SECOR
International Incorporated

CLEANUP ACTION PLAN

Former Columbia Marine Lines Facility
6305 Lower River Road
Vancouver, Washington

SECOR PN: 00255-003-01

Submitted by
SECOR International Incorporated
for

Mr. Rodney L. Brown
Martin and Brown, LLP
119 Second Avenue
Seattle, Washington 98101

September 26, 1996

Prepared by:

Paul R. Woods, P.E.
Principal Engineer

Reviewed by:

James G. Ritchie, R.G.
Principal Geologist

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1.0 INTRODUCTION

This document has been prepared in accordance with Washington Administrative Code (WAC)173-340-360 (10)(a) for a Cleanup Action Plan (CAP) for the former Columbia Marine Lines facility located at 6305 Lower River Road in Vancouver, Washington (the site). A CAP is typically prepared for the Washington Department of Ecology (Ecology) in response to an order or decree; however, the proposed cleanup at the site is to be conducted by Crowley Marine Services, Inc. (Crowley), formerly d.b.a. Columbia Marine Lines, as an independent cleanup action. The purpose of the CAP is to provide sufficient technical data to justify the selected cleanup action and to provide a technical document for review and comment by interested parties.

The CAP presents the information required by WAC 173-340-360 (10)(a) and includes: property description, site history, and land use; a summary of the results of remedial investigation work; interim cleanup actions and feasibility pilot testing; and a summary of the selected cleanup action.

2.0 SITE DESCRIPTION

2.1 PROPERTY DESCRIPTION

The site is located immediately north of the Columbia River and approximately 3 miles west of the city of Vancouver in Section 44, Township 2N, Range 1E, as indicated on Figure 1. Section 44 is designated as Section 19 on Metsker's Clark County map and Ecology water well files. The site is relatively flat, with the highest point on the site lying at approximately 32 feet elevation (mean sea level [msl] datum). The Columbia River is tidally dominated and typically ranges from about minus 5 to positive 5 feet msl.

The majority of the site is sparsely vegetated with grasses and moss. Alder and willows form a brushy thicket from the river's edge to about 200 feet inland. Willows, alders, and brush are present in isolated low-lying areas in the northern portion of the site. Two settling ponds now occupy a portion of the site to the northwest. The settling ponds are currently operated by Vanalco (formerly operated by ALCOA) as part of the aluminum manufacturing process.

2.2 SITE HISTORY

Columbia Marine Lines formerly operated a marine repair facility at the site (on the Columbia River). Columbia Marine Lines periodically placed residues from gas-freeing operations in a disposal pit located adjacent to the site on property owned by ALCOA. The pit was approximately 12 to 15 feet deep, 200 feet long, and 125 feet wide and was located approximately 400 feet north of the Columbia River and 300 feet east of Vanalco's settling ponds (Figure 2).

In January 1984, all liquids were removed from the pit, and the pit was filled with soil to prevent accumulation of surface water. On April 3, 1984, Columbia Marine Lines notified Ecology in writing of the past practice and closure of the former pit. Soil and groundwater characterization work was completed, and an interim corrective action was implemented in subsequent years. The interim action consisted of groundwater extraction, hydrocarbon product removal, and re-infiltration of extracted groundwater. The interim action was conducted from 1986 to the present. Product thickness is currently below recoverable levels. A summary of the site characterization and interim action work is presented in Section 3.0 of this document.

RCRA Enforcement Order

The former Columbia Marine Lines facility is currently under the ownership of Tidewater Barge Lines. ALCOA still owns the property where the former pit was located. There have been no significant changes in the surface features in the vicinity of the former pit area since the initial closure of the pit by filling.

2.3 LAND USE

The current zoning classification for the site and the ALCOA property is industrial. Surrounding land use patterns indicate that the properties will continue to have industrial land uses. Potable water is supplied to the properties by the city of Vancouver. Access to the site is restricted by fencing and site security measures.

3.0 SUMMARY OF REMEDIAL INVESTIGATION ACTIVITIES AND FEASIBILITY TESTING

This section summarizes the understanding of site geology, hydrogeology, contaminant identification, and distribution, and feasible remedial alternatives.

3.1 SITE GEOLOGY

The regional geology in the vicinity of the site includes volcanic rocks of Eocene to Miocene age. These formations are overlain by semi-consolidated Pliocene deposits of fine-grained sands, silts, and clays that comprise the lower member of the Troutdale Formation. The upper Troutdale member consists of cemented sandy gravels deposited in the late Pliocene Epoch. The Troutdale Formation is estimated to be over 1,000 feet thick in the Vancouver area and shows evidence of folding and faulting (Murdorf 1964).

Pleistocene glacial drift, typically comprised of tills, silts, and clays embedded with outwash sands and gravels, overlie the Troutdale Formation. This unit is, in turn, overlain by late Pleistocene fluvial and deltaic sediments deposited by the Columbia River. The sediments are comprised of stratified and cross-bedded gravels, sands, silts, and clays and are estimated to be several hundred feet thick in the Vancouver area. Terrace features in the Vancouver area are remnants of the erosional sequences caused by the down-cutting of the Columbia River through these deposits (Murdorf 1964).

Soil boring and sampling at the site has been predominantly limited to the upper 15 to 25 feet of soils. Data collected from this activity show that a sand and silt dredge material of variable thickness overlies natural Columbia River floodplain deposits.

3.2 SITE HYDROGEOLOGY

Saturated groundwater conditions are first encountered within the dredge fill material. Precipitation readily infiltrates into the subsurface, due to the moderate to high permeability of the fill material. Groundwater and infiltrating surface water accumulates at the base and within the fill material on top of the underlying low permeability floodplain deposits. This saturated zone is relatively thin (approximately 6 feet). Some monitoring wells completed in this zone have been dry during summer months. Based on hydrographs for wells completed within the fill material, precipitation appears to be the greatest source of water for this saturated zone. The hydrographs indicate that water levels drop through the summer months at a relatively rapid rate. This suggests that the fill saturated zone could become dry without the input of significant precipitation during winter months.

Limited groundwater elevation data are available for the site. Depth to groundwater in monitoring wells has ranged from 3.07 feet below top of casing in monitoring well MW-5 to 22.66 feet below top of casing in monitoring well MW-20. During the most recent groundwater monitoring event, the groundwater gradient was calculated to be approximately 0.03 foot per foot (ft/ft) with groundwater flow generally to the west.

The presence of the silt and clay layers within the upper portion of the floodplain deposits may retard vertical migration of groundwater from the fill material through the floodplain deposits. During late winter and early spring when water levels in the fill are highest, groundwater may seep to the surface at the toe of the fill slope near the Columbia River. This is evidenced by the significant water level drop observed in well MW-17, which is located closest to the river, at the edge of the major fill area. This well has an apparent seasonal water level fluctuation of over 8 feet, as compared to seasonal fluctuations of approximately 2.5 feet observed in other site wells. Well MW-17 is often dry during the summer months. Schematic cross section A-A' projects water table conditions within the fill material during seasonally high and low groundwater conditions (Figure 3).

Groundwater also appears to be present within the upper portion of the floodplain deposit, as monitored in wells MW-13 and MW-14. This is evidenced by the hydrograph for well MW-13, which has a similar water level fluctuation pattern to wells completed within the fill material. The similar pattern indicates that there is a hydraulic connection between the fill material and upper floodplain deposits. However, the increased inferred hydraulic gradient between well MW-13 and the fill material wells indicates that the upper floodplain deposits have a much lower hydraulic conductivity than the fill material, resulting in a significantly decreased rate of groundwater flow through this area.

3.3 CONTAMINANT IDENTIFICATION AND DISTRIBUTION

The materials formerly stored in the disposal pits consisted of dilute petroleum hydrocarbon fuel products. The constituents of concern are therefore benzene, toluene, ethylbenzene, and total xylenes (BTEX); total petroleum hydrocarbons as gasoline (TPH-G); total petroleum hydrocarbons as diesel (TPH-D); total petroleum hydrocarbons as oil (TPH-oil); and polycyclic aromatic hydrocarbons (PAHs). The constituents of concern have not been identified in surface soils and, during site investigations, appear to impact only shallow groundwater. The primary media of concern is the shallow groundwater. Historic groundwater monitoring has detected liquid-phase petroleum hydrocarbons (LPH) in a limited area. Interim corrective measures have reduced the presence of LPH from a maximum measured thickness of 0.15 foot to the current levels, which are reported as a sheen or less than measurable thicknesses. A description of the distribution of contaminants in groundwater is presented in the following sections.

3.3.1 Liquid-Phase Petroleum Hydrocarbons

Measurable LPH in the monitoring wells have significantly decreased since monitoring began at the site in the mid-1980s. The greatest LPH thicknesses were observed during initial monitoring, with over 6 feet of LPH in well MW-8. Since early 1995, LPH has been detected in three monitoring wells (MW-7, MW-8, and MW-19). Based on the documented reduction of LPH recovery, from over 500 gallons in 1986 to less than 50 gallons per year from 1990 to 1994, and the reduction in measured thickness since 1994, it is evident that the majority of LPH has been recovered from the water table surface and/or has degraded.

3.3.2 Dissolved-Phase Petroleum Hydrocarbons

Dissolved petroleum hydrocarbon compounds have also been detected in the shallow groundwater. A summary of the historic groundwater analytical results is presented in Tables 1 and 2. A graphical illustration of dissolved TPH concentrations is illustrated in Figure 4. The primary and most widespread contaminant of concern at the site is TPH-D. BTEX and PAH concentrations are low relative to the reported TPH-D concentrations.

During groundwater monitoring in November 1995, dissolved concentrations of TPH-G were reported at maximum concentrations of 5.4 milligrams per liter (mg/L). TPH-D concentrations in the diesel range were from below detectable limits to 490 mg/L. TPH-D concentrations in the heavy oil range were from below detectable limits to 7.4 mg/L.

3.4 FEASIBILITY TEST RESULTS

SECOR performed feasibility testing at the site in February and August 1996 to evaluate the possible effectiveness of groundwater extraction and oxygen release compound (ORC) in mitigating hydrocarbon-impacted groundwater. The feasibility testing included aquifer testing and natural bioattenuation monitoring and sampling, as described below.

3.4.1 Aquifer Testing

Aquifer testing was performed at the site to evaluate hydraulic characteristics of the shallow water-bearing dredge fill horizon. Tests were performed during February 1996 when the aquifer yield was assumed to be greatest. Slug tests were performed on wells MW-1, MW-7, MW-18, and EX-2 to collect data to estimate aquifer transmissivity. A step-drawdown test and a pumping test were conducted on well EX-2. During the time of highest yield, the aquifer sustained a maximum yield of 0.5 gallon per minute (gpm) in a 4-inch diameter groundwater monitoring well. No drawdown was measured in observation well MW-7, 20 feet away from well EX-2. The pump test data indicate a lateral formation transmissivity of 0.0005 square foot per minute (ft^2/min), which is consistent for a silt material.

Given the transmissivity determined through aquifer testing, aggressive capture and recovery of groundwater at the site would require extensive trenching in order to effectively implement a pump and treat corrective action.

3.4.2 In-Situ Bioremediation Monitoring

SECOR also evaluated the feasibility of using in-situ bioremediation for petroleum hydrocarbon-impacted groundwater. Biological activity was assessed using results of groundwater sampling and monitoring. Selected groundwater samples were analyzed for geochemical indicators of biological activity, including redox potential, electron acceptors, and byproducts of biodegradation. Redox potential is an indicator of the geochemical condition of the groundwater and measures the relative tendency of a dissolved species to gain or lose electrons. Electron acceptors utilized in hydrocarbon biodegradation reactions include dissolved oxygen, nitrate, and sulfate. Dissolved oxygen is used in aerobic reactions. Nitrate and sulfate are consumed in anaerobic denitrification and sulfanogenesis reactions that occur in the absence of oxygen. Ferrous iron is a common byproduct of anaerobic biodegradation reactions in which ferric iron is consumed. Historical and recent petroleum contaminant concentration data were also evaluated for trends indicating biological degradation.

Groundwater samples were analyzed for BTEX, TPH, and the following geochemical indicators: dissolved oxygen, redox potential, nitrate, sulfate, and ferrous iron. Groundwater monitoring results are presented in Tables 1 and 2. Contour maps of the measured geochemical indicator parameters are shown in Figures 7 through 11. Figure 4 shows the distribution of diesel-range TPH concentrations in the site groundwater, as encountered during the most recent (August 1, 1996) groundwater monitoring event. Figures 7 through 11 contain inferred contour lines near the disposal pits in the southwestern portion of the site (near wells MW-7 and MW-8), because data were not available in this area. Groundwater samples were not collected from wells MW-7 and MW-8 due to the presence of a free product sheen in these wells. Free product would damage field monitoring instruments and produce unreliable groundwater chemistry results. The contour lines in this area were drawn assuming the values in MW-7 and MW-8 were similar to those measured in other contaminated wells at the site.

