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REMEDIATION SYSTEM 6-MONTH EVALUATION

LOCKHEED PROPULSION COMPANY
BEAUMONT SITE NO. 1

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1.0 BACKGROUND AND REMEDIATION STRATEGY

This document describes the installation and startup of the Extraction and Treatment Systems at the Lockheed Beaumont facility, and presents data collected before installation (April 1994) and after six months of operation (July 1994—December 1994). These two data sets are compared and analyzed in this report and recommendations are presented for improving the system effectiveness. Section 2 presents the conceptual model for the site, and describes the effect of the January 1993 rains on the water levels at the site. The extraction/treatment systems in the Burn Pit Area (BPA) and the Rocket Motor Area (RMA) are discussed separately in Sections 3 and 4, respectively.

1.1 Site Background

The Lockheed Beaumont No. 1 Site occupies 9,100 acres approximately 70 miles east of Los Angeles. The site was used from 1960 to 1974 for mixing and testing of solid rocket motor propellant, ballistics testing, motor casing washout, and burning of waste propellant. Previous major documents completed for this project include:

- *Historical Report* (9/86);
- *Source and Hydrogeological Investigation* (2/90);
- *Treatability Study* (2/92);
- *Health Risk Assessment* (3/92);
- *Feasibility Study* (3/92);
- *Remedial Action Plan* (5/92);
- *Burn Pit Removal Action Report* (6/93);
- *Design Plan* (2/93);
- *Extraction System Installation Completion Report* (12/92); and
- *Draft Operations Plan* (6/94).

As presented in the approved *Remedial Action Plan* (1992) the remedial design implemented at the former Lockheed Propulsion Company test facility near Beaumont, CA (Beaumont No. 1 site) included two extraction/treatment systems. In the Rocket Motor Area groundwater is pumped from conventional extraction wells and treated using air stripping and vapor-phase carbon adsorption units. In the Burn Pit Area, the primary source of contamination, conventional soil vapor extraction (SVE) wells and two-phase high vacuum (two-phase) wells extract both soil vapor and groundwater. Contaminants in the vapor phase are destroyed by catalytic oxidation, with the exhaust gas cooled and neutralized before venting to the atmosphere. The groundwater extracted by the two-phase system is air stripped within the well casing as it is lifted to the surface and subsequently polished with liquid-phase carbon absorption. Treated groundwater from both areas are reinjected into the aquifer. The overall process diagram is shown in Figure 1-1.

1.2 Burn Pit Removal

Remediation of the Beaumont site was initiated by removing the burned debris from the former burn pits in the winter of 1992/93. All former burn pits were excavated and wastes were segregated and disposed off site in accordance with regulatory requirements. This activity is further described in the *Burn Pit Removal Action Report* (1993).

1.3 Remedial Action Strategy

The remediation strategy was developed by analyzing the partitioning of the contaminants between phases and different geologic units, and calculating the proportional mass of contaminants. This analysis was used in conjunction with subsurface modeling to design a remediation system focused on contaminant mass removal at the source and control downgradient of groundwater migration.

The remediation strategy focused on the higher concentration areas (source removal) because significantly more VOCs can be removed by processing relatively low

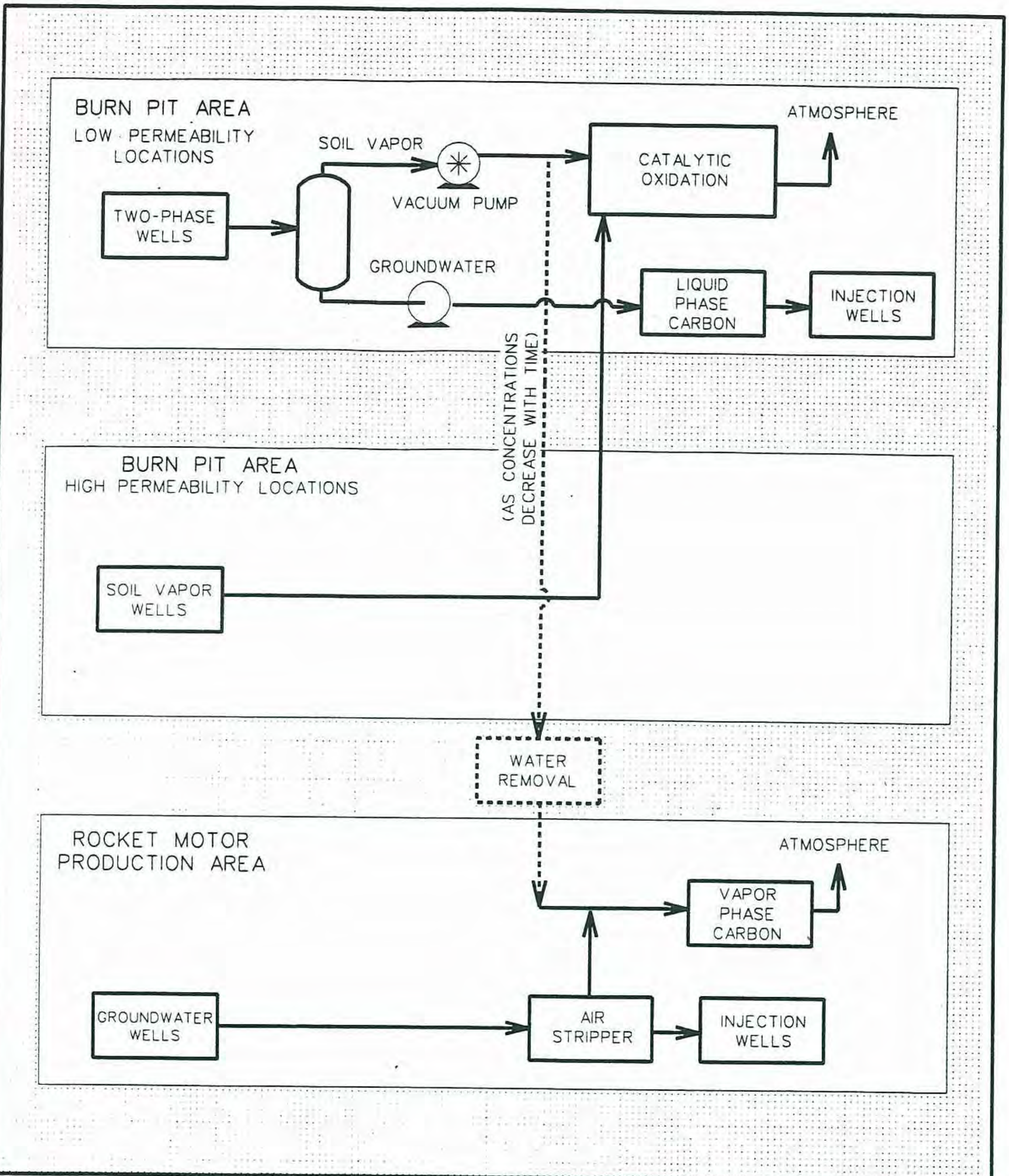

Figure 1-1 Process Configuration of Remedial Action

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volumes of soil vapor and groundwater. A combination of conventional and two-phase extraction techniques was applied in this area to match the permeability and contaminant levels of specific formations.

The number of wells required was determined by evaluating individual well production rates and comparing them with the extraction well field design criteria developed from groundwater flow simulation. Enough wells were installed to provide for extraction of a sufficient volume of vapor and groundwater to adequately capture the source contaminants and control further contaminant migration.

Pump-and treat methodology was applied as a migration control strategy at the downgradient boundary of significantly contaminated groundwater (the leading edge of the 400 μg/L plume). Groundwater extracted from the alluvium with conventional extraction wells is treated by air stripping with the effluent gas passed through a vapor-phase carbon adsorption system.

Contaminant concentrations in the vapor and groundwater extraction wells are routinely monitored and an "observational approach" based on this monitoring is used to guide the operation of both the soil vapor and groundwater extraction and treatment systems. As contaminant concentrations decline in the BPA, carbon adsorption will eventually become economically viable as the required frequency of regeneration decreases. Therefore, a carbon adsorption system may be installed in the future, replacing the catalytic oxidation unit, for treatment of low-concentration vapors.

2.0 SITE HYDROLOGY

2.1 Conceptual Model

The two principal geologic units of hydrologic interest at the site are younger, uncemented alluvial sediments (silts and fine sands), which overlie an older, competent, well-cemented sandstone (Mt. Eden formation). The younger sediments mask buried, previously eroded ridges of the sandstone. The permeability of the alluvium is approximately 10^{-3} centimeters per second (cm/s), and is 10 to 100 times more permeable than the unweathered sandstone, which has a permeability of 10^{-4} to 10^{-5} cm/s.

The hydrologic flow of the alluvial aquifer in the area of the burn pits is dominated by recharge from upland streams and surrounding mountains. The flow in the alluvial aquifer is affected by a subsurface ridge of less permeable sandstone underneath and south of the burn pit area. The flow of water in the alluvium is primarily to the west, passing by the south side of this subsurface ridge. Further downgradient, a confining silty/clay layer coupled with a narrowing of the alluvial aquifer restricts the flow of groundwater.

Prior to January 1993 the soil vapor contaminant plume existed in both the alluvial and sandstone formations. This plume contains chlorinated VOCs, primarily 1,1-dichloroethene (DCE), trichloroethene (TCE), and 1,1,1-trichloroethane (TCA). Figure 2-1 is an isopleth map of total VOC concentrations measured in soil vapor at a depth of five feet below ground surface (bgs) in the Fall of 1991. Soil vapor contaminant concentrations increased with depth. The highest values were found in the weathered, upper portion of the buried sandstone ridge beneath the former burn pits, where concentrations of total VOCs ranged up to 2,000,000 parts per billion by volume (ppbv). The most concentrated soil vapor contamination in the alluvium occurred immediately above the alluvial/sandstone contact.

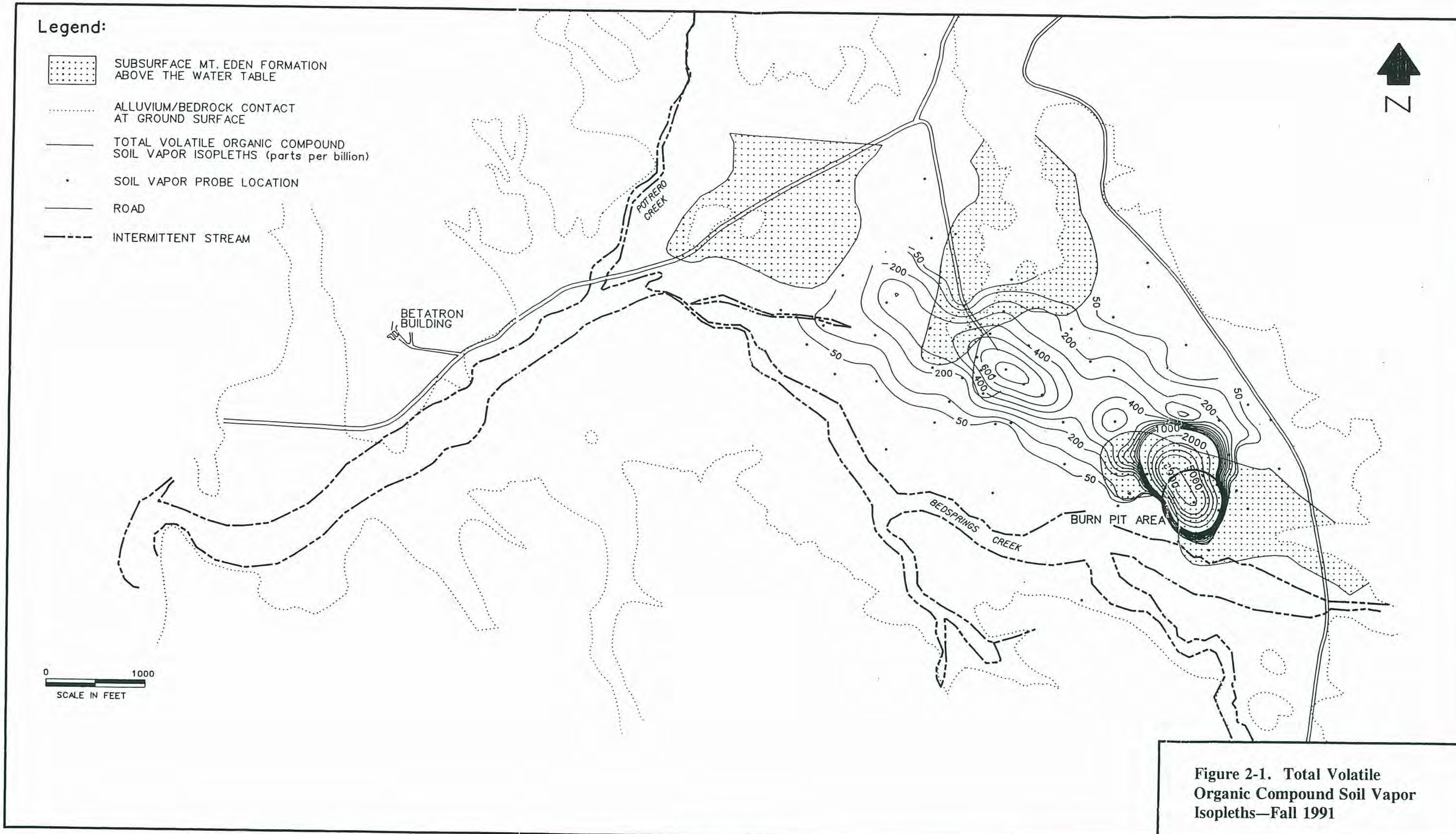

Figure 2-1. Total Volatile Organic Compound Soil Vapor Isopleths—Fall 1991

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Using the soil vapor plume as a guide for installing groundwater monitoring wells, a narrow groundwater plume containing these same contaminants was identified in the alluvial aquifer below the soil vapor plume, as shown in Figure 2-2. Again, the highest concentrations of VOCs were found in water samples from the weathered sandstone below the burn pits at concentrations above 10,000 micrograms per liter (μg/l). No VOC contamination was found in the burn pit wastes. Additionally, no residual VOCs were detected in soil samples collected from under the wastes in the burn pits. Since there is no longer a source in the form of residual waste, the "source" of contamination has become the mass of contaminants found in the soil vapor and groundwater in the formations directly under the burn pits.

