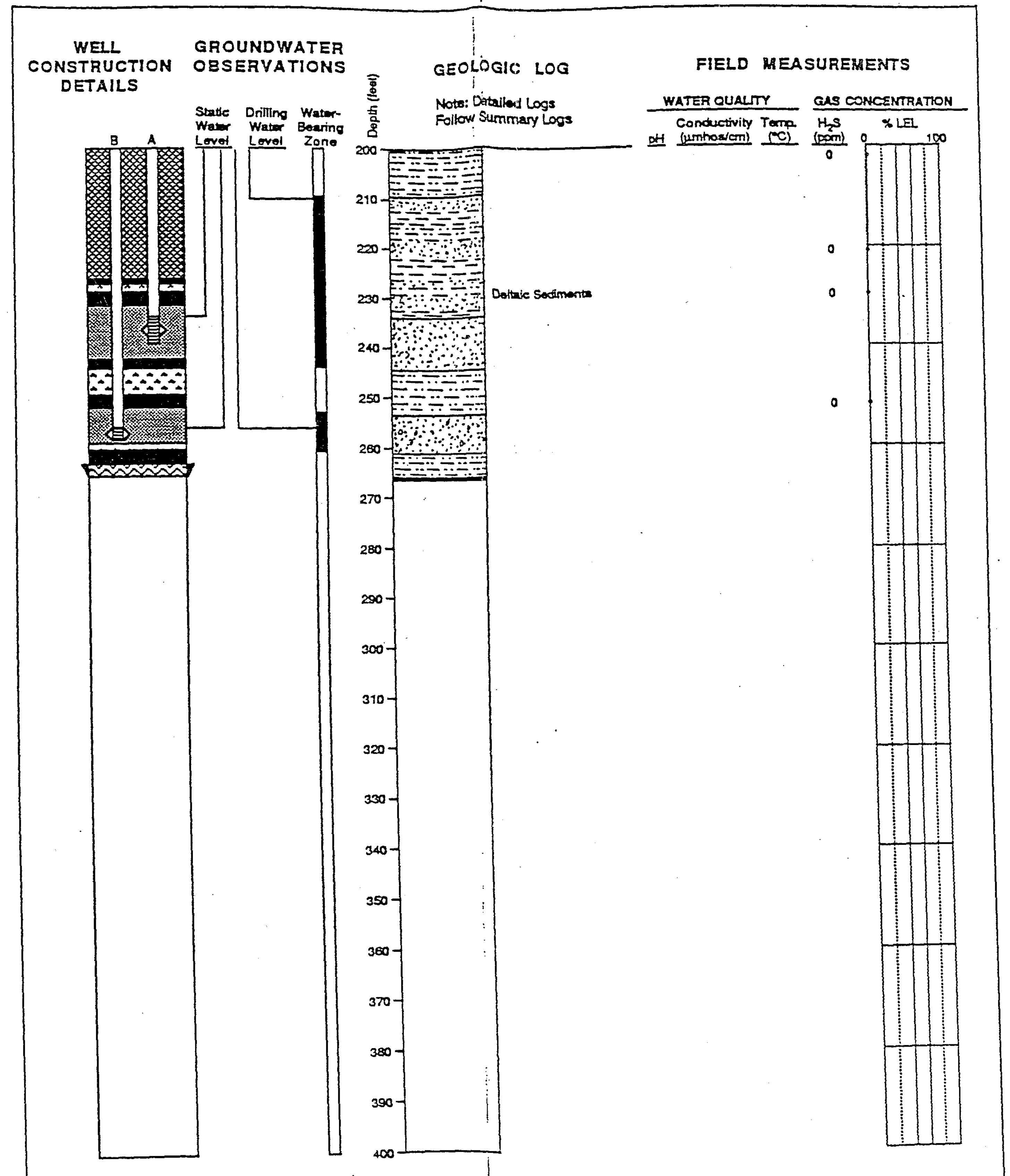
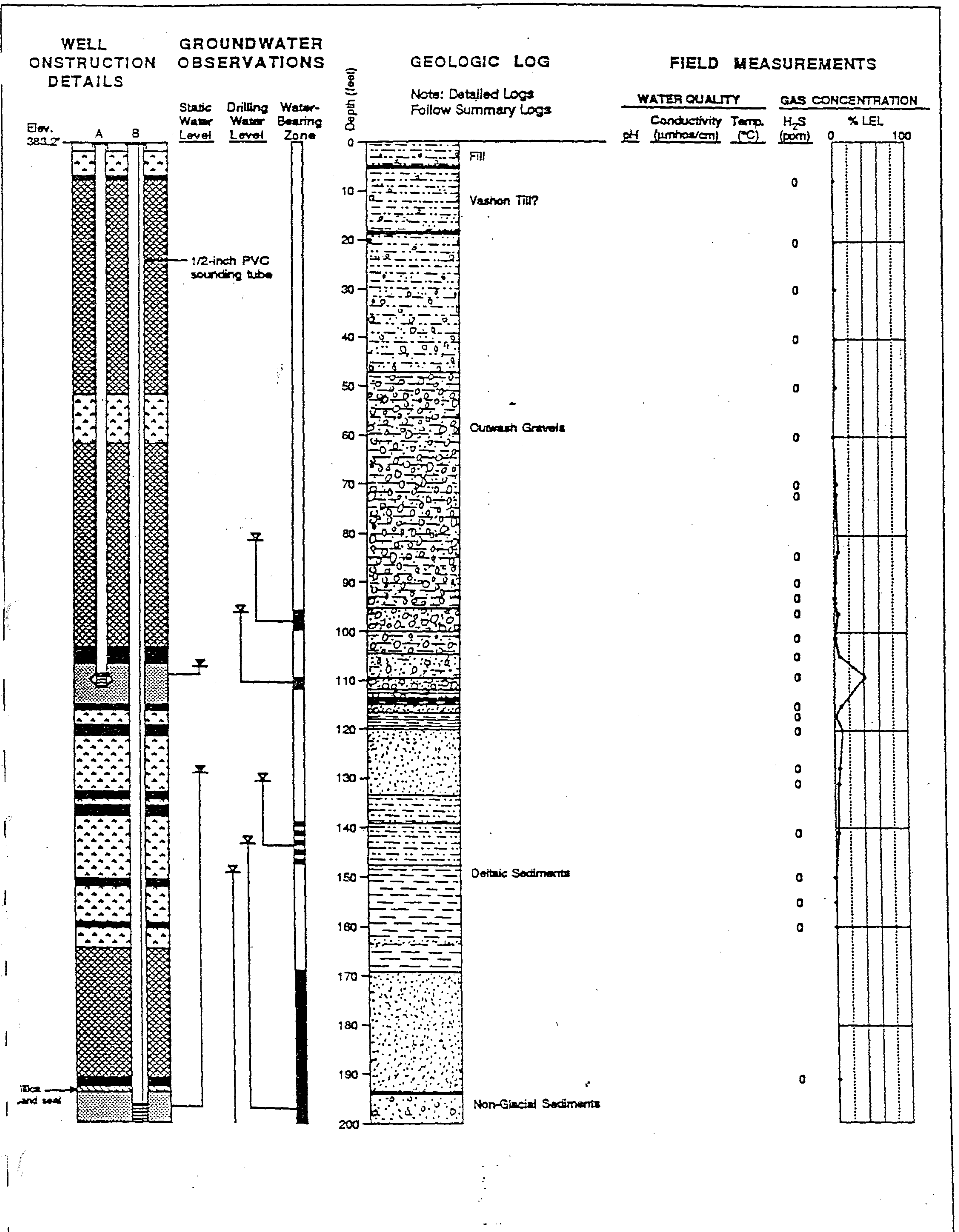
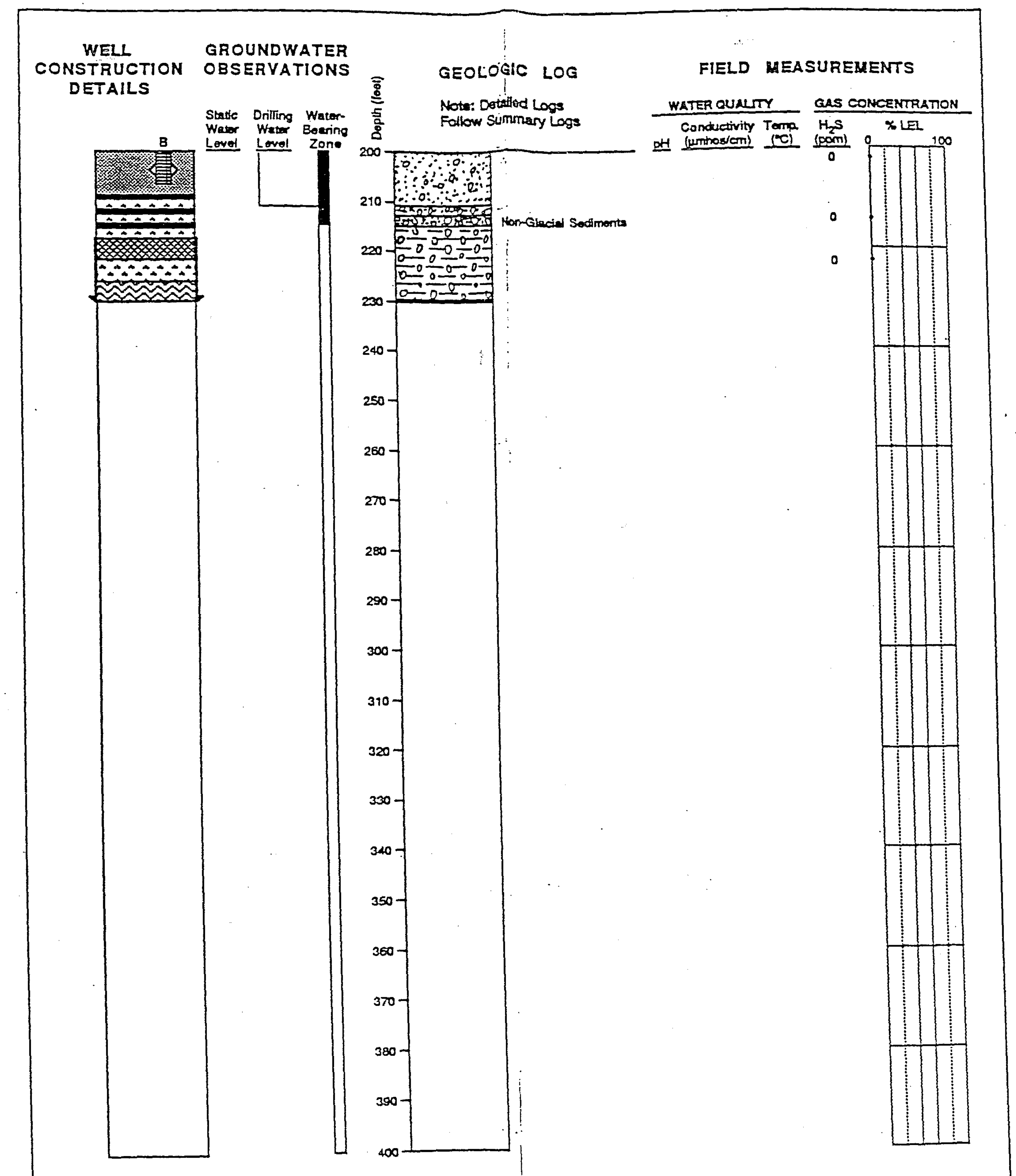


			PLATE
Applied Geotechnology Inc. Geotechnical Engineering Geology & Hydrogeology	Summary Log MW-12 Midway Landfill Kent, Washington		B7
JOB NUMBER 14,169.102	DRAWN KER	APPROVED MAA	DATE 7 Nov 87
REVISED	DATE		





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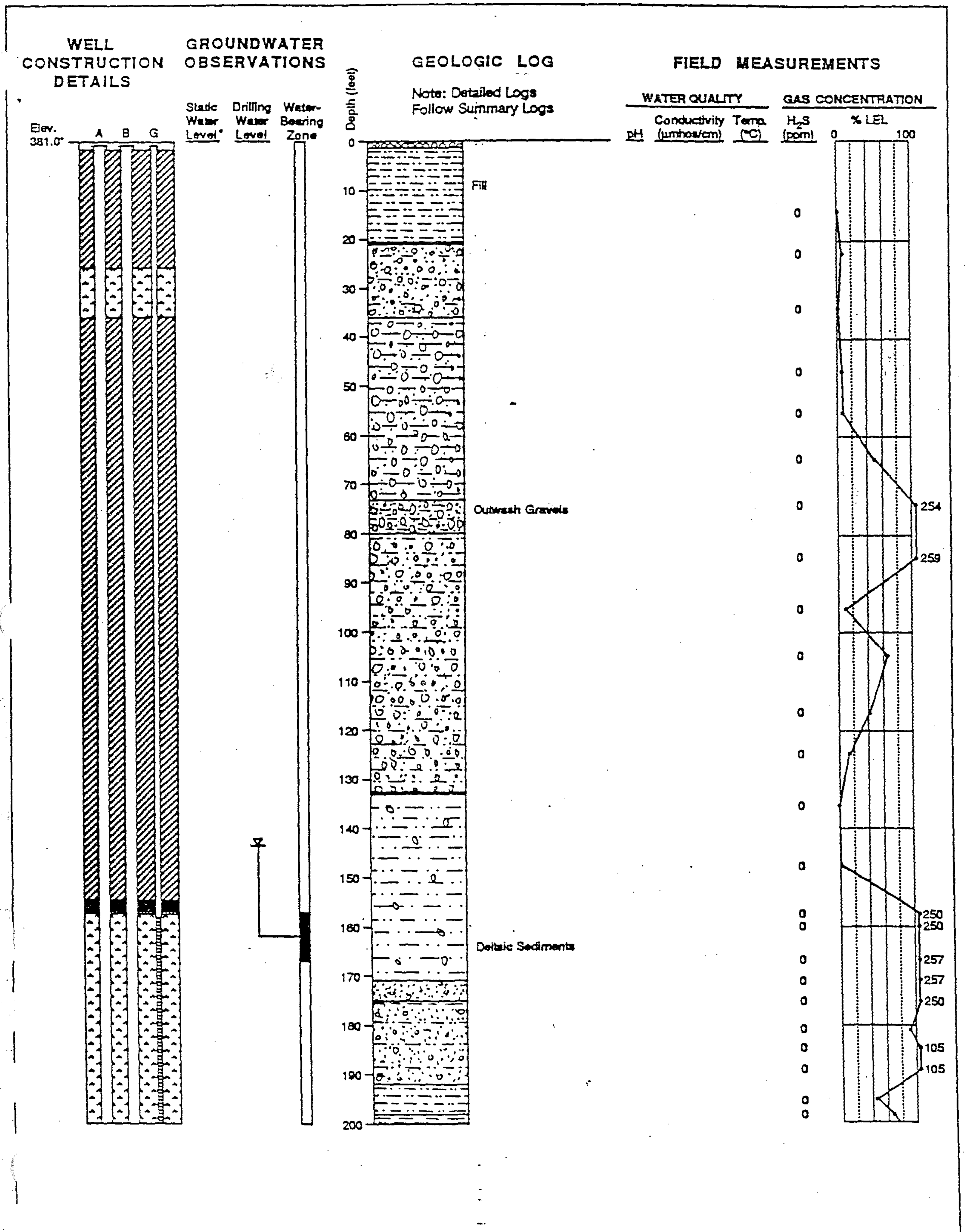
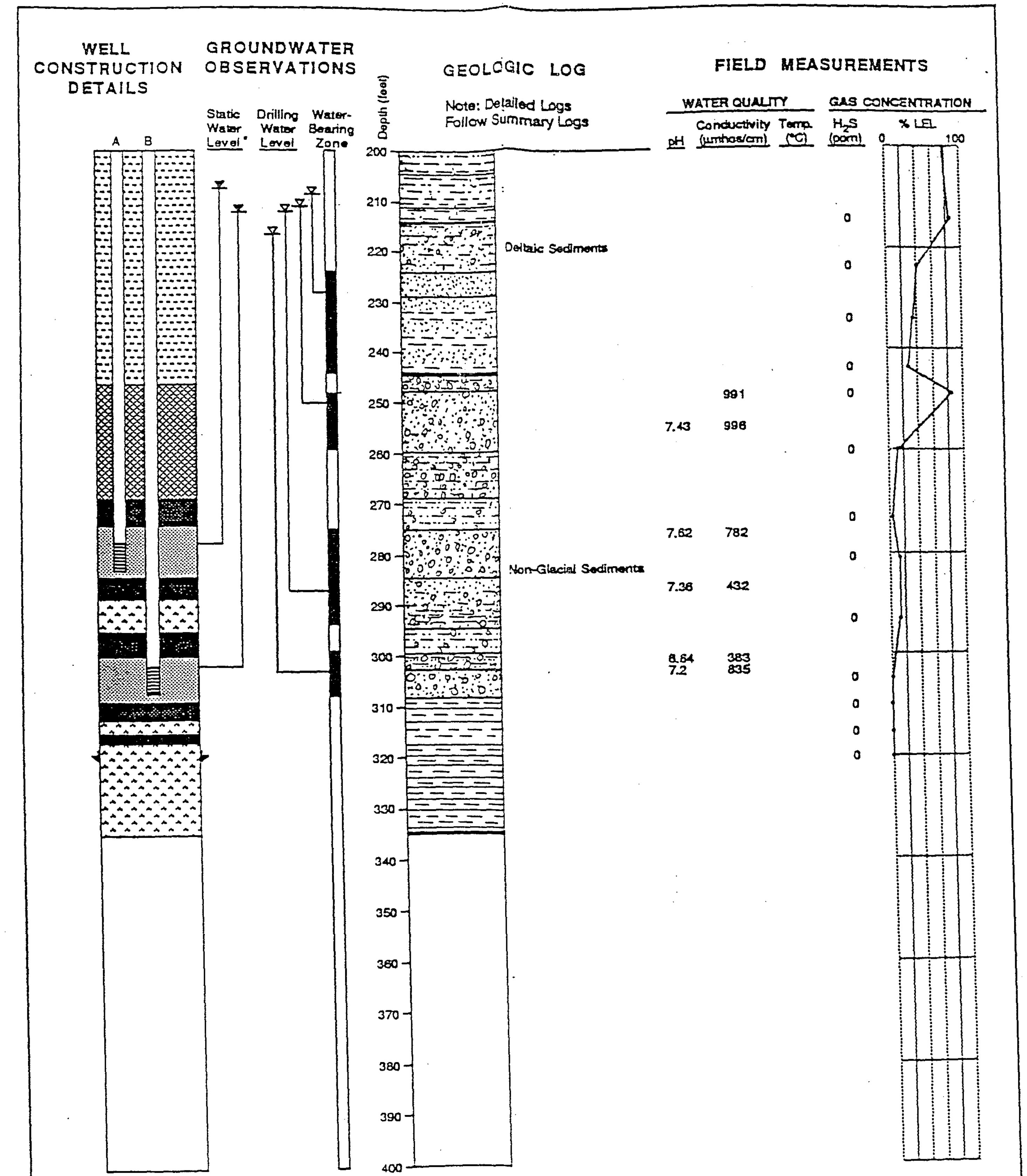
Summary Log MW-13
Midway Landfill
Kent, Washington

PLATE **B8**

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
14,169.102	KER	MAA	7 Nov 87		





* Static water level measured on 9-08-87.

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Summary Log MW-14
Midway Landfill
Kent, Washington

PLATE B9

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
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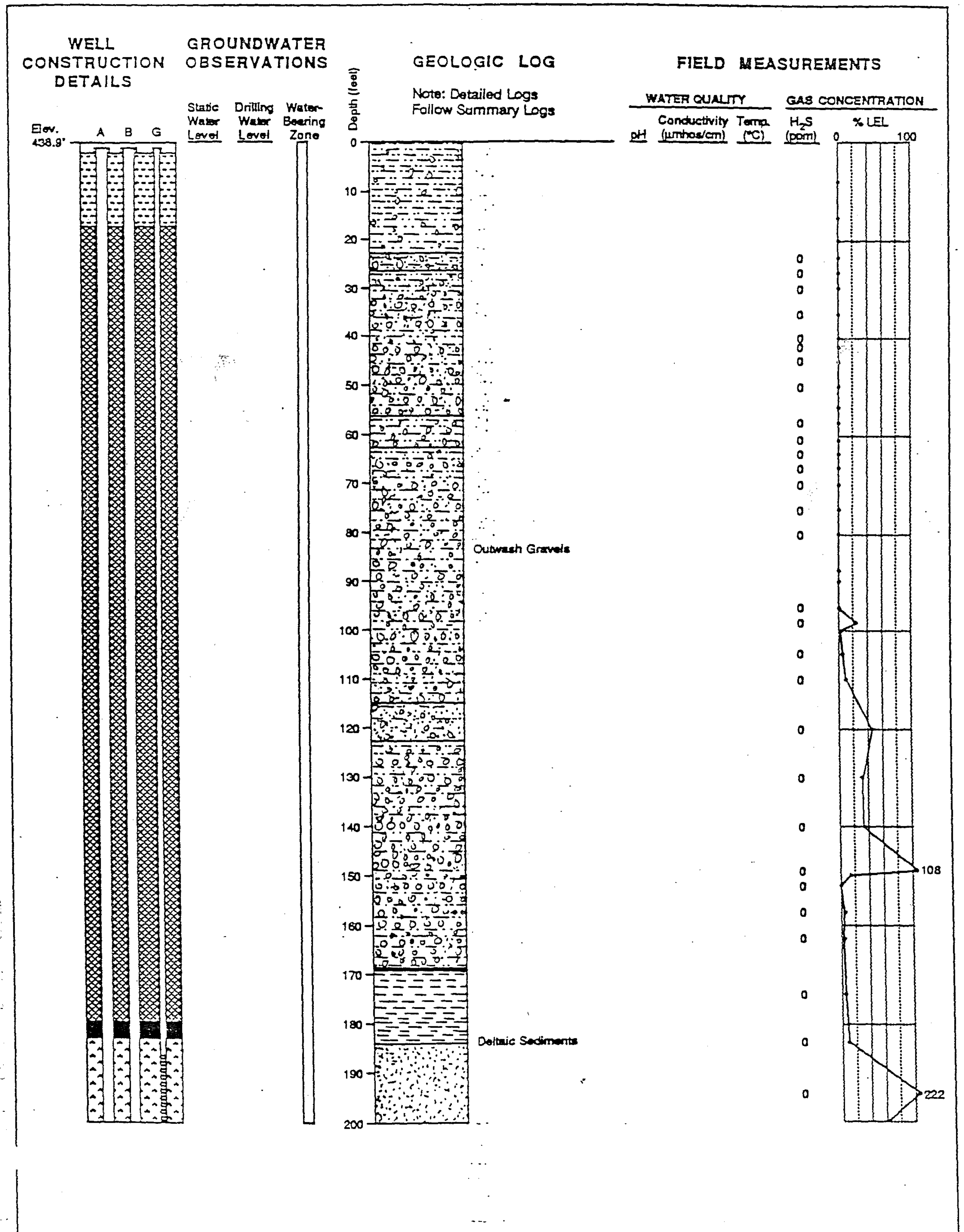