As shown in Figure 7, the redox potential in the groundwater is depleted in the contaminated area (-50 to 0 millivolts [mV]) relative to background redox potential values (+100 to +150 mV), indicating that reducing conditions exist within the impacted groundwater. Groundwater samples from monitoring wells MW-12, MW-13, and MW-14 are assumed to represent background conditions due to the historical absence of contamination present in these wells. Figure 8 shows that dissolved oxygen values in the impacted area (0.4 to 0.6 mg/L) are depleted relative to background values (1.0 to 4.8 mg/L). Figures 9 and 10 show that nitrate and sulfate concentrations in the impacted area are also lower than the background values. Ferrous iron values in the impacted groundwater (15 to 50 mg/L) appear to be elevated as compared to background values (<0.2 to 2). The geochemical results in Figures 7 through 11 indicate that dissolved oxygen, nitrate, and sulfate have been consumed, and ferrous iron has been produced in the impacted groundwater plume. The consumption of dissolved oxygen indicates that aerobic biodegradation has occurred. The consumption of nitrate and sulfate and the production of ferrous iron indicate that anaerobic biodegradation has occurred. The presence of reducing conditions in the impacted area shows that conditions are currently suitable for anaerobic biodegradation.

Petroleum hydrocarbon concentrations at the site have been generally decreasing from 1983 to the present, particularly BTEX concentrations in monitoring wells MW-2, MW-3, MW-4, MW-8, and MW-16. This decrease in constituent concentrations, in combination with the geochemical evidence of biological activity, indicates that natural biodegradation processes have been removing hydrocarbons from groundwater. Diesel-related hydrocarbons are still present in the groundwater. These components are believed to be biodegradable, although at a slower rate than the BTEX components. The conditions at the site are favorable for in-situ bioremediation using natural microorganisms. However, the remediation rate using natural anaerobic processes may be relatively slow. Enhancements to the natural biodegradation process would increase the rate of remediation. Addition of oxygen to the aquifer would stimulate aerobic biodegradation processes, which degrade contaminants at a higher rate than anaerobic processes. In addition, limited groundwater extraction with treatment, oxygenation, and surface application of the treated water would increase the rate of flushing of the contaminants through the aquifer, to remove contaminants from the most highly impacted areas, and would further increase the supply of oxygen to the subsurface.

4.0 TECHNICAL CONSIDERATIONS FOR SITE CLEANUP

4.1 TECHNICAL CONSIDERATIONS

In accordance with the requirements of WAC 173-340-360 (10)(a), the following technical considerations have been developed based on the results of the site investigation activities.

Constituents of Concern

- Total Petroleum Hydrocarbons (TPH) as diesel.

Media of Concern

- Shallow groundwater.

Restoration Time Frame

- Reasonable progression toward groundwater cleanup.

5.0 CLEANUP STANDARDS

Cleanup standards for the shallow groundwater at the site have been developed based on an assessment of potentially sensitive receptors, local groundwater quality, and Applicable or Relevant and Appropriate Requirements (ARARs). The following discussion presents the rationale for the selected cleanup standards.

5.1 REMEDIAL OBJECTIVES

Ecology has established that cleanup of hazardous substance sites shall be conducted with preference given to technologies which minimize the amount of untreated hazardous substances remaining at the site. The site conditions have been evaluated with regard to the preferred technologies presented in WAC 173-34-360(4). Based on an evaluation of the contaminants of concern, the media of concern, the site conditions, and the results of the feasibility pilot testing, the following technology was selected as technically feasible for remediation of the site.

Destruction or Detoxification

The selected cleanup action will destroy and/or detoxify the TPH-D in the groundwater. The proposed cleanup action will meet the requirements of Ecology by decreasing the concentrations of TPH-D in groundwater to below the proposed cleanup action levels for groundwater and surface water at the site.

5.2 REGIONAL GROUNDWATER QUALITY

The results of the feasibility pilot testing from the site have demonstrated that on-site groundwater is not suitable for domestic uses, based on the criteria presented in WAC 173-340-720(1)(a). There are no known drinking water wells located within the vicinity of the site.

5.3 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARs)

The Model Toxics Control Act (MTCA) requires that remedial actions at a site achieve a cleanup level that protects human health and the environment. In addition, the cleanup must comply with federal and state ARARs as specified in WAC 173-340-360. Only those state standards that are promulgated, identified by the state in a timely manner, and are more stringent than federal requirements may be considered ARARs (40 Code of Federal Regulations [CFR] 300.400 (g) (4)). An ARAR may describe a remediation requirement that may be either "applicable" or "relevant and appropriate," but not both. A brief definition of these requirements is presented below.

- Applicable requirements are those remedial standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance(s) at a site.

- Relevant and appropriate requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or promulgated under federal or state law that while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a site, address problems or situations sufficiently similar to those encountered at the site that their use is well suited to the particular site. However, in some circumstances, a requirement may be relevant but not appropriate for the site-specific situation.

5.3.1 Types of ARARs

The three general types of ARARs are: chemical-specific, action-specific, and location-specific requirements. Chemical-specific ARARs are generally health- or risk-based concentration limits for specific hazardous substances or chemicals. Examples of this type of ARAR are water quality standards and drinking water standards. Water quality standards for some chemicals are not strictly health-based and may instead be based on technological feasibility and other considerations. Examples of action-specific ARARs are the Resource Conservation and Recovery Act (RCRA) regulations for waste treatment, storage, and disposal. Location-specific ARARs impose restrictions on certain types of activities based on characteristics of the site. Examples of ARARs specific to location include regulations governing activities in wetlands, flood plains, and historical sites.

The following federal, state, and local requirements may be ARARs for media of concern at this site:

Groundwater Quality:

- U.S. EPA Maximum Contaminant Levels (40 CFR 141.11-141.16; 40 CFR 141.60-141.63) and Maximum Contaminant Level Goals (40 CFR 141.50-141.52) under the Safe Drinking Water Act.
- Water Quality Standards for Groundwaters of the State of Washington (WAC 173-200).
- Washington State MTCA Groundwater Cleanup Levels (WAC 173-340-720).

Surface Water Quality:

- U.S. EPA Clean Water Act (40 CFR 100-149).
- Washington State MTCA Surface Water Cleanup Levels (WAC 173-340-730).
- Water Quality Standards for Surface Waters of the State of Washington (WAC 173-201).

The following federal, state, and local requirements may be action-specific ARARs for this site:

General Implementation:

- Washington State Model Toxics Control Act (WAC 173-340).
- Washington State General Occupational Health Standards (WAC 296-62).
- Federal Occupational Safety and Health Act (29 CFR 1910.120).
- Washington State Environmental Policy Act

No location-specific ARARs have been identified for this site.

5.3.2 Summary of Primary ARARs

MTCA is the primary ARAR for the affected media at the site. MTCA authorized Ecology to adopt cleanup standards for remedial actions at hazardous waste sites. These regulations incorporate other federal and state requirements and are considered the primary ARARs for soil, groundwater, and surface water cleanup actions in Washington state. The processes for identifying, investigating, and remediating hazardous waste sites are defined, and cleanup levels are set for groundwater, soil, surface water, and air in WAC 173-340 Sections 720 through 750. Under MTCA, site-specific cleanup levels are contingent upon the anticipated future land use of the site. The regulation specifies three "methods" for use in establishing site cleanup levels for specific environmental media. Briefly, these are:

- **Method A** cleanup levels are set by the state of Washington and are delineated in the regulation for a specific subset of chemicals for environmental media. These values can be used as cleanup levels during "routine" site cleanups (e.g., few contaminants at the site, and all contaminants have Method A cleanup levels).

- **Method B** is the standard method for site cleanups under MTCA. Method B cleanup levels involve calculation of media-specific values for a given chemical from specified formulae provided in the regulation. The formulae require input of chemical-specific toxicological parameters, as well as physiological and exposure-based parameters. Parameter values and sources are explicitly stated in the regulation.

- **Method C** is the conditional method for site cleanups under MTCA. MTCA Method C levels involve calculations similar to Method B, with some modification of specific parameter values to meet special conditions associated with the site (i.e., industrial sites).

Consistent with the provisions in MTCA [WAC 173-340-720 (1) and (3) for groundwater cleanup standards], Method A cleanup levels allow groundwater cleanups based on protecting surface water. Therefore, the proposed groundwater cleanup levels for the site have been based on protection of surface water in the Columbia River.

5.4 CLEANUP CRITERIA

The primary goal of the cleanup action is to meet the proposed cleanup action levels throughout the site. The progress of the cleanup action will be evaluated on an annual basis to evaluate the effectiveness of achieving the cleanup levels throughout the site. Additional remedial technologies or conditional points of compliance may be considered if contaminant levels do not decrease below the proposed cleanup levels. As a secondary goal, the cleanup action will attempt to meet the cleanup action levels at the current downgradient edge of the groundwater monitoring well network (wells MW-13 and MW-14) while the cleanup proceeds.

5.4.1 Proposed Cleanup Action Levels

Groundwater at the site is not currently or reasonably expected in the future to be used as a source for drinking or other domestic water uses. In addition to the low probability of future use of site groundwater for drinking and domestic uses, the low permeability of the aquifer further supports the unsuitable nature of the shallow aquifer in the vicinity the site as a future drinking water source (see WAC 173-340-720 (ii) (A)). These considerations render the groundwater an unsuitable potable source. The groundwater cleanup levels for the site should therefore be based on protection of the beneficial uses of the adjacent Columbia River, consistent with the conditions specified in WAC 173-340-720 (1),(c). These conditions (italicized below) and their applicability to the site include:

- *There are known or projected points of entry of the groundwater into the surface water.*

  Groundwater levels indicate a mass flow to the south, with a potential aquifer discharge to the Columbia River.

- *Groundwater flow into surface waters will result in no exceedances of surface water cleanup levels at the point of entry or at any downstream location where it is reasonable to believe that hazardous substances may accumulate.*

  Applicable surface water standards could be used as groundwater remedial action objectives, such that groundwater concentrations at the point of discharge into the Columbia River will be in compliance with federal and state surface water standards.

  Cleanup action levels for groundwater at the site could be based on surface water criteria, as discussed above; however, to allow unrestricted future use of the site, a more conservative cleanup action level has been selected for groundwater cleanup. The groundwater cleanup action level for residential properties under MTCA Method A has been selected as the cleanup criteria. This represents the most conservative regulatory limit at this time.

- A Cleanup Action Level of 1,000 μg/L (parts per billion [ppb]) TPH is proposed for the shallow groundwater based on MTCA Method A WAC 173-340-720.1

5.4.2 Proposed Point of Compliance During Cleanup

- An interim point of compliance is proposed as the downgradient wells along the Columbia River. These include wells MW-13 and MW-14. The interim point of compliance will apply during cleanup activities.
- The interim point of compliance will require groundwater monitoring to confirm that cleanup action levels are being met until a point of compliance can be established throughout the site and at the point of discharge of groundwater to the Columbia River.

6.0 PROPOSED CLEANUP ACTION

The proposed cleanup action will include limited groundwater extraction and enhancement of natural attenuation of contamination. The proposed technology will detoxify and/or destroy the existing TPH concentrations in the groundwater.

The primary cleanup technology will consist of enhancement of natural attenuation of the constituents of concern through installation of ORC in the existing network of monitoring wells to increase dissolved oxygen in groundwater. Increasing oxygen concentrations enhances natural attenuation in the subsurface to reduce contaminant concentrations.

ORC is magnesium peroxide in a powder form contained within a permeable fabric sock. The socks will be placed below the water table in existing monitoring wells throughout the site. The ORC material slowly releases oxygen to the groundwater when it mixes with water. Molecular oxygen is transported to the water-bearing zone by diffusion, dispersion, and advection. An ORC installation is illustrated in Figure 6.

Natural attenuation reduces the concentration of contaminants in the subsurface by a combination of destructive and non-destructive mechanisms. Biodegradation by indigenous microorganisms is the primary mechanism for natural contaminant destruction. Non-destructive processes that also reduce contaminant concentrations include adsorption/desorption, advection, dispersion, diffusion, dilution, and volatilization. Natural attenuation has the following advantages over conventional engineered technologies: (1) Hydrocarbon constituents are destroyed rather than transferred to another location or medium, (2) treatment takes place in-situ which reduces the risk posed by removing the contaminants from the subsurface, and (3) natural attenuation is less costly than currently available active remediation technologies.

