GeoSolv, LLC

ENVIRONMENTAL AND HYDROGEOLOGICAL CONSULTING
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January 24, 2000

Barney M. Chan
Hazardous Materials Specialist
Alameda County Environmental Health
1131 Harbor Bay Parkway, Suite 250
Alameda, CA 94502-9335

Phone: **(510) 567-6765**
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SUBJECT: REMEDIAL ACTION PLAN (RAP) FOR DUAL PHASE GROUNDWATER EXTRACTION & VAPOR EXTRACTION FOR CLEANUP OF GASOLINE CONSTITUENTS IN SOIL & GROUNDWATER @
FORMER BILL CHUN SERVICE STATION
2301 SANTA CLARA AVENUE, ALAMEDA, CA 94501

Dear Barney:

This Remedial Action Plan (RAP) has been submitted as required by the Alameda County Environmental Health Services Department ACEHSD in a correspondence letter dated June 15, 1999 approving a workplan for remedial action by GeoSolv, LLC which confirmed the assertion, made by ENSR in their June 17, 1998 Corrective Action Evaluation and Feasibility Study, that dual phase groundwater extraction and treatment as well as vapor extraction would be the best method for cleanup of fuel hydrocarbons in soil and groundwater at the site. The workplan for a RAP also defined some of the criteria and parameters to be evaluated in this RAP. This RAP

provides the specific design criteria necessary to construct and implement the cleanup at the site and is based upon subsurface investigation, vapor well pilot testing, and slug testing of groundwater characteristics performed by previous consultants.

Sincerely,

REGISTERED GEOLOGIST
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CERTIFIED HYDROGEOLOGIST
NO. 466
STATE OF CALIFORNIA

Franklin J. Goldman
State Registered Geologist No. 5557
State Certified Hydrogeologist No. 466
CEO/GeoSolv, LLC

George T. Pavlov
Field Supervisor

CLEANUP STRATEGY

SUPPLEMENTAL DATA COLLECTION TO INITIATE RAP

The data obtained by previous environmental consultants regarding **Former Bill Chun Service Station**, located at 2301 Santa Clara Avenue, Alameda, CA 94501 (**See Figure 1**) is sufficient to chose an appropriate cleanup option, as well as to provide the basic design criteria for the pump and treat, together with vapor extraction systems. We recommend, however, that certain soil and groundwater characteristics be re-evaluated to refine the proposed design criteria. A simple sensitivity analysis utilizing revised groundwater and soil vapor characteristics can be applied to the existing design to make the cleanup process more effective.

Specifically, there is concern that the slug testing (e.g. single well aquifer testing by injecting a slug of water) performed to date, does not provide a representative evaluation of groundwater characteristics, would an aquifer test utilizing multiple observation wells. The slug test only provides an estimation of transmissivity in the immediate vicinity of the tested well, and does not address storativity at all. In addition, the typical discharge rate (in gallons per minute) from an extraction well has also not been adequately determined. This has made estimates of capture zones and zones of effective drawdown for groundwater extraction and injection wells subject to some interpretation. It is based upon groundwater characteristics typical of the soil types encountered at the site as well as the limited information provided by the slug testing. We therefore recommend that an aquifer test with observation wells be performed onsite to obtain accurate storativity, transmissivity and pumping well discharge values. In addition, pumping tests with observation wells depict the reaction of the aquifer to pumping across the entire site instead of just at one location.

The vapor well pilot test was performed at only one vacuum pressure and an insufficient number of vapor observation wells were measured for their reaction to air extraction. A new vapor pilot test should also be performed to better define the radius of influence for vapor extraction wells in both the silty sand and the clayey sand.

Aside from performing a vapor well pilot test and an aquifer test prior to installation of the remediation system, a round of groundwater monitoring should be performed in order to verify that the proposed zones of capture for the proposed groundwater extraction wells are adequate to envelop the dissolved benzene plume in groundwater. This will provide a base line measurements for groundwater monitoring during the remediation process.

In addition, a risk based corrective action (RBCA) evaluation should be performed to determine relative human health risk by establishing site specific target levels (SSTLs) for cleanup. A RBCA does not necessarily have to be performed prior to the initiation of soil and groundwater cleanup since the remediation system has been designed to attain the most effective cleanup possible. Also, SSTLs typically establish lower, less stringent, clean-up levels relative to those established based upon threats

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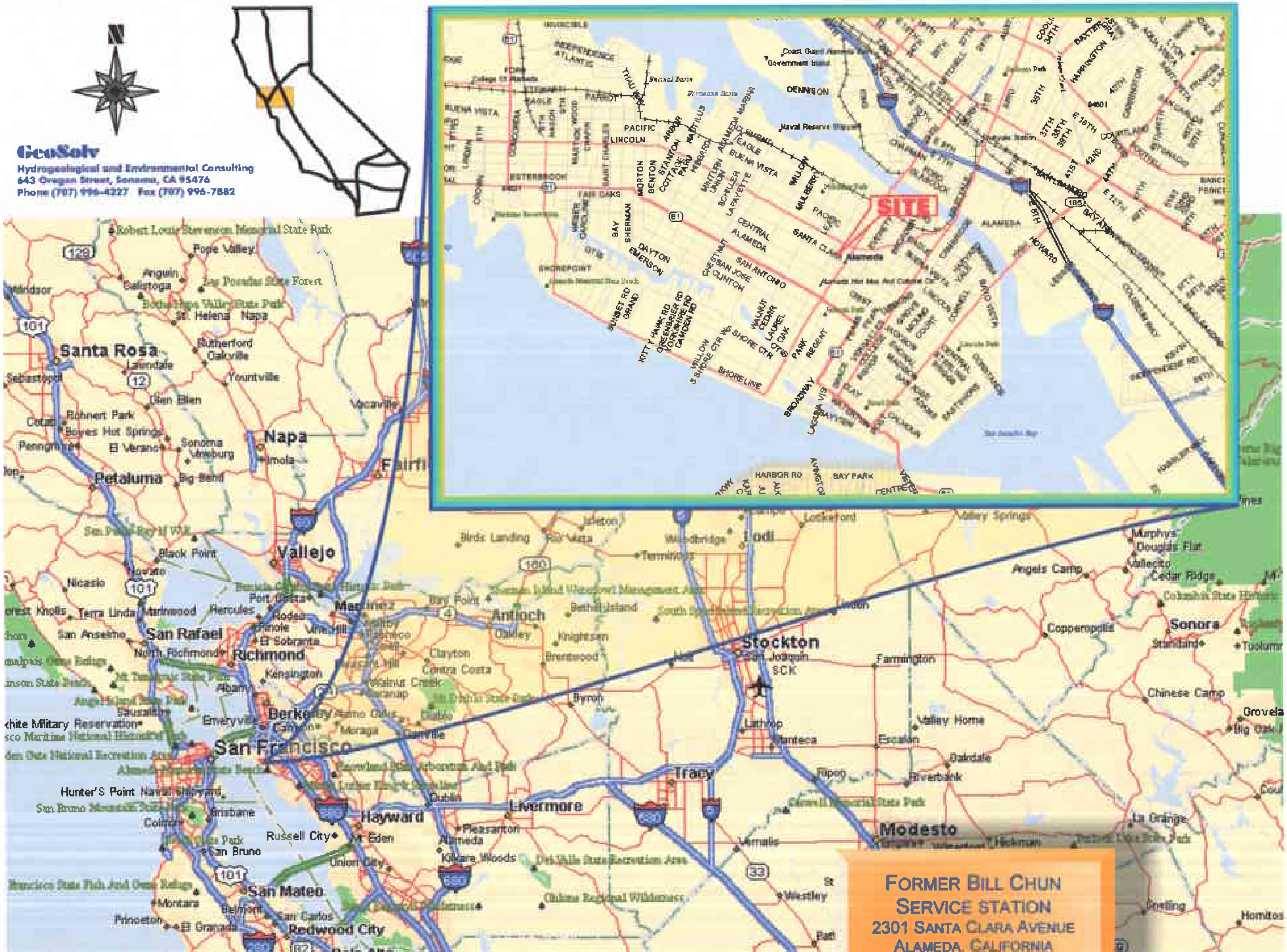