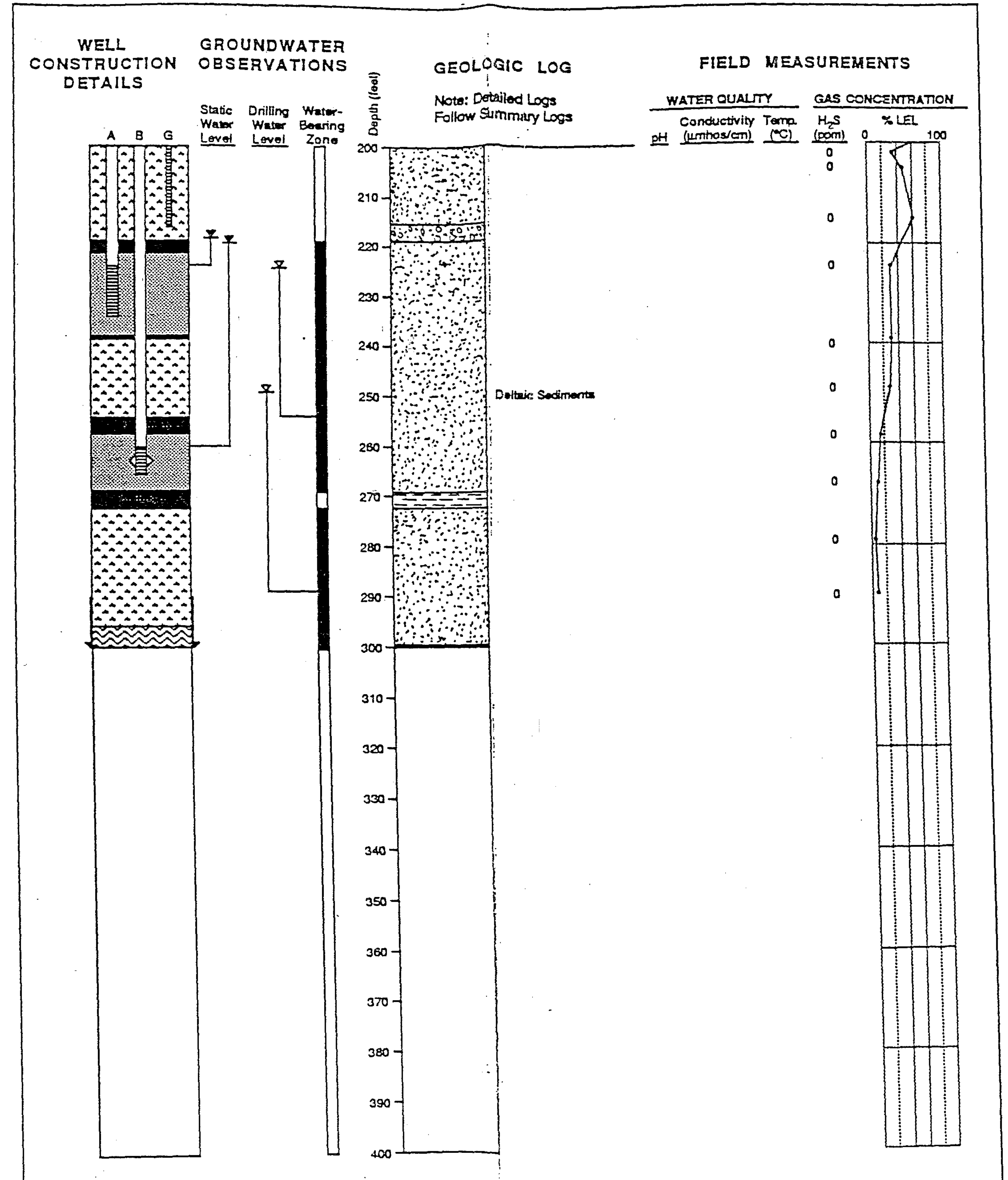

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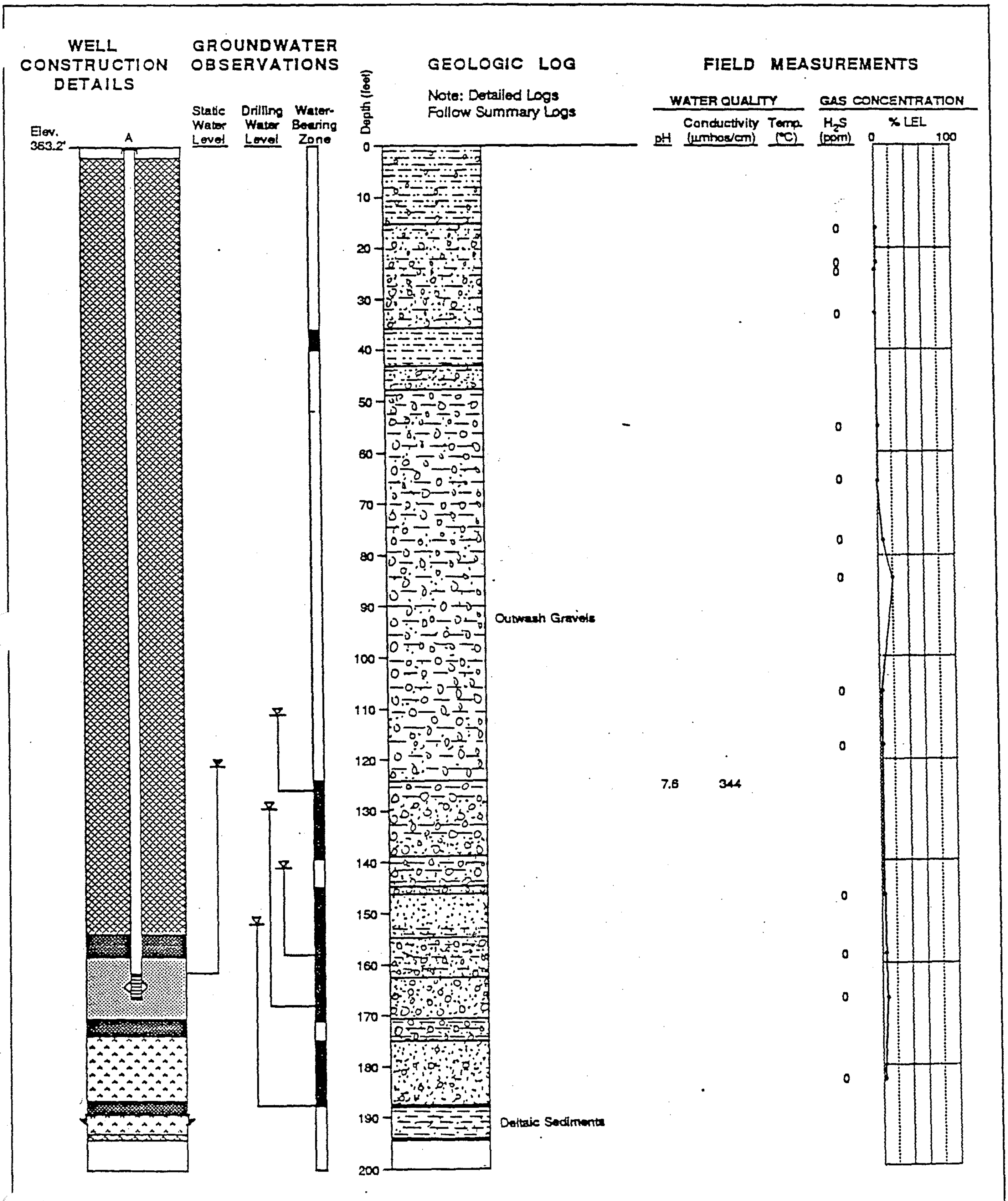
Summary Log MW-15
Midway Landfill
Kent, Washington

PLATE **B10**

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
14,169.102	KER	MAA	7 Nov 87		



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Summary Log MW-16

Midway Landfill
Kent, Washington

PLATE
B11

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
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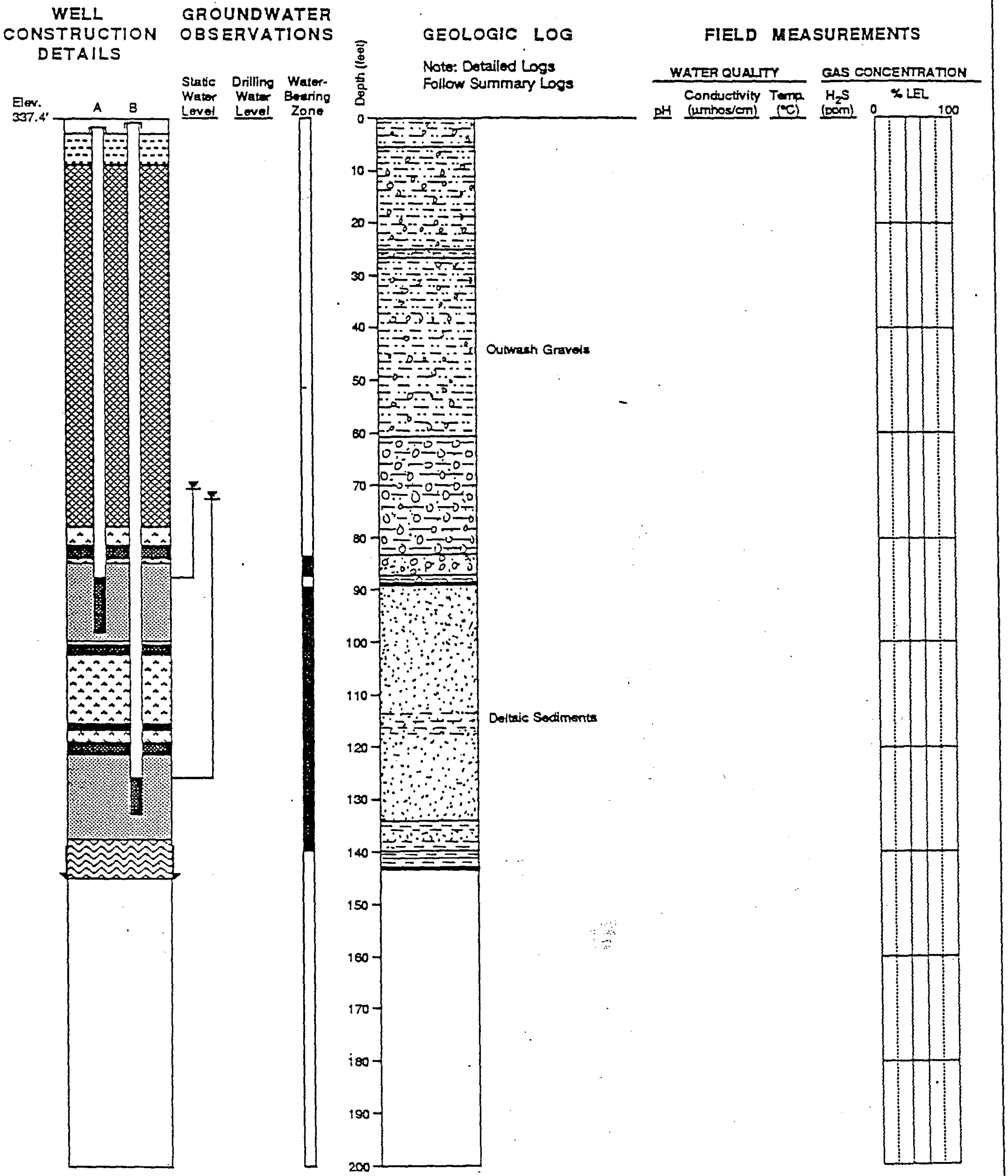

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Summary Log MW-17
Midway Landfill
Kent, Washington

PLATE **B12**

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
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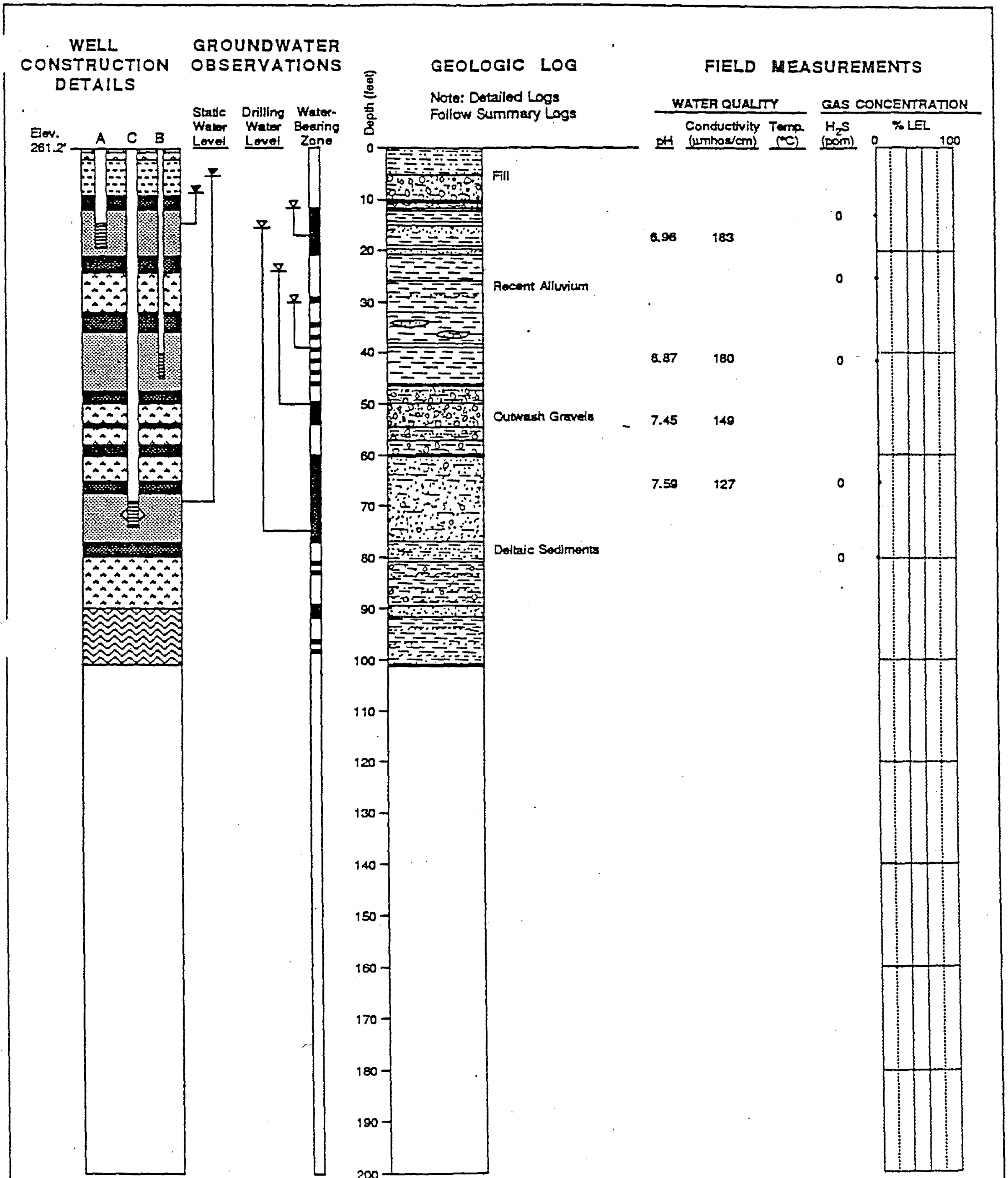

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Summary Log MW-25
Midway Landfill
Kent, Washington

PLATE B20

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
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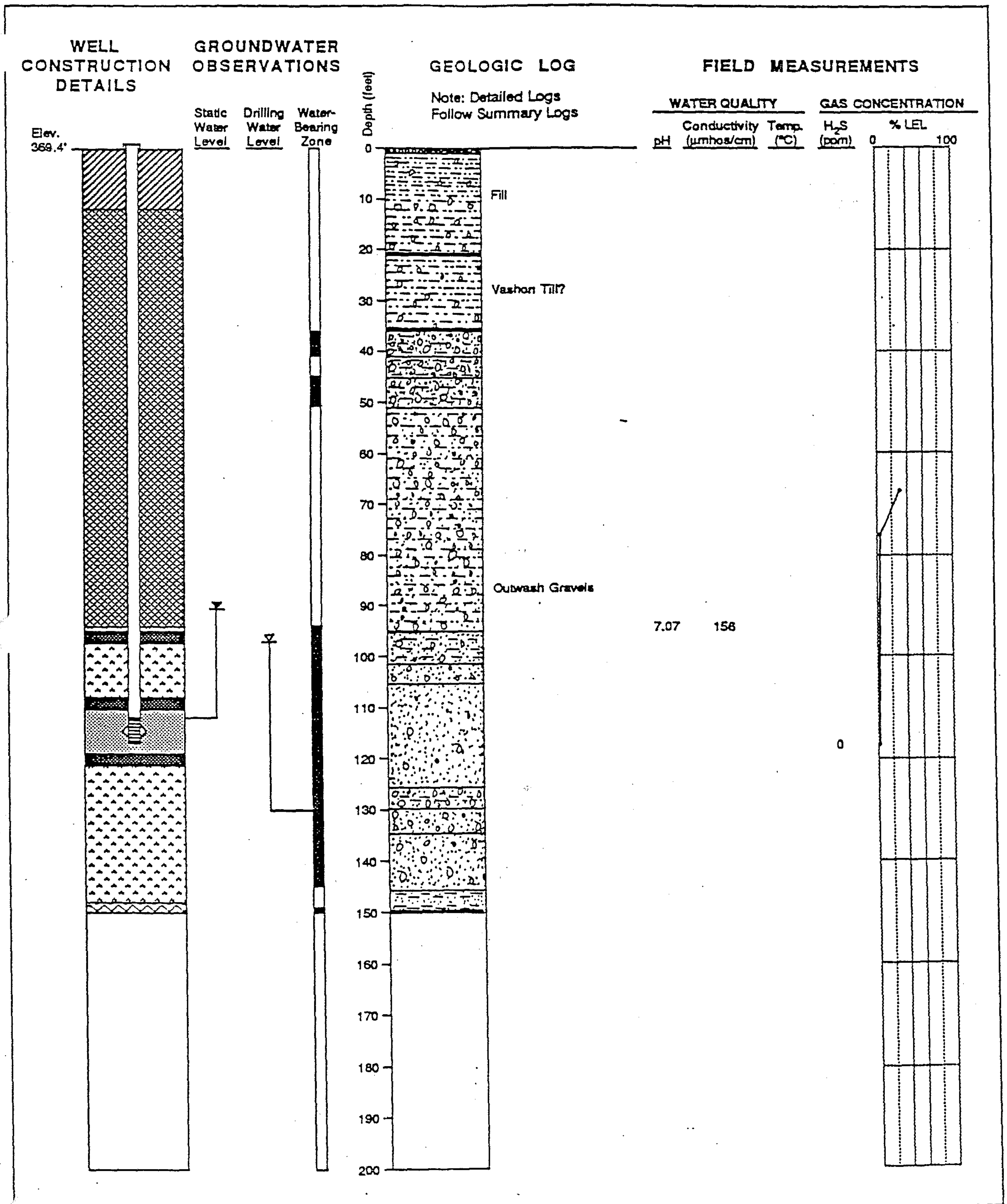

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Summary Log MW-26
Midway Landfill
Kent, Washington

PLATE **B21**

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
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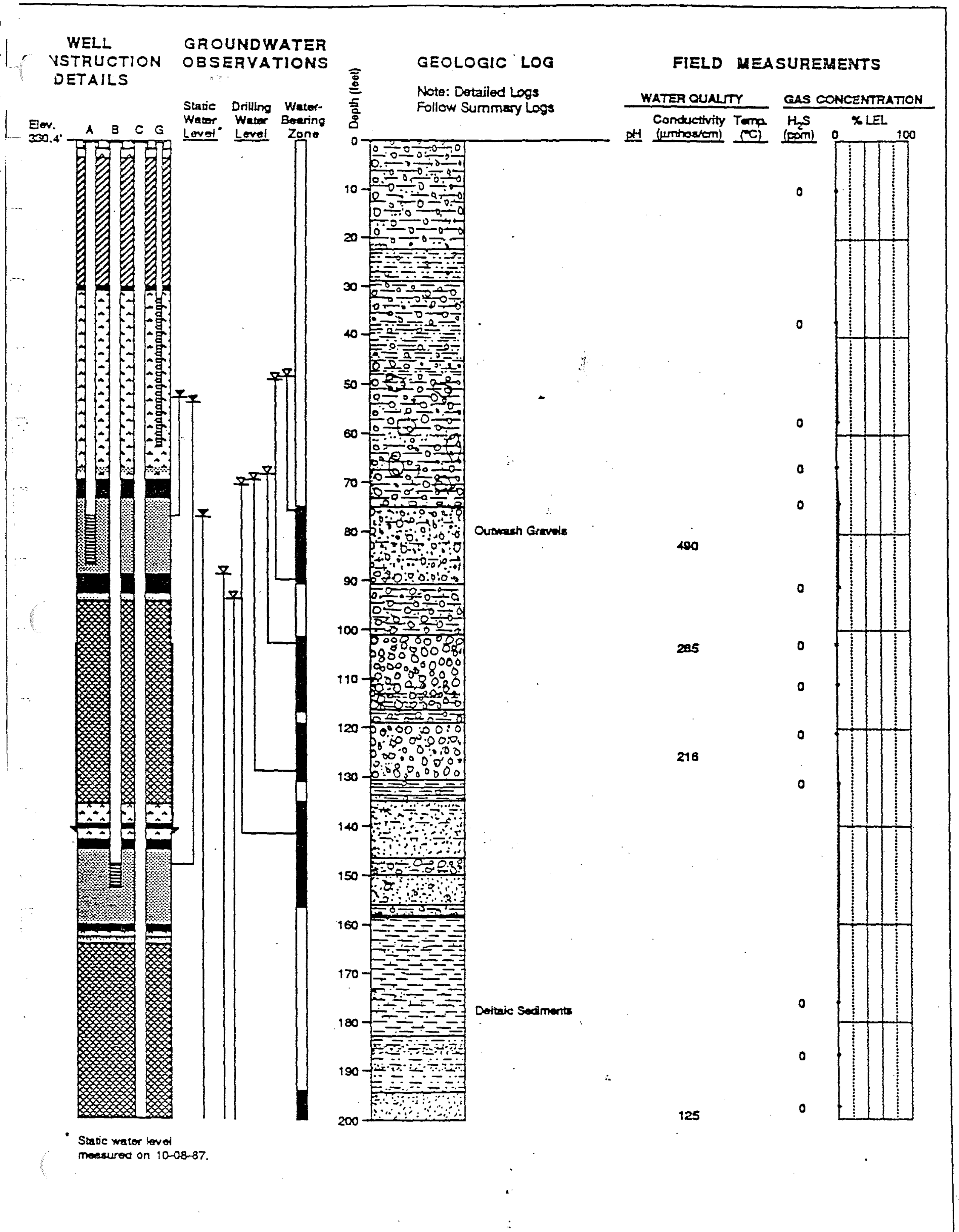

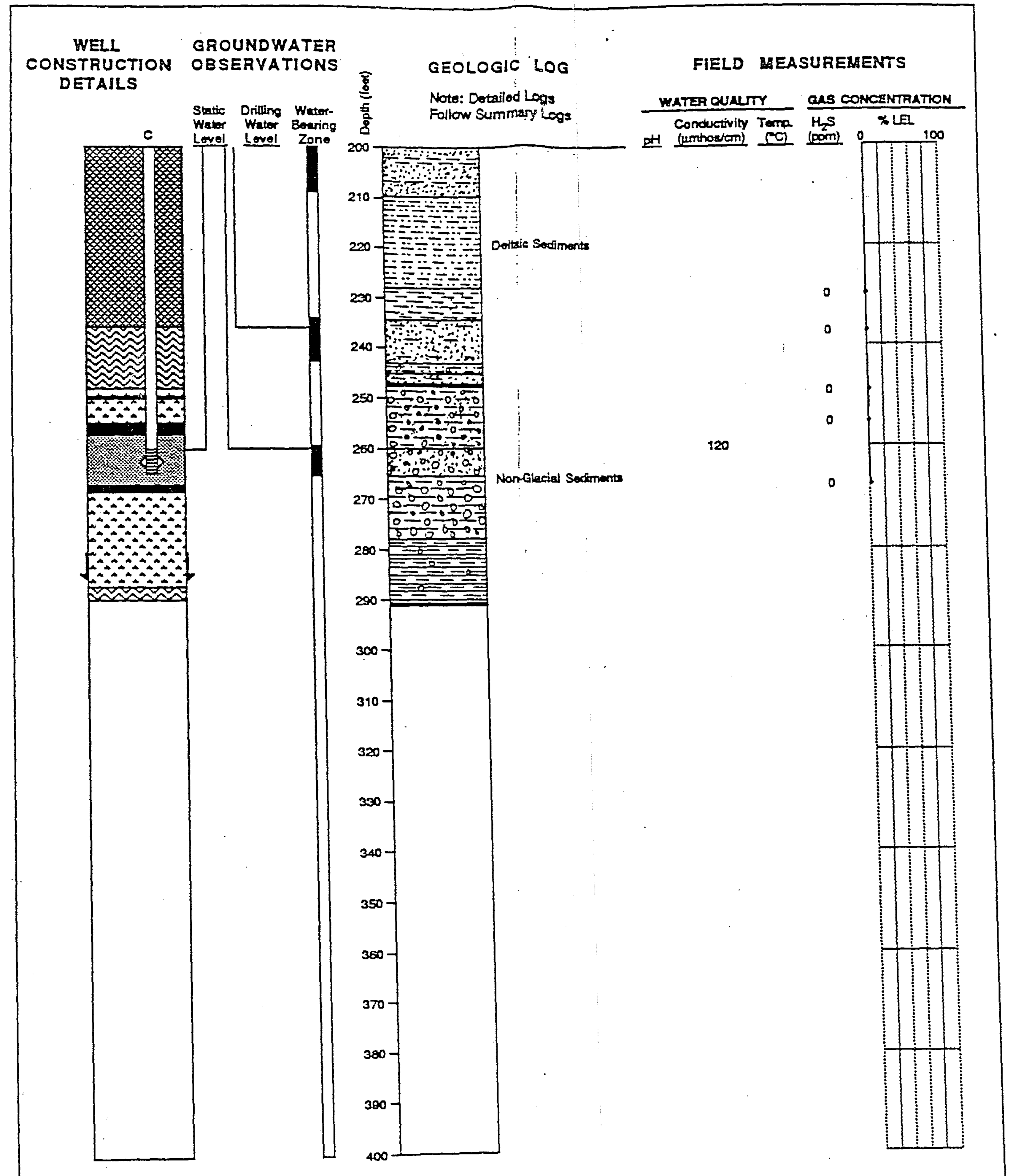

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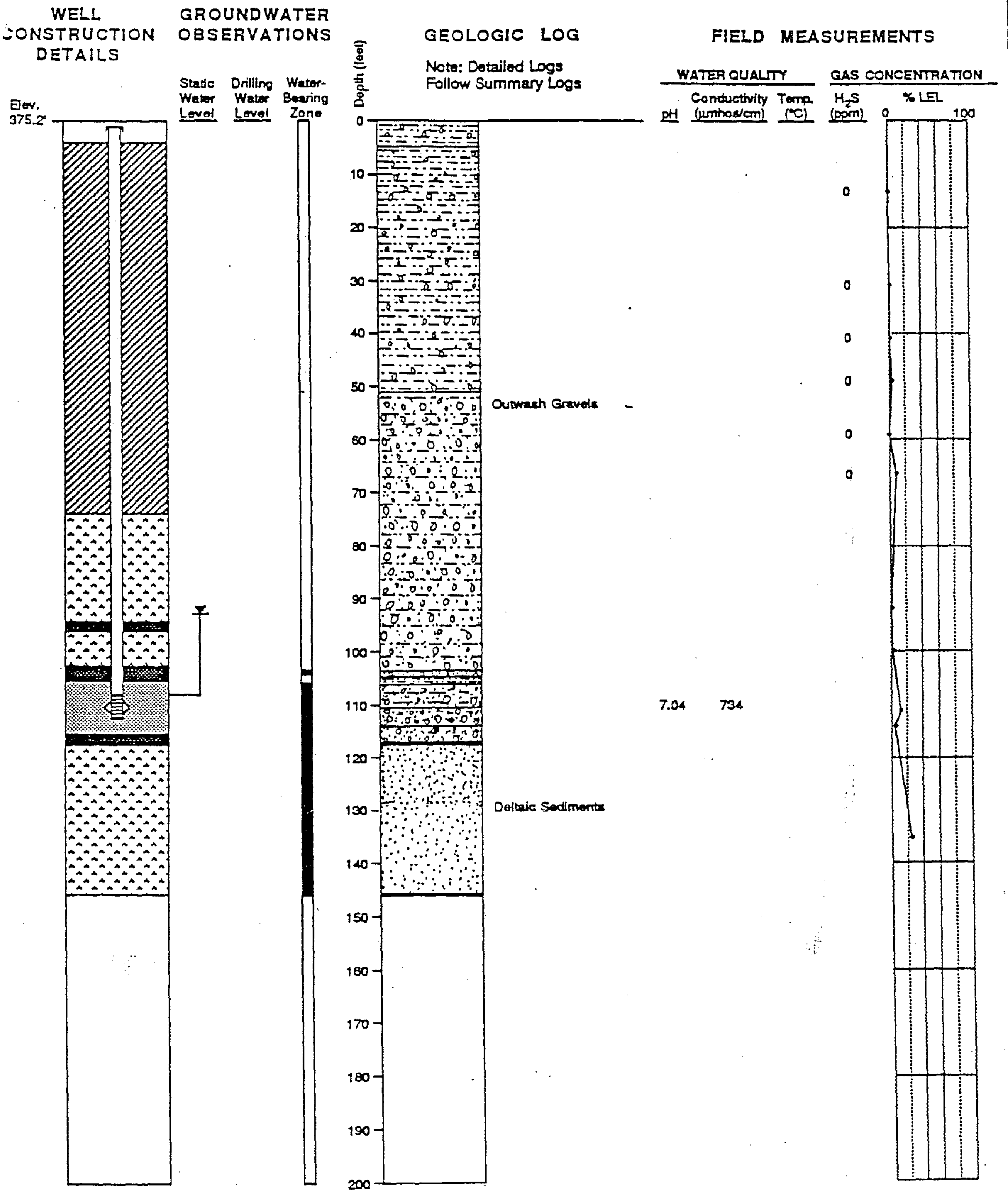
Summary Log MW-27
Midway Landfill
Kent, Washington