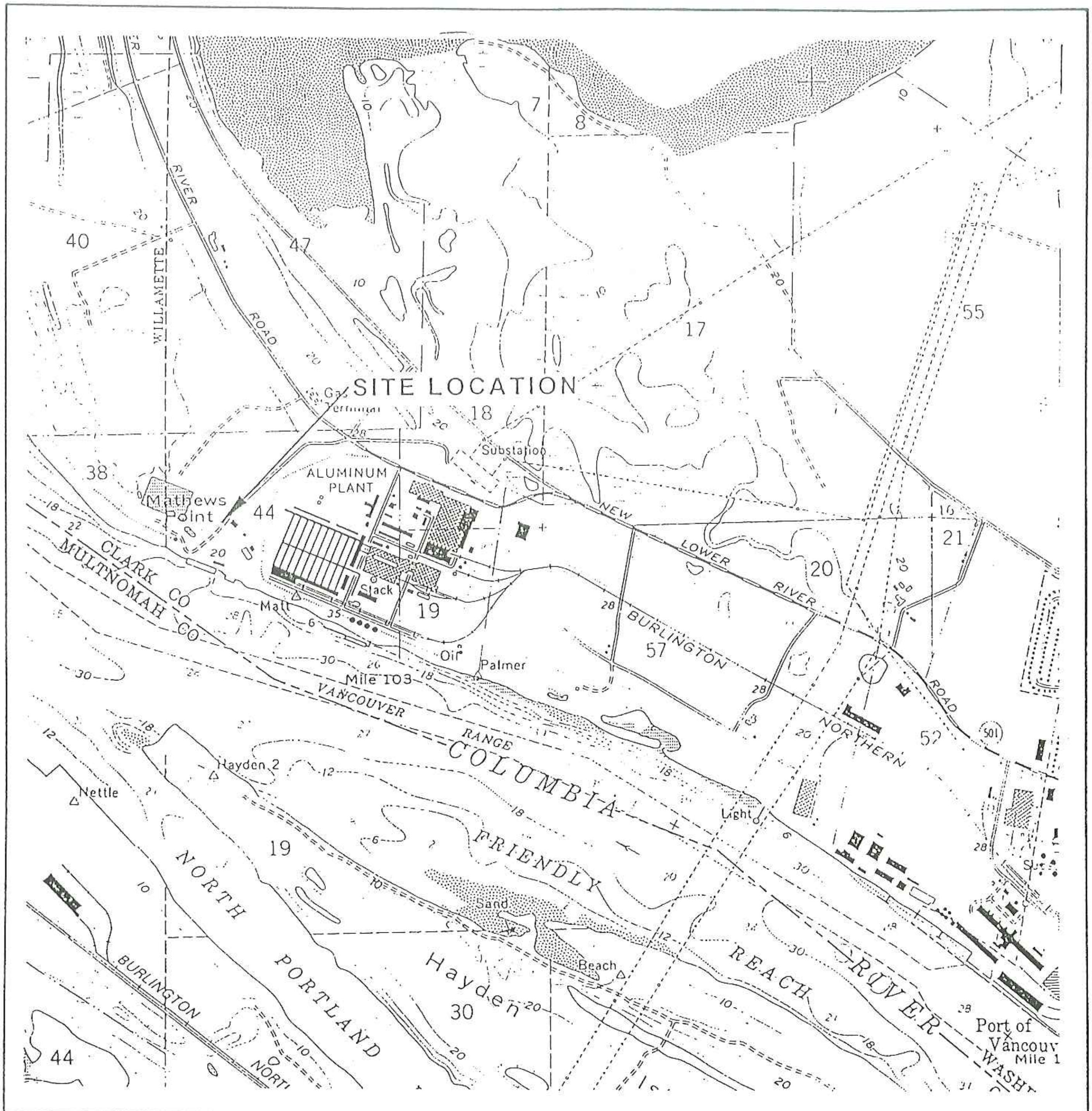
The biodegradability of petroleum hydrocarbon compounds by naturally-occurring microorganisms has been demonstrated in numerous laboratory and field studies. Although petroleum hydrocarbon constituents are readily biodegradable, natural biodegradation can be limited by the supply of nutrients (nitrogen, phosphorous, and other minerals, water, and/or electron acceptors) in the subsurface. In addition, biodegradation may be limited by temperature or by the presence of materials that are toxic to microorganisms. The most common limiting factor for natural in-situ biodegradation is the supply of electron acceptors. The most thermodynamically favorable electron acceptor is oxygen, which is used during aerobic biodegradation. Other electron acceptors, including nitrate, ferrous iron, sulfate, and carbon dioxide, are used in anaerobic biodegradation reactions. The supply of electron acceptors in the area of contamination is often limited because biodegradation reactions use them more quickly than they can be replaced by natural transport in the subsurface.

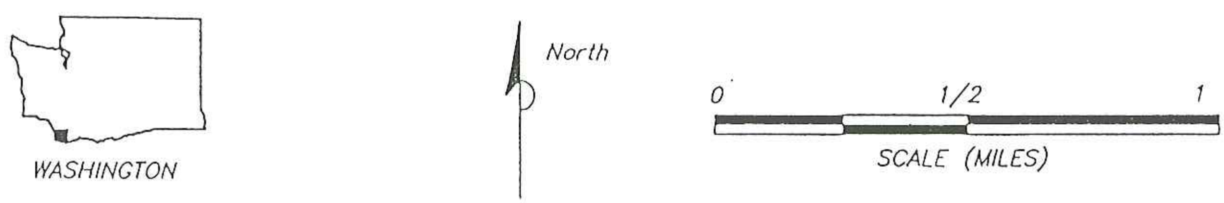
Demonstration of the feasibility of natural attenuation as a remedial approach usually shows: (1) evidence of biological activity at the site, (2) a documented decrease in contaminant mass over time, and (3) results of fate and transport modeling using site-specific data that show that natural attenuation has the potential to reduce contaminant concentrations to acceptable levels within a two- to five-year time frame.

A secondary cleanup technology will consist of limited and localized groundwater recovery in the shallow saturated zone within the area of the former disposal pit. Groundwater will be extracted from well MW-8 and possibly the existing groundwater extraction trench, treated with granular activated carbon, and then spray-applied to the immediate surface area. Recovery of groundwater is anticipated to be limited, but should help reduce TPH concentrations in the localized "hot spot." A process and instrumentation diagram of the proposed system is provided in Figure 5. In addition to removal of dissolved TPH, groundwater pumping and reapplication will flush soils in the unsaturated zone which have residual TPH to mitigate hydrocarbon leaching to groundwater. SECOR has estimated that a two-year operating period for the groundwater pumping system will yield approximately 20 pore volumes of water flushing through the impacted areas.

6.1 CLEANUP ACTION MONITORING

As required by the conditional point of compliance where groundwater flows to surface water, groundwater monitoring is required (WAC 173-340-720(6)(d)(iv). The cleanup action monitoring will consist of groundwater monitoring for both contaminants of concern and biodegradation parameters within the existing groundwater monitoring wells. The monitoring wells will be designed as the conditional points of compliance sampling locations for the duration of the cleanup action. A proposed sampling schedule is presented in Table 3. The results will be tabulated and summarized in brief summary reports following each sampling event.

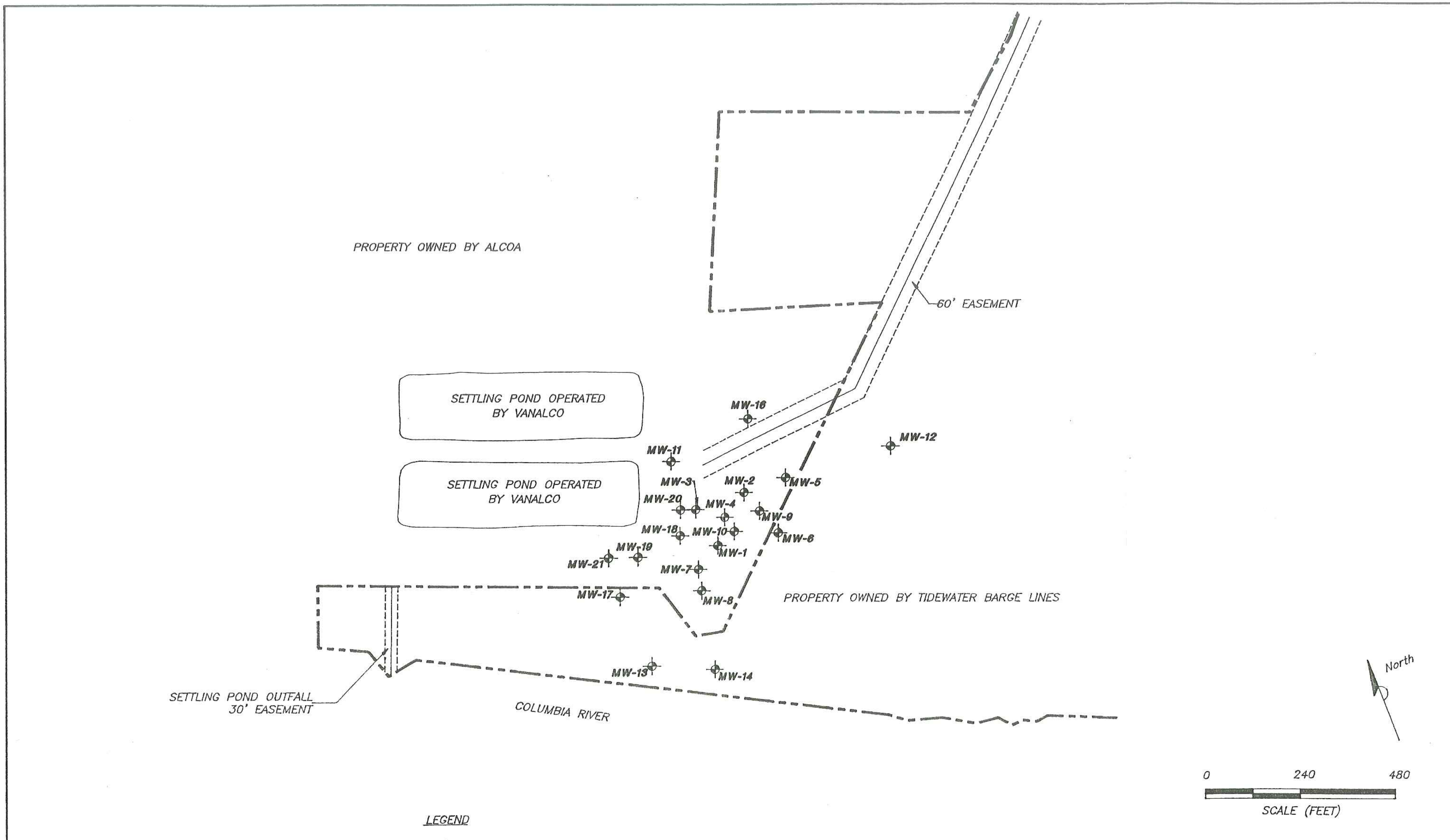




REFERENCE: USGS 7.5 MINUTE QUADRANGLE, VANCOUVER, WASHINGTON

SECOR International Incorporated	SITE LOCATION MAP FORMER COLUMBIA MARINE LINES FACILITY 6305 LOWER RIVER ROAD VANCOUVER, WASHINGTON	FIGURE: 1
	JOB#: 00255-003-01 APPR: PRW DWN: AJW DATE: 8/16/96	