As presented in the *Remedial Action Plan* (1992), analysis of the contaminant mass-to-volume ratio that existed in 1992 (discussed in more detail in Sections 3 and 4) showed that approximately 72% of the mass of VOCs at the site was in the soil vapor phase, primarily within the boundaries of the 1,000 ppbv soil vapor isopleth and the 1,000 μg/l groundwater isopleth; only 28% was in the groundwater. These areas within the 1,000 μg/l and 1,000 ppbv isopleths represent roughly 60% of the total mass of VOC contaminants in the entire plume. The boundaries of the 1,000 μg/l and the 1,000 ppbv isopleths are nearly coincident and appear to originate under the former burn pits. The soil vapor plume coincides with the groundwater plume primarily due to residual vapors at the source and from contaminants volatilizing from the groundwater surface into the vadose zone.

2.2 Historic Water Levels

Water levels have been monitored at the site since 1983, providing a view of the recent historic changes and trends in water levels. The most useful well for this review is OW-3, located in the RMA. This well was installed by Leighton & Associates in 1983 as part of a hydrologic study to determine the volume of water at the site which might

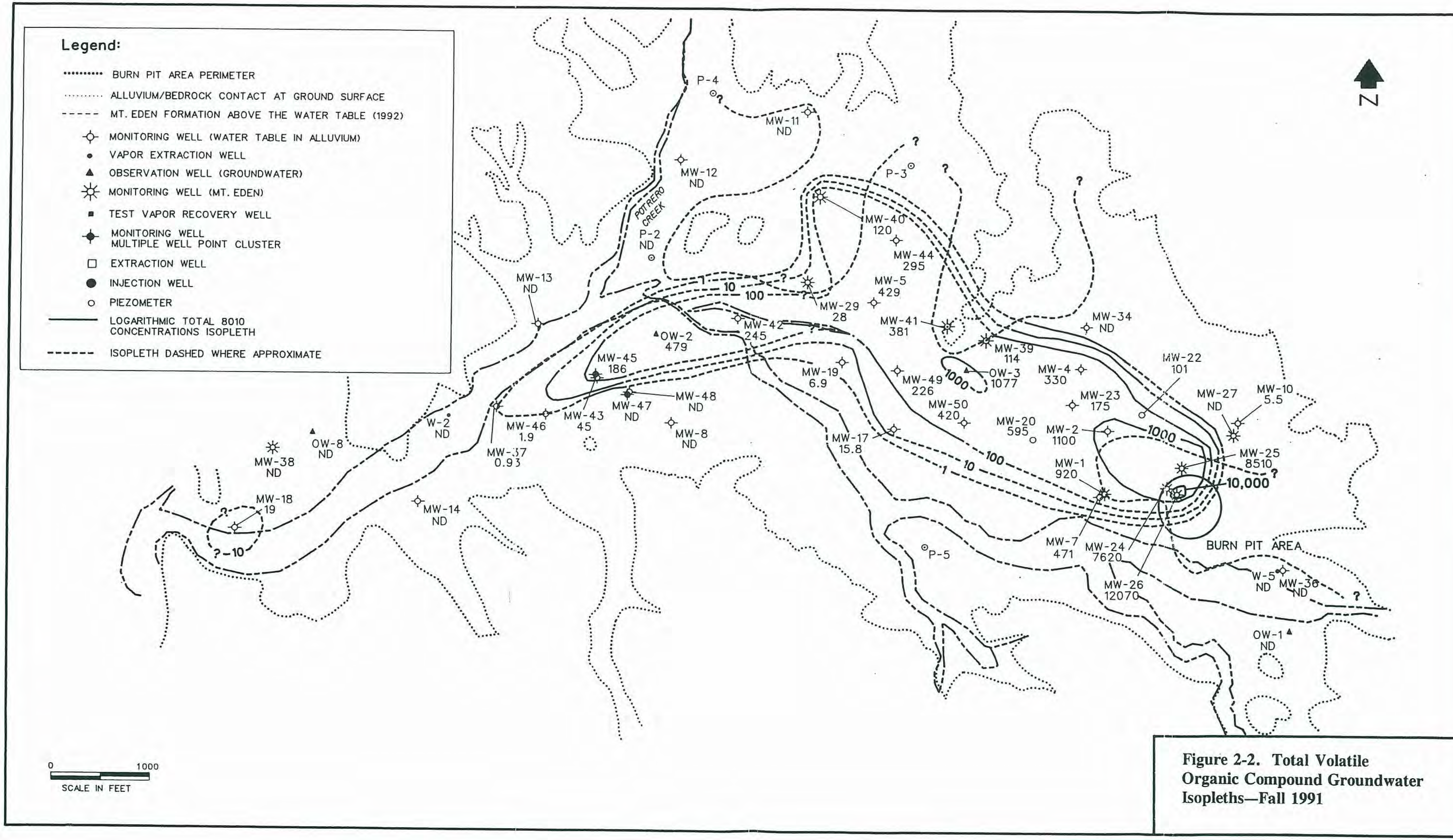

Figure 2-2. Total Volatile Organic Compound Groundwater Isopleths—Fall 1991

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be suitable for a local water supply. Water level data from this well have been collected periodically since 1983.

As illustrated in the hydrograph for OW-3, presented as Figure 2-3, the water level in the summer of 1983 was approximately 2,138 feet above mean sea level (ft msl). From 1983 until December of 1993, the water level dropped approximately 48 feet to a level of about 2,090 ft msl, due to drought conditions that occurred in California during that time. The same trend is evident in the hydrographs for MW-4 (Figure 2-4) in the middle of the groundwater plume and MW-26 (Figure 2-5) in the burn pit area. The Beaumont extraction system was installed in late 1992, and was designed to take advantage of the low water levels and the relatively focused areas of VOC contamination that were present at the time. However, heavy rainfall in January and February 1993 effectively ended the drought and brought the water levels to near their 1983 levels, rising almost 35 feet in this area. It is highly unlikely that the water levels will return to the design level within the near future, unless another prolonged drought occurs.

The cross-section in Figure 2-6 shows differences in water level elevations measured in October 1992, March 1993 and December 1994 in the Burn Pit Area. In October 1992, water levels were at approximately 2,095 feet above mean sea level (ft msl). After the rains in January 1993 water levels had risen over 35 feet, submerging the screens of the two-phase extraction wells (EWs) and partially covering or submerging screens of the vapor extraction wells. By April 1994 water levels had declined, but remained at a level above the EW screens. After four months of operation water levels in MW-61, located near EW-15, -16, and -18 (not shown), had declined over 20 feet to near October 1992 levels. Outside the influence of these three operational wells, water levels in EW-8 and EW-10 had only declined 10 feet. Water levels outside the influence of the operational extraction system will likely continue to decline or rise in response to seasonal rainfall.

Site-wide water contours maps were developed for January 1992, April 1994, September 1994, and December 1994 (Figure 2-7, 2-8, 2-9, and 2-10). The data to construct