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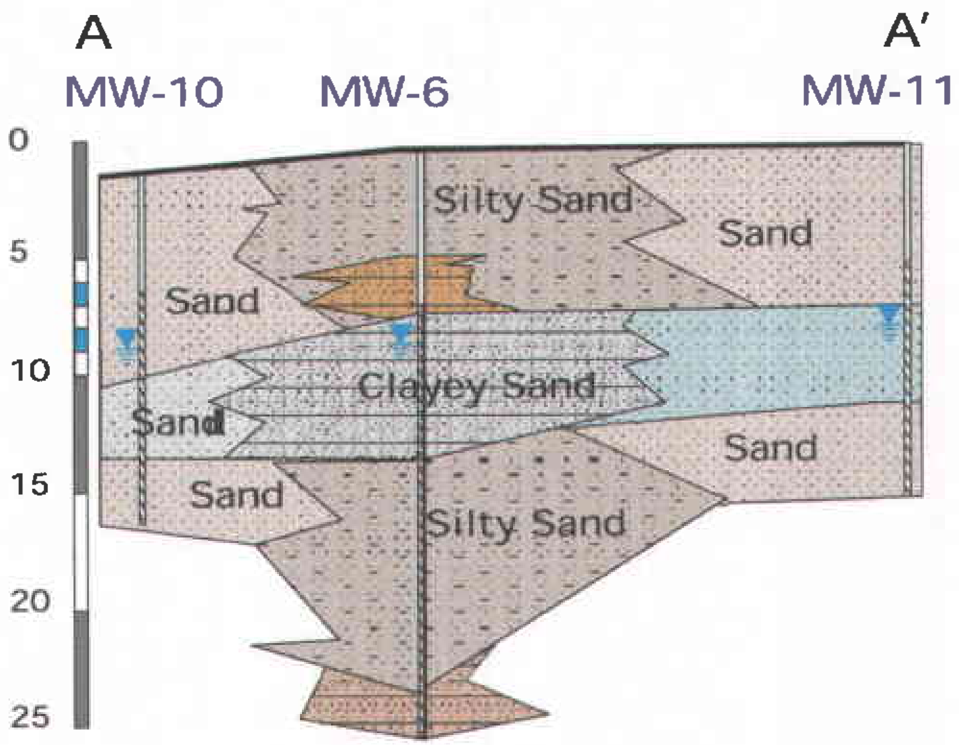
2301 SANTA CLARA AVENUE
ALAMEDA, CALIFORNIA

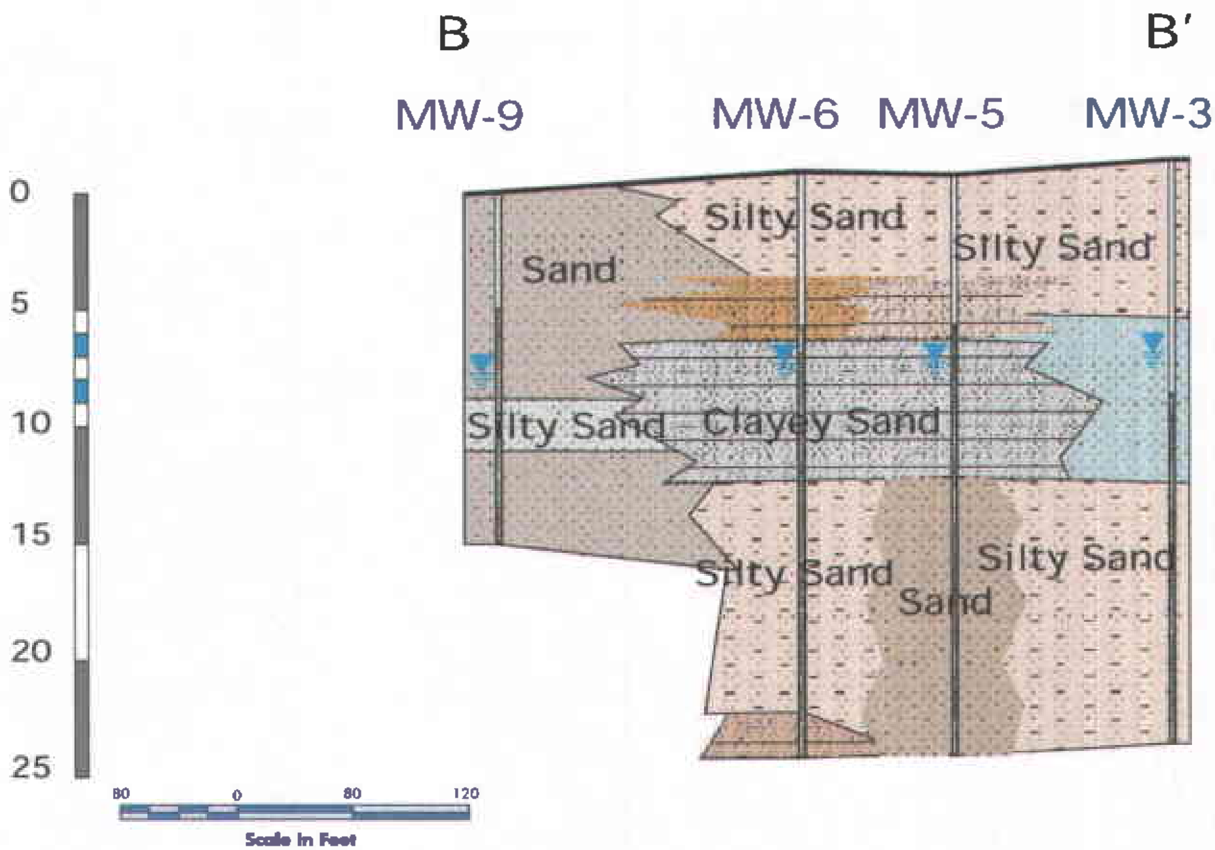
Figure 1

to water supplies and other non-human receptors. Identification of other sensitive receptors such as nearby water supply wells, aquifers with beneficial uses, surface waters, and environmental receptors should be performed and incorporated into a fate and transport analysis to determine if and when nearby receptors will be at risk. Completion of a sensitive receptor survey and a fate and transport analysis, which are typically components of a RBCA, could be critical to establishing cleanup levels if it is determined that specific receptors are at risk if the contamination is not reduced to a specified level within a limited time constraint (e.g. can a specific concentration of benzene in soil or groundwater reach a nearby water supply well if it is not remediated).