DWG: CR003104



SECOR
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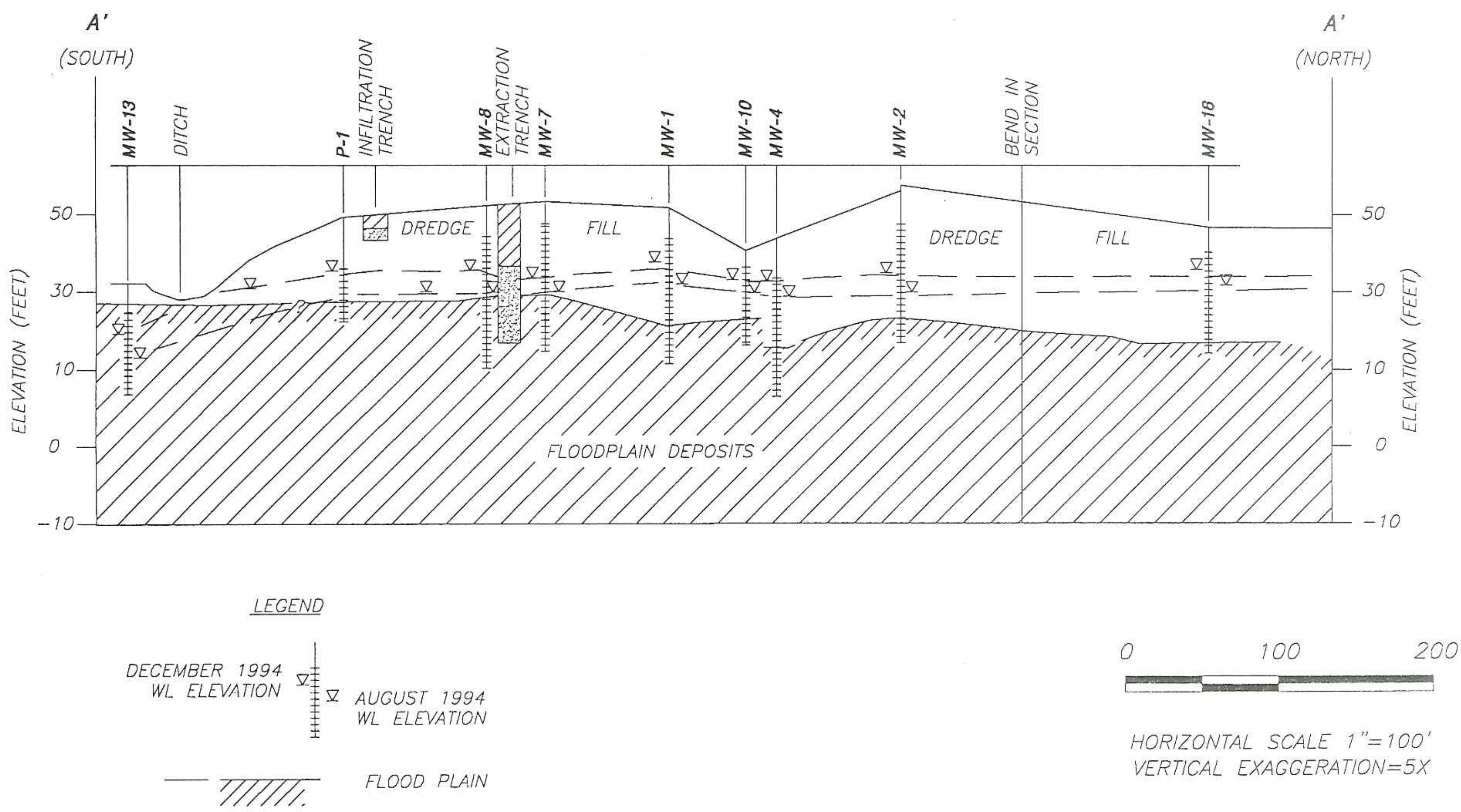
SITE PLAN

FORMER COLUMBIA MARINE LINES FACILITY
6305 LOWER RIVER ROAD
VANCOUVER, WASHINGTON

FIGURE: 2

JOB#: 00255-003-01 APPR: PRW DWN: AJW DATE: 9/24/96

DWG: CR003248



SECOR
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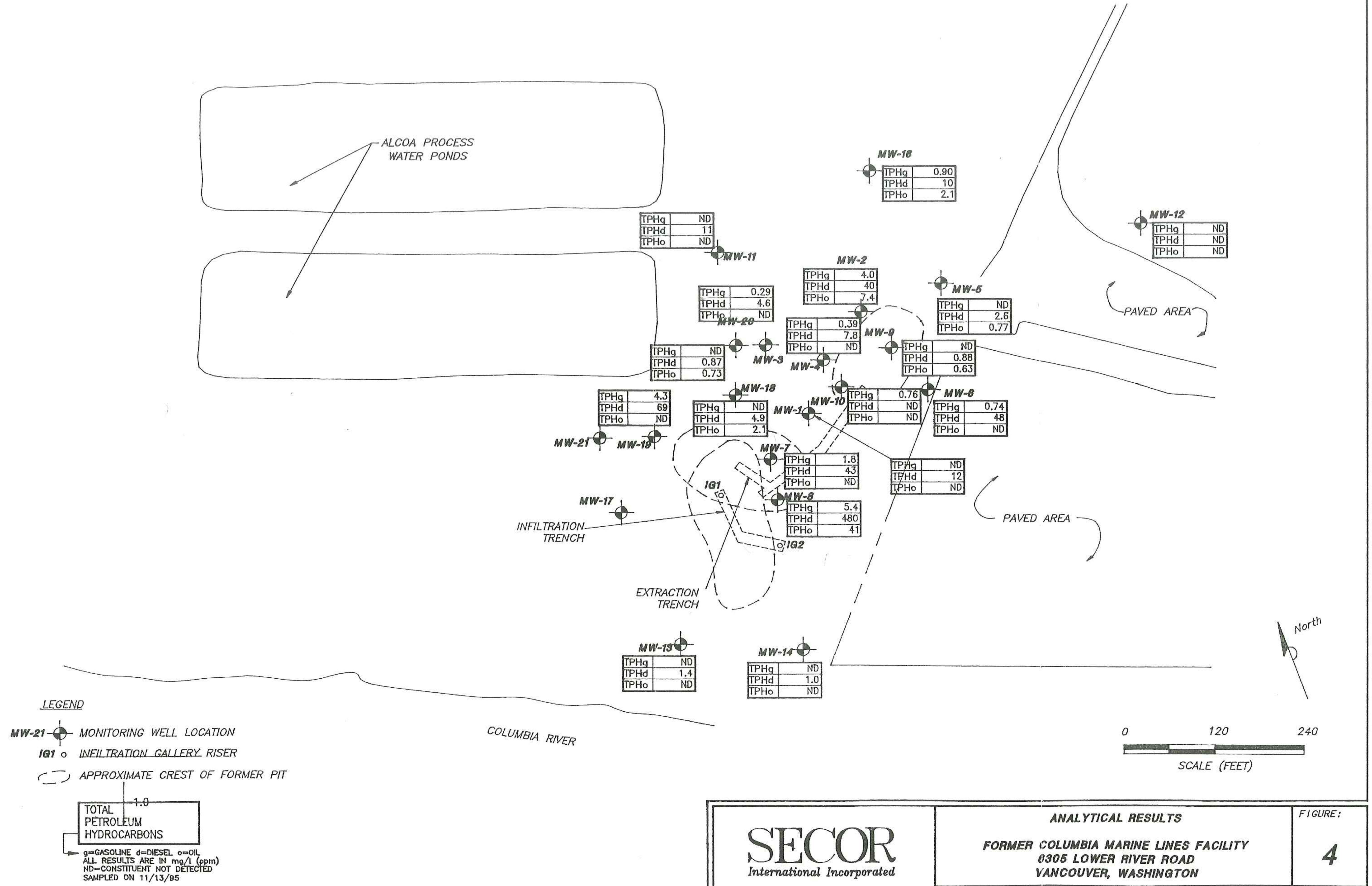
SCHEMATIC GEOLOGICAL CROSS SECTION

FORMER COLUMBIA MARINE LINES FACILITY
6305 LOWER RIVER ROAD
VANCOUVER, WASHINGTON

FIGURE: 3

JOB#: 00255-003-01 APPR: PRW DWN: AJW DATE: 9/24/96

DWG: CR00317A



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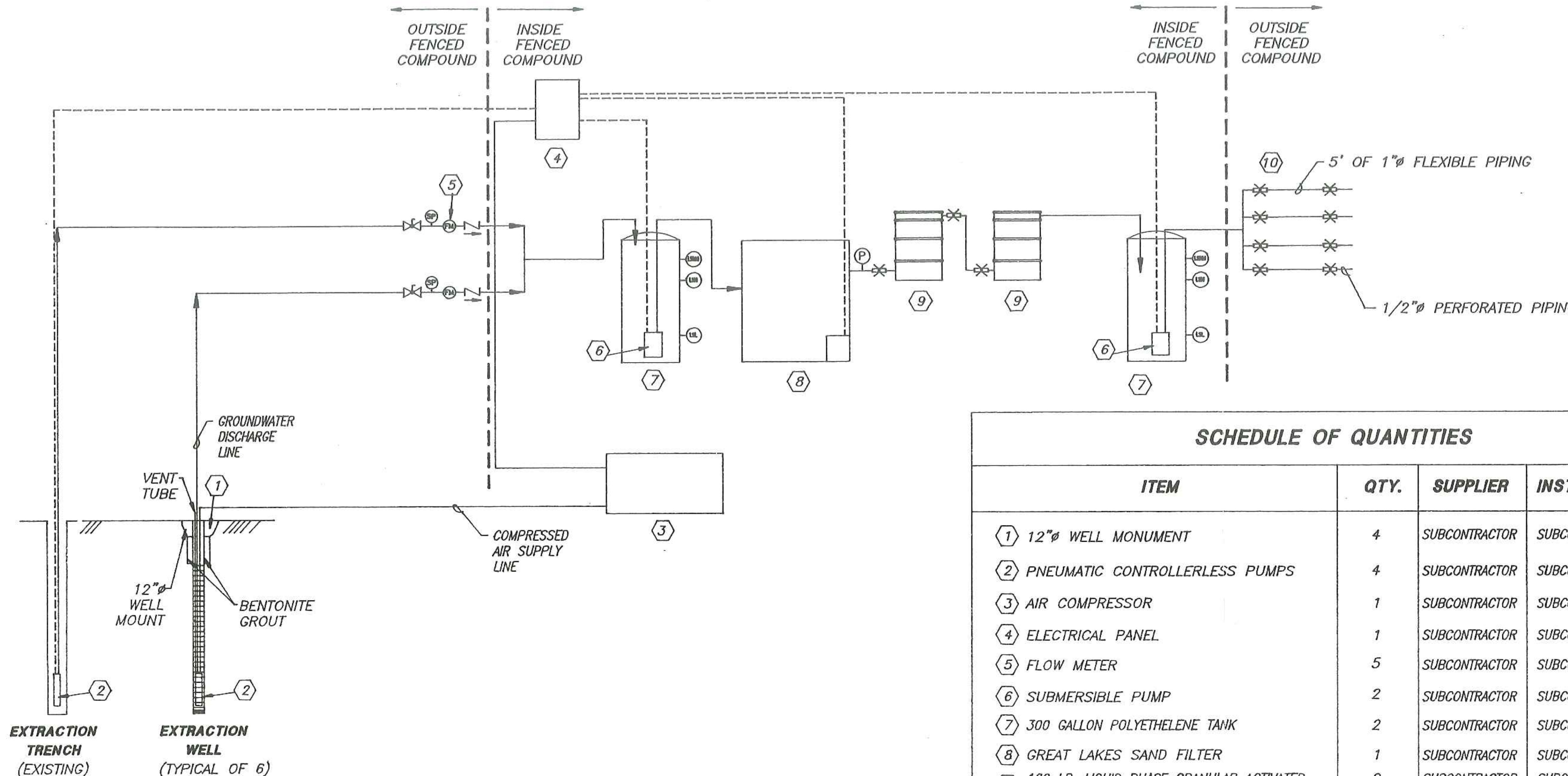
ANALYTICAL RESULTS

FORMER COLUMBIA MARINE LINES FACILITY
0305 LOWER RIVER ROAD
VANCOUVER, WASHINGTON

FIGURE: 4

JOB#: 00255-003-01 APPR: RW DWN: AJW DATE: 9/24/96

DWG: CR00323B



SCHEDULE OF QUANTITIES

ITEM	QTY.	SUPPLIER	INSTALLER
(1) 12"ø WELL MONUMENT	4	SUBCONTRACTOR	SUBCONTRACTOR
(2) PNEUMATIC CONTROLLERLESS PUMPS	4	SUBCONTRACTOR	SUBCONTRACTOR
(3) AIR COMPRESSOR	1	SUBCONTRACTOR	SUBCONTRACTOR
(4) ELECTRICAL PANEL	1	SUBCONTRACTOR	SUBCONTRACTOR
(5) FLOW METER	5	SUBCONTRACTOR	SUBCONTRACTOR
(6) SUBMERSIBLE PUMP	2	SUBCONTRACTOR	SUBCONTRACTOR
(7) 300 GALLON POLYETHELENE TANK	2	SUBCONTRACTOR	SUBCONTRACTOR
(8) GREAT LAKES SAND FILTER	1	SUBCONTRACTOR	SUBCONTRACTOR
(9) 180 LB. LIQUID PHASE GRANULAR ACTIVATED CARBON ADSORBERS	2	SUBCONTRACTOR	SUBCONTRACTOR
(10) CAMLOCK FITTINGS	11	SUBCONTRACTOR	SUBCONTRACTOR

LEGEND

- BALL VALVE
- CHECK VALVE
- FM FLOW METER
- SP SAMPLE PORT

NOTES:

1. SYSTEM IS NOT DESIGNED TO FUNCTION DURING FREEZE CONDITIONS. SYSTEM SHOULD BE TURNED OFF AND DRAINED SHOULD FREEZE CONDITIONS BE ENCOUNTERED.
2. ALL PIPING TO BE INSTALLED ABOVE GROUND. PIPING IS NOT DESIGNED FOR CARRYING LOADS DUE TO TRAFFIC, FOOT OR OTHERWISE.