PLATE
B22

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
14,169.102	KER	MAA	7 Nov 87		



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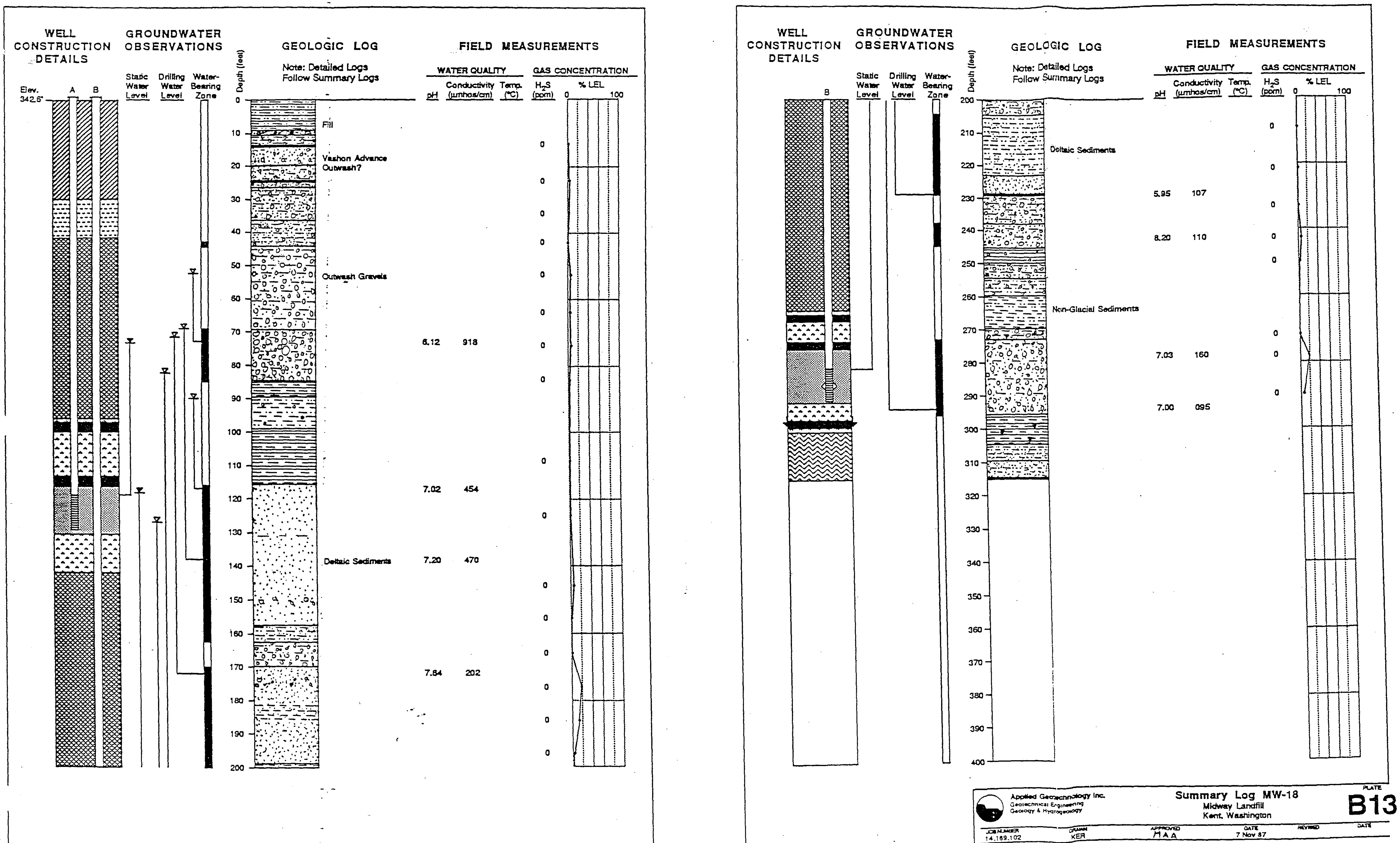
Summary Log MW-28
Midway Landfill
Kent, Washington

PLATE **B23**

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
14,169.102	KER	MAA	7 Nov 87		


WELL CONSTRUCTION DETAILS
GROUNDWATER OBSERVATIONS
Static Water Level
Drilling Water Level
Water-Bearing Zone
Depth (feet)
GEOLOGIC LOG
Note: Detailed Logs Follow Summary Logs
FIELD MEASUREMENTS
WATER QUALITY
pH
Conductivity (µmhos/cm)
Temp. (°C)
GAS CONCENTRATION
H2S (ppm)
% LEL
0
100
Elev. 342.5'
A
B
Fill
Vashon Advance Outwash?
Outwash Gravels
Deltaic Sediments
6.12
918
7.02
454
7.20
470
7.64
202
Deltaic Sediments
Non-Glacial Sediments
5.95
107
6.20
110
7.03
160
7.00
095
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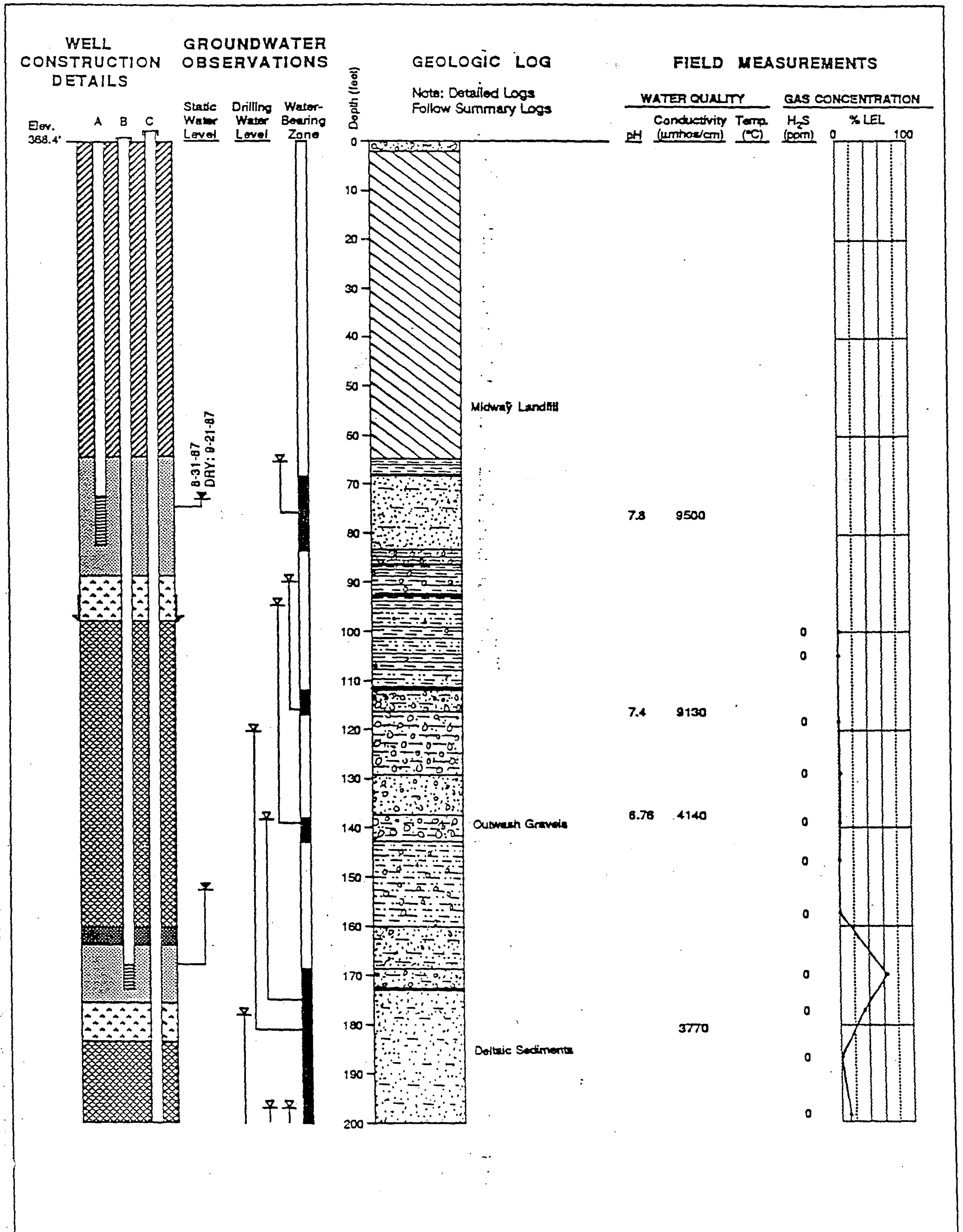
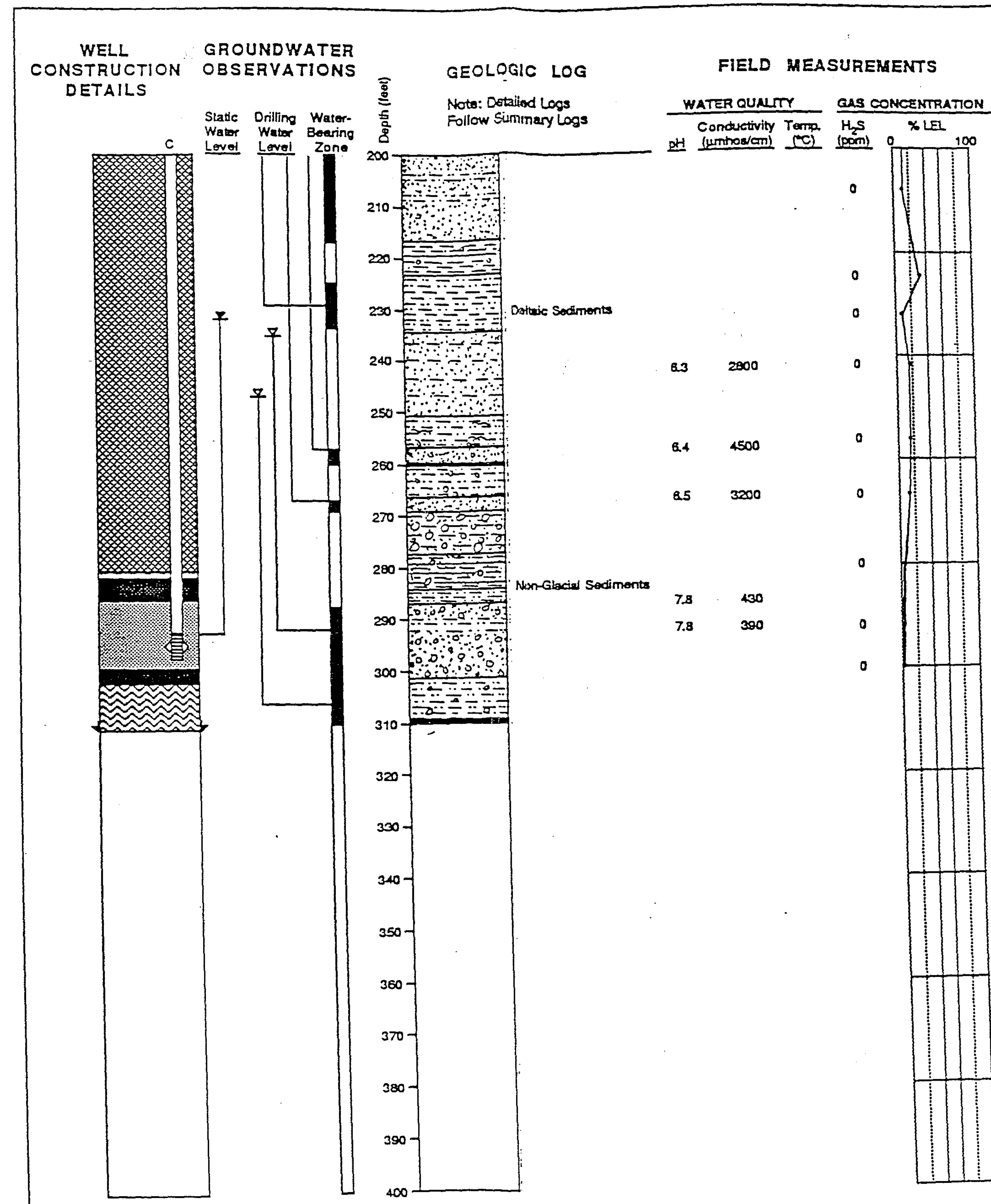
Summary Log MW-18
Midway Landfill
Kent, Washington
PLATE
B13
JOB NUMBER
14,169.102
DRAWN
KER
APPROVED
HAA
DATE
7 Nov 87
REVISED
DATE





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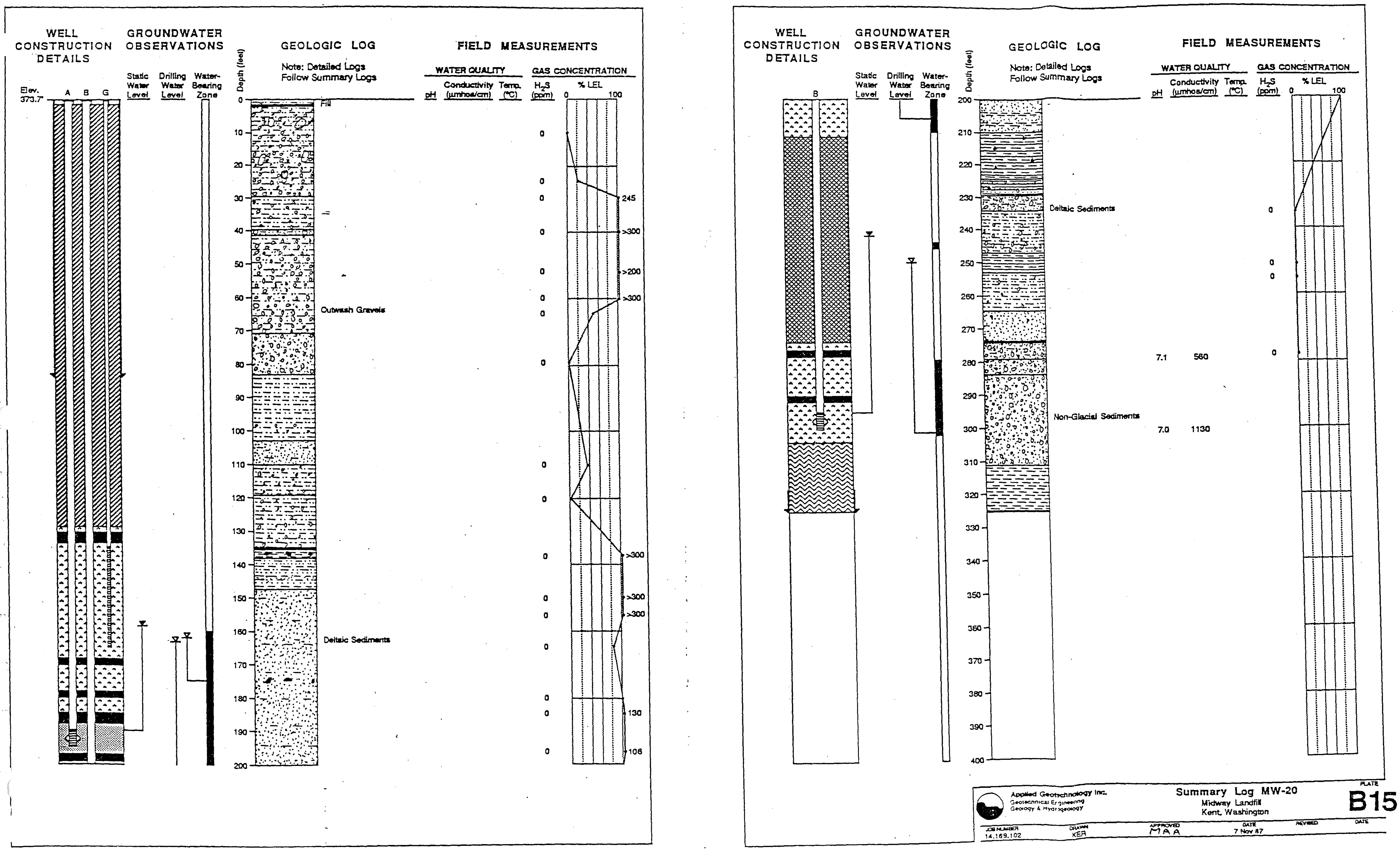
Summary Log MW-19
Midway Landfill
Kent, Washington

PLATE **B14**

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
14,169.102	KER	MAA	7 Nov 87		


WELL CONSTRUCTION DETAILS
GROUNDWATER OBSERVATIONS
GEOLOGIC LOG
FIELD MEASUREMENTS
Elev. 373.7'
A
B
G
Static Water Level
Drilling Water Level
Water-Bearing Zone
Depth (feet)
Note: Detailed Logs Follow Summary Logs
WATER QUALITY
GAS CONCENTRATION
pH
Conductivity (µmhos/cm)
Temp. (°C)
H_2S (ppm)
% LEL
Fill
Outwash Gravels
Deltaic Sediments
Non-Glacial Sediments
245
>300
>200
130
106
7.1
560
7.0
1130
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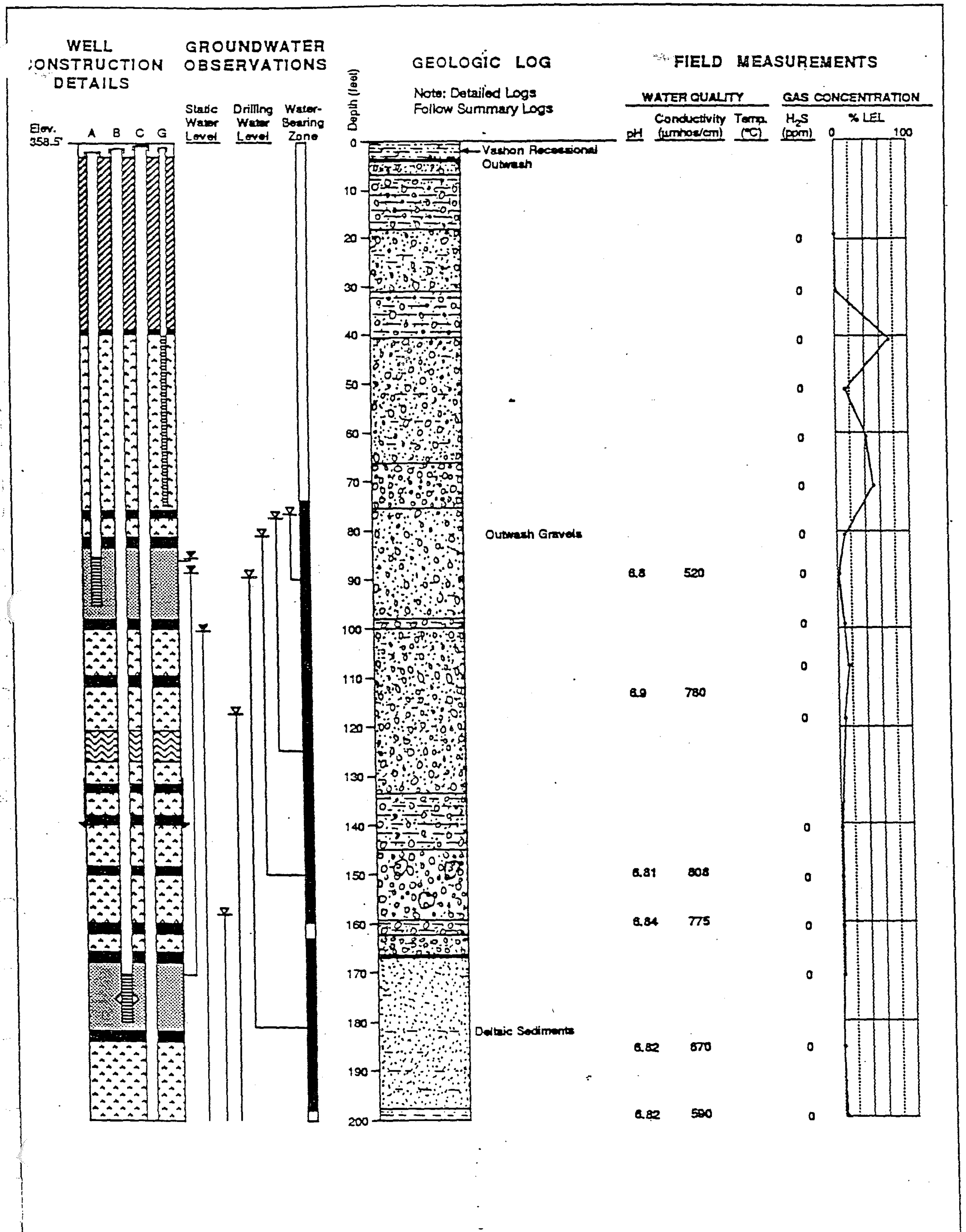
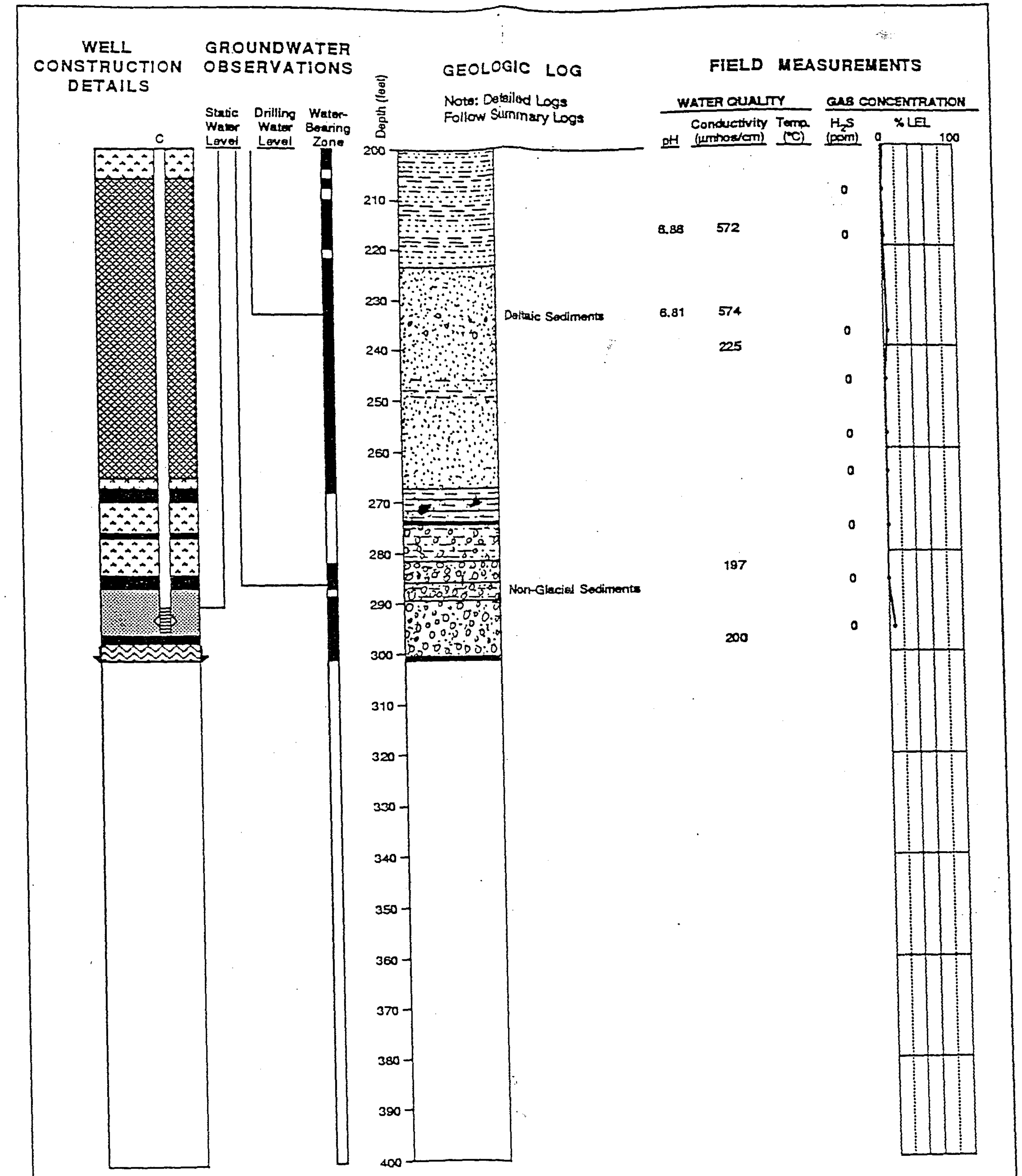
Summary Log MW-20
Midway Landfill
Kent, Washington
PLATE
B15
JOB NUMBER
14.169.102
DRAWN
KER
APPROVED
MAA
DATE
7 Nov 87
REVISED
DATE