Soil Contamination Targeted for Cleanup

The site is underlain predominantly by silty sand and sandy soil within the upper twenty (20) feet below ground surface (bgs). A laterally extensive, but not laterally continuous, clayey sand layer also exists between eight (8) and thirteen (13) feet bgs **(See Figure 2A and 2B for Lithologic Cross Sections)**.

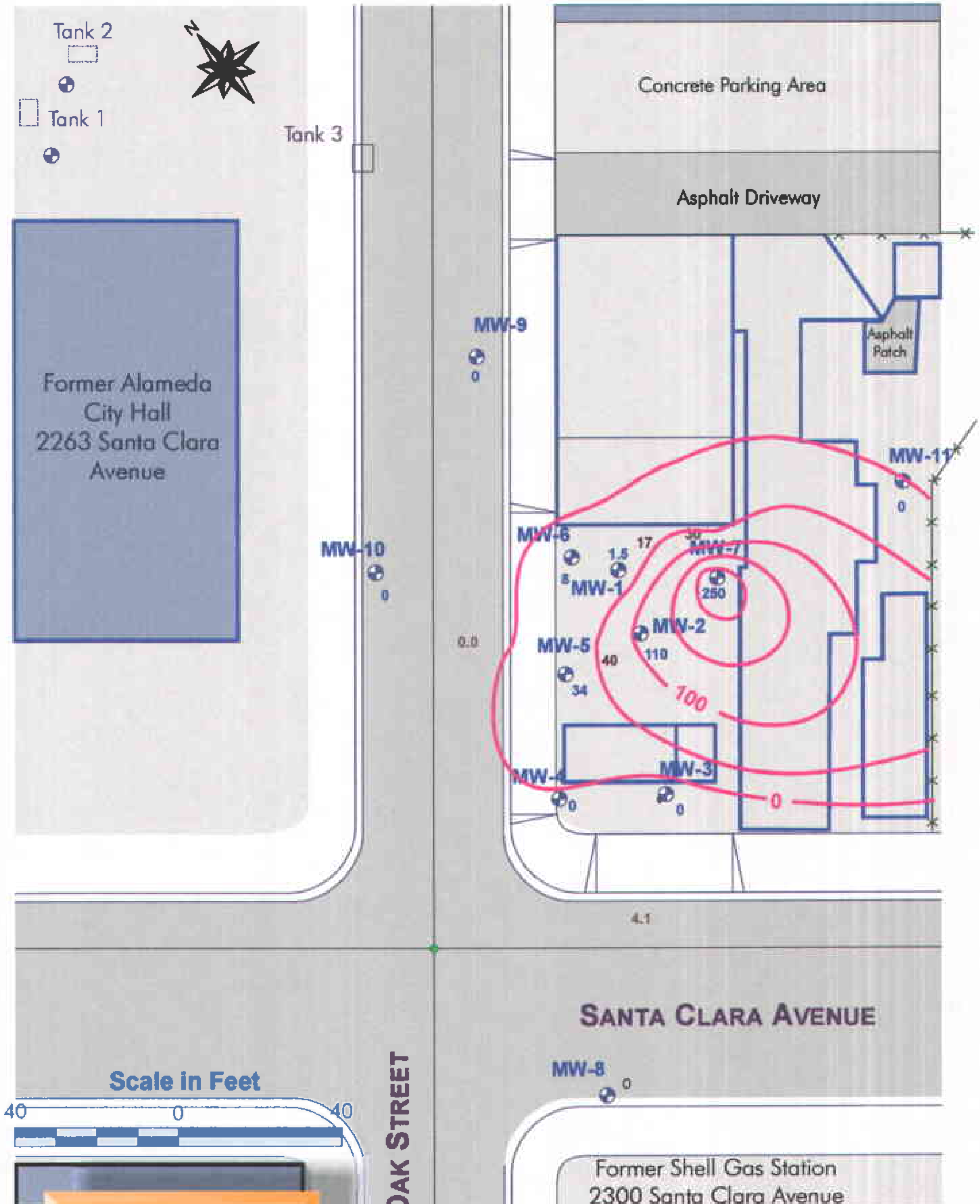




Since fuel hydrocarbons typically adsorb more readily to clayey and silty earth materials than sand, it is more likely that gasoline in soil will be found between 8 ad 13 feet bgs. In fact, most of the benzene contamination in soil onsite has been identified between 9 and 11 feet bgs **(See Figure 3 for Map of Benzene in Soil Between 9 & 11 Feet bgs)**. Since fuel hydrocarbons have a tendency to adsorb to soil within the zone of water table fluctuation (e.g. groundwater levels have been historically between (7½) and (9½) feet bgs beneath the site), it is safe to assume that "smear zone" exists between 7 and 10 feet bgs. **In summary, the target zone for soil cleanup is between 7 and 13 feet bgs within clayey sands and silty sands.**

Since the water table is as shallow as 7 ½ feet bgs and the worst soil contamination is as deep as 11 feet bgs, the cone of depression of the water table produced by the pumping well must be lowered by approximately 3 ½ feet. It has been estimated that a pumping rate of 15 gallons per minute in an extraction well can produce sufficient drawdown to expose the smear zone to the perforation intervals of vapor extraction wells based upon the field data obtained to date by previous consultants. The perforation intervals for the vapor extraction wells will be between 7 and 13 feet bgs. Based upon a radius of influence of 20 feet within the vapor extraction wells, as determined by a previous consultant's vapor well pilot test, and a radius of influence typical of silty sands, 23 vapor wells with sufficient overlap

assumes gw will be lowered at least to this depth



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Benzene in Soil
(9 to 11 Feet Interval)

Conc. in ppm ?