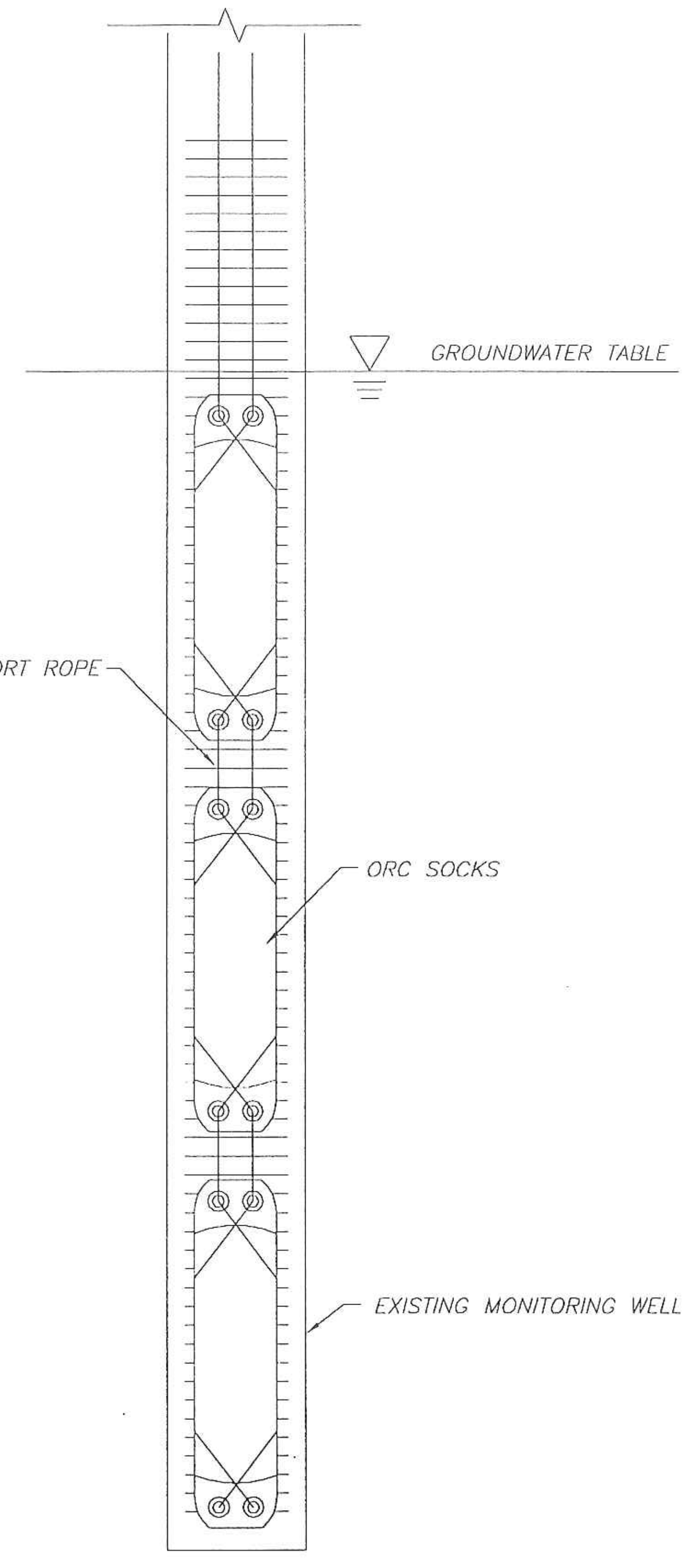
SECOR
International Incorporated

PROCESS AND INSTRUMENTATION DIAGRAM

FORMER COLUMBIA MARINE LINES FACILITY
6305 LOWER RIVER ROAD
VANCOUVER, WASHINGTON

FIGURE: 5

JOB#: 00255-003-01 APPR: PR DWN: AJW DATE: 9/24/96



SECOR
International Incorporated

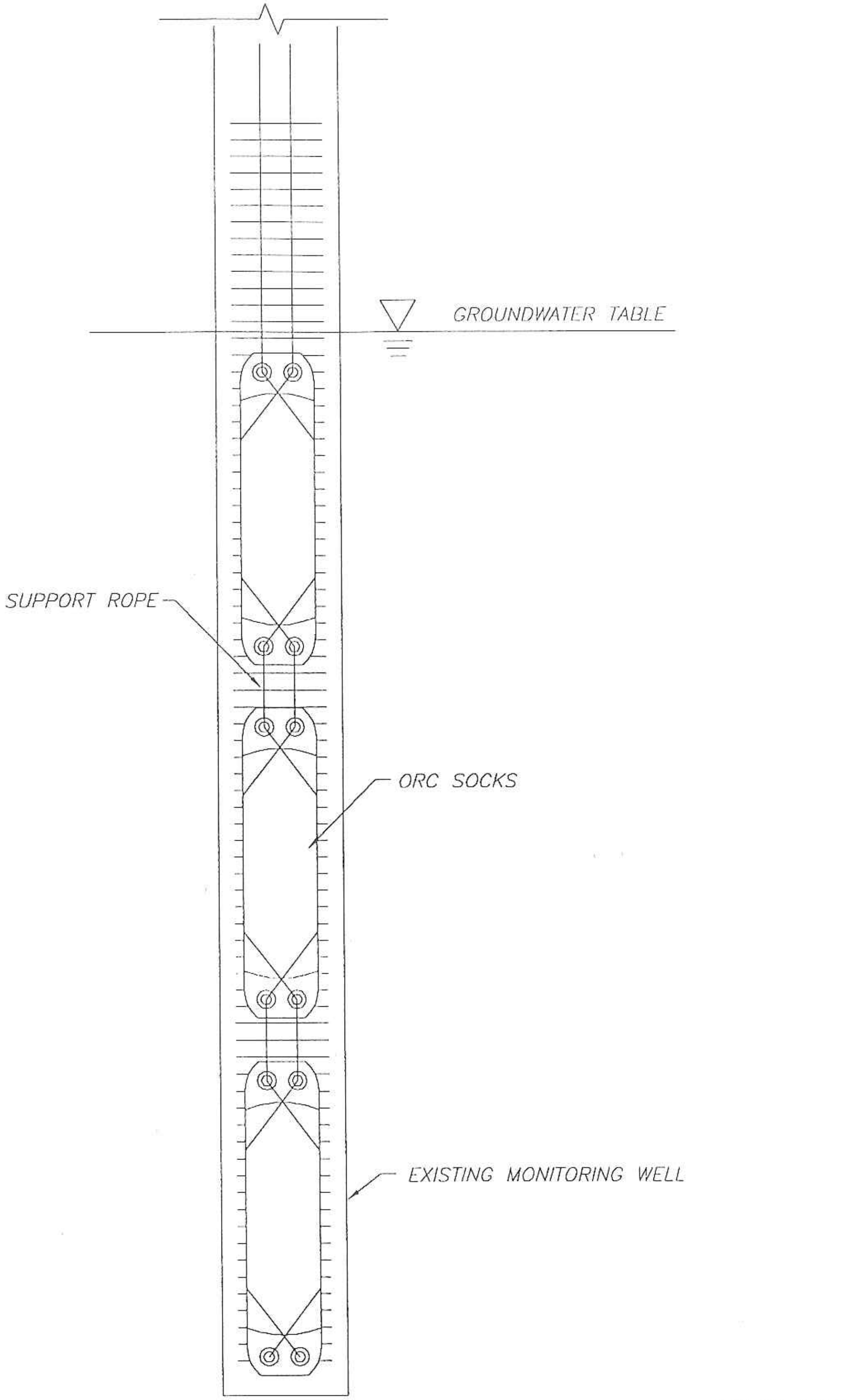
TYPICAL ORC INSTALLATION

FORMER COLUMBIA MARINE LINES FACILITY
6305 LOWER RIVER ROAD
VANCOUVER, WASHINGTON

FIGURE: 6

JOB#: 00255-003-01 APPR: PRW DWN: AJW DATE: 9/24/96

DWG: CR00318A



SECOR
International Incorporated

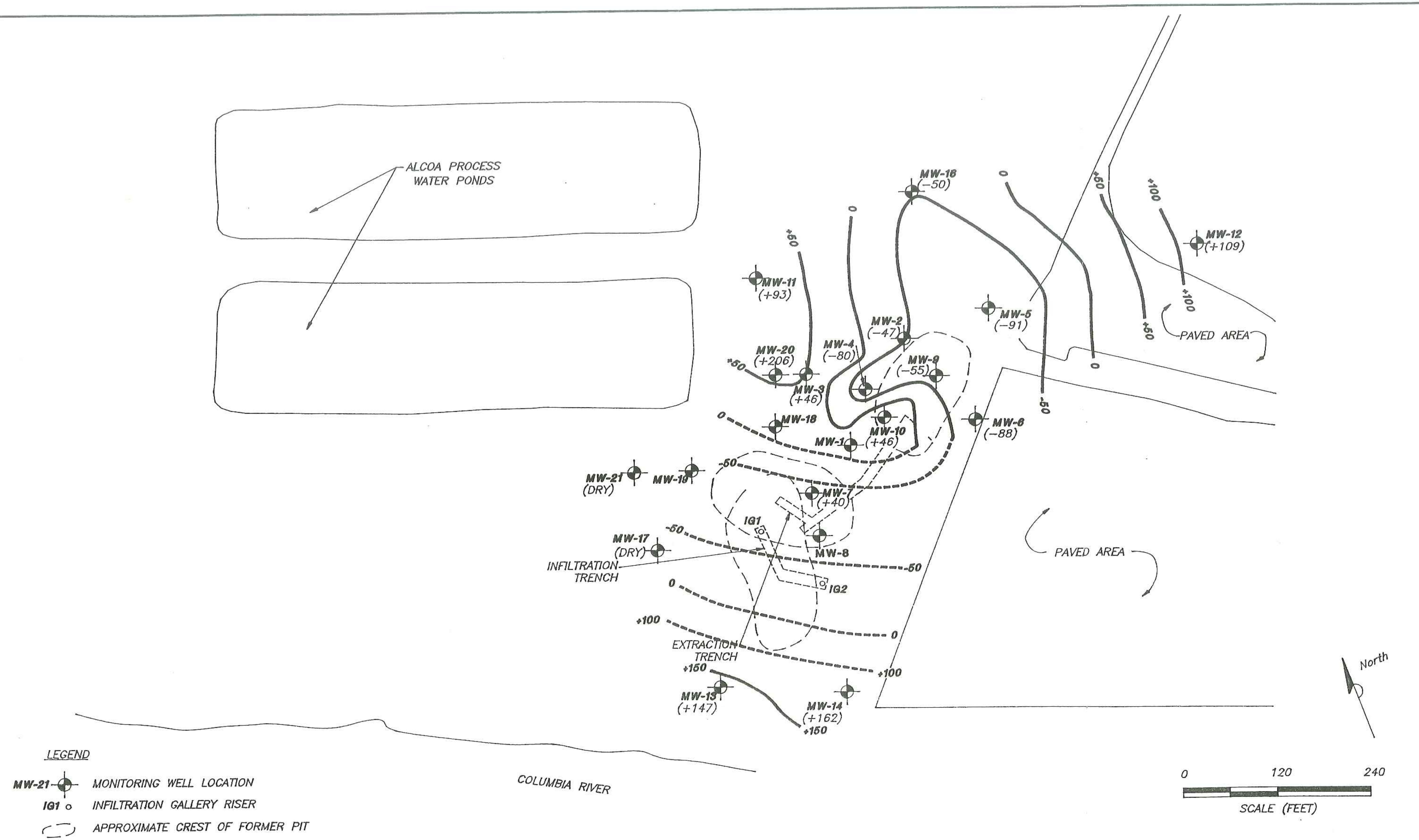
TYPICAL ORC INSTALLATION

FORMER COLUMBIA MARINE LINES FACILITY
6305 LOWER RIVER ROAD
VANCOUVER, WASHINGTON

FIGURE: 6

JOB#: 00255-003-01 APPR: PRW DWN: AJW DATE: 9/24/96

DWG: CR00318A



LEGEND

MW-21 MONITORING WELL LOCATION

IG1 o INFILTRATION GALLERY RISER

APPROXIMATE CREST OF FORMER PIT

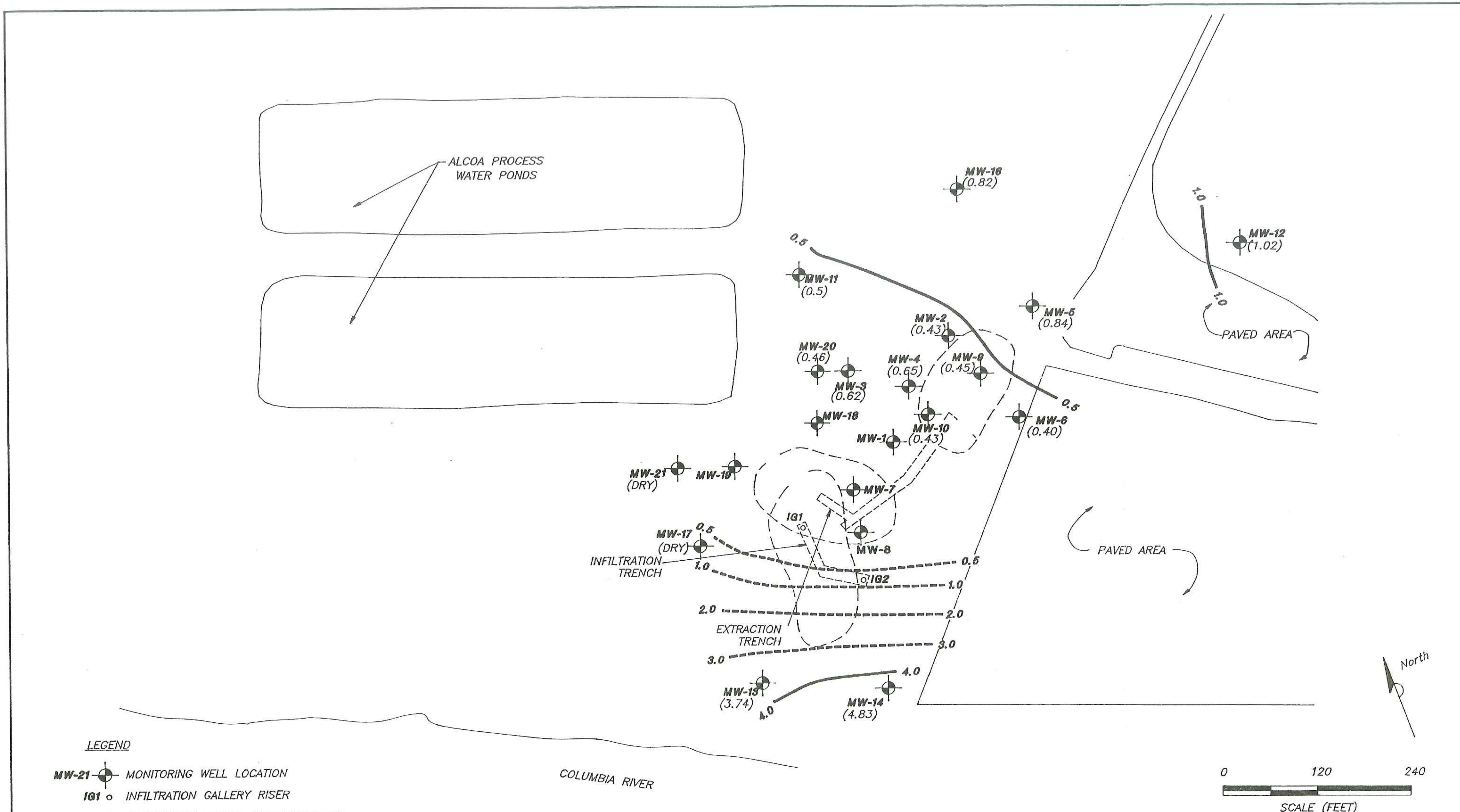
(+40) REDOX POTENTIAL (mV) ON 8/1/96

REDOX POTENTIAL CONTOUR 8/1/96

NOTE: DASHED CONTOUR LINES REPRESENT INFERRED VALUES IN AREAS WHERE MEASUREMENTS COULD NOT BE MADE DUE TO THE PRESENCE OF FREE PRODUCT.