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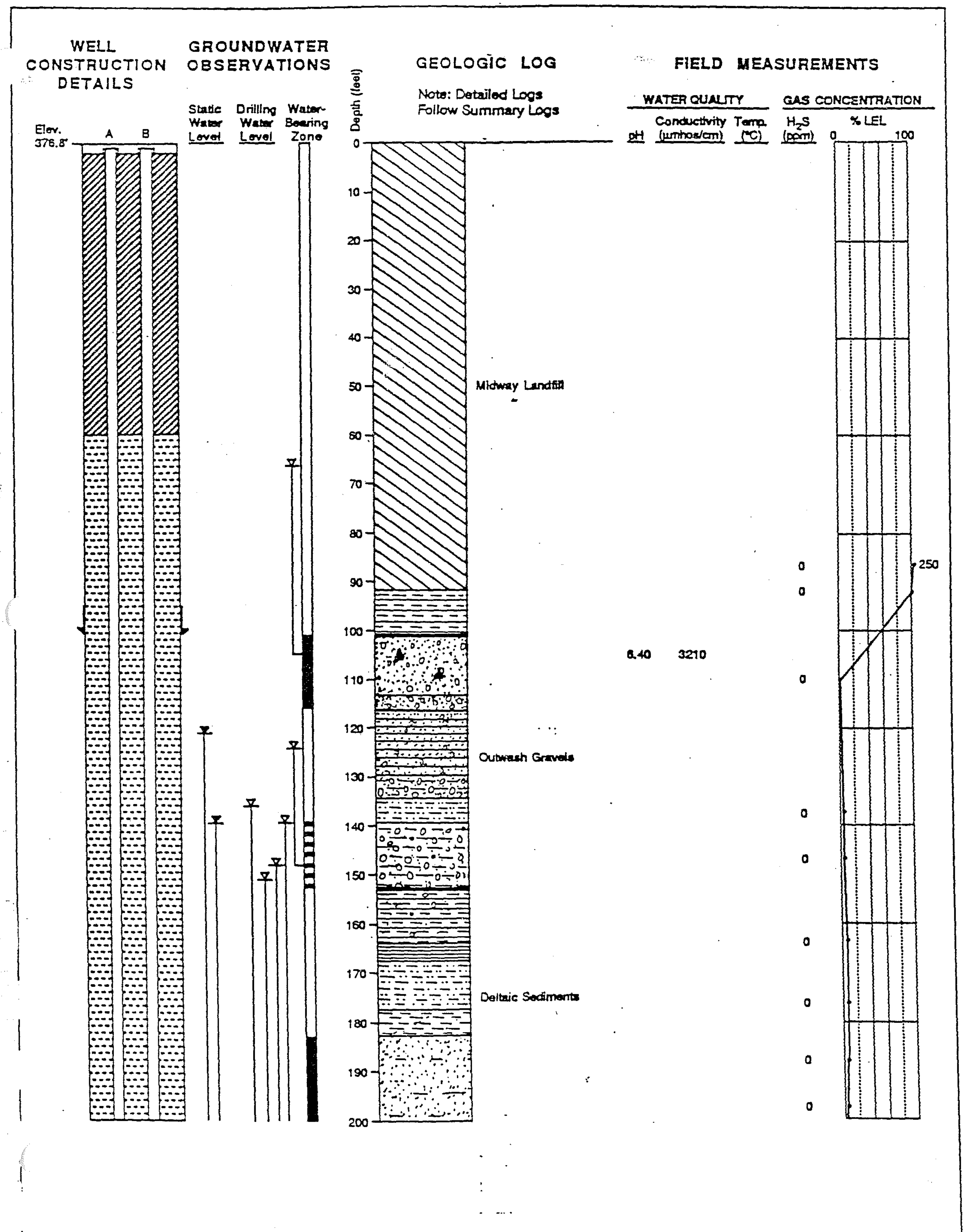
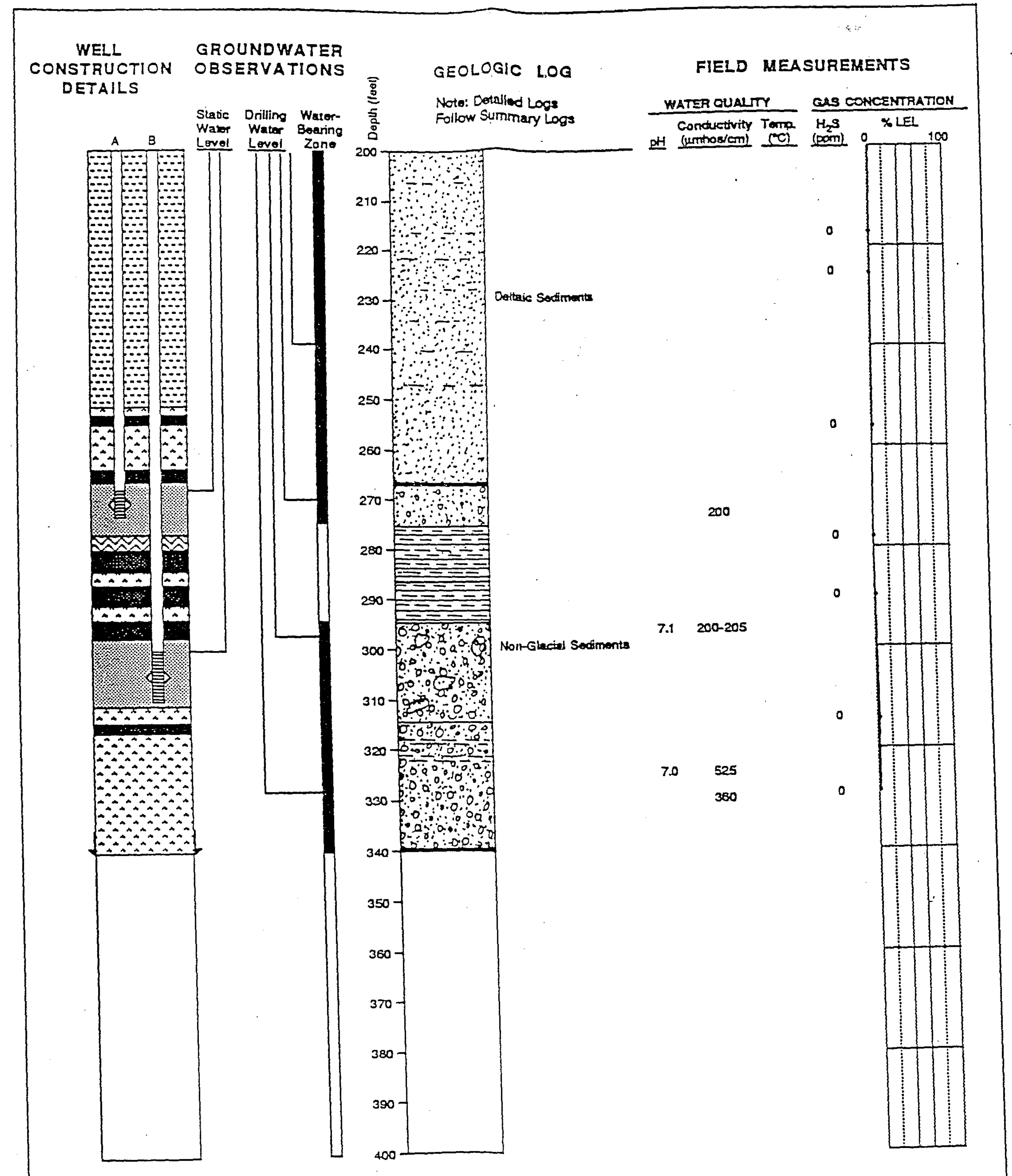
Summary Log MW-21
Midway Landfill
Kent, Washington

PLATE **B16**

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
14,169.102	KER	MAA	7 Nov 87		





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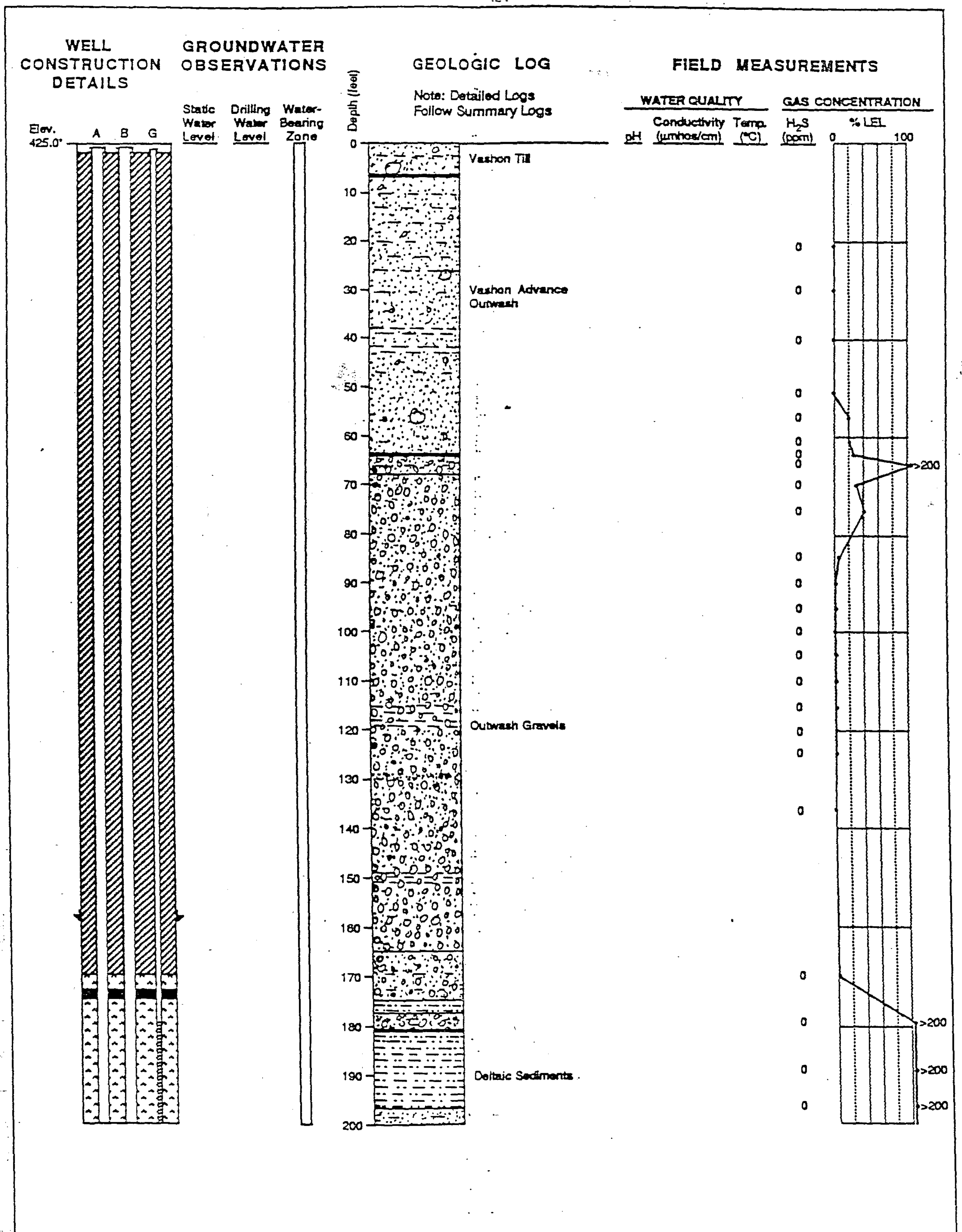
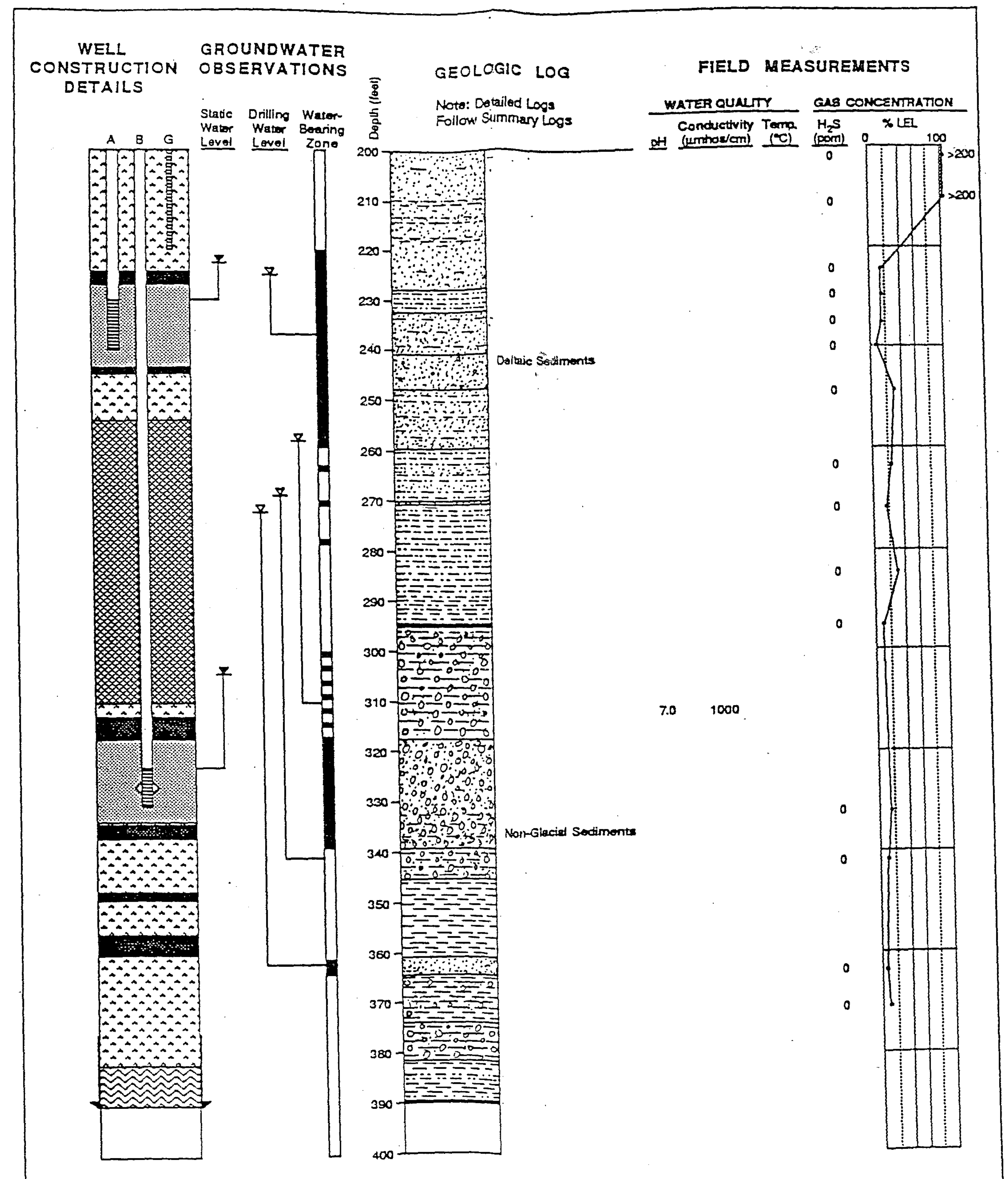
Summary Log MW-22
Midway Landfill
Kent, Washington

PLATE **B17**

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
14,169.102	KER	MAA	7 Nov 87		





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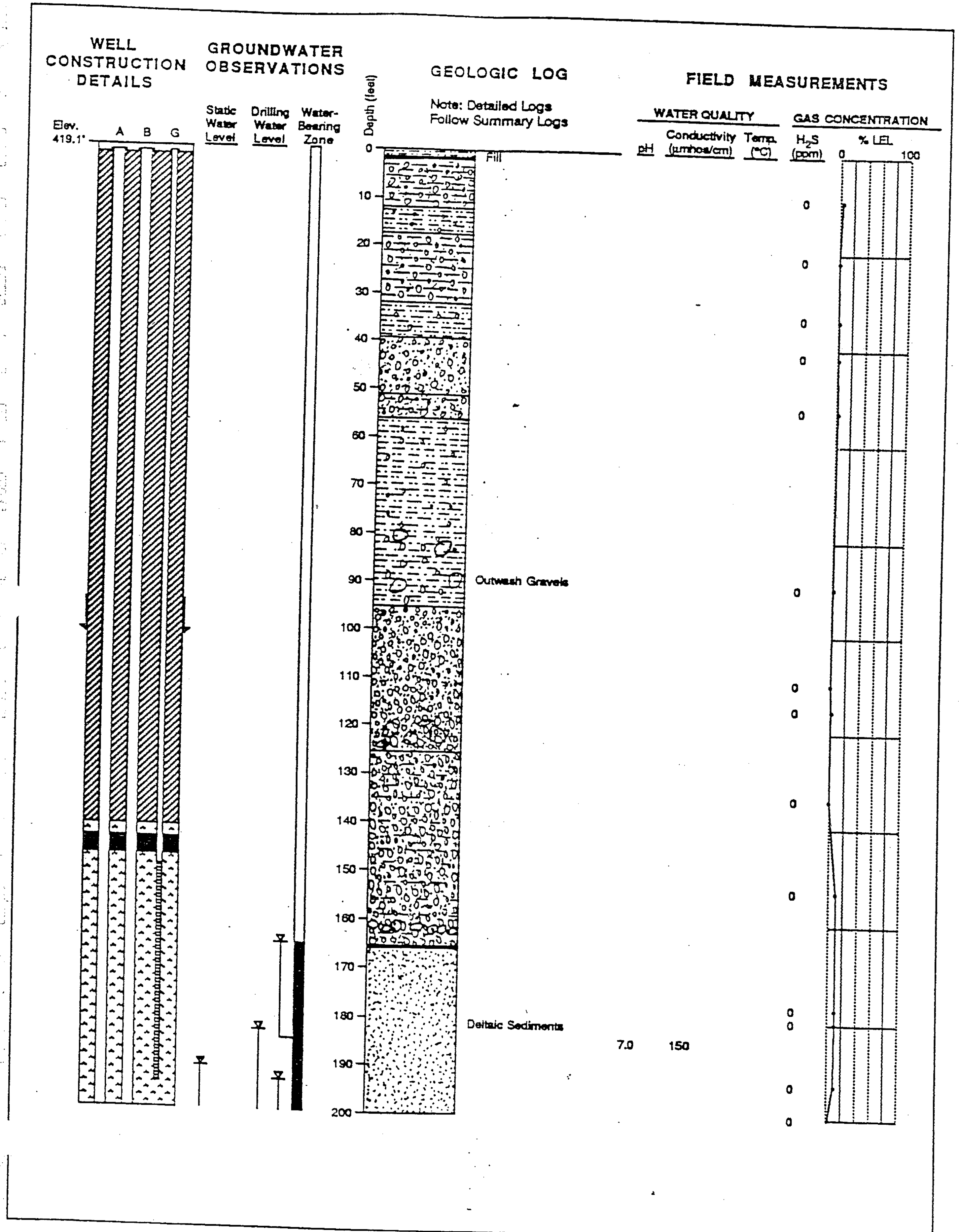
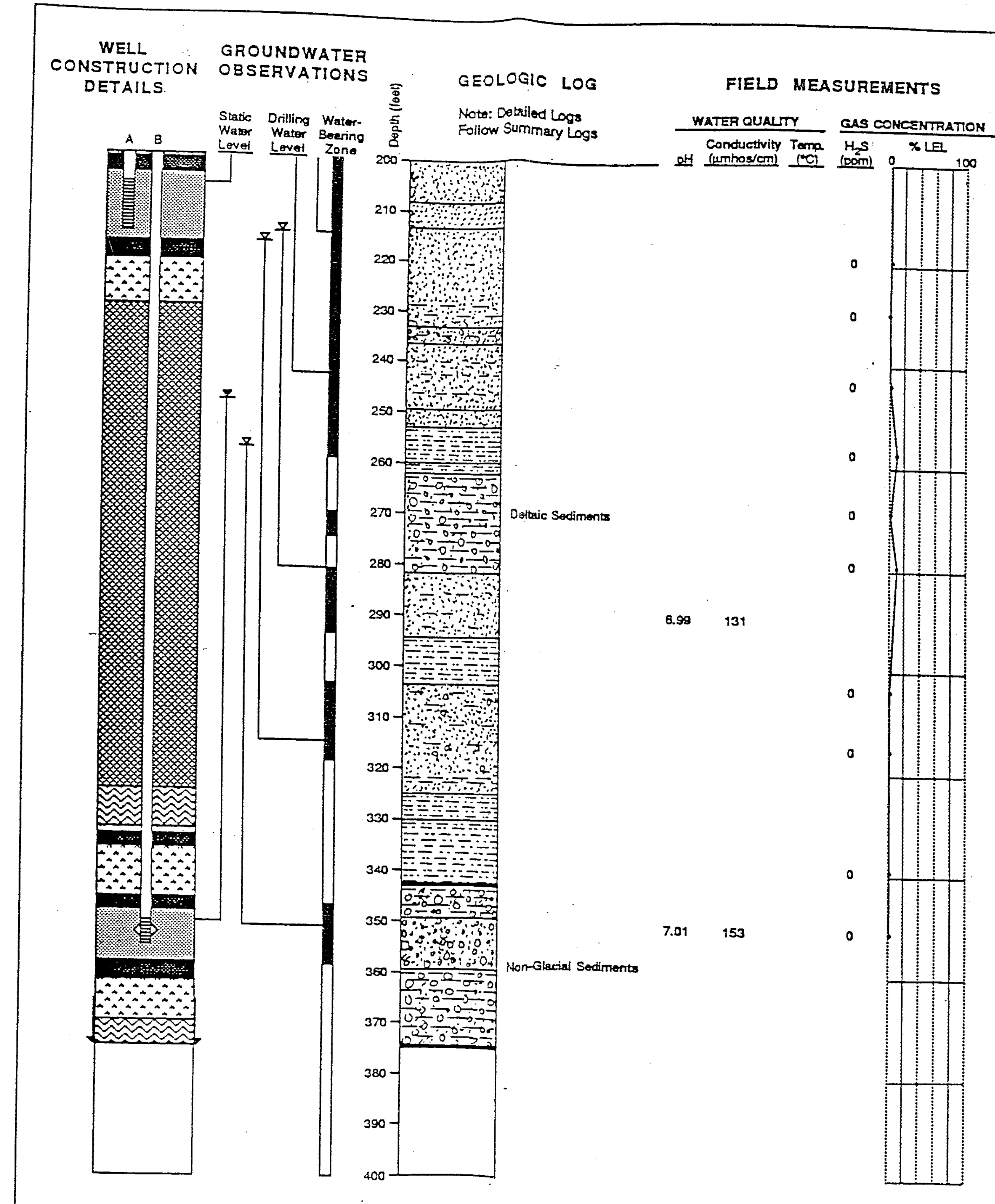
Summary Log MW-23
Midway Landfill
Kent, Washington

PLATE **B18**

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
14,169.102	XER	MAA	7 Nov 87		