Fig 3

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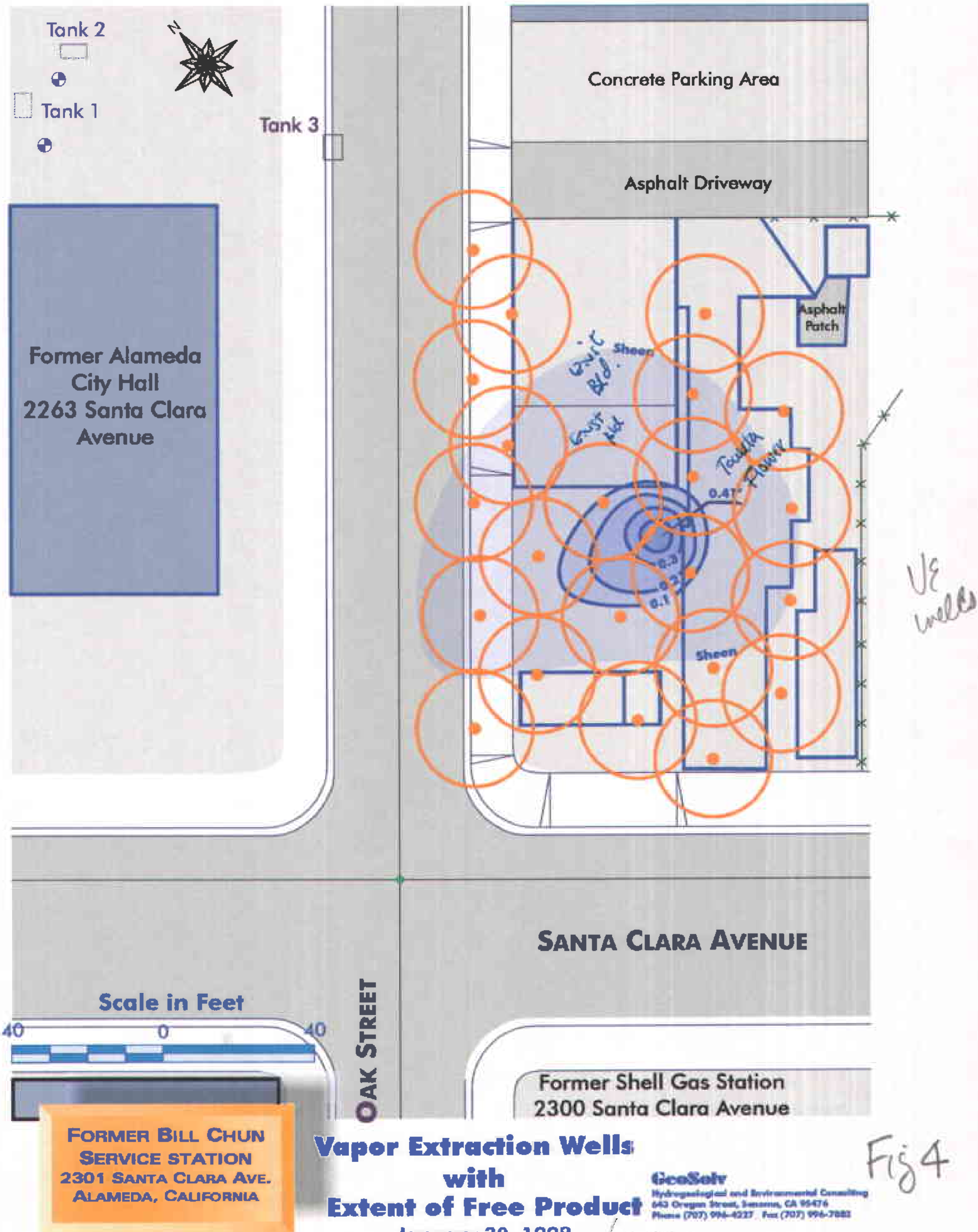

Vapor Extraction Wells with Extent of Free Product (in blue

January 30, 1998

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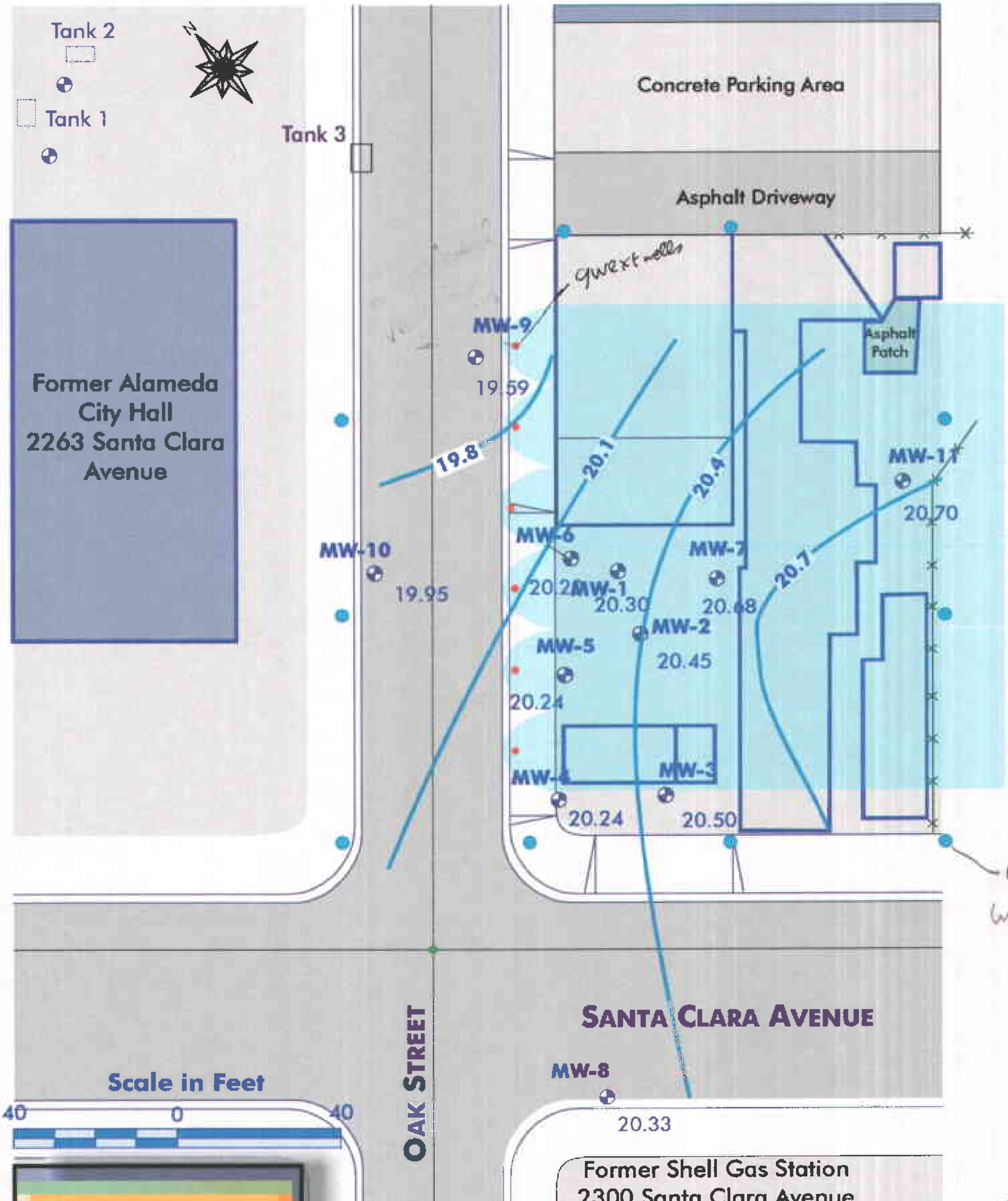
Fig 4

have been proposed to remediate the smear zone throughout the site **(See Figure 4 for Map of Vapor Extraction Well Locations).** Some vapor extraction wells could not be included in the plan due to well construction limitations or presence of physical structural obstructions onsite.