SECOR International Incorporated	REDOX POTENTIAL CONTOURS FORMER COLUMBIA MARINE LINES FACILITY 6305 LOWER RIVER ROAD VANCOUVER, WASHINGTON	FIGURE: 7
	JOB#: 00255-003-01 APPR: PRW DWN: AJW DATE: 9/26/96	

DWG: CR00316B



LEGEND

MW-21 MONITORING WELL LOCATION

IG1 o INFILTRATION GALLERY RISER

APPROXIMATE CREST OF FORMER PIT

(1.02) DISSOLVED OXYGEN LEVEL (mg/l) ON 8/1/96

DISSOLVED OXYGEN LEVEL CONTOUR 8/1/96

NOTE: DASHED CONTOUR LINES REPRESENT INFERRED VALUES IN AREAS WHERE MEASUREMENTS COULD NOT BE MADE DUE TO THE PRESENCE OF FREE PRODUCT.

SECOR International Incorporated

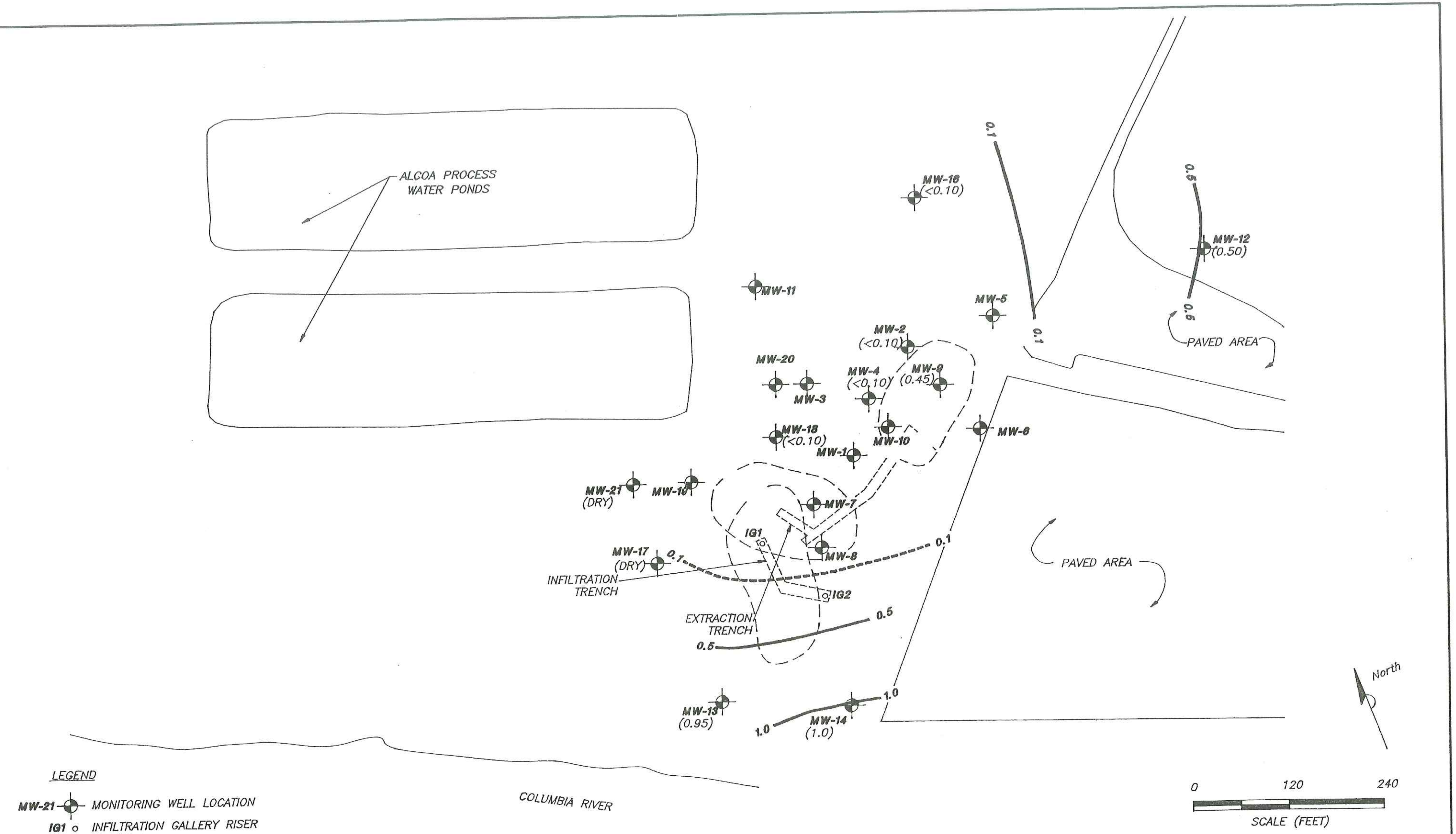
DISSOLVED OXYGEN CONCENTRATION CONTOURS

FORMER COLUMBIA MARINE LINES FACILITY
6305 LOWER RIVER ROAD
VANCOUVER, WASHINGTON

FIGURE: 8

JOB#: 00255-003-01 APPR: PRJ DWN: AJW DATE: 9/24/96

DWG: CR00317B



LEGEND

MW-21 MONITORING WELL LOCATION

IG1 o INFILTRATION GALLERY RISER

APPROXIMATE CREST OF FORMER PIT

(0.50) NITRATE CONCENTRATION LEVEL (mg/l) ON 8/1/96

NITRATE CONCENTRATION CONTOUR 8/1/96

NOTE: DASHED CONTOUR LINES REPRESENT INFERRED VALUES IN AREAS WHERE MEASUREMENTS COULD NOT BE MADE DUE TO THE PRESENCE OF FREE PRODUCT.