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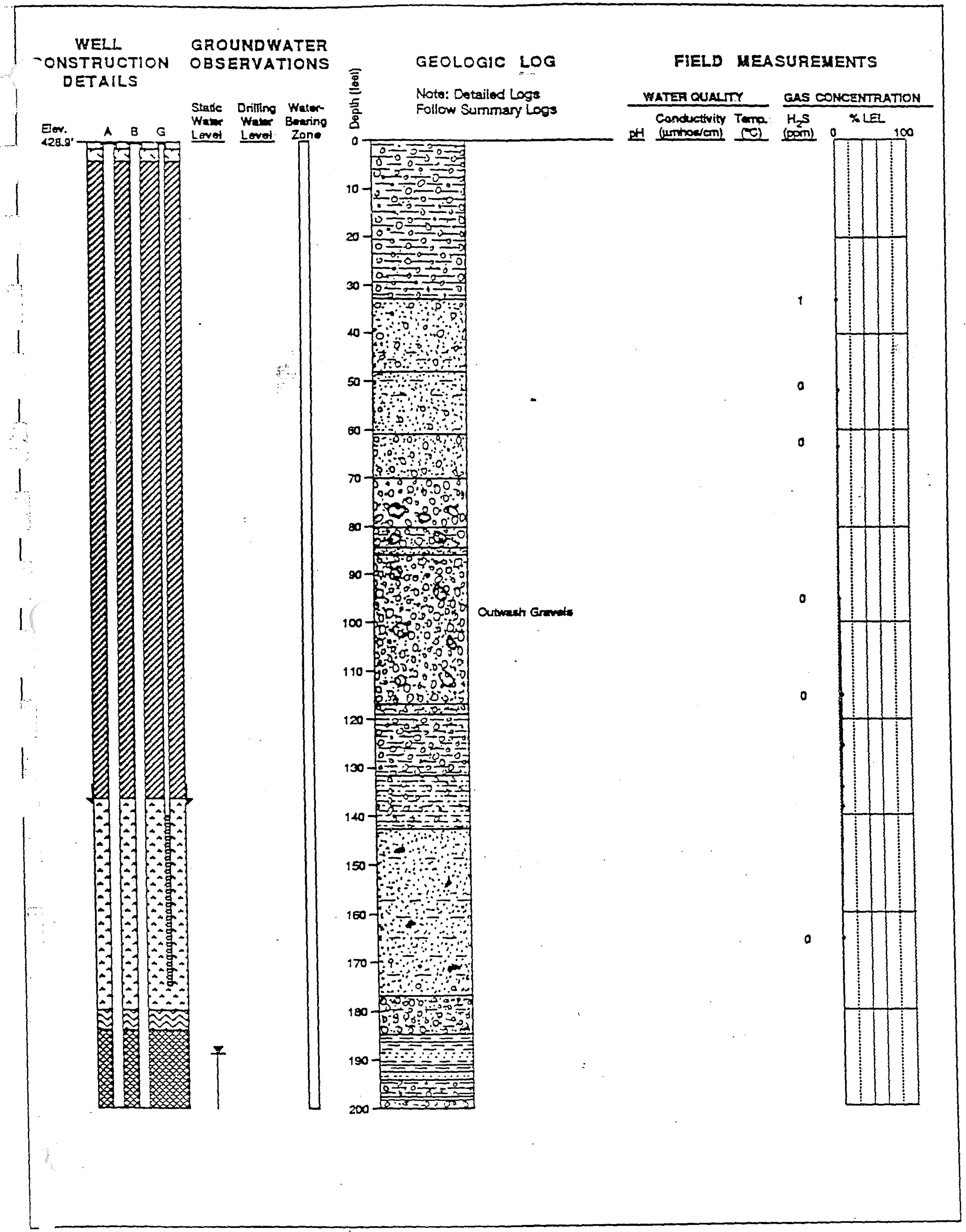
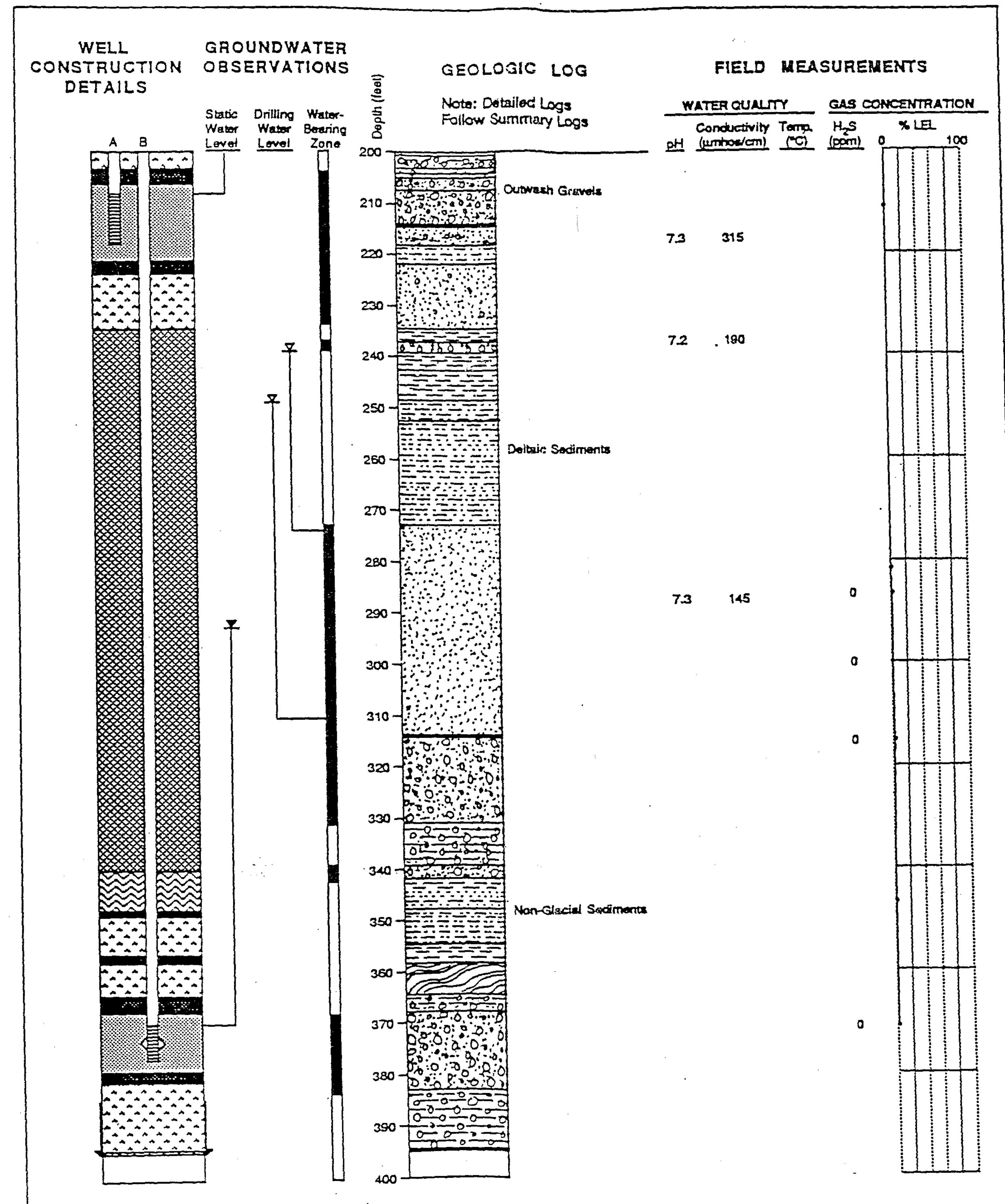
Summary Log MW-24
Midway Landfill
Kent, Washington

PLATE **B19**

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
14,169.102	XER	MAA	7 Nov 87		





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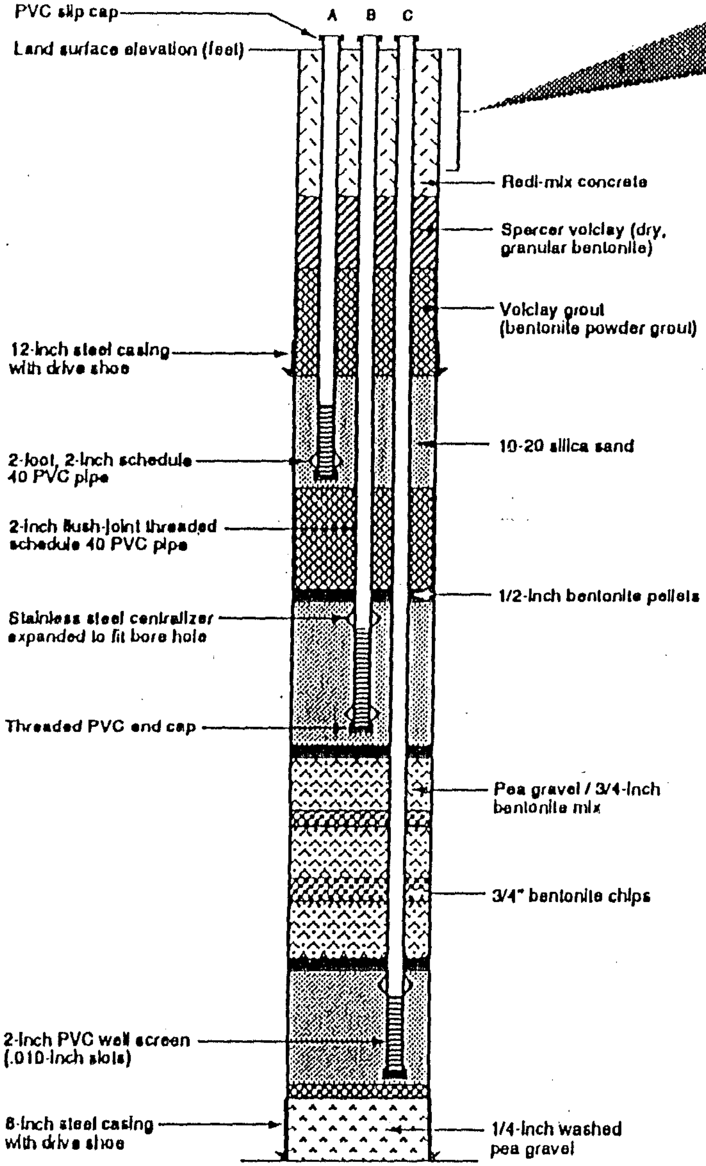
Summary Log MW-29
Midway Landfill
Kent, Washington

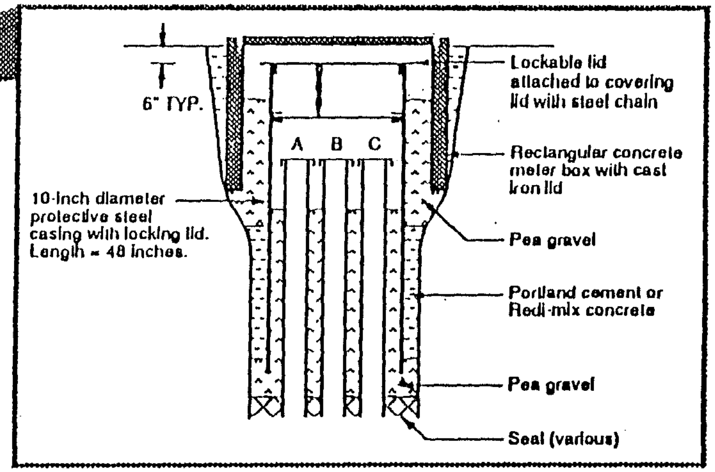
PLATE **B24**

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
14,159,102	KER	MAA	7 Nov 87		

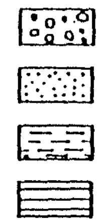
WELL COMPLETION DETAILS



SURFACE COMPLETION DETAIL



GEOLOGIC LOG



NOTE: Detailed geologic logs follow the summary logs.

NOTES REGARDING GROUNDWATER OBSERVATIONS

Static water level in monitoring well screened at indicated depth on January 10, 1989.

Water levels observed during drilling with boring at indicated depth. Water levels noted represent "stabilized" levels or overnight levels.

Water bearing zones defined as saturated sediments which yielded groundwater freely to the borehole.

NOTES REGARDING FIELD MEASUREMENTS

Gas concentration measurements taken inside casing approximately 6-inches below top of casing. Measurement types are as follows:

OVM = Organic vapor measurements with portable photoionization detector

H_2S = Hydrogen sulphide

% LEL = Percent lower explosive limit

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Summary Log Legend
Midway Landfill
Kent, Washington

PLATE 1

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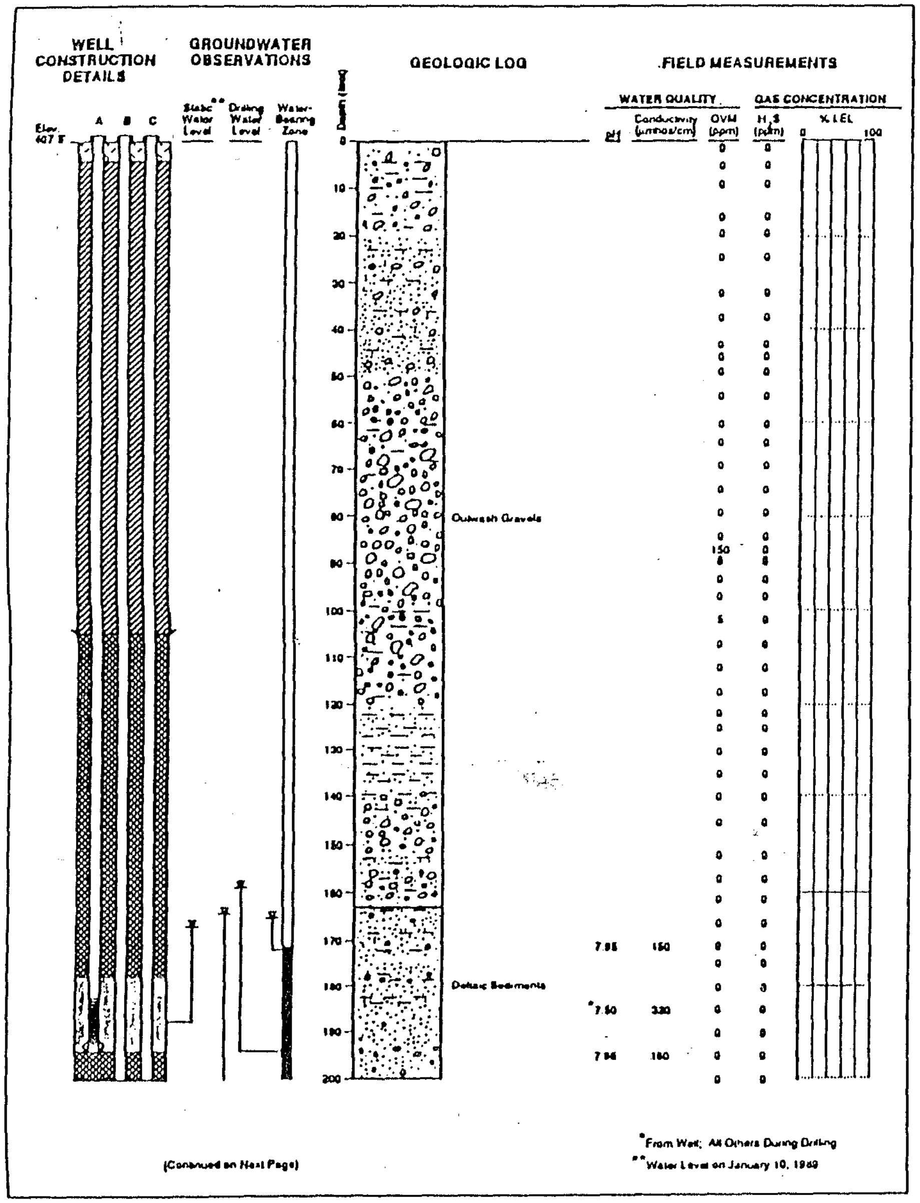

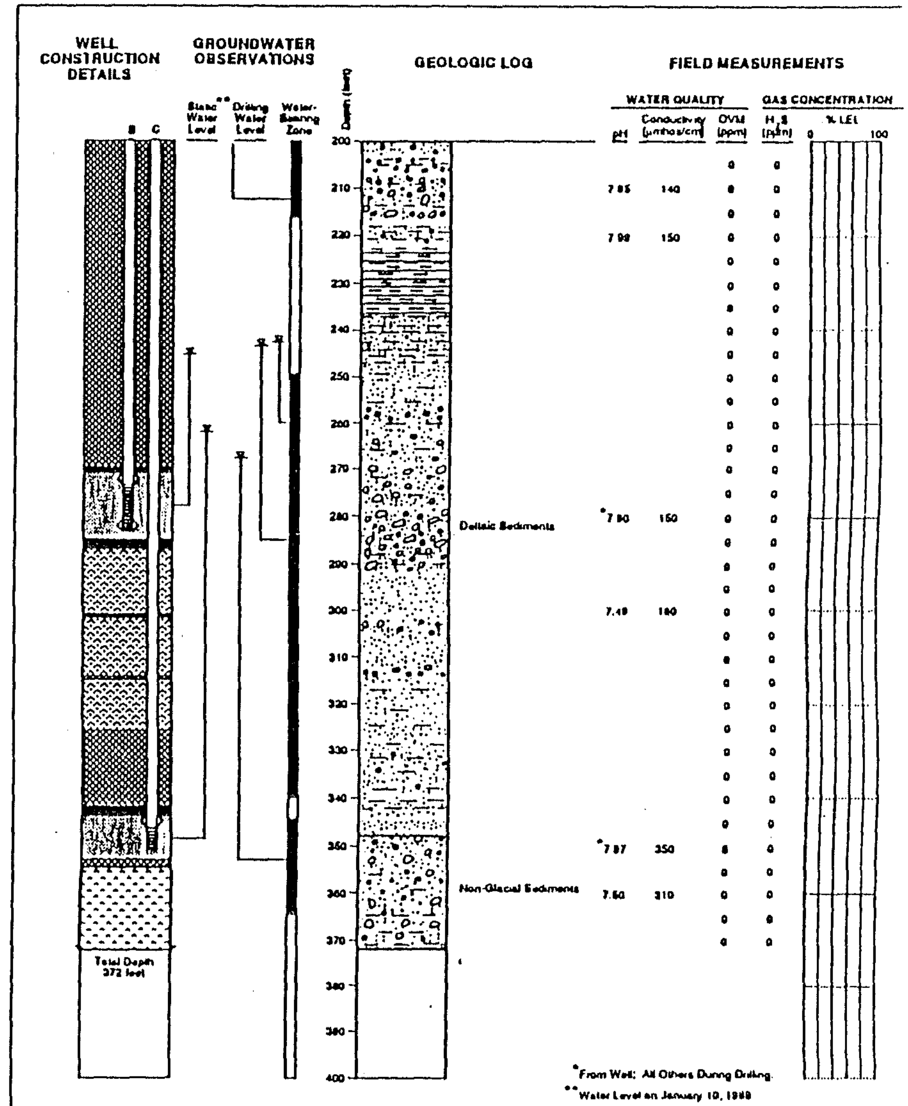

Applied Geotechnology Inc.
Geotechnical Engineering
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Summary Log MW-30
Midway Landfill
Kent, Washington

PLATE 2

APPENDIX B

Equipment and Instrumentation

A manual prepared for

Seattle Engineering Department
Solid Waste Utility
Seattle, Washington

OPERATION AND MAINTENANCE MANUAL
DEDICATED GROUNDWATER SAMPLING PUMPS
MIDWAY LANDFILL
KENT, WASHINGTON

AGI Project No. 14,169.102

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February 1988

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LIST OF ILLUSTRATIONS

I. INTRODUCTION

This manual is a guide to the operation and maintenance of dedicated sample pumps installed in the groundwater monitor well network at the Midway Landfill. The pumps have been installed in each of 46 individual monitor wells located at 23 separate boring locations (MW-7 through MW-29). Well installation details and depths, and elevation specifications are included in Tables 1 and 2 on the following pages.

The dedicated pumps were manufactured by the Robert Bennett Company of Amarillo, Texas. The pumps are designed to provide representative groundwater samples from depths to 500 feet using only compressed gas to power the pumps. Figure 1 provides a cross sectional view of the pump and its internal components.

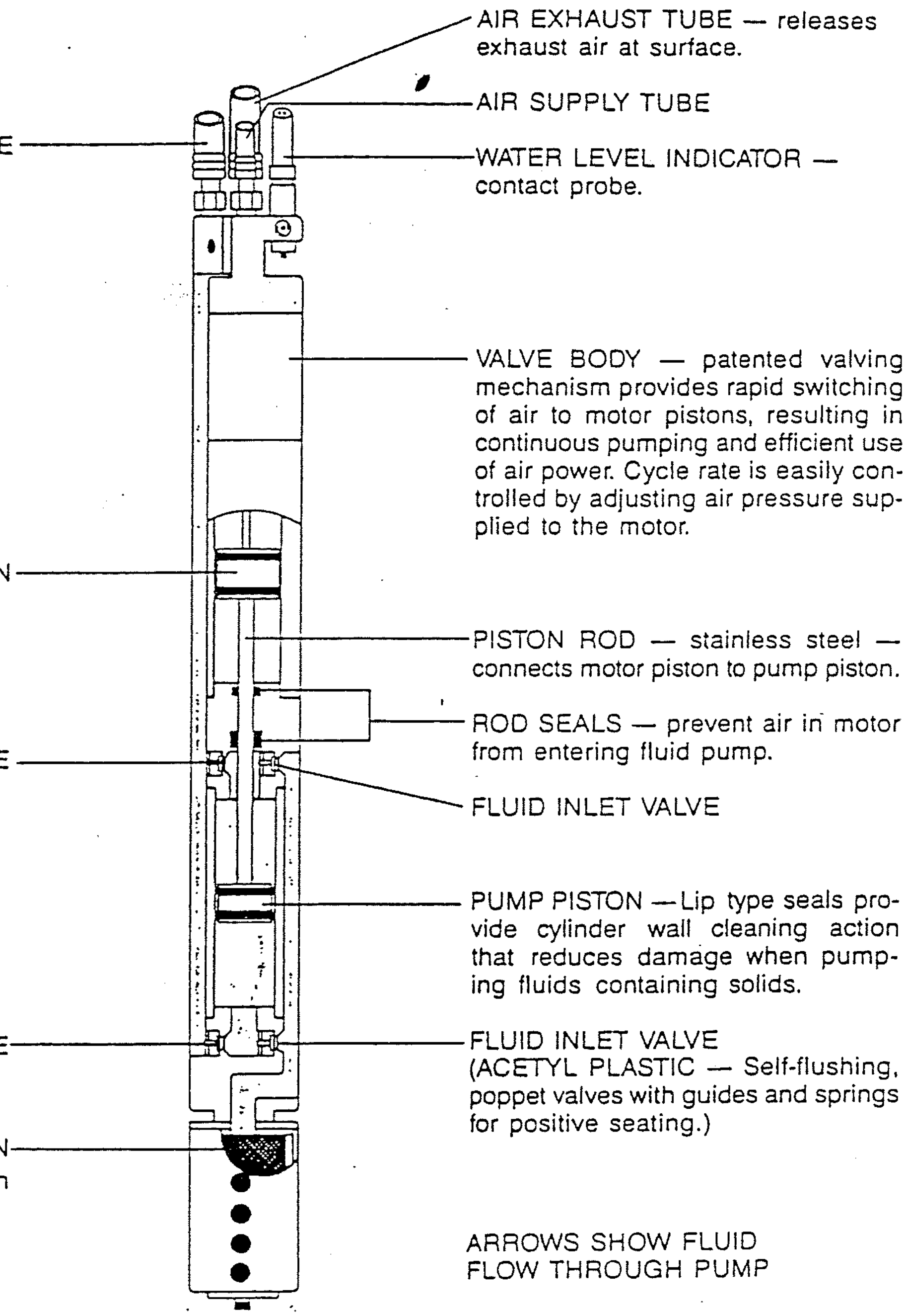
Sample quality is ensured by the following design features:

- Pumps are fabricated from stainless steel.
- Pump seals and water discharge tubes are made of Viton.
- Compressed gas does not contact the sample or other water within the well.
- Variable flow rate permits both rapid purging and low sampling rates from the same pump.

The pumps are installed near or within the upper portion of the screened zone of each well to provide the most representative water quality samples. However, sufficient casing storage should be purged from each well prior to sampling to ensure accurate results. Sampling protocol is outlined in detail in the Remedial Investigation Sampling and Analysis Plan, and is not discussed further in this manual.

The following two sections discuss operation and maintenance of the Bennett pumps. These topics are also covered in the Bennett pump manual provided in Section IV; however, the manual describes operation of the portable Bennett sampling pump and reel and is therefore of limited use for the Midway well installations. The Bennett pump manual does provide detailed pump disassembly and maintenance information, however.

Bennett Sample Pumps have automatic reciprocating piston motors, operated by compressed air, that generate power for operating a double acting, piston fluid pump. Models for lifts up to 500 feet have one motor piston; Models for lifts up to 1000 feet have two motor pistons, providing increased power for operating the pump. All models have a differential ratio between the motor pistons and the pump to accomplish lifts using low pressure air from small compressors.



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Cross Sectional View of Pump
Midway Landfill
Kent, Washington

FIGURE **1**

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II. PUMP OPERATION

Each dedicated pump installation includes the following components:

- <u>Bennett Model 180 Sample Pump</u>, placed near the top of the screened zone within each monitor well. Three different pump (piston) sizes were used at Midway, depending on well depth or space limitations as follows:

  8/8" (1") diameter piston for shallow wells < 300 feet in depth
  7/8" diameter piston for intermediate wells 300 to 400 feet in depth
  5/8" diameter piston for deep wells > 400 feet in depth.

  Piston size can be determined by checking the first three digits of the serial number of each pump.

  8/8" piston corresponds with 188
  7/8" piston corresponds with 187
  5/8" piston corresponds with 185

  The overall diameter of the 188 and 187 pumps is approximately 1.75 inches; for the 185 pump, it is approximately 1.0 inch.