GROUNDWATER CONTAMINATION CLEANUP STRATEGY

The predominant groundwater gradient flow direction is to the northwest based upon the most recent groundwater levels. Six (6) groundwater extraction well with 4 inch diameter steel casings, screened from 7 feet to 30 feet bgs, pumping at a rate of 15 gallons per minute, will produce a zone of capture which reaches upgradient, across the entire site, and a zone of effective drawdown to a depth of 30 feet bgs to entrain the dissolved benzene in groundwater **(See Figure 5 for Map of Groundwater Gradient Contours, Extraction Well Locations, and Zone of Capture with Calculation Spreadsheet)**. The groundwater extraction wells will be fitted with a dual phase system which will remove free product and groundwater which has a visible sheen o the water table. The overlap of the 6 groundwater extraction wells, which provides a seamless zone of capture across the site, is surrounded by groundwater injection wells which will provide both a hydrodynamic isolation as well as introductory points for injection of surfactants **(See Figure 6 for Map of Extraction and Injection Well Locations, Zone of Capture, and the Limits of Free Product and Sheen).** The injection rate will be controlled to maintain an optimal groundwater gradient for containing and extracting the contaminated water, and will be generally pumped at an extraction rate which is considerably less than that used for the extraction wells. The injection and pumping rates can be determined after a better evaluation of aquifer parameters and application of groundwater modeling.

Calculations for preliminary estimates of the zone of capture in an unconfined aquifer for the extraction wells may be found in Grubb (1993) and by Fetter (1994), Applied Hydrogeology, 3rd Ed. Pages 502-503. Preliminary estimates of the length and width of the zone of capture for the extraction wells were compared to type curves found in Fetter (1993), Contaminant Hydrogeology, Pages 408-412 and Domenico and Schwartz (1990), Pages 725-732. Application of zone of capture type curves was based upon estimates of pumping well discharge. Injection and extraction well location strategy was based upon typical well location patterns found in Fetter (1993), Contaminant Hydrogeology, Pages 414-416.



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Capture Zones and Groundwater Elevations

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Fig 5

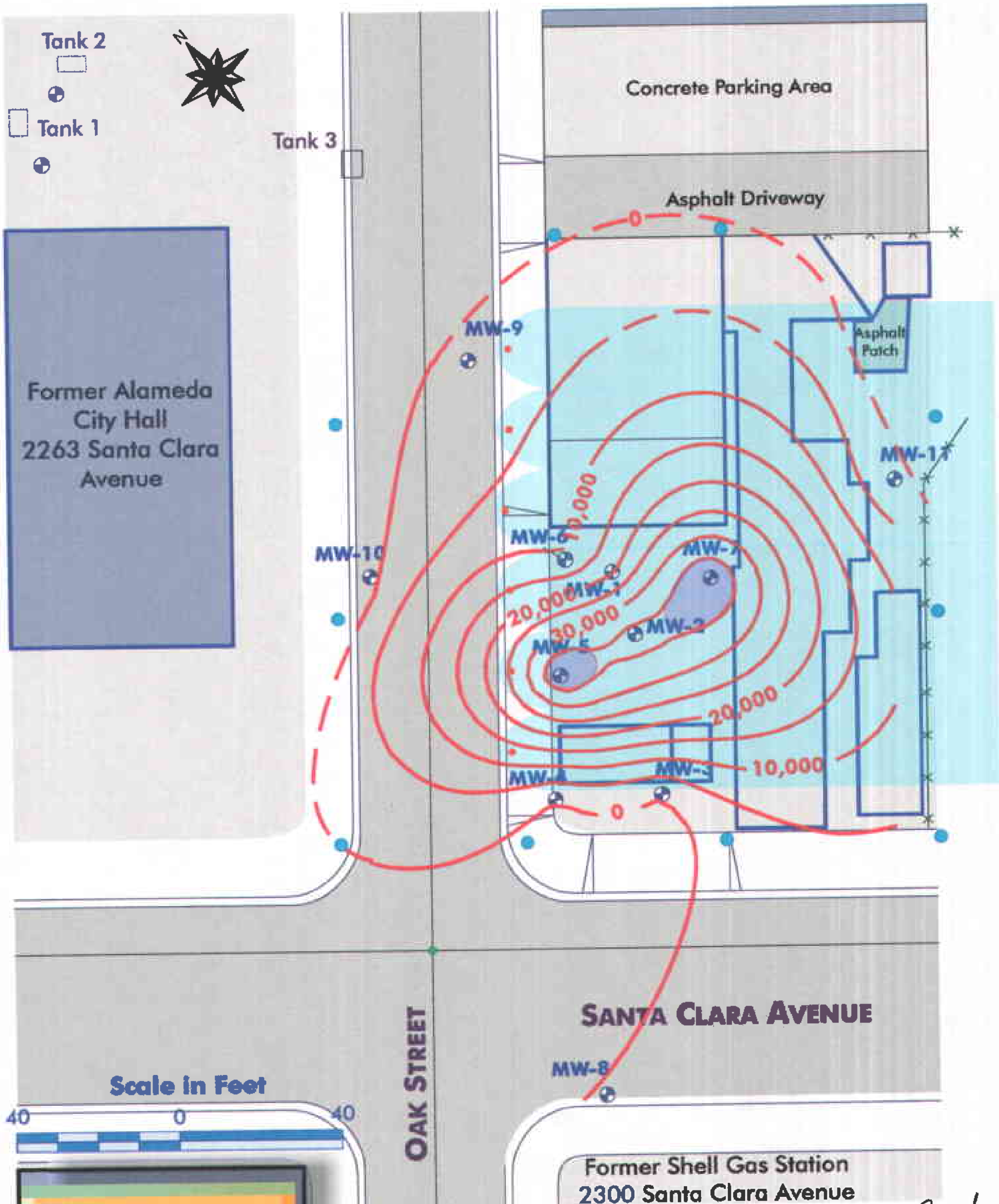

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Fig 6

Capture Zones and Benzene in Groundwater

March 06, 1997

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ENGINEERING DESIGN

REMEDIAL TECHNOLOGIES EMPLOYED

Overall Process Description

The general remedial objectives for the Chun site can be defined as follows:

- Containment and Collection of the Free Product
- Removal of Contaminants from the Vadose Zone Soils

Containment and collection of Free Product will be accomplished by a groundwater pumping and treating system. This system will be designed to separate and remove both immiscible and dissolved contaminants from the subsurface. In addition, groundwater pumping can be effectively used as a hydraulic barrier to prevent off-site migration of contaminant plumes by altering the natural groundwater gradient. By pumping water from a well, a depression is formed in the groundwater table from which Free-Floating Product becomes trapped and prevented from migrating off-site. Free Product removal will be enhanced through the used of Dual Phase Extraction (DPE). This technique involves applying a vacuum to the groundwater wells to increase the groundwater depression gradient and facilitate migration of free product through the soil. The criteria for well design, pumping system, and treatment are critically dependent on accurate assessment of soil stratigraphy and subsurface hydraulic conductivity. Prior testing and sampling performed by consultants is sufficient to prepare this RAP, but more comprehensive testing of hydraulic conductivity will be required to ensure coverage of the site and proper sizing for both the well pumps and surface treating equipment

Removal of contaminants from the vadose zone soils will be accomplished by a combination of soil vapor extraction and chemically-enahnced soil flushing. The soil vapor extraction is accomplished my applying a vacuum to wells screened in the contaminant zones. The vacuum decreases the soil vapor pressure, which in turn increases the relative volatility of contaminants. Moreover, the negative pressure gradients cause migration of air through the soil which carry away the volatilized contaminants. The collected soil gases are then destroyed on site by the use of a Catalytic Oxidation unit.