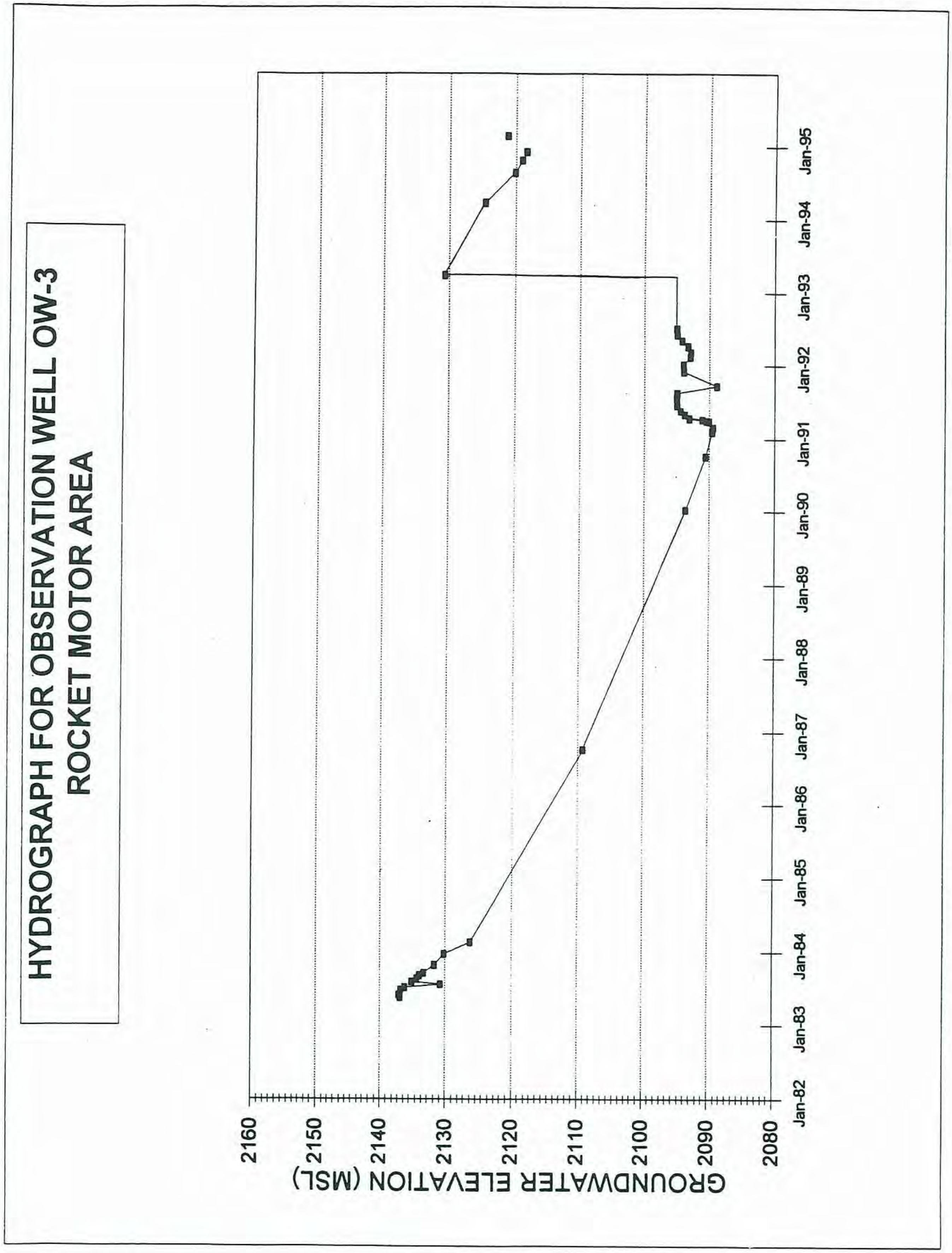

Figure 2-3. Hydrograph for Observation Well OW-3 Rocket Motor Area

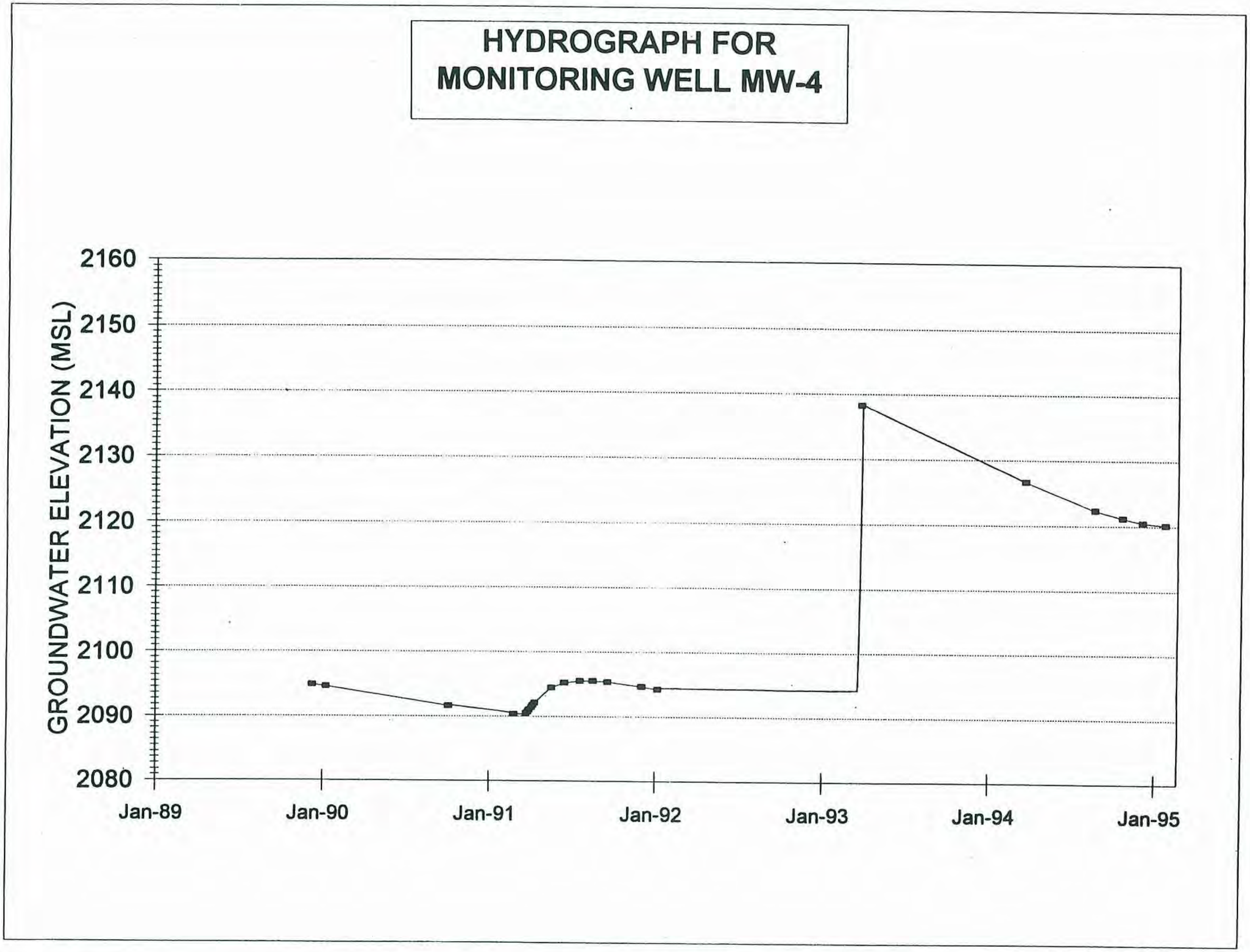

Figure 2-4. Hydrograph for Monitoring Well MW-4

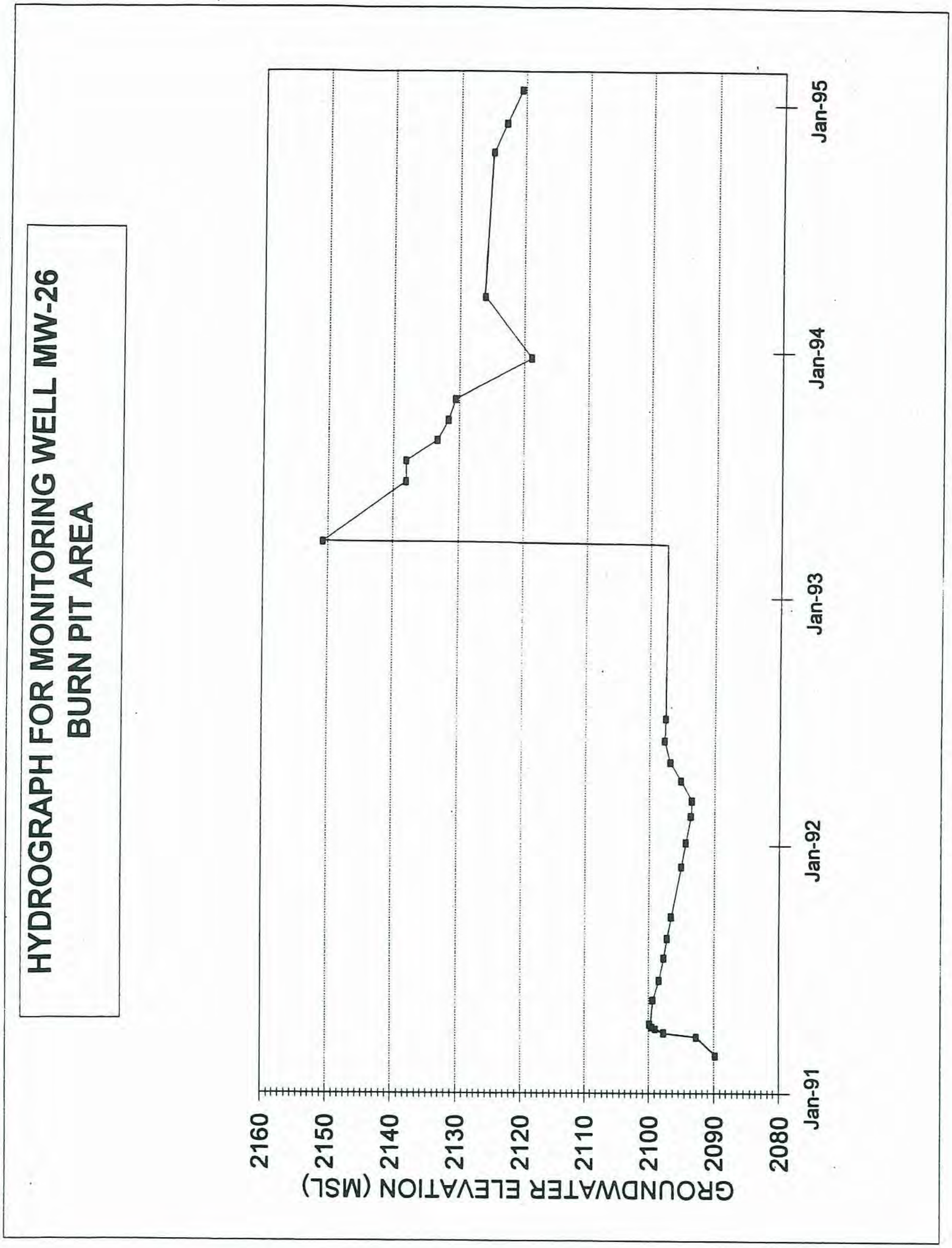

Figure 2-5. Hydrograph for Monitoring Well MW-26 Burn Pit Area

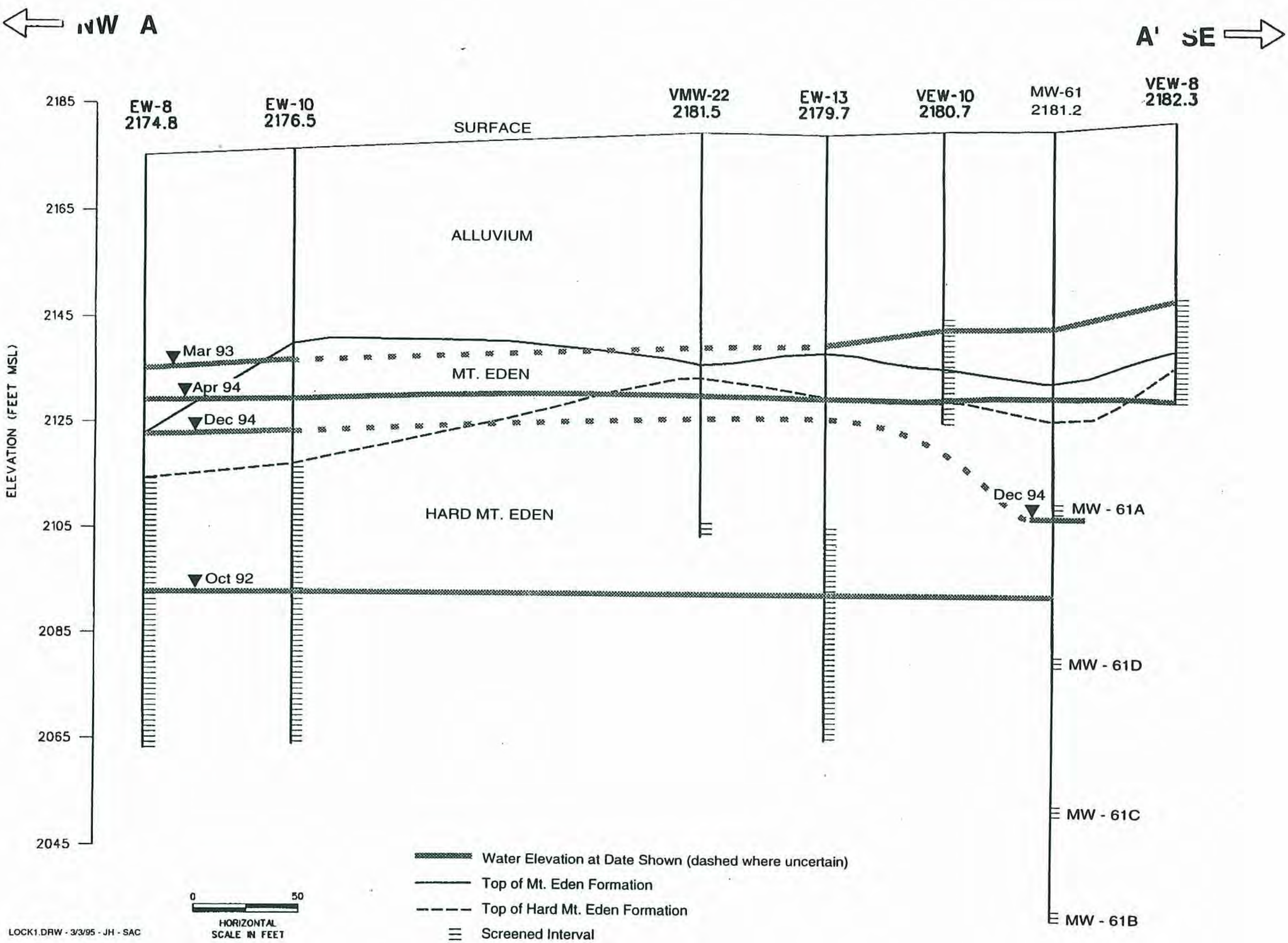

Figure 2-6. Generalized Cross Section and Historic Water Levels, Burn Pit Area

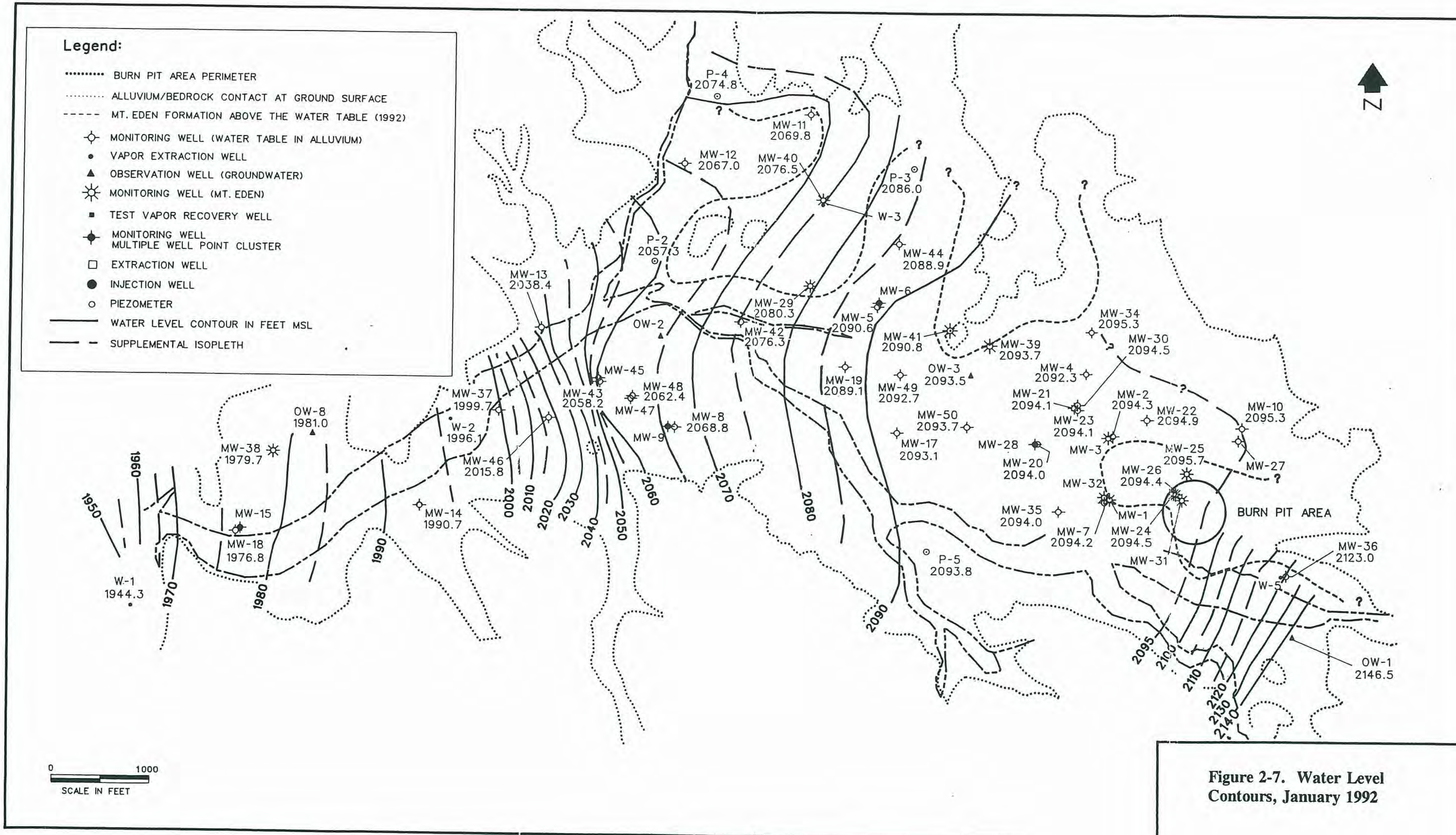

Figure 2-7. Water Level Contours, January 1992

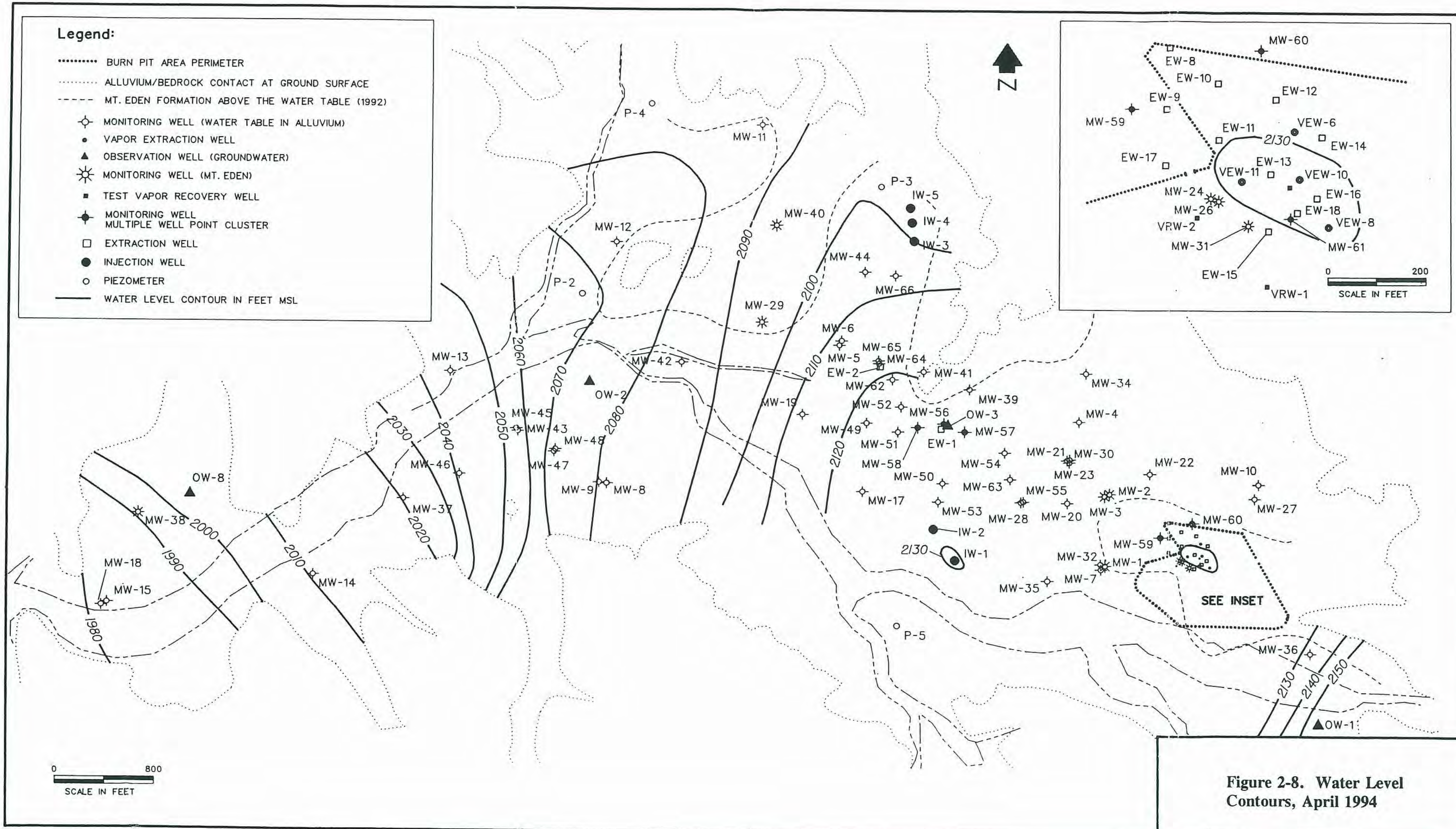

Figure 2-8. Water Level Contours, April 1994

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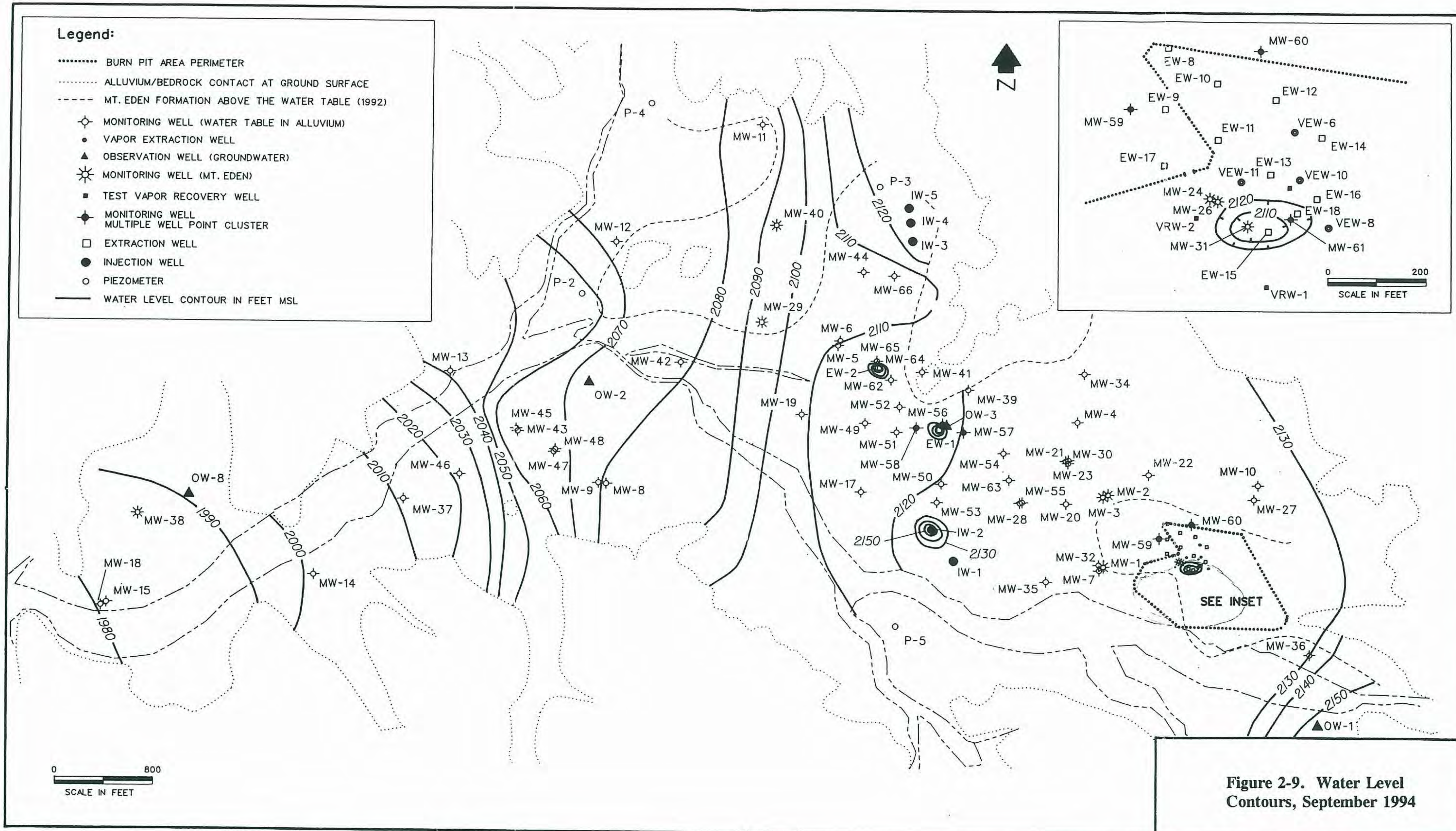

Figure 2-9. Water Level Contours, September 1994

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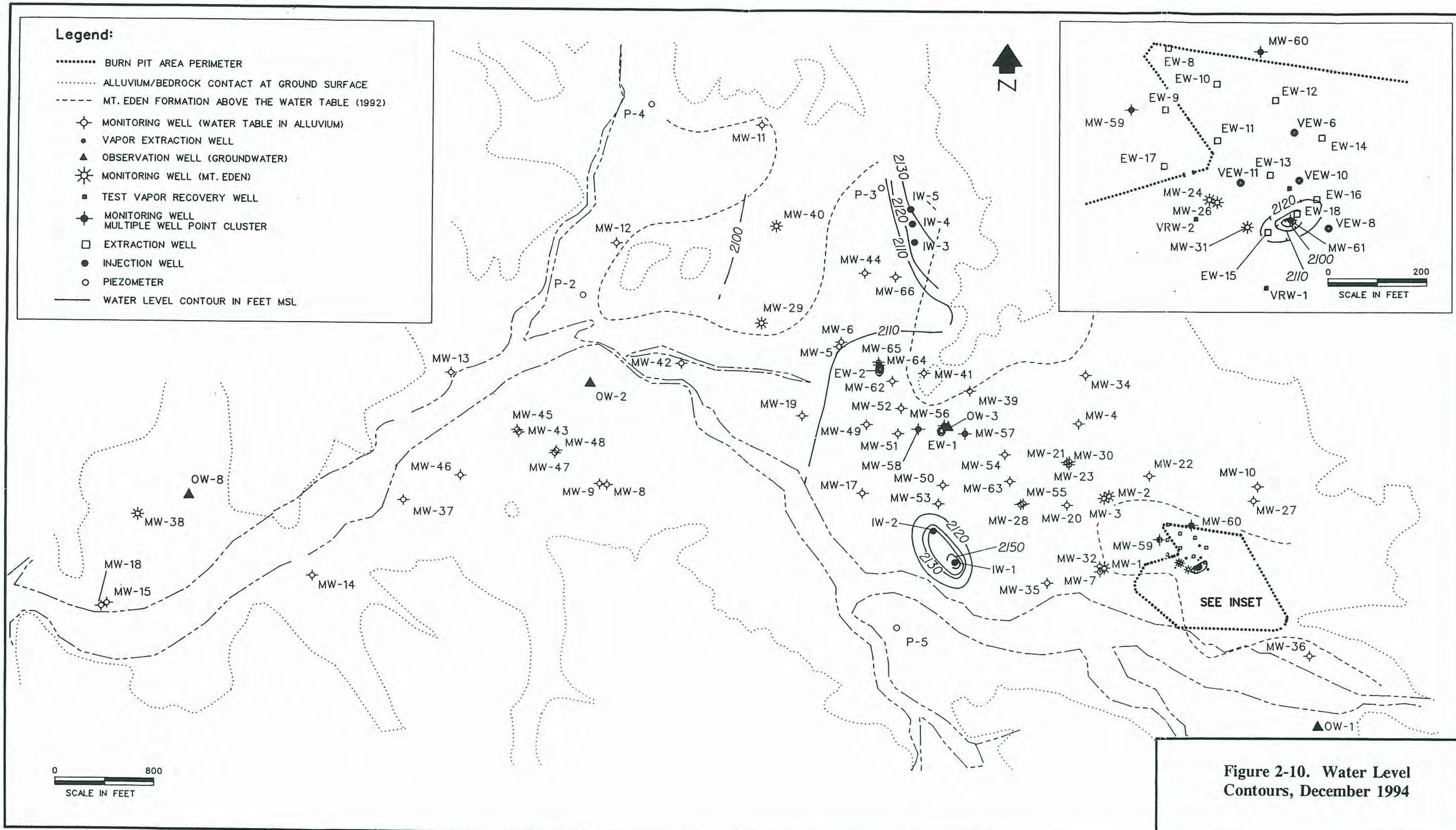

Figure 2-10. Water Level Contours, December 1994

these maps is found in Appendix A, along with data tables for the other maps in this report. Groundwater flow direction is generally westerly. Operation of the extraction/injection system has not altered the overall general direction of flow.

3.0 BURN PIT AREA REMEDIATION SYSTEM

The remediation system at the Burn Pit Area (BPA) was designed to extract and treat the most contaminated soil vapors and groundwater, thereby removing the source and reducing the risk for further migration of contaminants. Construction of the remediation system, which consists of five soil vapor extraction (SVE) wells, eleven two-phase (soil vapor and water) wells, a catalytic oxidation (catox) unit, and liquid-phase activated carbon, was completed in May 1994. Except for a few minor system enhancements, the remediation system was constructed as described in the *Design Plan* (1993) that was approved by the agencies. Table 3-1 outlines the system as it was built and describes any changes from the *Design Plan*. The remediation system was started in June 1994, system startup and shakedown lasted through July, and normal operation began in August. A summary of the design basis and major activities and system performance during the first six months of operation are described below.