SECOR International Incorporated

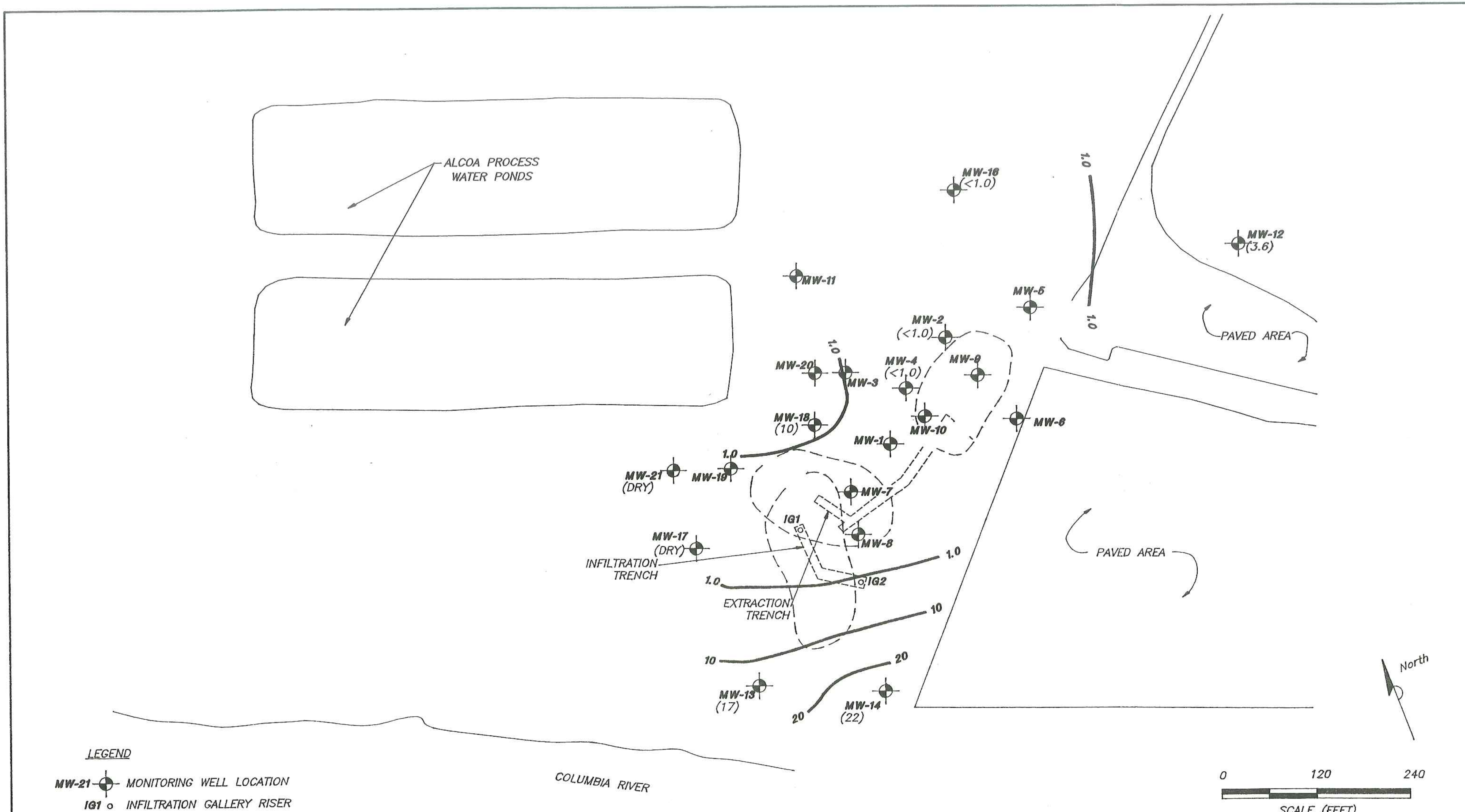
NITRATE CONCENTRATION CONTOURS

FORMER COLUMBIA MARINE LINES FACILITY
6305 LOWER RIVER ROAD
VANCOUVER, WASHINGTON

FIGURE: 9

JOB#: 00255-003-01 APPR: PR DWN: AJW DATE: 9/24/96

DWG: CR00318B



LEGEND

MW-21 — MONITORING WELL LOCATION

IG1 o INFILTRATION GALLERY RISER

APPROXIMATE CREST OF FORMER PIT

(3.6) SULFATE CONCENTRATION LEVEL (mg/l) ON 8/1/96

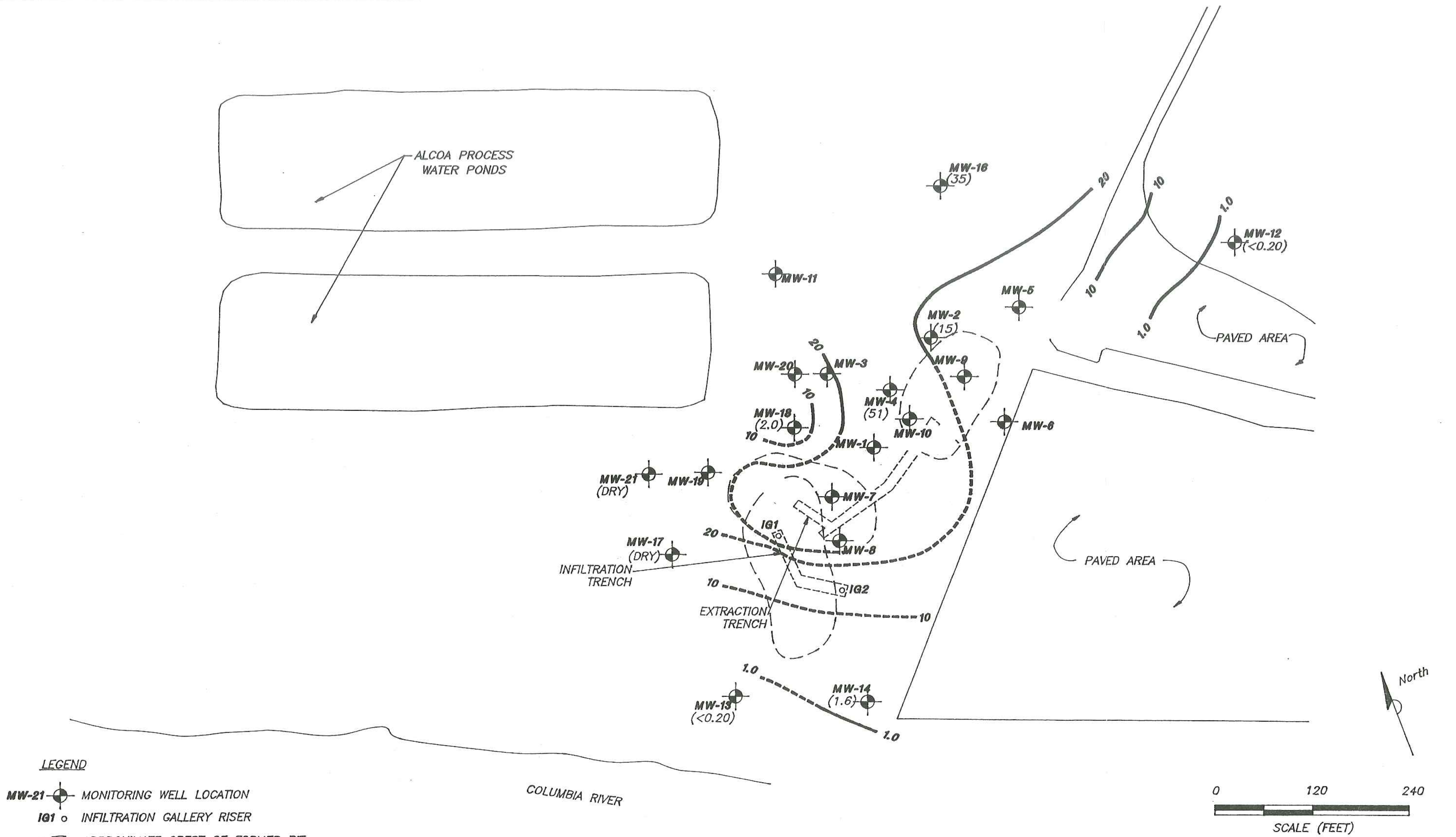
SULFATE CONCENTRATION CONTOUR 8/1/96

NOTE: DASHED CONTOUR LINES REPRESENT INFERRED VALUES IN AREAS WHERE MEASUREMENTS COULD NOT BE MADE DUE TO THE PRESENCE OF FREE PRODUCT.

SECOR International Incorporated	SULFATE CONCENTRATION CONTOURS FORMER COLUMBIA MARINE LINES FACILITY 6305 LOWER RIVER ROAD VANCOUVER, WASHINGTON	FIGURE: 10

JOB#: 00255-003-01 APPR: PRW DWN: AJW DATE: 9/24/96

DWG: CR003198



LEGEND

MW-21 MONITORING WELL LOCATION

IG1 o INFILTRATION GALLERY RISER

APPROXIMATE CREST OF FORMER PIT

(35) FERROUS IRON CONCENTRATION LEVEL (mg/l) ON 8/1/96

FERROUS IRON CONCENTRATION CONTOUR 8/1/96

NOTE: DASHED CONTOUR LINES REPRESENT INFERRED VALUES IN AREAS WHERE MEASUREMENTS COULD NOT BE MADE DUE TO THE PRESENCE OF FREE PRODUCT.

SECOR International Incorporated

FERROUS IRON CONCENTRATION CONTOURS

FORMER COLUMBIA MARINE LINES FACILITY
6305 LOWER RIVER ROAD
VANCOUVER, WASHINGTON

FIGURE: **11**

JOB#: 00265-003-01 APPR: [illegible] DWN: AJW DATE: 9/24/96

DWG: CR00320B

Table 1. Groundwater Analytical and Water Table Database
Former Columbia Marine Lines Facility
6305 Lower River Road, Vancouver, Washington

Sample Location/ TOC Elevation (feet)	Sample Date	TPH-G (mg/L)	TPH-D (mg/L) Diesel	TPH-D (mg/L) Heavy Oil	BTEX (μg/L) Benzene	BTEX (μg/L) Toluene	BTEX (μg/L) Ethyl-benzene	BTEX (μg/L) Total Xylenes	HVOCs (μg/L)	PAHs (μg/L)	DTW (feet)	LHT (feet)	WTE (feet)
MW-1 31.66	11/08/83	--	--	--	<20	<20	<20	--	--	--	--	--	--
	12/13/84	--	--	--	<5	<5	<5	<5	--	--	--	--	--
	11/13/95	<0.08	12	<5.0	<0.50	<0.50	<0.50	<0.50	ND	ND	9.19	0.00	22.47
	08/01/96	--	--	--	--	--	--	--	--	--	10.23	--	21.43
MW-2 33.97	11/08/83	--	--	--	510	450	100	770	--	--	--	--	--
	02/05/86	--	--	--	69	390	110	900	--	--	--	--	--
	08/28/90	<0.05	26.4	--	<100	<100	<100	566	--	--	--	--	--
	08/02/94	3.1	10	--	6.3	3.0	35	110	--	ND	--	--	--
	11/13/95	4.0	40	7.4	1.7	2.3	22	110	--	--	12.95	0.00	21.02
	08/01/96	<0.08	4.7	--	2.3	1.0	20	44	--	--	13.75	--	20.22
MW- 3 30.90	11/08/83	--	--	--	95	64	15	90	--	--	--	--	--
	12/17/84	--	--	--	<1	<1	<1	--	--	--	--	--	--
	11/13/95	0.29	4.6	<5.0	<0.50	<0.50	<0.50	<0.50	--	--	11.24	0.00	19.66
	08/01/96	--	--	--	--	--	--	--	--	--	11.11	--	19.79
MW-4 28.42	11/08/83	--	--	--	700	150	110	800	--	--	--	--	--
	12/12/84	--	--	--	<1	<1	<1	<1	--	--	--	--	--
	11/13/95	0.39	7.8	<5.0	3.0	1.4	1.1	6.7	--	--	8.27	0.00	20.15
	08/01/96	0.38	11	--	1.6	5.0	<0.50	<1.0	--	--	8.40	--	20.02
MW-5 23.37	11/08/83	--	--	--	35	<2	<2	--	--	--	--	--	--
	12/17/84	--	--	--	<20	380	<20	--	--	--	--	--	--
	11/13/95	<0.08	2.6	0.77	<0.50	<0.50	<0.50	<0.50	--	--	3.07	0.00	20.30
	08/01/96	--	--	--	--	--	--	--	--	--	3.60	--	19.77
MW-6 26.14	12/12/84	--	--	--	<1	<1	<1	<1	--	--	--	--	--
	11/13/95	0.74	48	<5.0	<0.50	<0.50	<0.50	<0.50	--	--	5.23	0.00	20.91
	08/01/96	--	--	--	--	--	--	--	--	--	5.50	--	20.64
MW-7 33.36	11/08/83	--	--	--	<20	<20	<20	--	--	--	--	--	--
	08/02/94	1.6	7.7	--	<2.5	<2.5	<2.5	<2.5	--	ND	--	--	--
	11/13/95	1.8	43	<5.0	1.6	1.2	<1.0	<1.0	--	--	12.54	0.00	20.82
	08/01/96	--	--	--	--	--	--	--	--	--	13.55	0.62	20.31

Table 1. Groundwater Analytical and Water Table Database (Continued)
Former Columbia Marine Lines Facility
6305 Lower River Road, Vancouver, Washington

Sample Location/ TOC Elevation (feet)	Sample Date	TPH-G (mg/L)	TPH-D (mg/L)		BTEX (μg/L)				HVOCs (μg/L)	PAHs (μg/L)	DTW (feet)	LHT (feet)	WTE (feet)
			Diesel	Heavy Oil	Benzene	Toluene	Ethyl-benzene	Total Xylenes					
MW-8 33.49	11/08/83	--	--	--	208	<2	<2	--	--	--	--	--	--
	11/13/95	5.4	490	41	2.0	1.5	1.9	5.0	--	--	12.90	0.50	20.99
	08/01/96	--	--	--	--	--	--	--	--	--	12.98	0.15	20.63
MW-9 26.36	12/13/84	--	--	--	<1	<1	<1	<1	--	--	--	--	--
	11/13/95	<0.08	0.88	0.63	<0.50	<0.50	<0.50	<0.50	--	--	4.25	0.00	22.11
	08/01/96	--	--	--	--	--	--	--	--	--	5.81	--	20.55
MW-10 25.89	11/13/95	0.76	<0.25	<5.0	1.1	1.0	1.2	1.5	--	--	5.09	0.00	20.80
	08/01/96	--	--	--	--	--	--	--	--	--	5.62	--	20.27
MW-11 25.89	12/17/84	--	--	--	<1	<1	<1	--	--	--	--	--	--
	08/02/94	<0.20	<0.50	--	<0.50	<0.50	<0.50	0.92	--	ND	--	--	--
	11/13/95	<0.08	11	<5.0	<0.50	<0.50	<0.50	<0.50	--	--	6.57	0.00	19.32
	08/01/96	--	--	--	--	--	--	--	--	--	6.71	--	19.18
MW-12 28.17	12/18/84	--	--	--	<1	<1	<1	--	--	--	--	--	--
	11/13/95	<0.08	<0.25	<0.50	<0.50	<0.50	<0.50	<0.50	--	--	6.07	0.00	22.10
	08/01/96	<0.08	<0.25	--	<0.50	<0.50	<0.50	<1	--	--	7.15	--	21.02
MW-13 22.78	12/19/84	--	--	--	<1	<1	<1	<2	--	--	--	--	--
	02/05/86	--	--	--	<1	<1	<1	<2	--	--	--	--	--
	08/28/90	<0.05	<0.05	--	<100	<100	<100	<100	--	--	--	--	--
	08/02/94	<0.20	1.2	--	<0.50	<0.50	<0.50	<0.50	--	ND	--	--	--
	11/13/95	<0.08	1.4	<0.50	<0.50	<0.50	<0.50	<0.50	--	--	10.60	0.00	12.18
	08/01/96	<0.08	0.90	--	<0.50	<0.50	<0.50	<1	--	--	10.70	--	12.08
MW-14 26.25	12/19/84	--	--	--	<1	<1	<1	--	--	--	--	--	--
	11/13/95	<0.08	1.0	<0.50	<0.50	<0.50	<0.50	<0.50	--	--	8.08	0.00	18.17
	08/01/96	<0.08	1.8	--	<0.50	<0.50	<0.50	<1	--	--	9.15	--	17.10
MW-15 26.24	02/05/86	--	--	--	<1	<1	<1	<2	--	--	--	--	--
	08/02/94	<0.20	<0.50	--	<0.50	<0.50	<0.50	<0.50	--	ND	--	--	--
	11/13/95	--	--	--	--	--	--	--	--	--	--	--	--
	08/01/96	--	--	--	--	--	--	--	--	--	--	--	--