In addition to soil vapor extraction, contaminants will be removed by in situ flushing of the vadose zone with clean water from the groundwater treating unit. In situ soil flushing is the extraction of contaminants from the soil with water mixed with solubility-enhancing chemicals, such as surfactants. Soil flushing is accomplished by passing the extraction fluid through in-place soils through an array of injection wells. The extraction fluid would then be recovered from the underlying aquifer and recycled.

Extraction Well Design

The remediation system, composed of both groundwater and soil vapor extraction and treating systems, will employ three types of extraction wells designs:

- Groundwater/Free Product Extraction Well with Vaccum Applied (Dual Phase Extraction Well)
- Soil Vapor Venting/Extracting Wells
- Clean Water Injection Wells

Groundwater Extraction wells will be strategically located to ensure full coverage of the site and to maximize the capture zone throughout the contamination plume. To maximize remediation effectiveness and minimize costs, these wells will be designed to provide the capability of both groundwater and soil vapor extraction. Site data indicates that substantial Free Product is laterally extensive across the site and floating on the water table between 7-1/2 feet and 9-1/2 feet bgs. When groundwater is pumped from these wells, the depression gradient will expose a smear zone of contaminated soils between 7 and 10 feet bgs. The Groundwater wells will be screened from 30 feet bgs up to 6 feet bgs. Soil gases will be extracted in the upper 5 feet of the well and groundwater extracted through the lower 25 feet.

Soil Vapor Wells will be installed along a grid pattern to ensure full coverage of the smear zone soil. These wells will be screened from 6 feet to 13 feet bgs to ensure coverage of soils exposed once the groundwater gradient is lowered by the groundwater pumping wells. All Groundwater Extraction wells and the Soil Vapor Extraction wells will be connected to the vacuum system. However, ~~the~~ some of the Soil Vapor Extraction wells will be opened to the atmosphere to allow ambient air to be drawn into the smear zone and migrate through the soil.

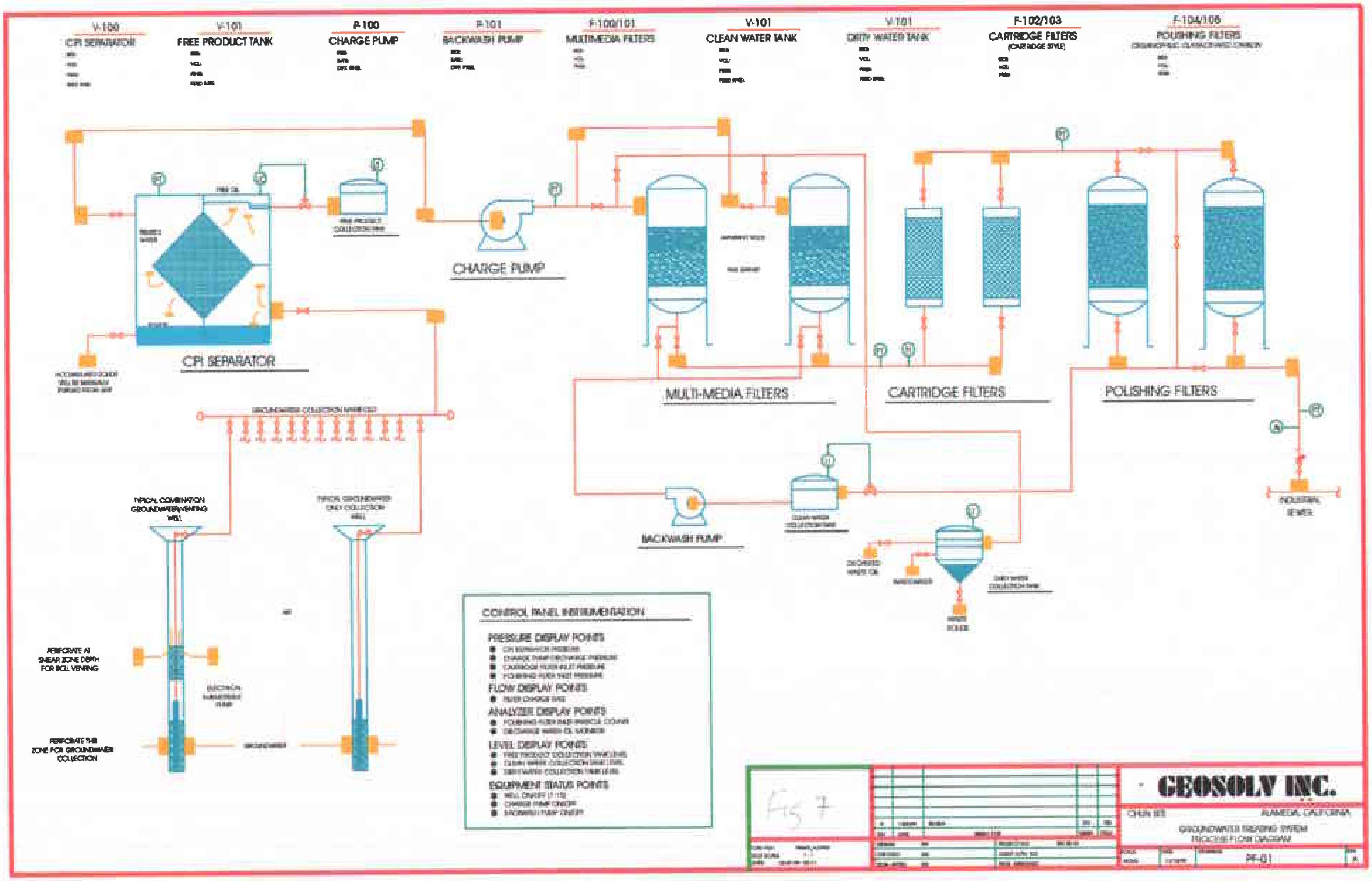
Groundwater Treating System

The groundwater pumping and treating system will be comprised of three integrated systems **(See Figure 7 for Groundwater Treatment Schematic)**:

- Groundwater and Free Product Pumping,
- Collection and Separation of Free Product, and
- Treating and Disposal of Recovered Groundwater

Groundwater and Free Product will be pumped to the surface by means of electrical submersible pumps. The elevation of these pumps in the well casing will be adjustable to optimize recovery of Free Product and groundwater at sufficient rates needed to depress the water table. Based on data collected by prior contractors conducting site assessments, the design rate for pumping is estimated to be 12-15 gallons per minute per well. The submersible pumps will supply sufficient discharge pressure to elevate the recovered fluids through the collecting manifold and into the first stage separator operating at 10 psig. is this also in question