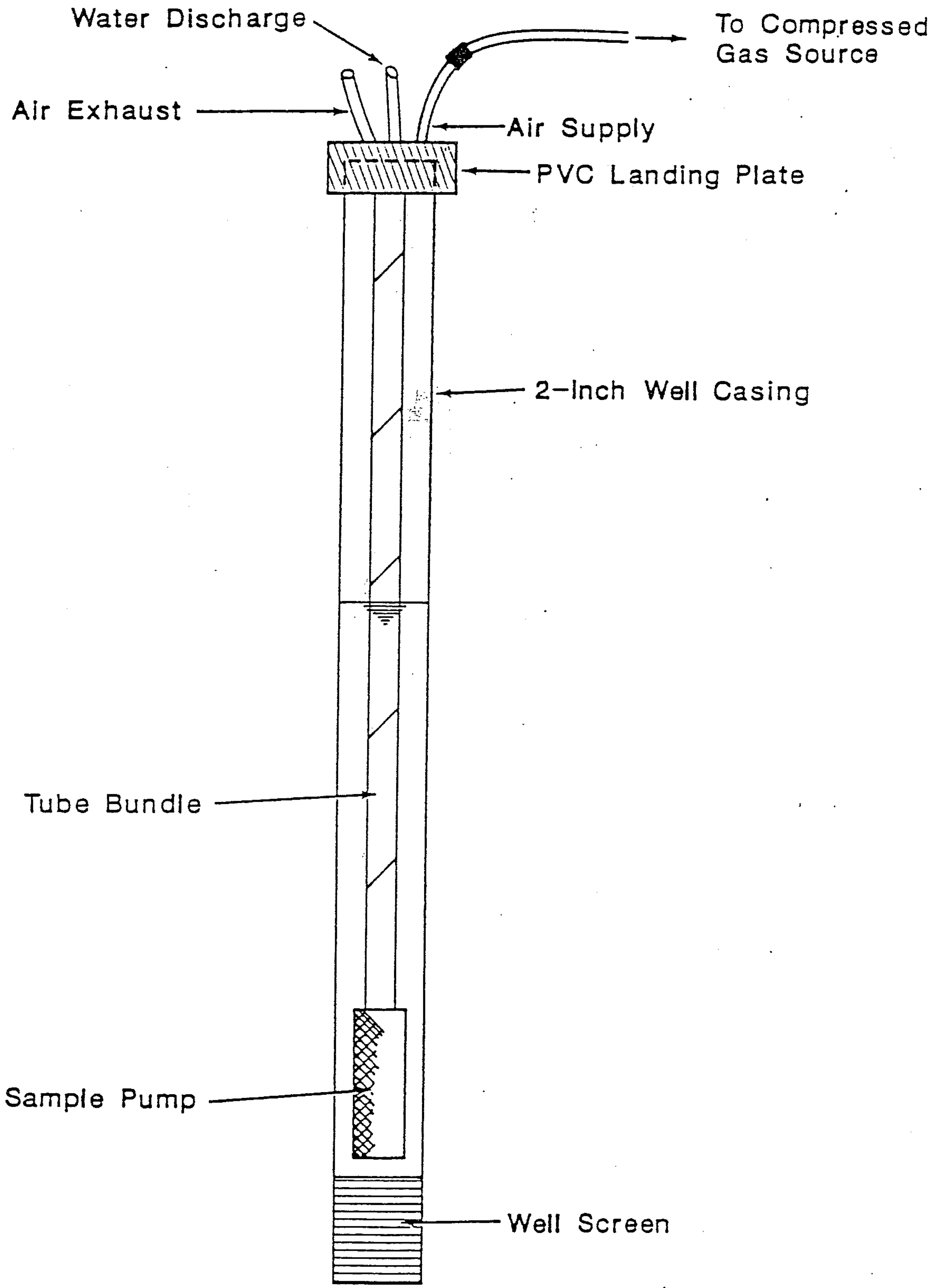
- <u>Tube Bundle</u> leading from the pump to the ground surface. The tube bundle consists of a polypropylene air inlet line, a polypropylene air exhaust line, and a Teflon water discharge line.

- <u>Stainless Steel Cable</u> which helps support the weight of the pump. The stainless cable is twisted together with the three tubes discussed above to form a compact bundle.

- <u>Landing Plate</u>, machined from PVC, which rests on top of the 2-inch well casing. The landing plate supports the weight of the pump and includes an access port to measure water levels in the well.

Configuration of the pump installation is shown on Figure 2. The landing plate assembly, located at the well head, is shown in detail on Figure 3. To operate the pump, the air supply tube protruding from the landing plate is pressurized by a compressed gas source. Either a portable compressor or compressed gas cylinder may be used for this purpose. Portable compressors should be capable of developing approximately 150 pounds per square inch (psi) pressure at a flow rate of roughly 2.5 cubic feet per minute (cfm). Compressed gas cylinders equipped with heavy-duty pressure regulators have proven more efficient for pump operation than portable compressors, however.

Below is a step-by-step outline for pump operation. The outline is a modified version of that provided in the pump manual (Section IV).



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Dedicated Sample Pump Installation Plan

Midway Landfill
Kent, Washington

FIGURE
2

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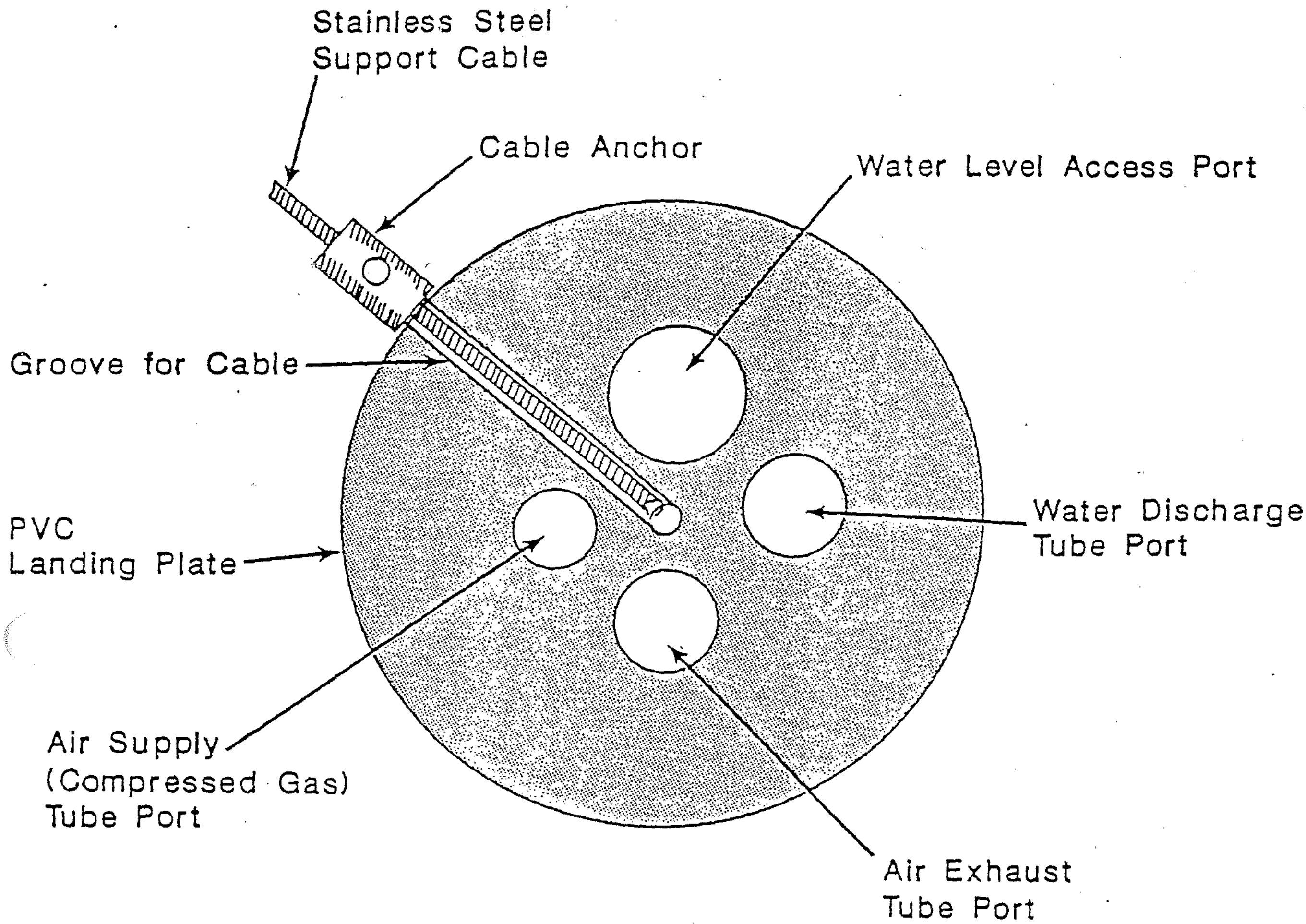

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Detail of Landing Plate Assembly (Top View)

Midway Landfill
Kent, Washington

FIGURE **3**

NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
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PUMP OPERATION

1. Measure water level in well. Calculate amount of water to be purged from well prior to sampling.

2. Attach high pressure air line (provided by Bennett) to the compressed gas source. Adjust all pressure regulators to no-flow position (counterclockwise).

3. Attach discharge end of high pressure line to the pump air supply tube protruding from the landing plate. The air supply tube is brittle in cold weather and needs to be handled gently to prevent damage.

4. Attach an appropriate length of Teflon tubing to the water discharge line to facilitate collection of purge or sample water.

5. Open main valve of compressed gas cylinder, or start air compressor.

6. Pressure up pump air supply line using the in-line pressure regulators. It is advisable to pressure the system gradually; in-line pressures of 150 psi or less are sufficient for pump operation.

   The in-line regulator on the Bennett high pressure air line has a locking yellow knob. Operate this regulator as follows:

   - Pull yellow knob OUT to unlock.
   - Push yellow knob IN to lock.
   - With cap unlocked - Turn clockwise to increase and counter-clockwise to decrease pressure and shut flow off.

7. Use the air pressure regulator to begin pump operation by slowly increasing the air pressure until the pump begins cycling. There may be a time lapse between pump start-up and water flow from the discharge line. Any of the following procedures can be used to determine whether the pump is cycling:

   - Listen for a soft clicking sound from pressure lines.
   - Observe the in-line pressure gauge for slight needle fluctuations as the pump cycles.
   - Place the end of the water discharge line in a container of water. Continuous bubbling will occur as the water is filling the discharge tube.
   - Place finger over the air exhaust line. A slight air flow indicates pump cycling has begun.

8. Once discharge from pump has begun, flow rate can be regulated by controlling flow and pressure to the pump. Increase discharge rate by increasing gas flow or pressure; decrease discharge rate by decreasing gas flow or pressure. If gas flow or pressure is lowered too far, pumping will cease, however.

9. To end pumping, turn all pressure regulators counterclockwise to eliminate gas flow. Air lines can then be disconnected from the pump.

The Bennett pumps require a minimum of experience to operate efficiently and reliably. However, a few suggestions are included below for troubleshooting if the pumps are not operating properly.

TROUBLESHOOTING GUIDE

Condition	Corrective Action
Pump fails to operate upon initial pressure-up	In-line pressure to pump may be too low. Increase pressure and flow.
Pump slows or ceases to operate	Check for low tank pressure on compressor or compressed gas cylinder. Replace or adjust as necessary.
Pump slows and ceases to operate; gas pressure constant	Water level in well may be lowered from pumping. Increase pressure until pump resumes operation. Check water level periodically to insure pump is fully submerged.
Pump slows and ceases to operate; water is silty or turbid	Turbid water is heavier than clear, and will require more pressure to lift. If increased pressure does not restart pump, pump intake screen or interior may be clogged with silt. Remove pump from well; inspect and clean as necessary. Refer to Section III for pump removal instructions; Section IV for pump disassembly and cleaning.

Pump cycles but little or no discharge observed at surface	Pump O-rings and seals may need replacement. Remove pump and replace if necessary (See Sections III and IV).
Pump cycles but little or no discharge observed at surface after a period of normal discharge	Water level in well has dropped below or to the pump intake. Check water level periodically to insure pump is fully submerged. Wait for well to recover before resuming pump operation. May need to pump at a lower rate.

III. PUMP REMOVAL AND MAINTENANCE

Pump Removal

The pump assembly can be readily removed from the well casing if necessary. The pump and tube bundle are not heavy for the shallow to moderately deep wells, although the length and stiffness of the tubing can be awkward unless properly handled. Care should also be exercised to keep all portions of the assembly from coming into contact with the ground or any other source of contamination. It is also advisable to wear protective gloves and clothing to prevent dermal contact with the pump or any surfaces which have contacted water in the well.

To remove the pump assembly, we recommend obtaining a large-diameter wooden spool or other cylindrical reel onto which the tube bundle may be wound. Support the spool on a pipe, or other device as an axle. The spool may thus be supported on the back of a pickup truck or van, or between any two stable uprights. A special stand for removing pumps set greater than 250 feet deep would aid in removing these heavier pumps.

Lift the landing plate directly off the top of the 2-inch well casing. If possible, position the landing plate on the spool such that the remainder of the tube bundle will not block access to the intake and discharge tubes protruding from the landing plate. This will enable the pump to be operated at the land surface, if required.

The pump and tube bundle may now be pulled out of the well and wound onto the spool. Once removed from the well, the pump may be inspected for clogging or other problems. Refer to Section IV for detailed pump disassembly and maintenance instructions.

Maintenance

The sample pump should operate trouble-free for extended periods without maintenance. The only parts subject to significant wear are the O-rings and seals in the pumps. Sample discharge rate may significantly decrease if these parts are worn or damaged. If sample discharge rate is very low even while the pump is cycling, these parts may need to be replaced. The pump should then be removed from the well and repaired.

Replacement seals and rings are readily available from the manufacturer, and can be installed in the field relatively quickly. The pumps can also be returned to the manufacturer for these repairs with a one to two-day turn-around time.

Detailed instructions for inspecting and replacing these pump components are provided in Section IV.

APPENDIX I

BENNETT SAMPLE PUMP MANUAL

BENNETT

SAMPLE

PUMPS

U.S. PATENT NO. 4295801

Canadian Patent Nos. 1166075 & 1187331

Manufactured By

ROBERT BENNETT COMPANY

AMARILLO, TEXAS U.S.A.

806-352-0264

P.O. Box 7644
Amarillo, Texas 79114

BENNETT SAMPLE PUMPS

Operating Instructions

The Bennett Sample Pumps are air operated and have a double acting, automatic reciprocating, piston type air motor (upper section) which drives a double acting piston type fluid pump (lower section). Rod seals between the air motor and the pump are used to prevent air contacting the fluid sample being pumped.

The automatic reciprocation of this pump is achieved by a patented valving mechanism that is an integral part of the air motor. This design provides an air motor that is easily controlled to operate at minimum to maximum cycle rates by adjusting the driving pressure. The cycle of the air motor is directly proportional to the pumping rate.

Pressurized air is supplied to the motor by plastic tubing in the tube bundle and the exhaust air is carried to the surface and released to atmosphere by another plastic tube.

The air motor does not generate elevated temperatures when operating and can be operated above water level, partially submerged, or fully submerged to depths of 500 feet.

Bennett Sample Pump units are fully assembled and performance tested prior to shipment. This service provides the operator with a unit that is properly connected and ready for operation.

We recommend operating the pump in a container of water prior to field use. This will enable the operator to become familiar with the operation of the pump.

COMPLETE THE FOLLOWING PROCEDURES TO PREPARE FOR OPERATING THE PUMP

1. Attach the air supply line (coiled at the rear of the instrument console) to your source of compressed air.
   NOTE: Air supply source should not exceed 150 psi.

2. The toggle switch located on the instrument panel activates the water level indicator system. Turn the switch to the "ON" position.

3. Place the pump in a container of water. The pulsating sonar alarm will sound when the water level probe (located in the top of the pump) contacts water. Raising the probe slightly above water level will cause the sonar to stop sounding.
   NOTE: The alarm can be turned to the "OFF" position after the water level is reached to conserve the replaceable 6 volt battery located inside the console.

4. The air pressure for pump operation is supplied and controlled by the adjustable pressure regulator located on the instrument panel. (Yellow knob directly below pressure gauge)

Regulator Operation

Pull yellow cap "OUT" to unlock
Push yellow cap "IN" to lock
With cap unlocked - Turn clockwise to increase pressure and counter clockwise to decrease pressure and to turn air off.

5. Use the air pressure regulator to begin pump operation by slowly increasing the air pressure, indicated by the pressure gauge on the panel, until the pump begins cycling.
NOTE: Allow a few minutes for the water discharge tube to fill and the flowmeter to begin operating.
There will be a time lapse between pump start-up and water flow registering on the flowmeter. The following procedures can be used to determine when the pump starts cycling:

A. Listen for a soft clicking sound (when in container)
B. Observe the pressure gauge for a slight needle fluctuation as the pump cycles.
C. Place the end of the water discharge tube (attached to the top of flowmeter) in a container of water Continous bubbling will occur as the water is filling the discharge tube.
D. Place finger over the air exhaust line (open end tube located inside the reel core). A slight air flow indicates pump cycling has begun.

Any of the methods suggested above may be used to determine pump cycling prior to a flow of water through the meter on the panel.

6. The following methods should be used for regulating the flow rate when water is flowing through the meter.

Increase the air pressure driving the pump to increase the flow rate.

Decrease the air pressure driving the pump to decrease flow rate.

7. The pump units are equipped with flow meters that have adjustable valves (black knob at bottom of meter) that can be used to obtain extremely low flow rates when desired.

Flow Meter Valve Operation

Turn knob counter clockwise several rounds for full open position.

Turn valve clockwise for restricted to fully closed position.

A. For extremely low flow rates, reduce the air pressure to the pump to obtain the lowest steady pump cycle rate.
B. Turn the flow meter valve toward the closed position to produce steady flow rates as low as a few drops per minute.
NOTE: When maximum pumping rates are desired, the flow meter valve should be in the full open position.

Maximum Recommended Pumping Rates for Bennett Sample Pump Units

Model No.	Pumping Rate	Air Requirements
180-125	60 gph	1.5 cfm @ 50
180-250	50 gph	1.8 cfm @ 75
180-375	45 gph	2.0 cfm @ 100
180-500	40 gph	2.2 cfm @ 125
180-625	35 gph	2.5 cfm @ 150

The air requirements shown above are approximate values required to obtain the recommended pumping rates shown for the maximum pumping lift capabilities of each model. The air pressure should be reduced when operating at lower pumping lifts, to maintain the recommended maximum pump flow rates.

The Bennett Sample Pump Units are designed for maximum operator convenience in field pumping applications. The tube bundle reel is an important part of each unit. It is used to store the coiled tube bundle and for raising and lowering the pump in the borehole.

Reel Features

The reels are equipped with a sprocket and chain drive system that has a reduction ratio for easy operation with a hand crank. Each drive system has a slide bolt lock (located at lower end of chain guard) for positive positioning of the pump. The drive system has a handbrake (handle extending from top of chain guard) that can be used for lowering the pump into the borehole.

Each reel is equipped with a dual gland rotary seal (located on axle inside console). One gland of the rotary seal supplies compressed air for operation of the pump and the other gland transmits water from the tube bundle to the flow meter. The rotary seal eliminates the need for disconnecting any lines when raising or lowering the pump in the borehole. This feature permits changing the pump to different settings while the pump is operating if desired.

The guide roller head with tube bundle measuring wheel and counter is another convenience feature of each pump unit. Use the bundle measuring system in this manner:

A. Lower the pump into the borehole until the white band marked "10 ft." is over the center of the aluminum measuring wheel. The marked band is set at 10 feet from the water level probe in the top of the pump.

B. Lift the tube bundle until it no longer contacts the measuring wheel. Roll the measuring wheel (forward or back) until the mechanical counter located to the side of the wheel reads "10.0" and place the tube bundle back on the measuring wheel. The measuring system register will show pump settings in "Feet and Tenth's of Feet". The counter will count back to the original reading as the tube bundle is raised from the borehole.

Pump Operation in the Field

The following procedures should be used for field pumping operations:

1. Lower the pump and tube bundle into the borehole until the white band marked "10 ft" is centered over the measuring wheel. Set the counter to read 10.0 using the method previously described.

2. Turn the water level indicator switch to the "ON' position.

3. Release the slide bolt lock and continue lowering the pump into the borehole. The handbrake may be used for controlling speed and stopping the reel.

4. The pulsating sonar alarm will sound when the water level is reached and a depth reading can be taken from the counter. The water level indicator can be turned "OFF" and the pump can be submerged to the desired setting. Engage the reel lock to hold this position.

5. Turn the air pressure on and adjust the regulator to obtain the desired pumping rate using the method described under Regulator Operation and Flow Meter Valve Operation.
   NOTE: The pump will begin cycling in the borehole with no water in the discharge tube at approximately the same air pressure required for operation in the container of water on the surface. The air pressure should be slowly increased as the pump begins lifting water in order to provide additional power to the pump and maintain lift and flow rate.

The following methods can be used for cleaning and flushing the pump unit:

1. The tube bundle and pump can be spray washed for external cleaning. Use an air nozzle to blow residual fluid from the tube recesses in the sidewalls of the pump. The pump filter screen can be removed for cleaning by removing the cap screw located at the extreme bottom of the pump filter shroud.

2. The pump system can be cleaned and flushed internally .

   A. Remove the filter screen housing from the bottom of the pump. (1/8" pipe threads)
   B. Attach a hose to the suction inlet of the pump and supply flushing fluid under pressure. More thorough flushing can

be accomplished by allowing the pump to cycle slowly for a few minutes while the flushing fluid is flowing.

C. Compressed air or nitrogen can be used to expel the fluid from the pump system using the method described above.

Flushing and purging the pump system can be accomplished <u>only</u> as described above. <u>The pump check valves will not permit reverse flow.</u>

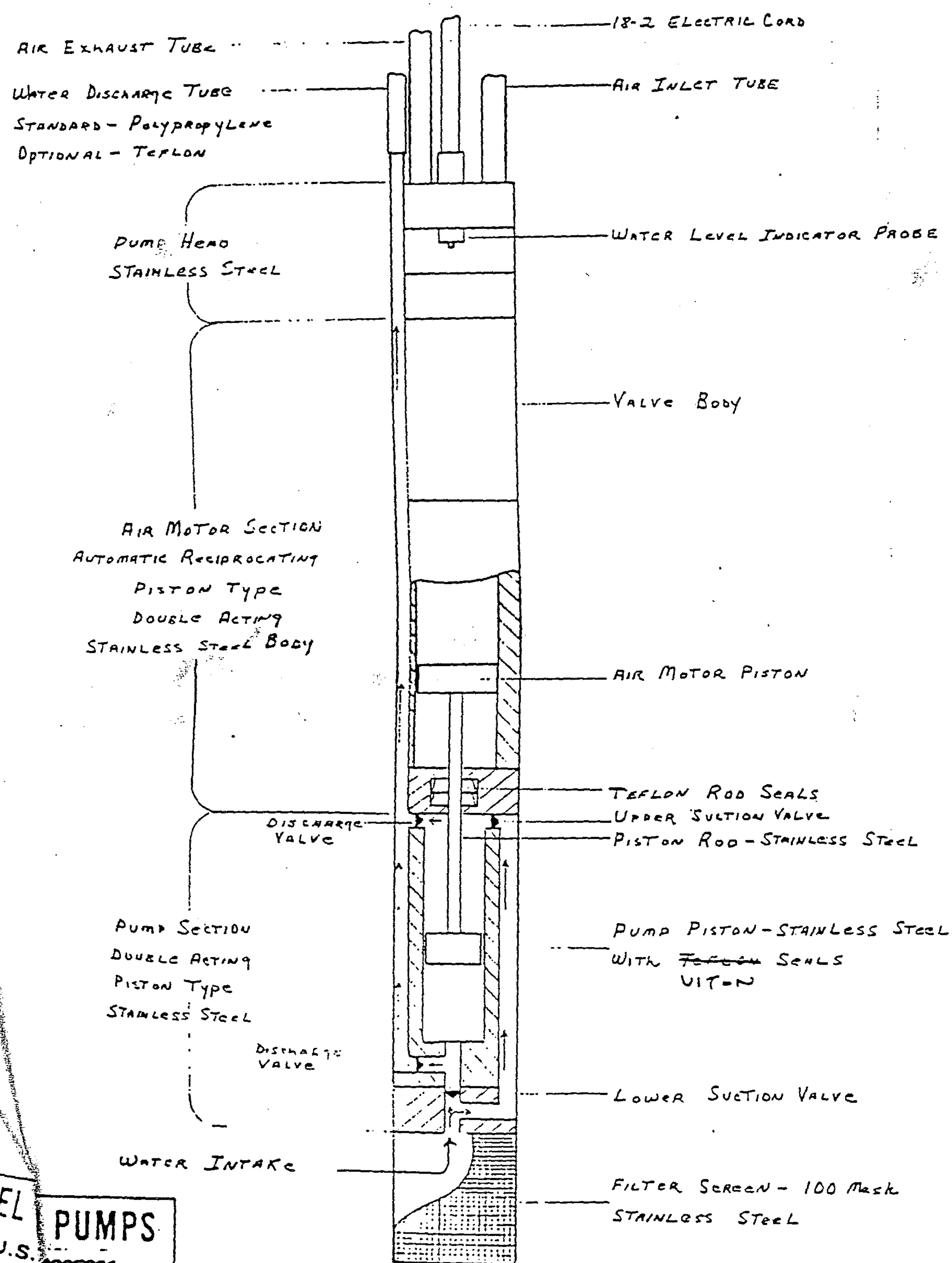
CAUTION: Purging the pump system of fluid with air or nitrogen is a necessity when the pump is not in use and is subject to subfreezing temperatures.

MANUFACTURE AND SALES

ROBERT BENNETT COMPANY

POST OFFICE BOX 7644
AMARILLO, TEXAS 79109
806-352-0264

BENNETT SAMPLE PUMPS



BENNETT SAMPLE PUMPS

U.S. PATENT No. 4295801
CANADIAN PATENT NO. 1166075

Manufactured By
ROBERT BENNETT COMPANY
AMARILLO, TEXAS U.S.A.
806-352-0264

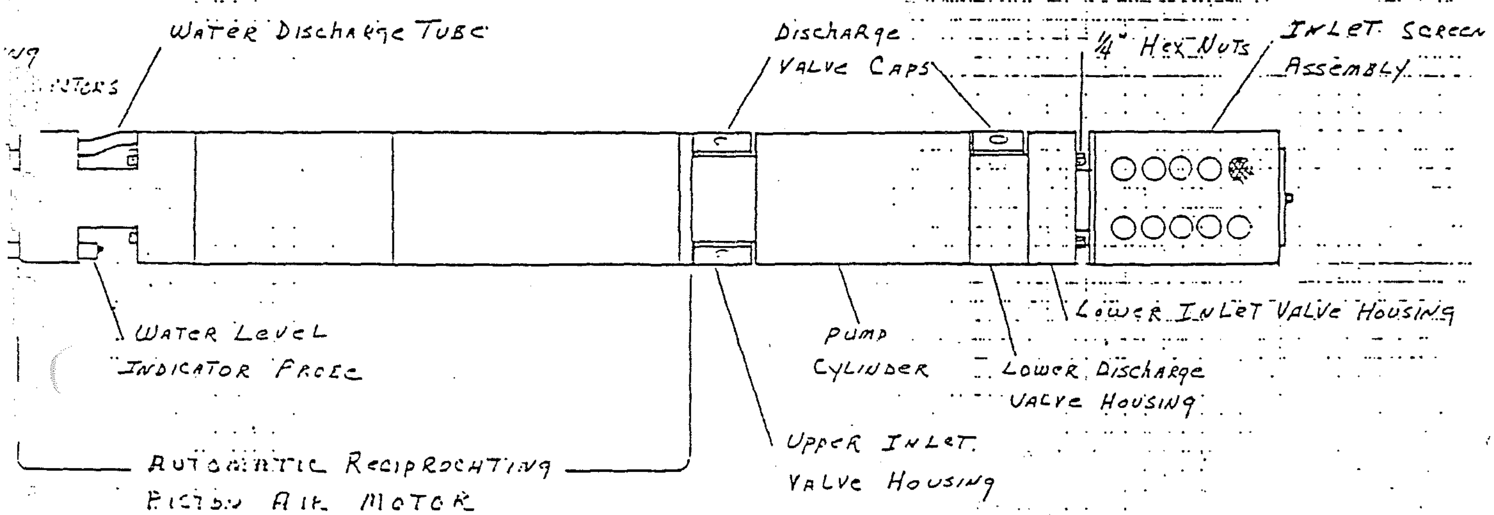


Figure 1 - Assembly View

Model 180 Pump

Figure 1 is an assembly view of the Model 180 pump identifying the pump body parts. The following pages contain step by step instructions for dis-assembly of the pump for cleaning and/or replacement of piston seals, rod seals and valves.