3.1 Summary of the Design Basis

Soil vapor in the BPA vadose zone originally contained an estimated 72 percent of the contaminant mass at the site, therefore remediation was focused in this area. Two-phase and conventional vapor extraction wells were installed within the 1,000 ppbv total VOC isopleth to extract contaminated groundwater and soil vapor. The eleven two-phase, high-vacuum extraction wells (flow rate of 3-5 scfm/well) are screened in the low-permeability Mt. Eden formation which underlays the alluvium. The five conventional soil vapor extraction wells (flow rate of 30-60 scfm/well) are installed along the Mt. Eden/alluvium interface and screened in the high-permeability alluvium.

The collection piping network consists of two systems as shown in Figure 3-1. The two-phase wells (EWs) are connected to a high-vacuum pump, and the SVE wells (VEWs) are connected to a low-vacuum pump. The high-vacuum pump is sized to deliver a total of 50-100 scfm from the two-phase wells at 22 inches of mercury ("Hg) using a 50 horsepower (Hp) liquid-ring vacuum pump. The low-vacuum pump is sized for 100-150 scfm

Table 3-1

Lockheed Beaumont No. 1 Facility
Burn Pit Area Remediation System

System Components As Built	Changes from 2/93 Design Plan
Extraction System: Eleven Two-Phase Extraction Wells Installed: EW-8, -9, -10, -11, -12 (MW-25), -13, -14, -15, -16, -17, -18 Five Soil Vapor Extraction Wells Installed: VEW-6, -8, -10, -11 and VRW-2	Wells were located and constructed according to the Design Plan with the following exceptions: • Added two-phase extraction well EW-18 between planned wells EW-15 and -16, to address high contaminant levels found in this area. • Converted MW-25 to two-phase extraction well EW-12. • Did not install VEW-5 because well drilling was interrupted by burn pit removal activities, and the water level had risen before excavation was completed.
Catalytic Oxidation Treatment Unit for Soil Vapor. Major system components: • Soil Vapor Feed System • Vapor Preheat Unit • Vapor Destruction Unit • Quench and Neutralization Unit	Built according to Design Plan.
Granular Activated Carbon Treatment for Groundwater	Built according to Design Plan.