The discharge of the groundwater pumps will be commingled into a centrally-located manifold adjacent to the treatment skid. The fluid level in each well will be regulated by adjusting the flow rate from each pump. Electrically actuated Flow Control Valves (FCV's) for each well will be located just prior to their connection to


V-100
CPI SEPARATOR
V-101
FREE PRODUCT TANK
P-100
CHARGE PUMP
P-101
BACKWASH PUMP
F-100/101
MULTIMEDIA FILTERS
V-101
CLEAN WATER TANK
V-101
DIRTY WATER TANK
F-102/103
CARTRIDGE FILTERS
(CARTRIDGE STYLE)
F-104/105
POLISHING FILTERS
CHARGE PUMP
CPI SEPARATOR
MULTI-MEDIA FILTERS
CARTRIDGE FILTERS
POLISHING FILTERS
GROUNDWATER COLLECTION MANIFOLD
TYPICAL COMBINATION GROUNDWATER/VENTING WELL
TYPICAL GROUNDWATER ONLY COLLECTION WELL
BACKWASH PUMP
INDUSTRIAL SEWER
CONTROL PANEL INSTRUMENTATION
PRESSURE DISPLAY POINTS
FLOW DISPLAY POINTS
ANALYZER DISPLAY POINTS
LEVEL DISPLAY POINTS
EQUIPMENT STATUS POINTS
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GROUNDWATER TREATING SYSTEM
PROCESS FLOW DIAGRAM

Fig 7

the collection manifold. All fluid collected will then be transferred by pressure gradient into the treatment skid.

The groundwater treatment skid will employ a series of oil collection and removal devices, each gradually reducing the level of contaminants to levels suitable for disposal in an industrial sewer (or alternatively, if an industrial sewer is not available, back into the aquifer). The primary separation of free product and groundwater will be accomplished by a Corrugated Plate Interceptor, or CPI, separator. CPI separators are common devices used for bulk oil and water separation because of their relatively compact size, high separation efficiency and ability to separate both solids and immiscible liquids from water. These units can handle fluctuations in feed composition from 100% Free Product to less than 1% Free Product without affecting effluent water quality. These units typically remove insoluble hydrocarbons to less than 200 ppm.

need Water Board permit

The next system in the process will be designed to remove insoluble hyrdocarbons to less than 5 ppm by using two backwashable, multimedia filters operating in parallel. These filters are the most economical way to reach this effluent concentration level because they need no media replacement since they can be periodically regenerated by in-situ backwashing. Multimedia filters employ a series of layers of different material, each providing a unique cleaning function. The first layer is anthracite or "coal rock." This material has a high affinity for hydrocarbons and is an excellent media for coalescing fine dispersions of oil and retaining them within the filter bed. The next set of layers are fine garnet sands in gradually-decreasing size, which are used to trap sediment particles and any insoluble hyrdocarbons passing through the anthracite layer. As the contaminants are collected within the filter media, the pressure drop across the bed increases. This pressure drop increase will be monitored and used to trigger an automated backwash sequence. As one filter is in backwash, the second filter will come on line to maintain continuous process flow through the system. The backwashing system is comprised of a pump that draws clean groundwater from a storage tank and flows through the filter in reverse direction to normal filter flow. Coalesced oil and trapped sediments are removed from the filter media and collected in a wastewater tank. The wastewater tank will have a conical bottom where solids can settled-out and removed for disposal. Small amounts of Free Product accumulating in the wastewater tank will be periodically decanted and disposed of. The remaining water in the wastewater tank can then be recycled back through the process to be cleaned. Backwashing frequency it typically once every 2-4 days.

The final treatment step involves microfiltration and adsorbtion of trace soluble and insoluble contaminants on to Granular Activated Carbon (GAC). Microfiltration is necessary as a pretreatment to prevent fine particles from contaminating the GAC beds. These filters, operating in parallel, will employ standard cartridge filters readily available by a host of manufacturers. Changeout of cartridge filters can be expected to occur every 2-3 weeks. GAC adsorption is particularly effective for removing contaminants at low concentrations (less than 10 mg/l) from water below allowable discharge levels. The units will be capable of operating in parallel or series, depending on the contaminant loading observed during operation and over the life of the remediation project. The beds will be periodically changed out with fresh carbon by contracting with a local GAC service company.

In addition to the standard pressure and flow monitoring instrumentation, the groundwater treating system will employ particle size monitors and hydrocarbon analyzers which will continuously monitor the treatment process to ensure optimum equipment performance and compliance with all discharge requirements.

Soil Vapor Extraction and Treating System

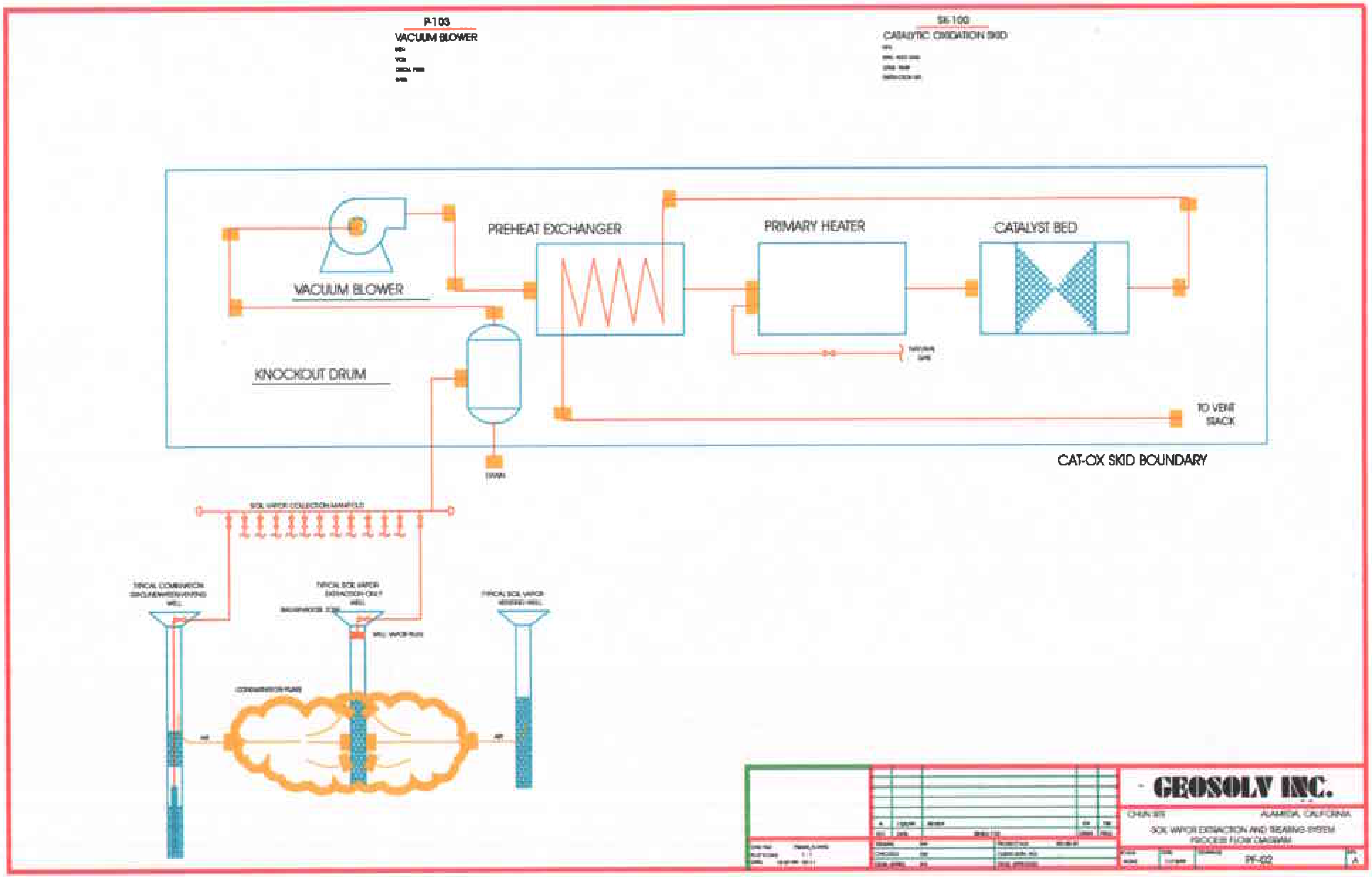
The soil vapor extracting and treating system (SVE System) is comprised of two subsystems **(See Figure 8 for Soil Vapor Extraction System Schematic).**