Table 1. Groundwater Analytical and Water Table Database (Continued)
Former Columbia Marine Lines Facility
6305 Lower River Road, Vancouver, Washington

Sample Location/ TOC Elevation (feet)	Sample Date	TPH-G (mg/L)	TPH-D (mg/L)		BTEX (μg/L)				HVOCs (μg/L)	PAHs (μg/L)	DTW (feet)	LHT (feet)	WTE (feet)
			Diesel	Heavy Oil	Benzene	Toluene	Ethyl-benzene	Total Xylenes					
MW-16 31.13	02/05/86	--	--	--	93	<10	<10	240	--	--	--	--	--
	08/28/90	1.0	4.91	--	<100	<100	<100	445	--	--	--	--	--
	08/02/94	1.1*	11*	--	2.0*	0.73*	0.74*	4.8*	--	11*	--	--	--
	11/13/95	0.90	10	2.1	0.64	1.3	53	7.9	--	--	9.94	0.00	21.19
	08/01/96	0.74	<0.50	--	<0.50	2.2	<0.50	3.0	--	--	10.36	--	20.77
MW-17 33.94	02/05/86	--	--	--	<1	<1	<1	<2	--	--	--	--	--
	11/13/95	--	--	--	--	--	--	--	--	--	DRY	DRY	DRY
	08/01/96	--	--	--	--	--	--	--	--	--	14.62	--	19.32
MW-18 33.19	11/13/95	<0.08	4.9	2.1	<0.50	<0.50	<0.50	<0.50	--	--	8.47	0.00	24.72
	08/01/96	<0.08	9.6	--	<0.50	1.1	0.82	<1.0	--	--	9.96	0.00	23.23
MW-19 33.67	12/05/86	--	--	--	140	<10	30	<20	--	--	--	--	--
	08/28/90	<0.05	35.2	--	<100	<100	<100	<100	--	--	--	--	--
	11/13/95	4.3	69	<25	<2.5	<2.5	<2.5	<2.5	--	--	14.77	0.00	18.90
	08/01/96	--	--	--	--	--	--	--	--	--	14.24	0.00	19.43
MW-20 30.36	02/05/86	--	--	--	<1	<1	<1	<2	--	--	--	--	--
	11/13/95	<0.08	0.87	0.73	<0.50	<0.50	<0.50	<0.50	ND	--	21.99	0.00	8.37
	08/01/96	--	--	--	--	--	--	--	--	--	22.66	--	7.70
MW-21 30.06	02/05/86	--	--	--	<1	<1	<1	<2	--	--	--	--	--
	11/13/95	--	--	--	--	--	--	--	--	--	DRY	DRY	DRY
	08/01/96	--	--	--	--	--	--	--	--	--	10.65	--	19.41
P-1 29.35	11/13/95	--	--	--	--	--	--	--	--	--	9.74	0.00	19.61
	08/01/96	--	--	--	--	--	--	--	--	--	--	--	29.35
P-2 25.22	11/13/95	--	--	--	--	--	--	--	--	--	4.35	0.00	20.87
	08/01/96	--	--	--	--	--	--	--	--	--	--	--	25.22
EX-1 32.30	11/13/95	--	--	--	--	--	--	--	--	--	14.72	0.00	18.57
	08/01/96	--	--	--	--	--	--	--	--	--	--	--	25.22
EX-2 33.53	02/03/96	5.3	13	2.5	1.4	1.3	0.54	2.4	--	--	--	--	--
	08/01/96	--	--	--	--	--	--	--	--	--	--	--	33.53

Table 1. Groundwater Analytical and Water Table Database (Continued)
Former Columbia Marine Lines Facility
6305 Lower River Road, Vancouver, Washington

Sample Location/ TOC Elevation (feet)	Sample Date	TPH-G (mg/L)	TPH-D (mg/L)		BTEX ($\mu g/L$)				HVOCs ($\mu g/L$)	PAHs ($\mu g/L$)	DTW (feet)	LHT (feet)	WTE (feet)
			Diesel	Heavy Oil	Benzene	Toluene	Ethyl-benzene	Total Xylenes					
PMX-5 26.70	08/02/94	<0.2	1.3	--	<0.5	<0.5	<0.5	<0.5	--	ND	--	--	--
	11/13/95	--	--	--	--	--	--	--	--	--	--	--	--
	08/01/96	--	--	--	--	--	--	--	--	--	--	--	26.70
MTCA Method A Cleanup Levels		1	1		5	40	30	20	Various	0.1**			

TOC = Top of casing elevation relative to assigned benchmark.
DTW = Depth to water below top of casing.
LHT = Liquid hydrocarbon thickness.
WTE = Water table elevation.
-- = Not measured, not analyzed, or not sampled.
ND = Not detected above laboratory method reporting limit (MRL).
* = Results include higher of 08/02/94 MW-16 or bind duplicate listed as "MW-30." Fluorene was detected at 11 $\mu g/L$ in MW-30; all other PAH results were below method reporting limits.
** = MTCA Method A cleanup level for carcinogenic PAHs.

TPH-G analysis by Washington DOE Method WTPH-G.
TPH-D analysis by Washington DOE Method WTPH-D Extended.
BTEX analysis by EPA Method 8020.
HVOC analysis by EPA Method 8010.
PAH analysis by EPA Method 8310.

Analytical methods prior to 1995 include Hydrocarbon Scan by EPA Methods 3510/Modified 8015, and Oil and Grease by EPA Method 413.1.

Note: Water elevation corrected if liquid hydrocarbon present, corrected water level elevation = TOC - [(depth to water) -(LH thickness x 0.80)].

Table 2. Groundwater Analytical and Water Table Database
Former Columbia Marine Lines Facility
6305 Lower River Road, Vancouver, Washington

Sample Location/ TOC Elevation (feet)	Sample Date	Iron (mg/L)	Dissolved Oxygen (mg/L)		EH (mv)		Nitrate N (mg/L)	Sulfate (mg/L)	DTW (feet)	LHT (feet)	WTE (feet)	Bicarbonate Alkalinity (mg $CaCO_3$/L)
			Pre-Purged	Post-Purged	Pre-Purged	Post-Purged						
MW-1 31.66	08/01/96	--	0.38	--	40.1	--	--	--	10.23	--	21.43	--
MW-2 33.97	08/01/96	15	0.43	--	-47.0	-64.7	<0.10	<1.0	13.75	--	20.22	130
MW- 3 30.90	08/01/96	--	0.62	--	46.3	--	--	--	11.11	--	19.79	--
MW-4 28.42	08/01/96	51	0.55	0.65	--	-80.1	<0.10	<1.0	8.40	--	20.02	170
MW-5 23.37	08/01/96	--	0.84	--	-90.5	--	--	--	3.60	--	19.77	--
MW-6 26.14	08/01/96	--	0.40	--	-88.0	--	--	--	5.50	--	20.64	--
MW-7 33.36	08/01/96	--	--	--	--	--	--	--	13.55	0.62	20.31	--
MW-8 33.49	08/01/96	--	--	--	--	--	--	--	12.98	0.15	20.63	--
MW-9 26.36	08/01/96	--	0.45	--	-55.3	--	--	--	5.81	--	20.55	--
MW-10 25.89	08/01/96	--	0.43	--	45.9	--	--	--	5.62	--	20.27	--
MW-11 25.89	08/01/96	--	0.48	--	93.0	--	--	--	6.71	--	19.18	--
MW-12 28.17	08/01/96	<0.20	0.75	1.02	109.2	75.7	0.50	3.6	7.15	--	21.02	74
MW-13 22.78	08/01/96	<0.20	0.72	3.74	147.2	113.0	0.95	17	10.70	--	12.08	426

Table 2. Groundwater Analytical and Water Table Database (Continued)
Former Columbia Marine Lines Facility
6305 Lower River Road, Vancouver, Washington

Sample Location/ TOC Elevation (feet)	Sample Date	Iron (mg/L)	Dissolved Oxygen (mg/L)		EH (mv)		Nitrate N (mg/L)	Sulfate (mg/L)	DTW (feet)	LHT (feet)	WTE (feet)	Bicarbonate Alkalinity (mg $CaCO_3$/L)
			Pre-Purged	Post-Purged	Pre-Purged	Post-Purged						
MW-14 26.25	08/01/96	1.6	0.40	4.83	162.1	85.1	1.0	22	9.15	--	17.10	78
MW-15 26.24	08/01/96	--	--	--	--	--	--	--	--	--	--	--
MW-16 31.13	08/01/96	35	0.46	0.82	--	-49.8	<1.0	<1.0	10.36	--	20.77	130
MW-17 33.94	08/01/96	--	--	--	--	--	--	--	14.62	--	19.32	--
MW-18 33.19	08/01/96	2.0	0.41	--	< -1500	--	<1.0	10	9.96	0.00	23.23	29
MW-19 33.67	08/01/96	--	NM*	--	NM*	--	--	--	14.24	0.00	19.43	--
MW-20 30.36	08/01/96	--	0.46	--	205.9	--	--	--	22.66	--	7.70	--
MW-21 30.06	08/01/96	--	--	--	--	--	--	--	10.65	--	19.41	--
P-1 29.35	08/01/96	--	--	--	--	--	--	--	--	--	29.35	--
P-2 25.22	08/01/96	--	--	--	--	--	--	--	--	--	25.22	--
EX-1 32.30	08/01/96	--	--	--	--	--	--	--	--	--	25.22	--
EX-2 33.53	08/01/96	--	--	--	--	--	--	--	--	--	33.53	--

Table 2. Groundwater Analytical and Water Table Database (Continued)
Former Columbia Marine Lines Facility
6305 Lower River Road, Vancouver, Washington

Sample Location/ TOC Elevation (feet)	Sample Date	Iron (mg/L)	Dissolved Oxygen (mg/L)		EH (mv)		Nitrate N (mg/L)	Sulfate (mg/L)	DTW (feet)	LHT (feet)	WTE (feet)	Bicarbonate Alkalinity (mg $CaCO_3$/L)
			Pre-Purged	Post-Purged	Pre-Purged	Post-Purged						
PMX-5 26.70	08/01/96	--	--	--	--	--	--	--	--	--	26.70	--

TOC = Top of casing elevation relative to assigned benchmark.
DTW = Depth to water below top of casing.
LHT = Liquid hydrocarbon thickness.
WTE = Water table elevation.
-- = Not measured, not analyzed, or not sampled.
ND = Not detected above laboratory method reporting limit (MRL).
EH = Oxidation Reduction Potential
*NM = Due to heavy sheen on DTW indicator
mg/L = milligrams per liter.
mv = millivolts

Note: Water elevation corrected if liquid hydrocarbon present, corrected water level elevation = TOC - [(depth to water) -(LH thickness x 0.80)].

Table 3. Bioattenuation Parameter Monitoring Frequency Schedule
Former Columbia Marine Lines Facility
6305 Lower River Road, Vancouver, Washington

Well	Monitoring Parameter							
	TPH-G	BTEX	Iron	D.O.	Eh	Nitrate	Sulfate	Alkalinity
MW-1	A	A						
MW-2	Q	Q	Q	Q	Q	Q	Q	Q
MW-3	A	A						
MW-4	Q	Q	Q	Q	Q	Q	Q	Q
MW-5	A	A						
MW-6	A	A						
MW-7	A	A						
MW-8	A	A						
MW-9	A	A						
MW-10	A	A						
MW-11	A	A						
MW-12	Q	Q	Q	Q	Q	Q	Q	Q
MW-13	Q	Q	Q	Q	Q	Q	Q	Q
MW-14	Q	Q	Q	Q	Q	Q	Q	Q
MW-15	A	A						
MW-16	Q	Q	Q	Q	Q	Q	Q	Q
MW-17	A	A						
MW-18	Q	Q	Q	Q	Q	Q	Q	Q
MW-19	A	A						
MW-21	A	A						

Q = monitoring for these parameters will be conducted quarterly.
A = monitoring for these parameters will be conducted annually.