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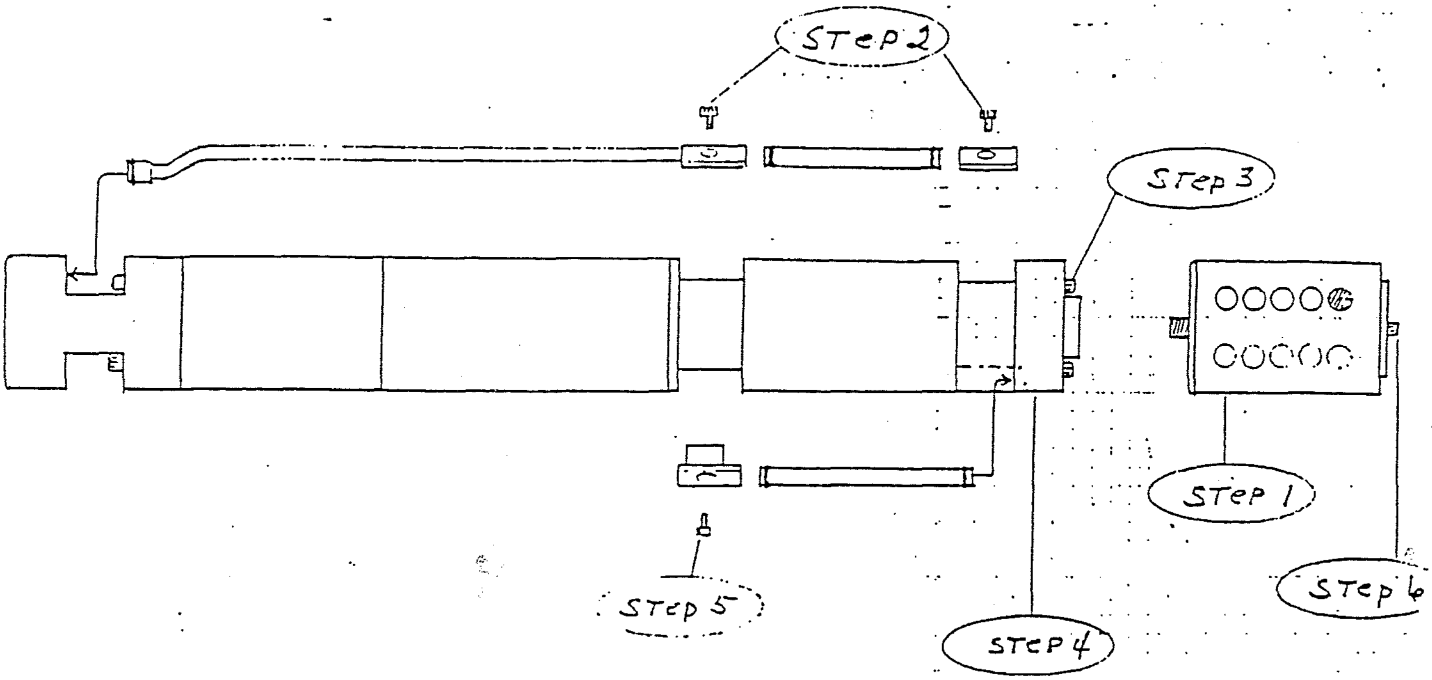

FIGURE 2

Figure 2. Dis-assembly Procedures

Step 1. Remove the inlet screen assembly from the pump. (1/8" pipe threads)

2. Remove the four cap screws, recessed in the discharge valve caps. Lift the valve caps upward until they clear the pump body and pull the discharge tube from the socket at the top end of the pump.

3. Remove the four 8-32 hex nuts from the stud bolts.

4. Slide the lower suction valve housing from the stud bolts.

5. Remove the 2 cap screws, recessed in the upper suction valve housing, and lift the part from the pump.

6. Remove the cap screws at the end of the inlet screen for removing the screen element. The screen may be cleaned by using a stiff brush and water.

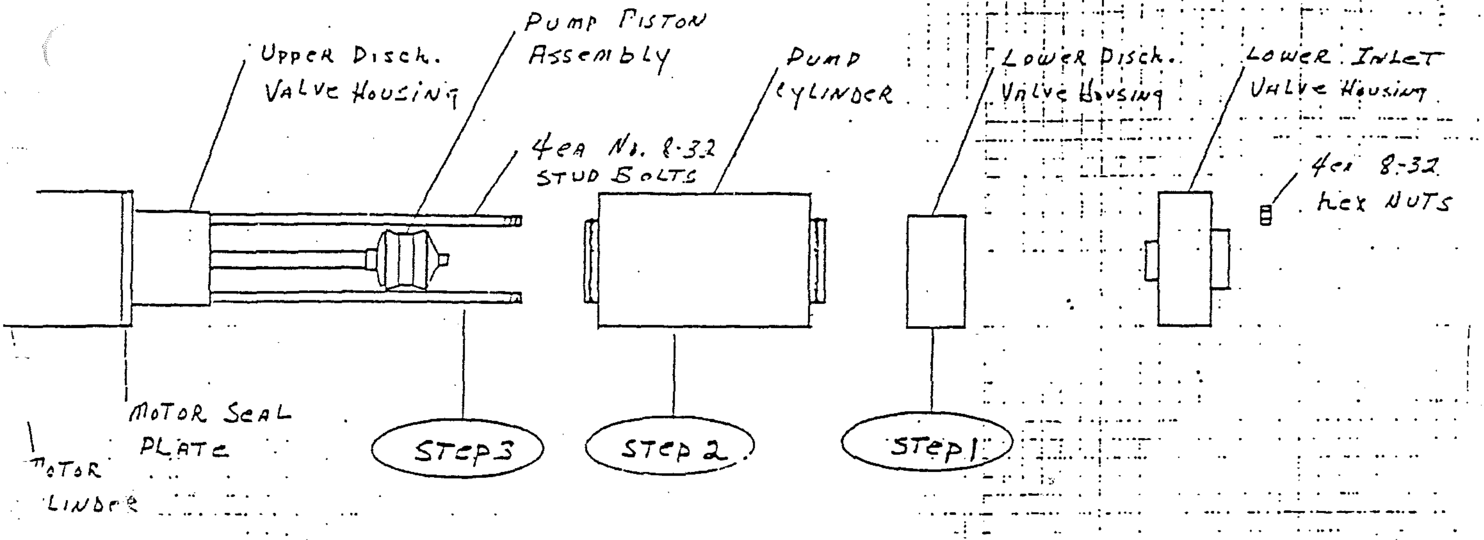

FIGURE 3

Figure 3.

Step 1. Slide the lower discharge valve housing from the stud bolts.

2. Slide the pump cylinder from the stud bolts, exposing the pump piston.

3. Remove all four 8-32 stud bolts from the pump body in order to replace the piston seals.

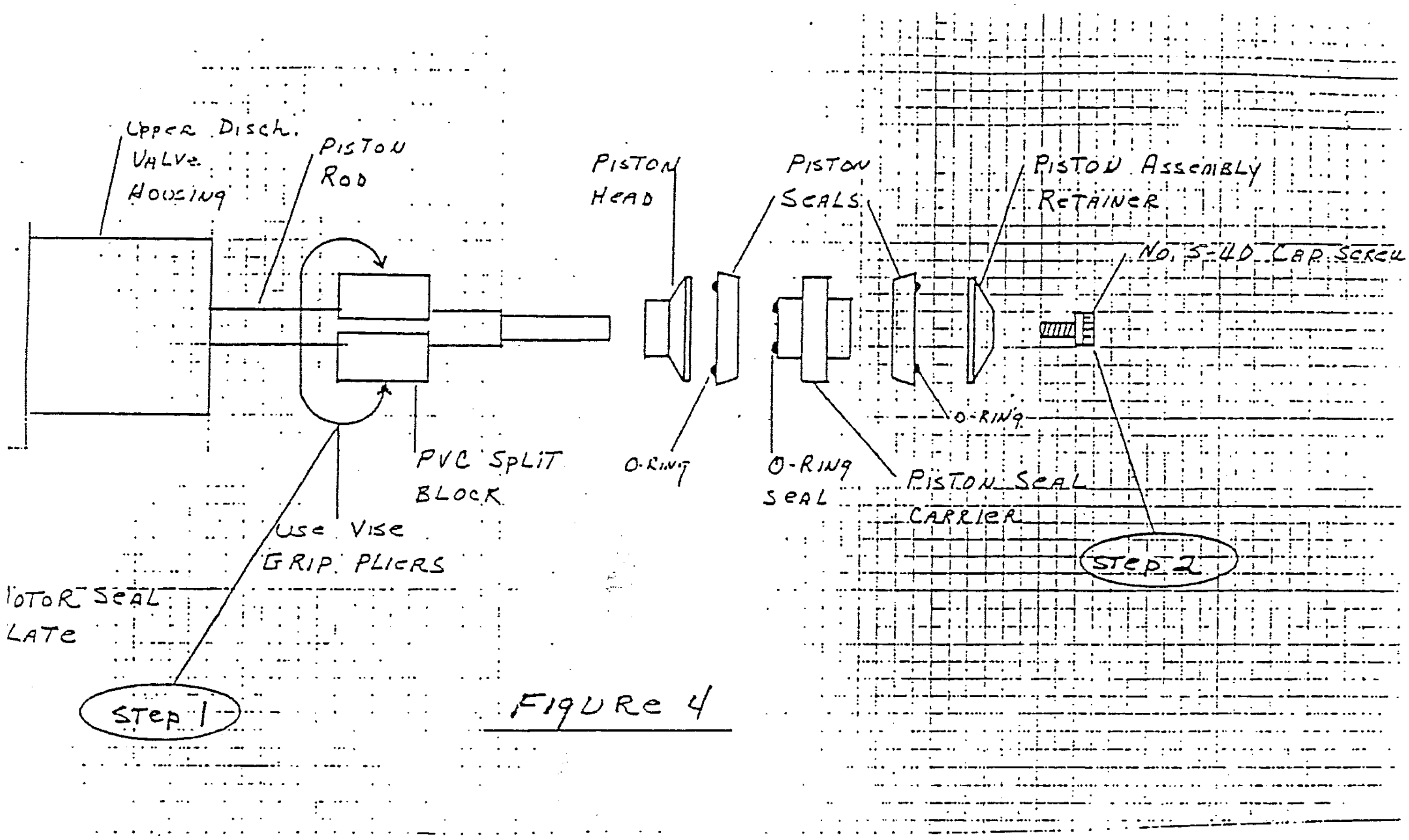

Figure 4.

Step 1. Place split block (PVC plastic provided in repair kit) around piston rod as shown. Pull piston outward if rod is not extended sufficiently. Grip split block with vise-grip pliers.

2. Remove the no. 5-40 cap screws and slide the piston assembly from the rod.
Note: When replacing the piston seals be sure the new seals are facing in opposite directions as shown.

The piston seal carrier may be turned in either direction.

Remove the vise-grip pliers and split block from the piston rod and proceed to Figure 5 for rod seal replacement.

Caution: Never grip the piston rod directly with pliers as this will cause damage to the rod finish. The rod operates through seals that prevent water from entering the air motor.

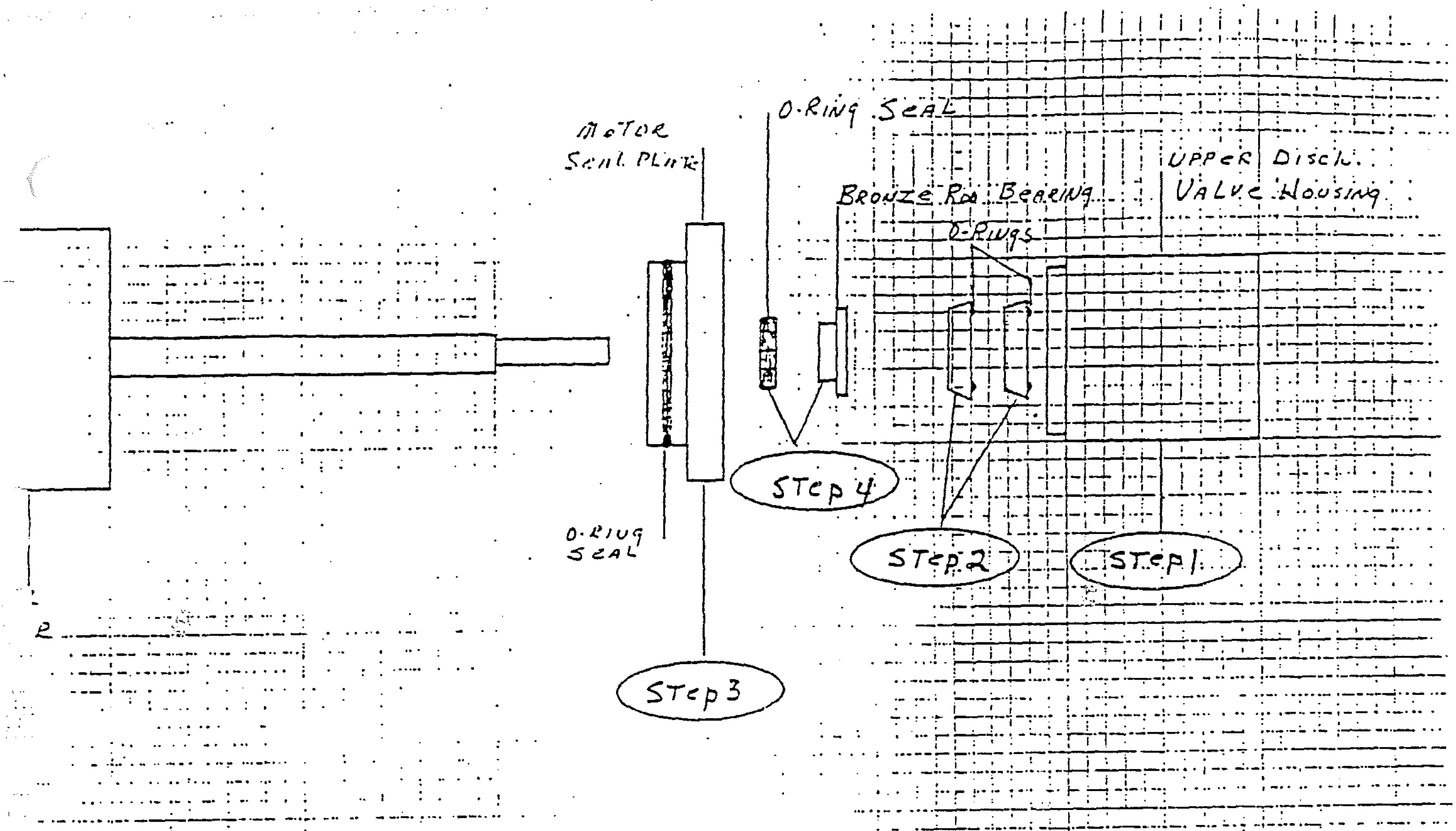

Figure 5

Figure 5.

Step 1. Remove the upper discharge valve housing from the piston rod.

2. Remove the piston rod seals from valve housing
   Note: Be sure to install both seals as shown when replacing the rod seals.

3. Remove the seal plate from lower end of air motor cylinder.

4. Remove the bronze rod bearing and o-ring seal from seal plate.

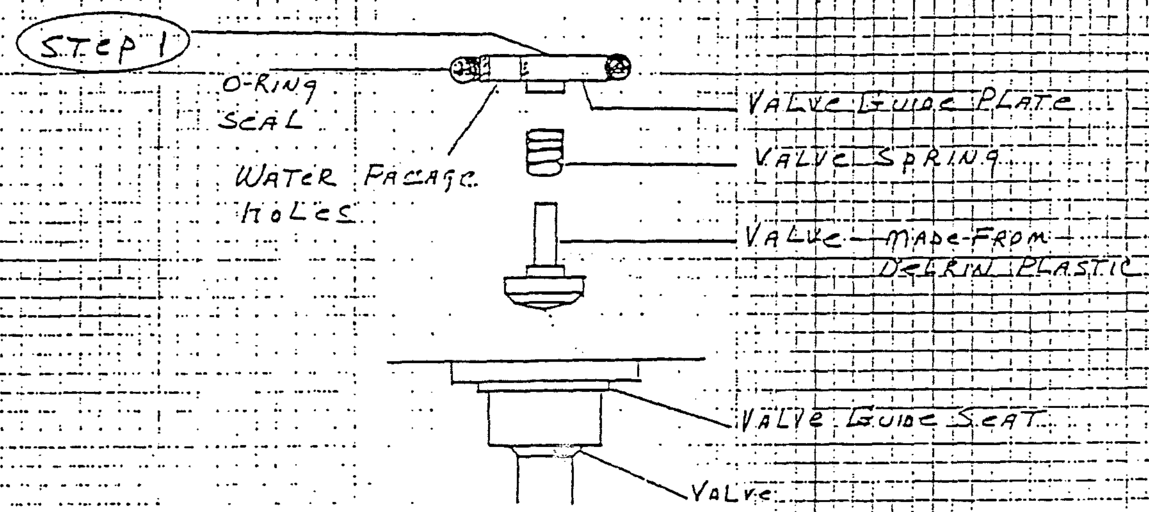

Figure 6 - Pump Valve Detail

Figure 6.

Step 1. Remove the valve guide plate from its seat by pulling upward. The plate is held in place by the o-ring seal. (Be careful not to loose the small valve springs.)

Note: The model 180 pump is double acting and therefore has an inlet and discharge valve for each end of the pump cylinder. All four valves are interchangeable.

Proceed as follows after pump has been dis-assembled:

1. Clean all parts in preparation for re-assembly.

2. The model 180 pump repair kit contains replacements for the pump valves, piston seals, rod seals, tube seals, and cylinder seals. Examine the tube seals and the cylinder seals. If there are no nicks or cuts in the o-rings, they may be reused.

3. The pump valves and springs may be re-used if they appear to be clean and undamaged.

4. The pump piston seals and rod seals are the most affected by wear during pumping because of the solid particles present in many boreholes. These seals should be replaced when the pumping rate shows a significant decline.

5. Determine which parts are to be replaced and proceed with re-assembly in essentially the reverse of dis-assembly procedure.

Service Notes:

A. A very small amount of silicone grease may be used to coat the o-ring rod seal before installation.

B. The cup type rod seals and piston seals do not require lubrication other than the water being pumped.

C. The o-ring tube seals and cylinder seals may be lubricated slightly for ease of installation.

D. The pump valves should be installed completely free of any kind of grease or lubricant to prevent restricting the valve movement.

E. The hex nuts and cap screws should be tightened using only moderate torque.

F. The inlet screen assembly may be tightened by hand using heavy torque.

Place the pump in a container of water after it has been re-assembled and allow it to operate for 10 to 15 minutes to allow the new seals a break in period.

APPENDIX II

PUMP MAINTENANCE RECORDS

APPENDIX II

PUMP MAINTENANCE RECORDS

It is advisable to keep maintenance records for each pump. A blank sample form is attached for your use if desired. Also attached are maintenance records for a number of wells which have already exhibited some problem.

SAMPLE

MIDWAY LANDFILL
Pump Maintenance Record

Well No.: ____

Pump Depth: _____

Date	Name	Action

APPENDIX C

Field Forms

Well #: ____________

Sample #: __________

Groundwater Sampling Field Data Sheet

Project Number: ______________________ Date: ______________________

Project Name: ______________________ Location: ______________________

Project Address: ______________________ Sampled By: ______________________

Client Name: ______________________ Purged By: ______________________

Casing Diameter: 2" __________ 4" __________ 6" __________ Other ______________

Depth to Water (feet): ______________________ Purge Volume Measurement Method: ______________

Depth of Well (feet): ______________________ Date Purged: ______________________

Reference Point (surveyors notch, etc.): ______________ Purge Time (from/to): ______________

Date/Time Sampled: ______________________

Purge Volume Calculation: $(\pi r^2 h)(7.48\ \text{gal/ft}^3)(5\ \text{casing volumes})$

Purge Volume (gallons) for: 2" = (0.80)(h); 4" = (3.26)(h); 6" = (7.40)(h)

Calculated Purge Volume (gallons): __________ Actual Purge Volume (gallons): __________

TIME (2400 hr)	CUMULATIVE VOLUME (gal)	PH (units)	Ec (µmhos/cm 25° c)	COLOR (visual)	TURBIDITY (visual)	ODOR	OTHER

Purging Equipment: ______________________ Sampling Equipment: ______________________

Laboratory: ______________________ Date Sent to Lab: ______________________

Chain-of-Custody (yes/no): ______________ Field QC Sample Number: ______________

Shipment Method: ______________________ Split with (name(s)/organization(s)): ______________

Well Integrity: ______________

Remarks: ____

____

____

____

____

____

____

Signature: ______________________ Page ____ of ______

Chain of Custody Record & Laboratory Analysis Request

Date ____________

Page ________ of ________

Number of coolers: ________

Cooler Temp: ____________

Analytical Resources, Incorporated
Analytical Chemists and Consultants
400 Ninth Avenue North
Seattle, WA 98109-4708
(206) 621-6490
(206) 621-7523 (Fax)

ARI Client: Phone#:

Client Contact:

Client Project ID:

Samplers:

	Sample ID	Date	Time	Matx	No Cont	Lab ID	Analysis Required								Notes/Comments
1															
2															
3															
4															
5															
6															
7															

ARI Project No:	Relinquished by: (Signature)	Relinquished by: (Signature)	Relinquished by: (Signature)
T.A.T. Requested:	Printed Name:	Printed Name:	Printed Name:
Comments/Special Instructions:	Company:	Company:	Company:
	Date: Time:	Date: Time:	Date: Time:
	Received by: (Signature)	Received by: (Signature)	Received by: (Signature)
	Printed Name:	Printed Name:	Printed Name:
	Company:	Company:	Company:
	Date: Time:	Date: Time:	Date: Time:

Limits of Liability: ARI will perform all requested services in accordance with appropriate methodology following Standard Operating Procedures and our Quality Assurance Program. This program meets standards for the industry. The total liability of ARI, its officers, agents, employees, or successors, arising out of or in connection with the requested services, shall not exceed the invoiced amount for said services. The acceptance by the client of a proposal for services by ARI releases ARI from any liability in excess thereof, not withstanding any provision to the contrary in any contract, purchase order or co-signed agreement between ARI and the client.