- Soil Gas Vacuum Generation and Collection System
- Soil Gas Contaminant Destruction System

Both Dual Phase Extraction wells and Soil Vapor Extraction wells will be connected via steel pipe to a vapor collection manifold located adjacent to the SVE System. At the collection manifold, each well will be connected to an electrically-actuated, three-way valve. This valve will allow any given well to be connected to the vacuum source or open to air. This feature will allow remote operation of each well to either vacuum or venting service. The SVE wells will be located in a grid pattern to ensure full coverage of the smear zone soil. The vacuum extraction will be operated in various patterns where a vacuum well will be surrounded by venting wells. This will allow more localized concentration of the remediation efforts and may decrease overall remediation time as compared to subjecting the entire site to vacuum at once.

The vacuum collection manifold will connect to a knock-out drum which will protect the pump from damage due to an accidental influx of liquids entrained with in the extracted soil gas. Vacuum will be supplied by a liquid-ring vacuum pump included on the SVE system skid. The required level of vacuum to be applied is dependent on the radius of influence needed for the site. Prior testing indicated that a radius of influence of 15 ft. can be achieved using 50 inches of water vacuum. However, using this radius would require an infeasible number of extraction wells to cover the entire site. The prior test performed is sufficient to indicate that the soil is susceptible to Soil Vapor Extraction. Based on balancing the covering of the contamination zone and the feasibility of the number of wells which could reasonably be employed, a minimum radius of influence of 20-25 feet is needed. Additional testing is required to determine the level of vacuum necessary to reach the targeted 20-25 feet radius of influence. This testing will involve applying varying amounts of vacuum to wells and measuring the induced vacuum in each of the nearby wells, including higher levels of vacuum than that used by prior consultants. The results will be critical to accurate design specifications for the system to ensure proper sizing of the vacuum pump and catalytic oxidation system.

The discharge of the vacuum pump will contain soil gas (mixture of air and hydrocarbon vapors). This gas is then passed through an effluent preheater, in which hot gas from the combustion chamber is cooled by transferring heat to the incoming gas. This feature is designed to reduce supplemental fuel (natural gas) requirements by recovering and reusing waste heat. The preheated soil gas then passes into the



P-103
VACUUM BLOWER
SK-100
CATALYTIC OXIDATION SKID
PREHEAT EXCHANGER
PRIMARY HEATER
CATALYST BED
VACUUM BLOWER
KNOCKOUT DRUM
TO VENT STACK
CAT-OX SKID BOUNDARY
GEOSOLV INC.
ALAMEDA, CALIFORNIA
SOIL VAPOR EXTRACTION AND TREATING SYSTEM
PROCESS FLOW DIAGRAM
PF-02
A

primary heating chamber where a gas-fired burner heat the soil gas to 600°-700°F. The hot gas then passes into the catalyst bed where all hydrocarbons are destroyed. Catalytic oxidation typically provides a destruction efficiency of hyrdocarbons of 99.99%, well within AQMD discharge specifications. The combusted gas is cooled by the preheat exchanger and the gas exhausted via a stack at the site.

Surfactant- Enhanced Soil Flushing System

To aid in the recovery of contaminants from the vadose zone soils and capillary fringe, water injection wells will be installed at specific locations. These wells will be screened above the zones sought to be cleaned so that water injected into the well will travel down through the contaminated soils and be recaptured by nearby groundwater extraction wells. Non-toxic, biodegradable surfactants will be added to the injected water to facilitate the groundwater pumping process. The addition of surfactants increases the mobility and solubility of the contaminants sorbed to the soil matrix. They can also facilitate the entrainment of hydrophobic contaminants to allow removal and assure that multi-phase contaminants can be effectively removed. Thus, it can increase the contaminant mass removal per pore volume of ground water flushing through the contaminated zone.

The implementation of surfactant-enhanced recovery requires the injection of surfactants into a contaminated aquifer. The system will utilize a pump to extract clean groundwater from the treatment process. A chemical feed pump will inject a controlled amount of surfactant into the groundwater. The pressurized mixture is then distributed to injection wells and controlled by hand-adjusted flow control valves.

Maintenance and Operation of the Systems

Both the Groundwater Pumping System and Soil Vapor Extraction Systems will be designed for stand-alone operation. However, periodic maintenance will be required to ensure proper operation of the equipment and maximization of equipment operating life. A contract maintenance technician will be required to visit the site at least once a week to verify and check proper equipment operation. At least once every 2-3 months a comprehensive system diagnostic test will be required to verify that all control components, instrumentation and critical processing components are functioning properly.

A key design feature of this system will be its remote monitoring and control capabilities. By using a combination of a Personal Computer (PC) and Programmable Logic Controller (PLC), the entire system operation can be monitored and controlled from any location in the world. Analog instrumentation will be used to continuously monitor system pressure, groundwater levels, temperature, flow rates, contaminant compositions and local environment LEL. Discrete instrumentation will be used to monitor system alarms, equipment and valve operation status. These instruments will be connected to the PLC which will be programmed to shutdown the groundwater pumping wells or the vacuum pump in the event the input instrumentation indicates that a problem exists with the equipment operation. The PC will interface with the PLC and perform two functions: 1) Provide a dial-up terminal to interface with the

PLC to check equipment status, operating variables, and remote control of process equipment, and 2) provide a 24 hr per day "dial-out" function to alert Geosolve personnel of any system problems so that prompt servicing may be initiated if needed.