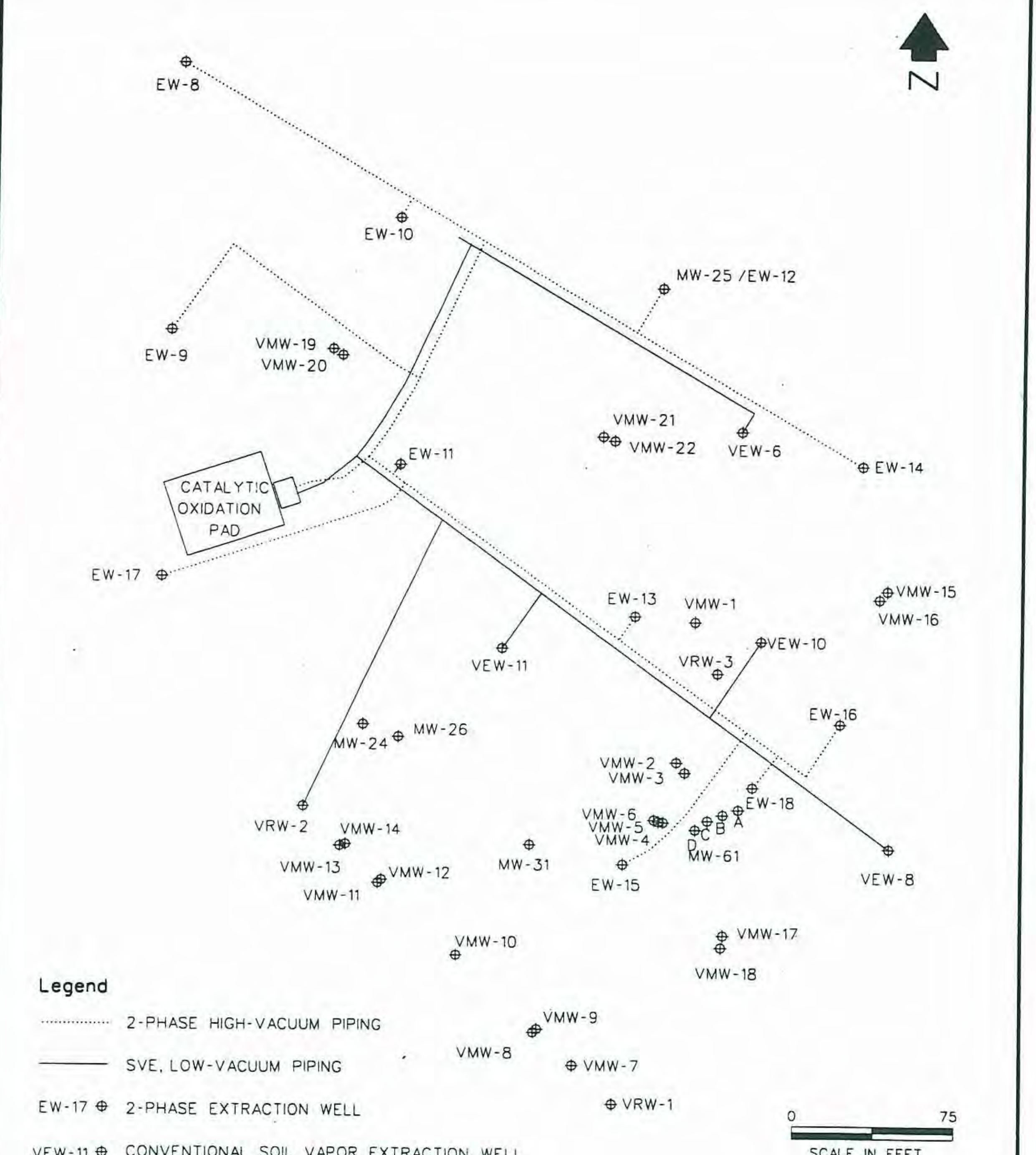

Figure 3-1 Two-Phase and SVE Extraction Network, Burn Pit Area

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from the conventional vapor extraction wells at 6-8" Hg using a 30 Hp vacuum pump. Flow from the individual wells is controlled by a valve at the wellhead. Total flow from each system is controlled by an electronic flow controller at the treatment pad. The vapor from each system is sent through a knockout pot to remove entrained water, then collected in a manifold and fed to the treatment unit.

The vapor is treated by the HD CatOx™ unit designed by King, Buck & Associates and fabricated by Catalytic Combustion. The design concentration for the catox system is 350 ppmv total VOCs, with a maximum influent concentration of 2,000 ppmv, and an average destruction efficiency of 95%.

The soil vapor is heated using a heat exchanger and an electrical heater to achieve the desired temperature in the catalytic reactors. There are two reactors, in series, which contain a total of two cubic feet of Allied Signal's proprietary halohydrocarbon destruction catalyst (HDC™). The lifetime of the catalyst is expected to be at least 15,000 hours. Vapors exiting the catox reactors are quenched and neutralized using a refrigeration system and a soda ash scrubber. This system cools the hot gas exiting the reactor and neutralizes the hydrogen chloride generated during destruction of the VOCs. Approximately 1.7 gallons of waste brine are generated per pound of VOCs destroyed.

The water from the two-phase wells is pumped from the knockout pots to two skid-mounted liquid-phase carbon units, each containing 5,000 pounds of carbon. The two carbon units can operate in series (normal operation) or in parallel, and are piped so that when contaminants break through the carbon of the primary unit, that unit may be taken off line for replacement of spent carbon while the groundwater flows to the second unit. The treated water is then sent to the injection wells discussed in Section 4. The waste brine from the catox unit is fed into the treated water stream through a metering pump in accordance with the Waste Discharge Requirements.

3.2 Extraction System (SVE and Two-Phase Wells)

As part of the design phase of the burn pit area extraction system, numerical modeling was used to determine groundwater extraction locations and pumping rates needed to create a capture zone that would include contamination in the Mt. Eden formation beneath the burn pit area. Based on the results of this modeling, eleven two-phase wells were installed to remove the high-concentration vapor and groundwater from the Mt. Eden and five low-vacuum SVE wells were installed to remove soil vapor from the alluvium. Wells were spaced assuming a radius of influence of 75 feet based on data gathered during the Treatability Study.

All five SVE wells and four two-phase wells (EW-13, -15, -16, and -18) were brought on line during the system startup period and remain on line under normal operation as outlined in Table 3-2. Due to the heavy rains in the Beaumont area in January 1993 the subsurface conditions at the time of startup were much different from the original design condition. The elevated water table partially covered or submerged the installed screens of all SVE wells and submerged the screens of all two-phase wells.

This increase in water levels also significantly changed the phase distribution of contaminants. A large portion of the previously unsaturated alluvium and Mt. Eden formation beneath the burn pits (containing 72% of the total contaminant mass in 1992) is now saturated. The saturation of the former vadose zone, particularly the lower portion which contained elevated concentrations of VOCs, has caused much less contamination to be accessible to extraction by the SVE and two-phase wells. This is shown by the low soil vapor concentration of 20-30 ppmv VOC entering the catox during system startup, compared to an average influent VOC concentration of 300 ppmv found during the Treatability Study and factored into the design. Since startup, the influent VOC concentration has dropped to 6-8 ppmv indicating that the system is effective in removing contamination; however, the low influent concentration has resulted in a contaminant mass removal rate that is much lower than originally calculated.

Table 3-2

Operations Summary for the Burn Pit Remediation System (Period: April - December 1994)

Operational Period	Time Frame	Percent Uptime	Major Activities	Major Issues	Solutions/Major Repairs and/or Maintenance
I. Baseline Sampling	April-May 1994	Not applicable. Baseline sampling was conducted prior to the completion of the remediation system.	• Sampled 29 wells to establish site baseline conditions.*	None.	None.
II. System Startup/ Shakedown	June-July 1994	10%	<u>Extraction System (SVE and two-phase wells)</u>: • Brought five SVE wells (VEW-6, -8, -10, -11, and VRW-2) and four two-phase wells (EW-13, -15, -16, and -18) on line during startup. <u>Treatment System (Catalytic Oxidizer)</u>: • Started up the catalytic oxidizer and allowed it to run at different operating conditions. Tested system shutdown mechanisms. • Repaired problems identified during startup/shakedown and performed various system modifications. • Collected weekly carbon effluent water samples, when available, per the Waste Discharge Requirements. • Monitored influent and effluent vapor quality on a weekly basis, per the SCAQMD air permit. • Programmed the Programmable Logic Controller (PLC) to accommodate system modifications. • Performed one round of regular system maintenance in July.	<u>Extraction System</u>: • The installed screens of most SVE wells were substantially covered due to the increase in water levels. • The installed screens of all two-phase wells were totally submerged. <u>Treatment System</u>: • Minor shutdowns due to field startup conditions. • Startup effort indicated that additional process parameters need to be recorded to allow for complete remote monitoring of system performance. • The chiller compressor malfunctioned.	<u>Extraction System</u>: None. <u>Treatment System</u>: • Startup problems were eliminated when both extraction and treatment systems stabilized. • Two additional flow transmitters and analog temperature equipment were installed. • Diagnostic of the problem revealed that the compressor windings were shorted to the compressor case, with blown fuses. Compressor did not overload and contaminate the refrigerant. Cause of failure was due to slugging of refrigerant because crankcase heater was inoperational. A new chiller compressor was installed. Procedures were changed to ensure that the crankcase heater is energized for a minimum of 8 hours before the compressor is started.

Table 3-2

(Continued)

Operational Period	Time Frame	Percent Uptime	Major Activities	Major Issues	Solutions/Major Repairs and/or Maintenance
III. Normal Operation	August-December 1994	80-90%	• The above-mentioned five SVE and four two-phase wells were on line. • Soil vapor extraction rate from SVE wells was about 35 scfm per well at 75 inches H_20. Influent soil vapor concentration was observed to decrease from 30 ppmv at startup to 6 ppmv during normal operation. • Soil vapor extraction rate from two-phase wells was 15 scfm per well at 25 inches Hg, and groundwater extraction rate was 2-2.5 gpm per well. Influent soil vapor concentration was observed to decrease from 20 ppmv at startup to 8 ppmv during normal operation. Influent groundwater concentration was approximately 60 μg/l. • Collected weekly carbon effluent water samples, when available, per the Waste Discharge Requirements. • Monitored influent and effluent vapor quality on a weekly basis, per the SCAQMD air permit. • Monitored the influence of the extraction system by measuring water levels and recording vacuums at monitoring wells in the Burn Pit Area. • Programming of the PLC was completed in December.	• The installed screens of most SVE wells remained substantially covered. The installed screens for two-phase wells remained totally submerged. • System back pressure was observed to increase drastically over time.	• Diagnostic of the problem revealed that some solids ($CaCO_3$) had been deposited inside the quench tube, thereby causing an increase in system back pressure. Solids deposition was speculated to be based on two factors: the design of the spray system inside the quench tube and the low VOC concentrations in the influent soil vapor. The quench tube is currently being modified to prevent future occurrence of solids deposition.
IV. Six-Month Evaluation Sampling	December 1994	Not applicable. System was shut down during sampling.	• Sampled 13 wells.**	None.	None.

* Wells sampled to establish baseline condition included: EW-8, -9, -10, -11, -12, -13, -14, -15, -16, -17, -18, MW-59A, B, C, D, MW-60A,B, MW-61A, B, MW-26, and VEW-6, -8, -10, -11, VRW-1, VMW-3, -8, -13.

** Wells sampled for six-month evaluation included: EW-8, -9, -10, -11, -12, -14, -17, MW-59A, C, MW-61, A, B, MW-4, VRW-1, -2, -3.

The system has remained on line in spite of the high water level and low extraction efficiency. The two-phase wells continue to be the most effective method for extracting the contaminants locked in the low permeability Mt. Eden formation. The SVE wells are kept on line to remove the contaminant mass in the remaining vadose zone beneath the burn pits.

3.3 Treatment System (Catalytic Oxidizer)

In early June 1994, representatives from the vendor (King, Buck, & Associates) and manufacturer (Catalytic Combustion) of the catalytic oxidizer were on site to lead the startup effort and train operating personnel. During this period, the system was powered up and allowed to run under various operating scenarios to ensure that equipment and instrumentation were installed properly and were functional, and to determine optimal instrument settings. Any necessary repairs or system modifications identified during startup were implemented. In addition, the programmable logic controller (PLC) was programmed to allow for remote monitoring of system performance and to accommodate system modifications.

Operational problems encountered in this timeframe were limited to typical startup shutdowns. They were eliminated after the extraction and treatment systems stabilized and proper instrument settings were entered into the PLC. In the later part of July, system repair and maintenance was performed and additional instrumentation (flow/temperature transmitters) was installed to allow for more complete remote monitoring of system performance.

Normal system operation began in August 1994. The catalytic oxidizer is currently operating at the design flow capacity of 200-230 scfm. From startup through December 31, 1994, approximately 35 million scf of vapor were treated, with an average concentration of 8 ppmv. Additionally, approximately 438,000 gallons of groundwater was extracted by the two-phase wells and treated using the liquid-phase activated carbon.

The performance of the catalytic oxidizer has been monitored on a weekly basis to ensure compliance with the SCAQMD air permit and the RWQCB Waste Discharge Requirements. All effluent discharge requirements have been met to date.

3.4 Comparison of Monitoring Data to Baseline Conditions—Groundwater

Baseline data were collected from monitoring and extraction wells in April 1994, including soil vapor and groundwater samples for VOC analysis and water level measurements. After startup of the extraction system monitoring wells and inactive extraction wells were used to measure water levels in September and December 1994, and to collect groundwater analytical samples in December 1994. A series of vacuum measurements were also taken from the vapor monitoring wells in December 1994. Isopleth maps of these data are shown in Figures 3-2 and 3-3.

Prior to startup of the extraction system, the April 1994 water levels reflected the effects of heavy rains in January 1993, as shown in Figure 3-2. Water level measurements collected from wells screened in the alluvium and the Mt. Eden formation are similar, suggesting a degree of hydraulic connection between the two formations. These water level data, collected prior to system startup, indicate that a groundwater mound was present beneath the burn pits as a result of recharge from the wet season. By September 1994, water levels had dropped less than five feet except beneath three of the operating two-phase extraction wells, EW-15, EW-16 and EW-18. In this area the water level dropped approximately 10 feet as seen by the water level drop in MW-61B shown on Figure 2-9 (MW-61B is located between EW-15 and EW-18). The groundwater mound apparent in April is not present in September. Instead, contours of September water levels indicate a groundwater depression beneath these three operating EWs. Extraction from the three wells has resulted in an increasing depression based on a water level decline of almost 40 feet in MW-61B from April to December 1994 (Figure 3-3).