Midway Groundwater / Oil Thickness Measurements

ate: **Job No:**

Present at Site: **Location:**

DATE	WELL NO.	DEPTH TO WATER	WELL DEPTH	MEASURING POINT	COMMENTS
	2				
	5				
	7				
	8				
	13				
	14				
	20				
	24				
	26				
	27				
	29				
	30				
	35S				
	36D				
	38D				
	40D				
	45D				
	48S				
	49D				
	50S				
	52S				
	53D				
	54D				
	55				
	56S				
	56D				

Copies to PMX

Signed:

Midway Groundwater / Oil Thickness Measurements

te: Job No:

Present at Site: Location:

DATE	WELL NO.	DEPTH TO WATER	WELL DEPTH	MEASURING POINT	COMMENTS
	AN-M				
	AO-M				
	AR-M				
	AV-S				
	AW-S				
	AM-M				
	PA2-S				
	PA3-S				
	PA4-S				
	PA5-S				
	PA6-S				
	PC-4S				
	PC-6S				
	PC-7S				
	PD-1S				
	PD-3S				
	PD-7S				
	PD-10S				
	PD-11S				
	TW-1				
	LW-1				
	MW19-A				
	MW19-B				
	MW19-C				

Copies to PMX

Signed:

Midway Groundwater / Oil Thickness Measurements

.te: **Job No:**

Present at Site: **Location:**

DATE	WELL NO.	DEPTH TO WATER	WELL DEPTH	MEASURING POINT	COMMENTS
	MW-2				
	MW-4				
	MW-7A				
	MW-7B				
	MW-8A				
	MW-8B				
	MW-9A				
	MW-11A				
	MW-13A				
	MW-13B				
	MW-14B				
	MW-15A				
	MW-16				
	MW-17A				
	MW-17B				
	MW-18A				
	MW-20A				
	MW-20B				
	MW-21A				
	MW-21B				
	MW-23A				
	MW-23B				
	MW-24A				
	MW-24B				
	MW-26				
	MW-27A				
	MW-28				
	MW-29A				
	MW-29B				
	MW-30A				
	MW-30B				
	MW-30C				

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Signed:

way ... Jun... ter / ... Thi... ss Measurements ... Present at site:

Date	Well #	Well Depth	*Previous D.T.F.	Sounder On	Sounder Off	*Oil Cut	Difference	*Oil Thickness	*D.T.F.	Color	Comment
	16										
	17										
	21										
	23										
	31										
	32										
	33										
	39D										
	41D										
	41S										
	42D										
	43D										
	44D										
	46D										
	47D										
	50D										
	54S										
	PA1S										
	PD4S										
	LW-2										

* DTW: Depth to Water
* DTF: Depth to Fluid = DTW minus oil thickness (Units - Feet)
* Sounder On: Where probe clears possible oil on descent into water
* Sounder Off: Where probe clears possible oil on ascent from water
* Oil Cut: Measurement of oil on cable to end of probe, less tip
* Difference: Sounder On minus Sounder Off

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SIGNED: JOB NO:

APPENDIX D

Standard Probe Testing Time Table

Standard Probe Testing Time Table

For

Midway Landfill

Seattle Public Utility
Solid waste field operation
Landfill closure

May 26, 1999

Standard Probe Testing Time Table

Pressure		29-S		31-S		32-S		34-S		35-S	
(In/Wc)	Cap.	1/2	3.5	1/2	5.5	1/2	3.5	1/2	6.5	1/2	6.0
0.0	859		0.16		0.25		0.16		0.29		0.27
-5.0	841		0.16		0.25		0.16		0.30		0.28
-10.0	823		0.16		0.26		0.16		0.30		0.28
-15.0	804		0.17		0.26		0.17		0.31		0.29
-20.0	771		0.18		0.28		0.18		0.33		0.30
-25.0	736		0.18		0.29		0.18		0.34		0.31
-30.0	695		0.19		0.31		0.19		0.36		0.33
-35.0	656		0.21		0.32		0.21		0.38		0.35
-40.0	615		0.22		0.35		0.22		0.41		0.38
-45.0	575		0.23		0.37		0.23		0.44		0.40
-50.0	535		0.25		0.40		0.25		0.47		0.43

Pressure		37-S		37-M		37-D		39-S		43-S	
(In/Wc)	Cap.	1/2	4.3	1/2	30.0	1/2	58.0	1/2	6.2	1/2	6.3
0.0	859		0.19		1.35		2.61		0.28		0.28
-5.0	841		0.20		1.38		2.66		0.28		0.29
-10.0	823		0.20		1.41		2.72		0.29		0.30
-15.0	804		0.21		1.44		2.78		0.30		0.30
-20.0	771		0.22		1.50		2.90		0.31		0.32
-25.0	736		0.23		1.57		3.04		0.33		0.33
-30.0	695		0.24		1.67		3.22		0.34		0.35
-35.0	656		0.25		1.76		3.41		0.36		0.37
-40.0	615		0.27		1.88		3.64		0.39		0.40
-45.0	575		0.29		2.01		3.89		0.42		0.42
-50.0	535		0.31		2.16		4.18		0.45		0.45

Standard Probe Testing Time Table

Pressure		44-S		44-M		44-D		45-S		45-M		45-D		46-S	
(In/Wc)	Cap.	1/2	6.3	1/2	20.0	1/2	72.0	1/2	6.1	1/2	20.0	1/2	65.0	1/2	6.4
0.0	859		0.28		0.90		3.23		0.27		0.90		2.92		0.29
-5.0	841		0.29		0.92		3.30		0.28		0.92		2.98		0.29
-10.0	823		0.30		0.94		3.38		0.29		0.94		3.05		0.30
-15.0	804		0.30		0.96		3.46		0.29		0.96		3.12		0.31
-20.0	771		0.32		1.00		3.60		0.31		1.00		3.25		0.32
-25.0	736		0.33		1.05		3.78		0.32		1.05		3.41		0.34
-30.0	695		0.35		1.11		4.00		0.34		1.11		3.61		0.36
-35.0	656		0.37		1.18		4.24		0.36		1.18		3.82		0.38
-40.0	615		0.40		1.26		4.52		0.38		1.26		4.08		0.40
-45.0	575		0.42		1.34		4.83		0.41		1.34		4.36		0.43
-50.0	535		0.45		1.44		5.19		0.44		1.44		4.69		0.46

Pressure		49-S		50-S		50-M		50-D		58-S	
(In/Wc)	Cap.	1/2	6.2	1/2	6.3	1/2	20.0	1/2	70.0	1/2	6.2
0.0	859		0.28		0.28		0.90		3.14		0.28
-5.0	841		0.28		0.29		0.92		3.21		0.28
-10.0	823		0.29		0.30		0.94		3.28		0.29
-15.0	804		0.30		0.30		0.96		3.36		0.30
-20.0	771		0.31		0.32		1.00		3.50		0.31
-25.0	736		0.33		0.33		1.05		3.67		0.33
-30.0	695		0.34		0.35		1.11		3.89		0.34
-35.0	656		0.36		0.37		1.18		4.12		0.36
-40.0	615		0.39		0.40		1.26		4.39		0.39
-45.0	575		0.42		0.42		1.34		4.70		0.42
-50.0	535		0.45		0.45		1.44		5.05		0.45

Standard Probe Testing Time Table

Pressure		59-S		59-M		59-D		60-S		61-S		64-S		69-S	
(In/Wc)	Cap.	1/2	6.0	1/2	21.0	1/2	69.0	1/2	6.2	1/2	6.3	1/2	6.3	1/2	6.3
0.0	859		0.27		0.94		3.10		0.28		0.28		0.28		0.28
-5.0	841		0.28		0.96		3.17		0.28		0.29		0.29		0.29
-10.0	823		0.28		0.98		3.24		0.29		0.30		0.30		0.30
-15.0	804		0.29		1.01		3.31		0.30		0.30		0.30		0.30
-20.0	771		0.30		1.05		3.45		0.31		0.32		0.32		0.32
-25.0	736		0.31		1.10		3.62		0.33		0.33		0.33		0.33
-30.0	695		0.33		1.17		3.83		0.34		0.35		0.35		0.35
-35.0	656		0.35		1.24		4.06		0.36		0.37		0.37		0.37
-40.0	615		0.38		1.32		4.33		0.39		0.40		0.40		0.40
-45.0	575		0.40		1.41		4.63		0.42		0.42		0.42		0.42
-50.0	535		0.43		1.51		4.98		0.45		0.45		0.45		0.45

Pressure		76-S		76-M		76-D		79-S		79-M		79-D	
(In/Wc)	Cap.	1/2	6.3	1/2	20.0	1/2	71.0	1/2	6.0	1/2	36.0	1/2	70.0
0.0	859		0.28		0.90		3.19		0.27		1.62		3.14
-5.0	841		0.29		0.92		3.26		0.28		1.65		3.21
-10.0	823		0.30		0.94		3.33		0.28		1.69		3.28
-15.0	804		0.30		0.96		3.41		0.29		1.73		3.36
-20.0	771		0.32		1.00		3.55		0.30		1.80		3.50
-25.0	736		0.33		1.05		3.72		0.31		1.89		3.67
-30.0	695		0.35		1.11		3.94		0.33		2.00		3.89
-35.0	656		0.37		1.18		4.18		0.35		2.12		4.12
-40.0	615		0.40		1.26		4.46		0.38		2.26		4.39
-45.0	575		0.42		1.34		4.77		0.40		2.42		4.70
-50.0	535		0.45		1.44		5.12		0.43		2.60		5.05

Standard Probe Testing Time Table

Pressure		80-M		80-D		81-M		81-D		82-S		82-M		82-D	
(In/Wc)	Cap.	1/2	12.0	1/2	68.0	1/2	19.0	1/2	64.0	1/2	9.0	1/2	29.0	1/2	76.0
0.0	859		0.54		3.05		0.85		2.88		0.40		1.30		3.41
-5.0	841		0.55		3.12		0.87		2.94		0.41		1.33		3.49
-10.0	823		0.56		3.19		0.89		3.00		0.42		1.36		3.56
-15.0	804		0.58		3.26		0.91		3.07		0.43		1.39		3.65
-20.0	771		0.60		3.40		0.95		3.20		0.45		1.45		3.80
-25.0	736		0.63		3.57		1.00		3.36		0.47		1.52		3.98
-30.0	695		0.67		3.78		1.06		3.55		0.50		1.61		4.22
-35.0	656		0.71		4.00		1.12		3.77		0.53		1.71		4.47
-40.0	615		0.75		4.27		1.19		4.02		0.56		1.82		4.77
-45.0	575		0.81		4.56		1.28		4.30		0.60		1.95		5.10
-50.0	535		0.87		4.91		1.37		4.62		0.65		2.09		5.48

Pressure		85-M		85-D		87-S		87-M		87-D	
(In/Wc)	Cap.	1/2	44.0	1/2	78.4	1/2	8.1	1/2	25.5	1/2	68.9
0.0	859		1.98		3.52		0.36		1.15		3.10
-5.0	841		2.02		3.60		0.37		1.17		3.16
-10.0	823		2.06		3.68		0.38		1.20		3.23
-15.0	804		2.11		3.76		0.39		1.22		3.31
-20.0	771		2.20		3.92		0.41		1.28		3.45
-25.0	736		2.31		4.11		0.42		1.34		3.61
-30.0	695		2.44		4.35		0.45		1.42		3.83
-35.0	656		2.59		4.61		0.48		1.50		4.05
-40.0	615		2.76		4.92		0.51		1.60		4.32
-45.0	575		2.95		5.26		0.54		1.71		4.62
-50.0	535		3.17		5.66		0.58		1.84		4.97

Standard Probe Testing Time Table

Pressure (In/Wc)	Cap.	88-S 1/2	5.4	88-M 1/2	19.9	88-D 1/2	53.8	AF-S 1/2	7.5	AF-M 3/4	35.0	AF-D 3/4	96.0
0.0	859		0.24		0.89		2.42		0.34		3.54		9.70
-5.0	841		0.25		0.91		2.47		0.34		3.61		9.91
-10.0	823		0.25		0.93		2.52		0.35		3.69		10.13
-15.0	804		0.26		0.96		2.58		0.36		3.78		10.37
-20.0	771		0.27		1.00		2.69		0.38		3.94		10.81
-25.0	736		0.28		1.04		2.82		0.39		4.13		11.33
-30.0	695		0.30		1.10		2.99		0.42		4.37		11.99
-35.0	656		0.32		1.17		3.16		0.44		4.63		12.71
-40.0	615		0.34		1.25		3.38		0.47		4.94		13.55
-45.0	575		0.36		1.34		3.61		0.50		5.29		14.50
-50.0	535		0.39		1.44		3.88		0.54		5.68		15.58

Pressure (In/Wc)	Cap.	AG-S 1/2	6.0	AG-D 3/4	33.0	AI-S 1/2	27.0	AI-M 1/2	47.0	AI-D 1/2	93.0
0.0	859		0.27		3.34		1.21		2.11		4.18
-5.0	841		0.28		3.41		1.24		2.16		4.27
-10.0	823		0.28		3.48		1.27		2.20		4.36
-15.0	804		0.29		3.56		1.30		2.26		4.46
-20.0	771		0.30		3.72		1.35		2.35		4.66
-25.0	736		0.31		3.89		1.42		2.46		4.88
-30.0	695		0.33		4.12		1.50		2.61		5.16
-35.0	656		0.35		4.37		1.59		2.76		5.47
-40.0	615		0.38		4.66		1.69		2.95		5.84
-45.0	575		0.40		4.98		1.81		3.15		6.24
-50.0	535		0.43		5.36		1.95		3.39		6.71

Standard Probe Testing Time Table

Pressure		AJ-S		AJ-M		AJ-I		AJ-D		AJ-W	
(In/Wc)	Cap.	1/2	24.0	1/2	46.0	1/2	85.0	1/2	117.5	3/4	167.5
0.0	859		1.08		2.07		3.82		5.28		16.93
-5.0	841		1.10		2.11		3.90		5.39		17.29
-10.0	823		1.13		2.16		3.99		5.51		17.67
-15.0	804		1.15		2.21		4.08		5.64		18.09
-20.0	771		1.20		2.30		4.25		5.88		18.86
-25.0	736		1.26		2.41		4.46		6.16		19.76
-30.0	695		1.33		2.55		4.72		6.52		20.93
-35.0	656		1.41		2.71		5.00		6.91		22.17
-40.0	615		1.51		2.89		5.33		7.37		23.65
-45.0	575		1.61		3.09		5.70		7.89		25.29
-50.0	535		1.73		3.32		6.13		8.48		27.19

Pressure		AK-S		AK-M		AK-I		AK-D		AK-W	
(In/Wc)	Cap.	1/2	23.0	1/2	52.0	1/2	101.0	1/2	152.0	3/4	206.0
0.0	859		1.03		2.34		4.54		6.83		20.82
-5.0	841		1.06		2.39		4.63		6.97		21.27
-10.0	823		1.08		2.44		4.74		7.13		21.73
-15.0	804		1.10		2.50		4.85		7.30		22.25
-20.0	771		1.15		2.60		5.06		7.61		23.20
-25.0	736		1.21		2.73		5.30		7.97		24.30
-30.0	695		1.28		2.89		5.61		8.44		25.74
-35.0	656		1.35		3.06		5.94		8.94		27.27
-40.0	615		1.44		3.26		6.34		9.54		29.08
-45.0	575		1.54		3.49		6.78		10.20		31.11
-50.0	535		1.66		3.75		7.29		10.96		33.43

Standard Probe Testing Time Table

Pressure		AL-S		AL-M		AL-I		AL-D		AL-W	
(In/Wc)	Cap.	1/2	23.0	1/2	52.0	1/2	96.0	1/2	144.0	3/4	180.0
0.0	859		1.03		2.34		4.31		6.47		18.20
-5.0	841		1.06		2.39		4.41		6.61		18.58
-10.0	823		1.08		2.44		4.50		6.75		18.99
-15.0	804		1.10		2.50		4.61		6.91		19.44
-20.0	771		1.15		2.60		4.81		7.21		20.27
-25.0	736		1.21		2.73		5.03		7.55		21.24
-30.0	695		1.28		2.89		5.33		8.00		22.49
-35.0	656		1.35		3.06		5.65		8.47		23.83
-40.0	615		1.44		3.26		6.02		9.04		25.41
-45.0	575		1.54		3.49		6.44		9.66		27.18
-50.0	535		1.66		3.75		6.92		10.39		29.21

Pressure		AM-S		AM-M		AM-D		AN-S		AN-M		AO-S		AO-M	
(In/Wc)	Cap.	3/4	25.0	3/4	52.5	3/4	83.0	1/2	6.0	1/2	22.0	1/2	5.0	1/2	21.0
0.0	859		2.53		5.31		8.39		0.27		0.99		0.22		0.94
-5.0	841		2.58		5.42		8.57		0.28		1.01		0.23		0.96
-10.0	823		2.64		5.54		8.76		0.28		1.03		0.23		0.98
-15.0	804		2.70		5.67		8.96		0.29		1.06		0.24		1.01
-20.0	771		2.82		5.91		9.35		0.30		1.10		0.25		1.05
-25.0	736		2.95		6.19		9.79		0.31		1.15		0.26		1.10
-30.0	695		3.12		6.56		10.37		0.33		1.22		0.28		1.17
-35.0	656		3.31		6.95		10.99		0.35		1.29		0.29		1.24
-40.0	615		3.53		7.41		11.72		0.38		1.38		0.31		1.32
-45.0	575		3.78		7.93		12.53		0.40		1.48		0.34		1.41
-50.0	535		4.06		8.52		13.47		0.43		1.59		0.36		1.51

Standard Probe Testing Time Table

Pressure		AP-S		AP-M		AP-D		AQ-S		AQ-I		AQ-D	
(In/Wc)	Cap.	1/2	5.0	3/4	30.0	1/2	58.0	1/2	9.0	3/4	60.0	3/4	77.0
0.0	859		0.22		3.03		2.61		0.40		6.07		7.78
-5.0	841		0.23		3.10		2.66		0.41		6.19		7.95
-10.0	823		0.23		3.17		2.72		0.42		6.33		8.12
-15.0	804		0.24		3.24		2.78		0.43		6.48		8.32
-20.0	771		0.25		3.38		2.90		0.45		6.76		8.67
-25.0	736		0.26		3.54		3.04		0.47		7.08		9.08
-30.0	695		0.28		3.75		3.22		0.50		7.50		9.62
-35.0	656		0.29		3.97		3.41		0.53		7.94		10.19
-40.0	615		0.31		4.24		3.64		0.56		8.47		10.87
-45.0	575		0.34		4.53		3.89		0.60		9.06		11.63
-50.0	535		0.36		4.87		4.18		0.65		9.74		12.50

Pressure		AR-S		AR-D		AV-S		AV-M		AV-D		AV-W		AW-S	
(In/Wc)	Cap.	1/2	8.0	3/4	76.0	1/2	21.0	1/2	52.0	3/4	95.0	3/4	135.0	3/4	10.0
0.0	859		0.36		7.68		0.94		2.34		9.60		13.65		1.01
-5.0	841		0.37		7.85		0.96		2.39		9.81		13.94		1.03
-10.0	823		0.38		8.02		0.98		2.44		10.02		14.24		1.06
-15.0	804		0.38		8.21		1.01		2.50		10.26		14.58		1.08
-20.0	771		0.40		8.56		1.05		2.60		10.70		15.20		1.13
-25.0	736		0.42		8.97		1.10		2.73		11.21		15.93		1.18
-30.0	695		0.44		9.50		1.17		2.89		11.87		16.87		1.25
-35.0	656		0.47		10.06		1.24		3.06		12.57		17.87		1.32
-40.0	615		0.50		10.73		1.32		3.26		13.41		19.06		1.41
-45.0	575		0.54		11.48		1.41		3.49		14.35		20.39		1.51
-50.0	535		0.58		12.33		1.51		3.75		15.42		21.91		1.62

Standard Probe Testing Time Table

Pressure		B-S		B-M		B-D		C-S		C-M		C-D		C16-D	
(In/Wc)	Cap.	3/16	12.5	3/16	32.5	3/16	57.5	3/4	24.0	3/4	40.5	3/4	56.0	3	10.0
0.0	859		0.08		0.21		0.36		2.43		4.09		5.66		16.17
-5.0	841		0.08		0.21		0.37		2.48		4.18		5.78		16.52
-10.0	823		0.08		0.21		0.38		2.53		4.27		5.91		16.88
-15.0	804		0.08		0.22		0.39		2.59		4.37		6.05		17.28
-20.0	771		0.09		0.23		0.40		2.70		4.56		6.31		18.02
-25.0	736		0.09		0.24		0.42		2.83		4.78		6.61		18.88
-30.0	695		0.10		0.25		0.45		3.00		5.06		7.00		19.99
-35.0	656		0.10		0.27		0.48		3.18		5.36		7.41		21.18
-40.0	615		0.11		0.29		0.51		3.39		5.72		7.91		22.59
-45.0	575		0.12		0.31		0.54		3.62		6.12		8.46		24.16
-50.0	535		0.13		0.33		0.58		3.90		6.57		9.09		25.97

Pressure		D-S		D-M		D-D		H-S		H-M		H-D	
(In/Wc)	Cap.	3/4	13.5	3/4	43.5	3/4	74.0	3/16	9.5	3/16	33.5	3/16	65.5
0.0	859		1.36		4.40		7.48		0.06		0.21		0.41
-5.0	841		1.39		4.49		7.64		0.06		0.22		0.42
-10.0	823		1.42		4.59		7.81		0.06		0.22		0.43
-15.0	804		1.46		4.70		7.99		0.06		0.23		0.44
-20.0	771		1.52		4.90		8.33		0.07		0.24		0.46
-25.0	736		1.59		5.13		8.73		0.07		0.25		0.48
-30.0	695		1.69		5.43		9.25		0.07		0.26		0.51
-35.0	656		1.79		5.76		9.79		0.08		0.28		0.54
-40.0	615		1.91		6.14		10.45		0.08		0.30		0.58
-45.0	575		2.04		6.57		11.17		0.09		0.32		0.62
-50.0	535		2.19		7.06		12.01		0.10		0.34		0.66

Standard Probe Testing Time Table

Pressure		I-S		I-M		I-D		J-S		J-M		J-D	
(In/Wc)	Cap.	3/16	11.4	3/16	40.5	3/16	69.5	3/16	12.0	3/16	43.8	3/16	72.5
0.0	859		0.07		0.26		0.44		0.08		0.28		0.46
-5.0	841		0.07		0.26		0.45		0.08		0.28		0.47
-10.0	823		0.08		0.27		0.46		0.08		0.29		0.48
-15.0	804		0.08		0.27		0.47		0.08		0.30		0.49
-20.0	771		0.08		0.29		0.49		0.08		0.31		0.51
-25.0	736		0.08		0.30		0.51		0.09		0.32		0.53
-30.0	695		0.09		0.32		0.54		0.09		0.34		0.57
-35.0	656		0.09		0.34		0.57		0.10		0.36		0.60
-40.0	615		0.10		0.36		0.61		0.11		0.39		0.64
-45.0	575		0.11		0.38		0.66		0.11		0.41		0.68
-50.0	535		0.12		0.41		0.70		0.12		0.44		0.74

Pressure		K-S		K-M		K-D		L-S		L-M		L-D	
(In/Wc)	Cap.	3/16	12.2	3/16	49.8	3/16	79.8	3/16	12.7	3/16	53.7	3/16	96.0
0.0	859		0.08		0.31		0.50		0.08		0.34		0.61
-5.0	841		0.08		0.32		0.51		0.08		0.35		0.62
-10.0	823		0.08		0.33		0.53		0.08		0.35		0.63
-15.0	804		0.08		0.34		0.54		0.09		0.36		0.65
-20.0	771		0.09		0.35		0.56		0.09		0.38		0.68
-25.0	736		0.09		0.37		0.59		0.09		0.40		0.71
-30.0	695		0.10		0.39		0.62		0.10		0.42		0.75
-35.0	656		0.10		0.41		0.66		0.11		0.44		0.79
-40.0	615		0.11		0.44		0.70		0.11		0.47		0.85
-45.0	575		0.12		0.47		0.75		0.12		0.51		0.91
-50.0	535		0.12		0.51		0.81		0.13		0.54		0.97

Standard Probe Testing Time Table

Pressure		M-S		M-M		M-D		N-S		N-M		N-D	
(In/Wc)	Cap.	3/16	12.7	3/16	62.9	3/16	102.1	3/16	12.5	3/16	50.5	3/16	86.5
0.0	859		0.08		0.40		0.65		0.08		0.32		0.55
-5.0	841		0.08		0.41		0.66		0.08		0.33		0.56
-10.0	823		0.08		0.41		0.67		0.08		0.33		0.57
-15.0	804		0.09		0.42		0.69		0.08		0.34		0.58
-20.0	771		0.09		0.44		0.72		0.09		0.36		0.61
-25.0	736		0.09		0.46		0.75		0.09		0.37		0.64
-30.0	695		0.10		0.49		0.80		0.10		0.39		0.68
-35.0	656		0.11		0.52		0.84		0.10		0.42		0.72
-40.0	615		0.11		0.56		0.90		0.11		0.45		0.76
-45.0	575		0.12		0.59		0.96		0.12		0.48		0.82
-50.0	535		0.13		0.64		1.04		0.13		0.51		0.88

Pressure		O-S		O-M		O-D		Q-S		Q-M		Q-D	
(In/Wc)	Cap.	3/4	12.2	3/4	39.2	3/4	73.3	3/16	10.0	3/16	35.0	3/16	100.0
0.0	859		1.23		3.96		7.41		0.06		0.22		0.63
-5.0	841		1.26		4.05		7.57		0.06		0.23		0.65
-10.0	823		1.29		4.14		7.73		0.07		0.23		0.66
-15.0	804		1.32		4.23		7.92		0.07		0.24		0.67
-20.0	771		1.37		4.41		8.26		0.07		0.25		0.70
-25.0	736		1.44		4.62		8.65		0.07		0.26		0.74
-30.0	695		1.52		4.90		9.16		0.08		0.27		0.78
-35.0	656		1.61		5.19		9.70		0.08		0.29		0.83
-40.0	615		1.72		5.53		10.35		0.09		0.31		0.88
-45.0	575		1.84		5.92		11.07		0.09		0.33		0.94
-50.0	535		1.98		6.36		11.90		0.10		0.36		1.01

Standard Probe Testing Time Table

Pressure (In/Wc)	Cap.	R-S 1/2 8.0	R-D 1/2 40.0	MW8-D 3/4 17.0	MW10-D 3/4 21.0	MW14-D 3/4 158.0	MW15-D 3/4 186.0	MW20-D 3/4 140.0
0.0	859	0.36	1.80	1.72	2.12	15.97	18.80	14.15
-5.0	841	0.37	1.84	1.76	2.17	16.31	19.20	14.45
-10.0	823	0.38	1.88	1.79	2.22	16.67	19.62	14.77
-15.0	804	0.38	1.92	1.84	2.27	17.06	20.09	15.12
-20.0	771	0.40	2.00	1.91	2.37	17.79	20.95	15.77
-25.0	736	0.42	2.10	2.01	2.48	18.64	21.94	16.52
-30.0	695	0.44	2.22	2.12	2.62	19.74	23.24	17.49
-35.0	656	0.47	2.35	2.25	2.78	20.91	24.62	18.53
-40.0	615	0.50	2.51	2.40	2.96	22.31	26.26	19.77
-45.0	575	0.54	2.68	2.57	3.17	23.86	28.09	21.14
-50.0	535	0.58	2.89	2.76	3.41	25.64	30.19	22.72

Pressure (In/Wc)	Cap.	MW23-D 3/4 180.0	MW24-D 3/4 150.0	MW27-D 3/4 30.0	MW29-D 3/4 138.0
0.0	859	18.20	15.16	3.03	13.95
-5.0	841	18.58	15.49	3.10	14.25
-10.0	823	18.99	15.83	3.17	14.56
-15.0	804	19.44	16.20	3.24	14.90
-20.0	771	20.27	16.89	3.38	15.54
-25.0	736	21.24	17.70	3.54	16.28
-30.0	695	22.49	18.74	3.75	17.24
-35.0	656	23.83	19.85	3.97	18.27
-40.0	615	25.41	21.18	4.24	19.48
-45.0	575	27.18	22.65	4.53	20.84
-50.0	535	29.21	24.35	4.87	22.40