A small capture zone has been created surrounding EW-15 and -18 as seen from water level data from wells screened in the Mt. Eden formation. However, this zone is less than

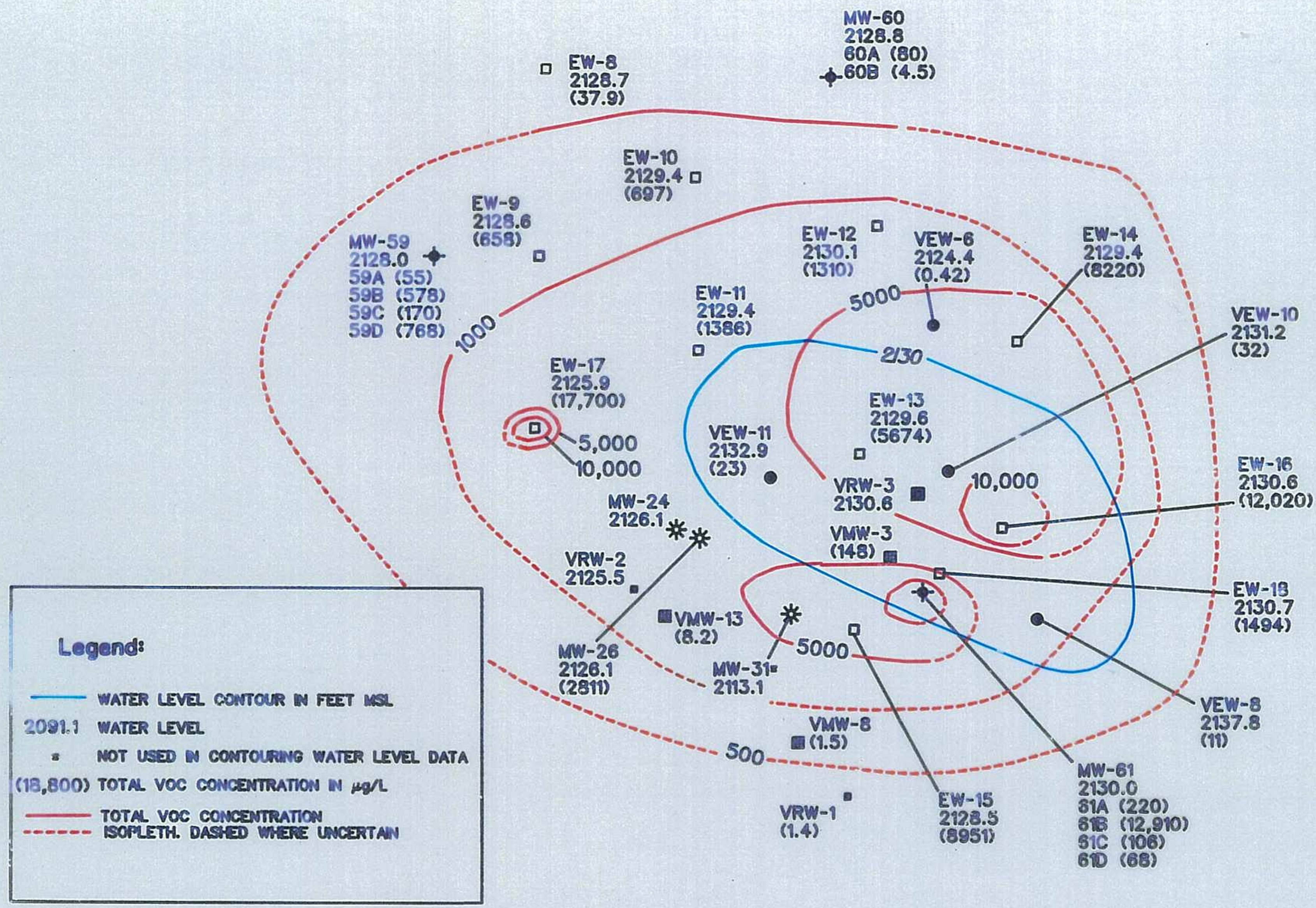

Figure 3-2 April 1994-Water Levels and Contaminant Concentrations

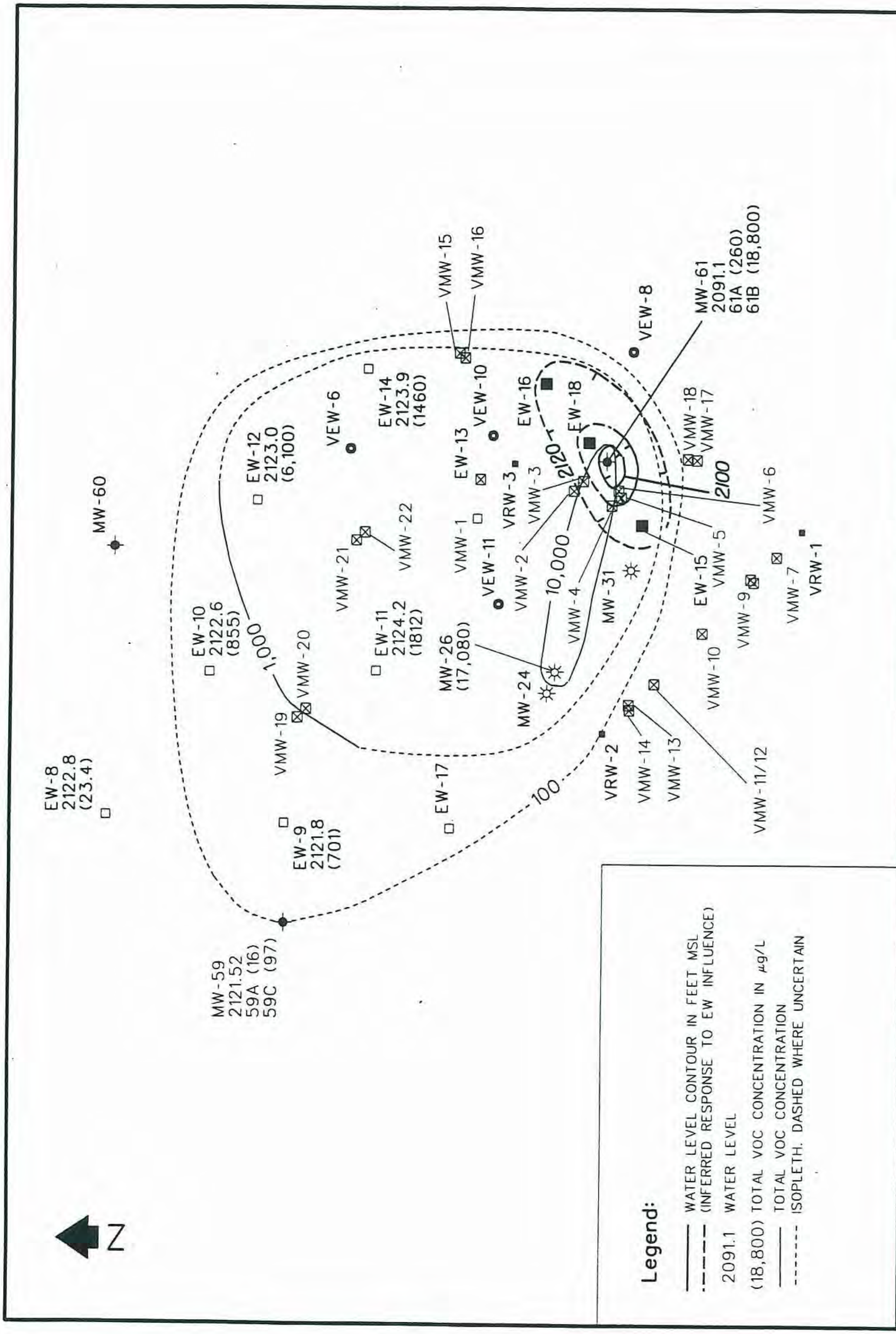

Figure 3-3 Water Levels and Contaminant Concentrations in Groundwater, December 1994

what would have been established if the two-phase system were operating under design conditions.

The groundwater samples collected in April 1994, prior to system startup, were used to create the total VOC concentration isopleths shown in Figure 3-2. Total VOC concentrations were highest in samples from wells screened in the Mt. Eden approximately 100 to 115 feet below ground surface (ft bgs). VOCs in three wells (EW-16 and -17, and MW-61B) were at levels above 10,000 μg/l, with EW-17 the highest, at 17,200 μg/l. These wells are not adjacent and are separated by wells with lower VOC levels. The lowest VOC concentrations were detected deep in the Mt. Eden and in shallow alluvial wells. This contaminant distribution pattern implies that the high VOC levels are most likely caused by preferential contaminant migration in fractures in the Mt. Eden formation or pockets of contamination in the weathered Mt. Eden material.

Contaminant concentrations in alluvial wells were significantly less than in the Mt. Eden wells. VOC concentrations in alluvial wells located within the 1,000 μg/l isopleth contour for Mt. Eden wells are less than 35 μg/l, except in the sample from VMW-3 that had a concentration of 148 μg/l.

Groundwater samples were collected from 11 wells screened in the Mt. Eden formation in the Burn Pit Area during December 1994. Results from most wells sampled during both months indicate a decrease or no change in concentration. Exceptions include MW-61B (in the vicinity of EW-15 and EW-18) with an increase of total VOCs from 12,910 to 18,800 μg/l; MW-26 with an increase from 2,800 to 17,000 μg/l; and EW-12 (formerly MW-25) with an increase from 1,300 to 6,100 μg/l. These increases may be the result of contamination formerly in the vapor/sorbed phases dissolving in groundwater during the rise in water levels. Most of the contaminants, as shown by the 10,000, 1,000 and 100 μg/l isopleths, are outside the zone of influence of the EWs currently on line (EW-13, -15, -16 and -18).

3.5 Comparison of Monitoring Data to Baseline Conditions—Vapor

Vacuum distribution and analytical data for vapor in the alluvium and Mt. Eden at the burn pit area are shown contoured on Figures 3-4, 3-5, 3-6 and 3-7. These include alluvial vapor concentration isopleth maps for April 1994 and December 1994, and a vacuum distribution map for December 1994, as well as a Mt. Eden December 1994 vacuum distribution map. Vacuum distribution data is not available for April 1994 because the system was not operational at that time. Vacuum data are presented in tabular form in Appendix A.

The December 1994 alluvial vacuum distribution, shown in Figure 3-4, indicates a measurable vacuum influence of 0.3" H_20 at VMW-16 and- 22, which are each about 65 feet away from VEW-10 and -6, respectively. Additionally, VMW-14 shows an influence of 0.4" H_20 at about 50 feet from VRW-2. These measurements compare favorably with the design radius of influence of 75 feet for 0.1" H_2O.

In the Mt. Eden formation (Figure 3-7), there is a small zone near EW-15 and -18 which has a vacuum influence of 0.9" to greater than 3" H_2O. This indicates that there may be a small area of influence from the high vacuum of the two-phase system, and that even though the two-phase wells are submerged, there may be some vapor continuity with the well screens.

Soil vapor contaminant concentrations for April 1994 (Figure 3-5) were as high as 147,800 ppmv at VMW-3. VEW-8, -10 and -11, located at an approximately equal distances from VMW-3, had VOC levels greater than 10,000 ppmv.

In December 1994, the VOC concentration in VMW-3 was 5,620 ppmv, indicating that the SVE system has effectively eliminated the 100,000 ppmv soil vapor VOC isopleth (Figure 3-6). The area within the 10,000 ppmv isopleth was also reduced to approximately one quarter of its April size, with the December 5,000 ppmv isopleth covering

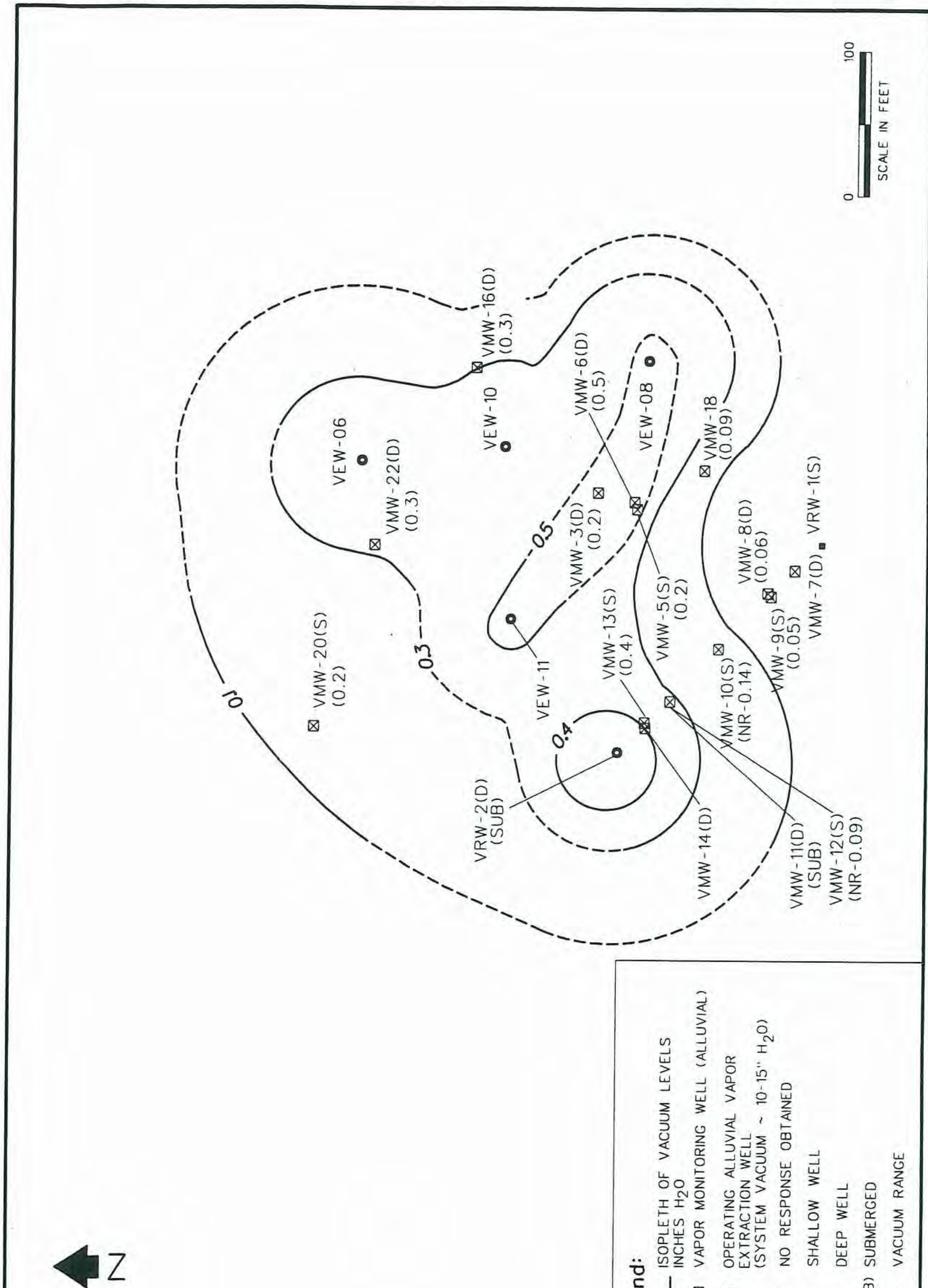

Figure 3-4 Vacuum Distribution in Alluvium, December 1994 (Burn Pit Area)

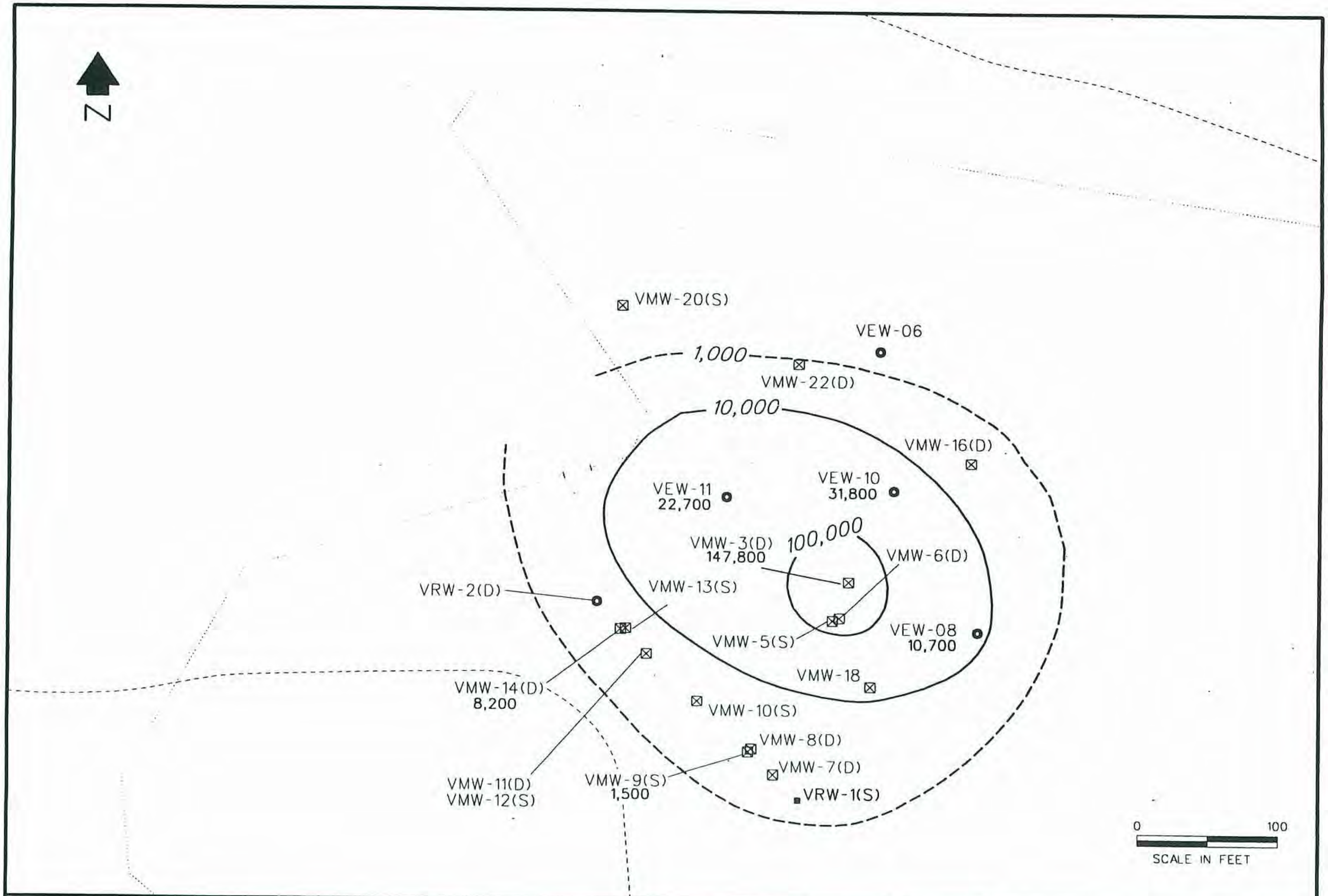

Figure 3-5 Soil Vapor Concentrations in Alluvium, April 1994

LOCK17 BPSV2Q94 SAC VRL

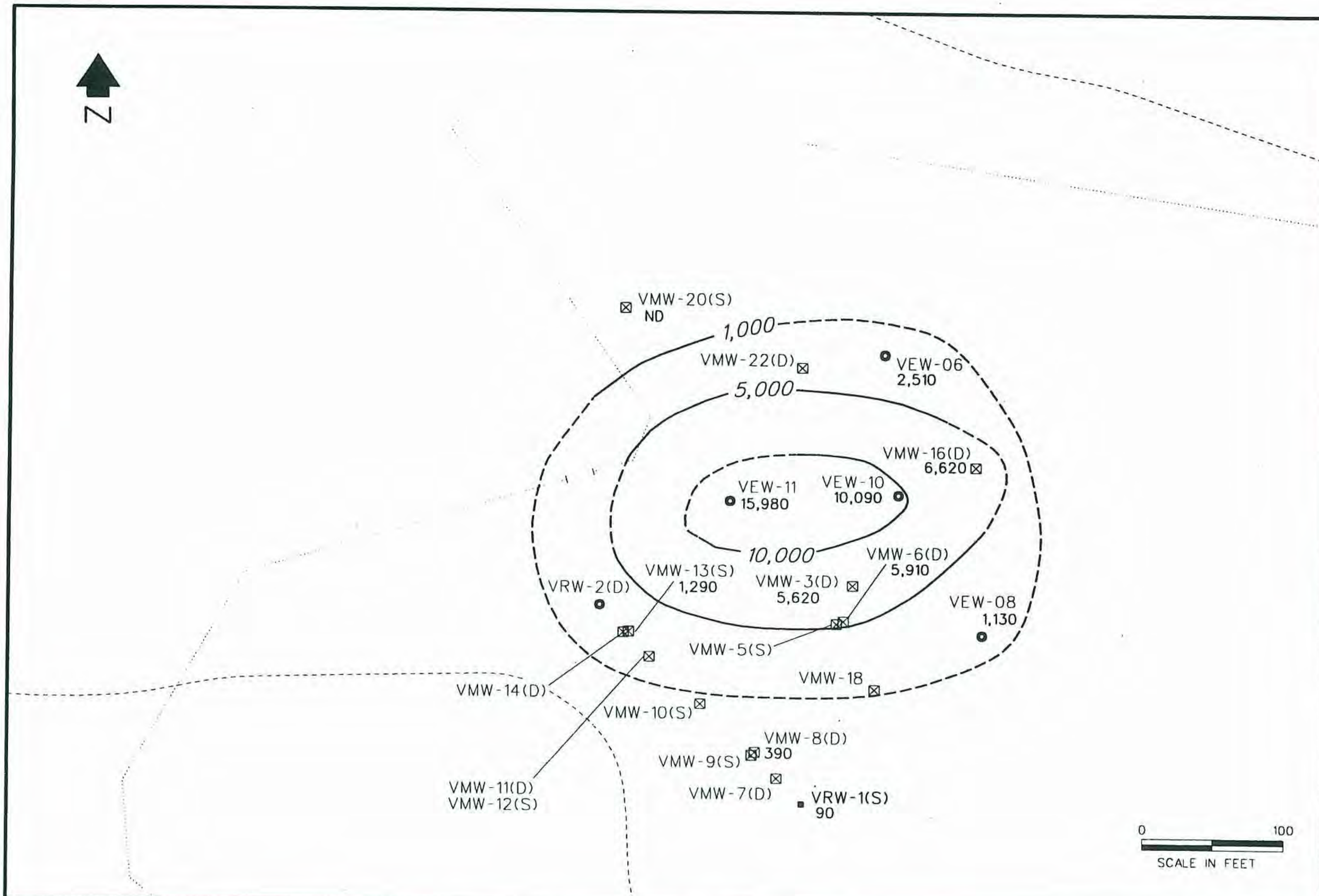

Figure 3-6 Soil Vapor Concentrations in Alluvium, December 1994

LOCK17 BPSV4Q94 SAC VRL

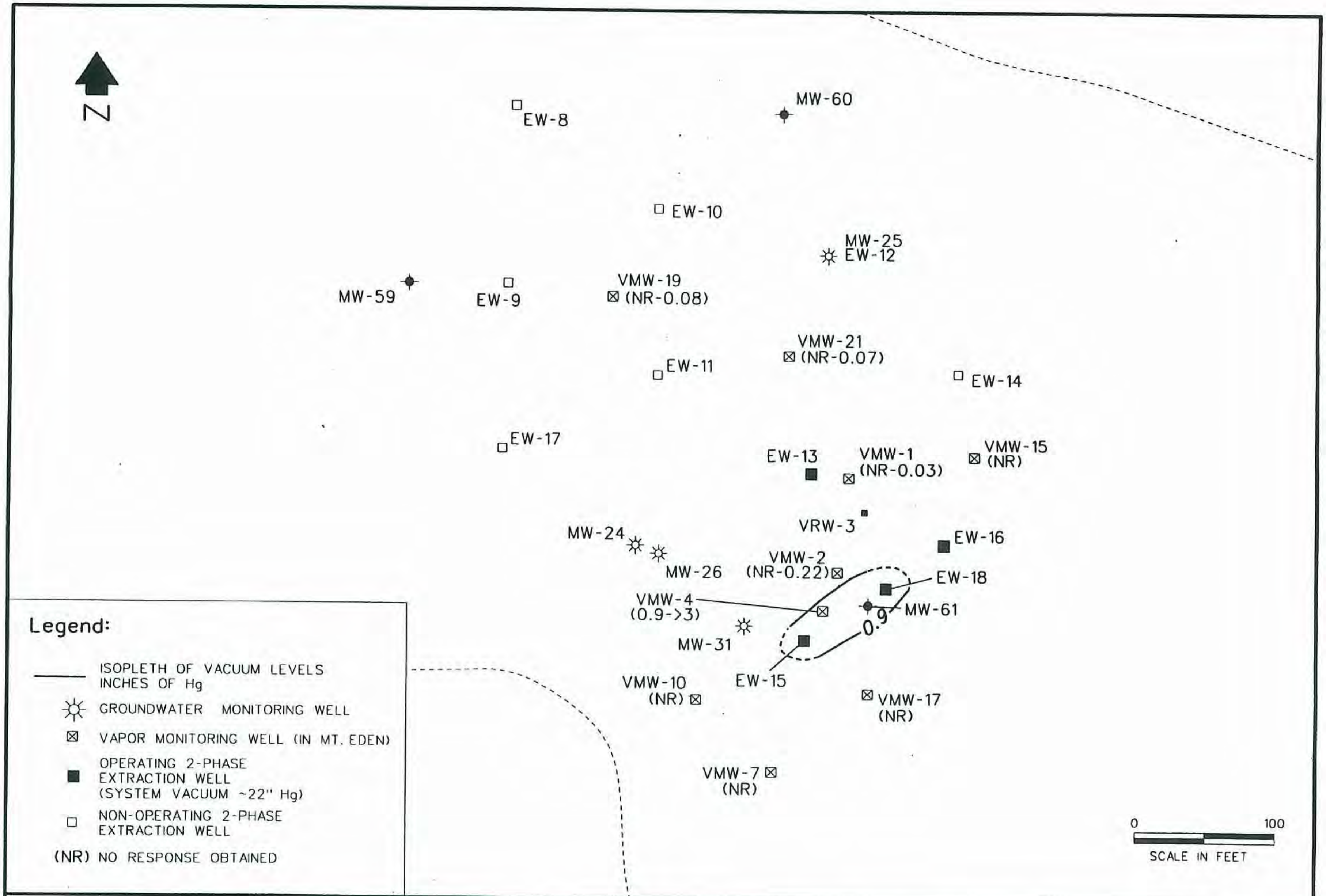

Figure 3-7 Vacuum Distribution in the Mt. Eden Formation, December 1994 (Burn Pit Area)

LOCK17 BPVACMT3 SAC VRL

approximately the same area as the April 10,000 ppmv isopleth. The location of the 1,000 ppmv isopleths is approximately the same in the two sampling events. This is largely due to a VOC concentration of 2,510 ppmv in December at VEW-6 which was not sampled in April. These reductions illustrate the effectiveness of the SVE system in removing contaminants from the vadose zone.

3.6 Contaminant Mass Removal—Burn Pit Area

As discussed briefly in Section 1, the conceptual model of the Beaumont site prepared in 1992 showed that approximately 72% of the contaminant mass of VOC's was in the soil vapor and 28% was in the groundwater. The highest contaminant levels were found at the Burn Pit Area in the weathered Mt. Eden material along the alluvium/Mt. Eden contact. This contaminant distribution is portrayed in Figure 3-8 for soil vapor, and Figure 3-9 for groundwater. These figures only show contaminants within the 400 μg/l (groundwater) or ppmv (soil vapor) contours, because the mass of contamination below these levels totals less than 2% of the entire mass at the site. A graphical display of contaminant distribution for 1992 is shown in the left-hand graph of Figure 3-10. The data from which these graphs were constructed is contained in Tables 3-3 and 3-4.

The rise in water levels due to the January 1993 rains partially covered or submerged many of the well screens, significantly changing the mass of contamination exposed to the vapor extraction system, although the total mass and relative position of the contamination remain essentially unchanged. The heavy winter rains caused most of the subsurface Mt. Eden ridge to be covered with water and the vadose zone portion of all of the two-phase wells became saturated. The screens in the conventional SVE wells were also partially, if not fully, submerged. The distribution of contaminants shifted almost entirely to the groundwater, leaving little available mass for removal by two-phase or SVE. A graphical representation of this phase shift is shown in the right-hand graph of Figure 3-10.

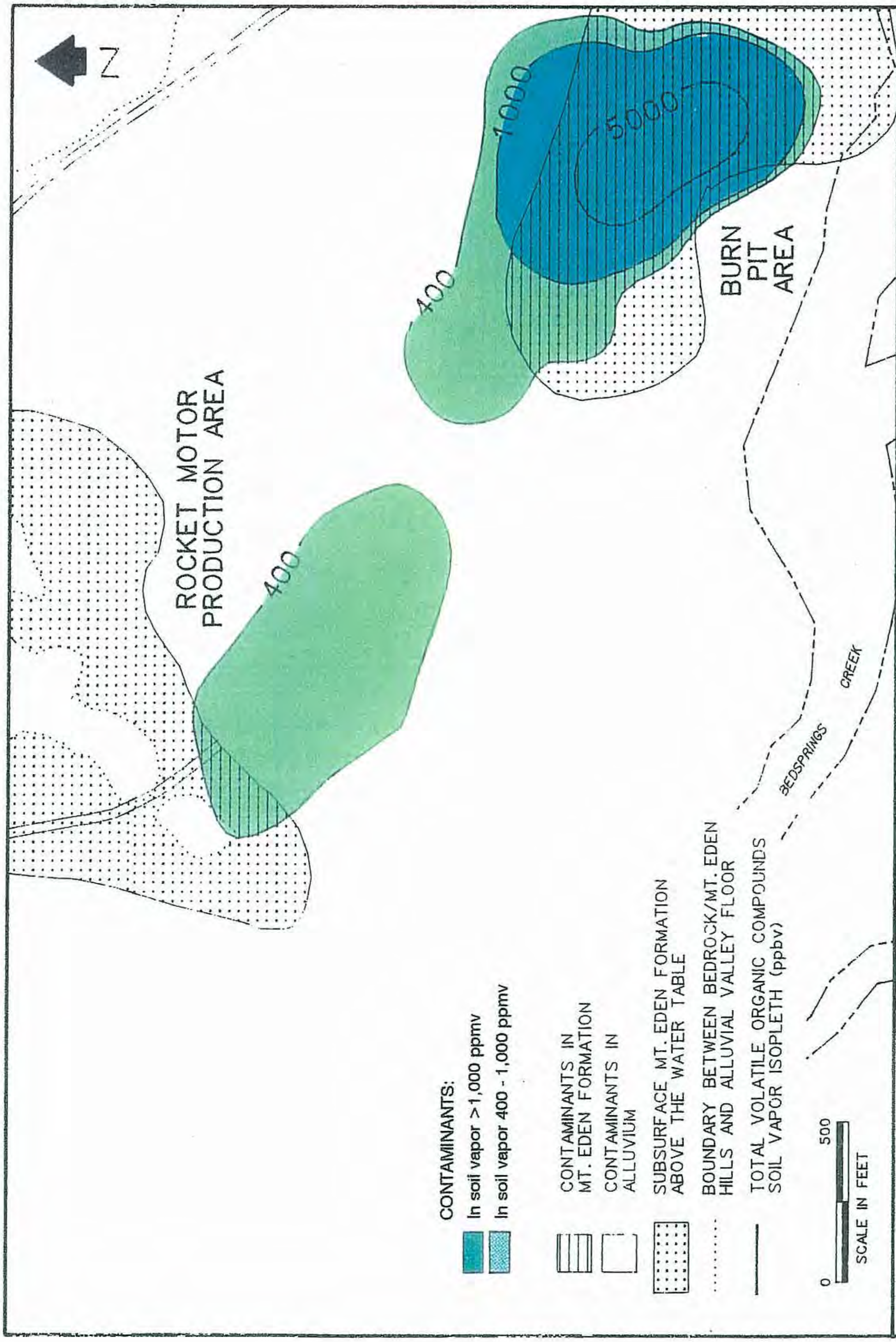

Figure 3-8. Lockheed Beaumont No. 1 Distribution of Contaminant Mass in Soil Vapor (1992)

VRL RAP SVMASS 5/04/92

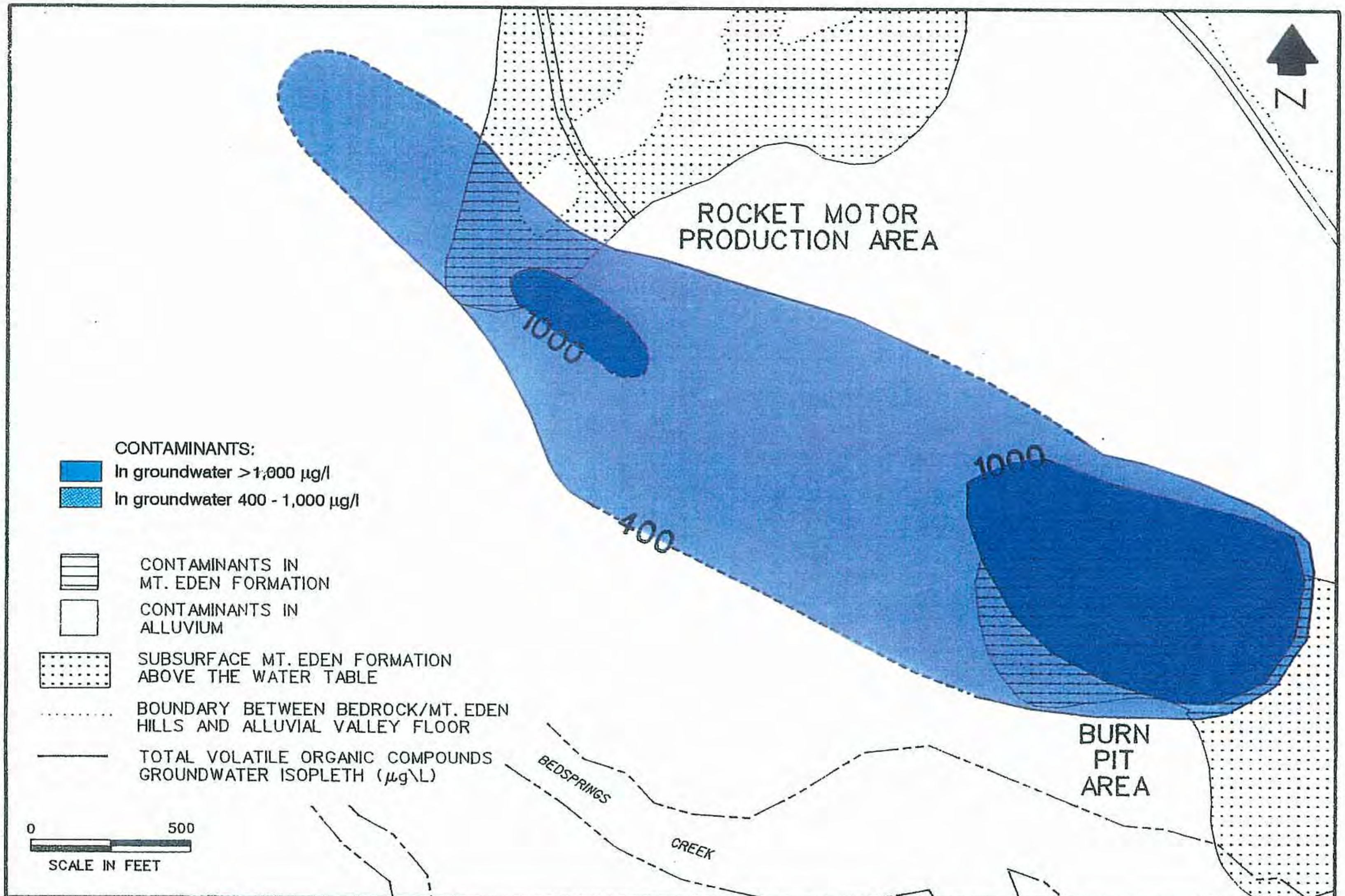

Figure 3-9. Lockheed Beaumont No. 1 Distribution of Contaminant Mass in Groundwater (1992)

VRL RAP GWMASS 5/04/92

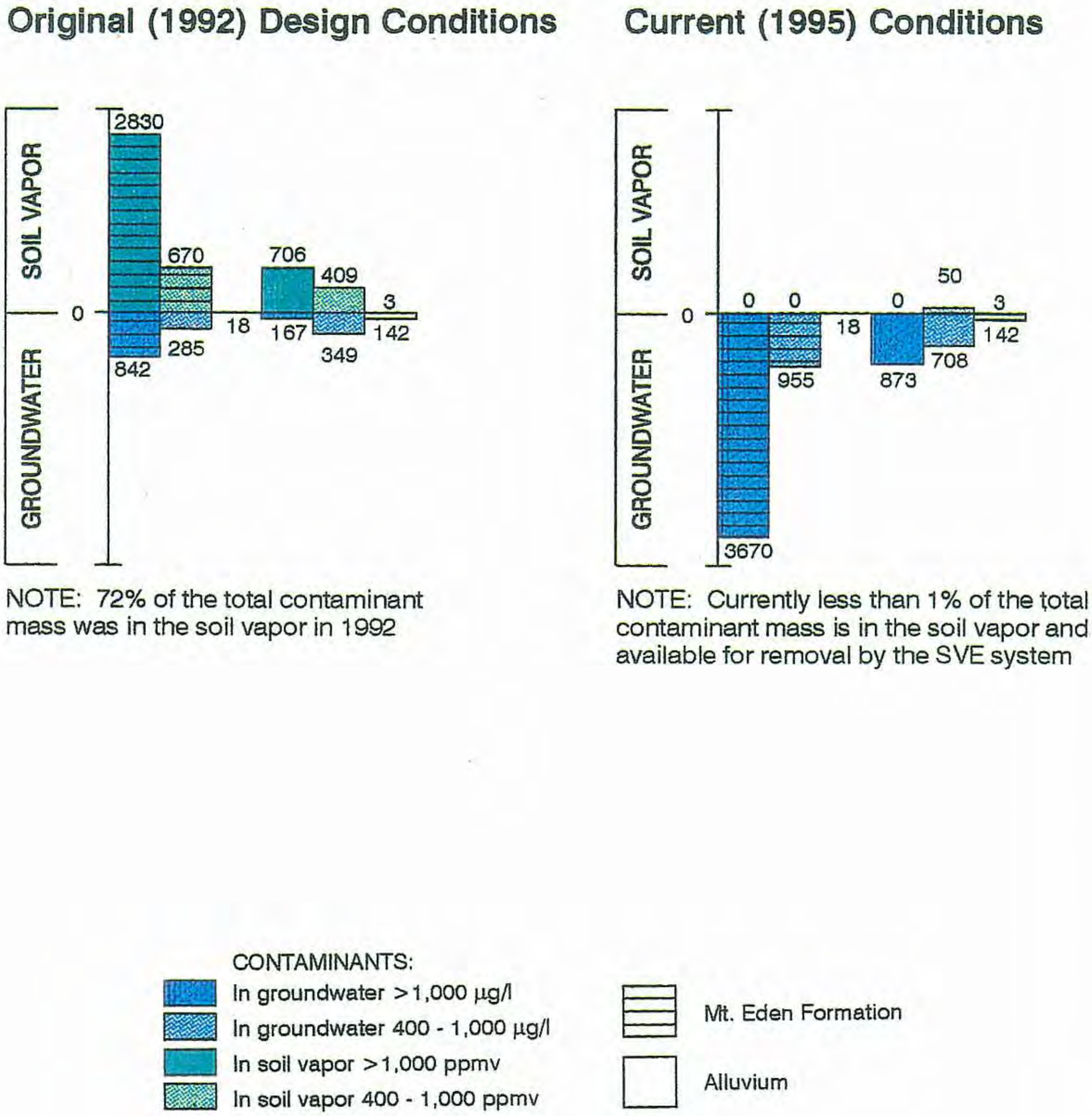

Figure 3-10. Distribution of Contamination at Lockheed Beaumont No. 1 Site (pounds HVOC)

Table 3-3

Distribution of Contaminant Mass in Soil Vapor

		Original Design (1992) Conditions (prior to rise in water level)		Current (1995) Conditions	
Isopleth Boundary	Formation	Volume (millions SCF)	% of Total Mass	Volume (millions SCF)	% of Total Mass
200-400 ppbv	Mt. Eden	0	0	0	0
	Alluvium	19.8	.05	19.8	0.05
	Total	19.8	.05	19.8	0.05
400-1000 ppbv	Mt. Eden	1.6	10.4	0	0
	Alluvium	16.3	6.4	2.0	0.8
	Total	17.9	16.8	2.0	0.8
>1000 ppbv	Mt. Eden	2.7	44	0	0
	Alluvium	6.8	11	0	0
	Total	9.5	55	0	0
Total Mass in Soil Vapor		47.2	72	21.8	<1

Notes:

1. This analysis includes only those HVOCs within the 200 ppbv isopleth to represent the total mass in the soil vapor. Data for lower concentrations (at shallow depths) were not considered adequate or reliable for the mass balance.

2. Totals have been rounded to 3 significant figures.

Table 3-4

Distribution of Contaminant Mass in Groundwater

		Original (1992) Design Conditions (prior to rise in water level)		Current (1995) Conditions	
Isopleth Boundary	Formation	Volume (millions gallons)	% of Total Mass	Volume (millions gallons)	% of Total Mass
1-400 μg/l (Note 1)	Mt. Eden	44.7	0.3	44.7	0.3
	Alluvium	242	2.2	Not Calculated	2.2
	Total	287	2.5	Not Calculated	2.5
400-1000 μg/l	Mt. Eden	59.8	4.4	71.8	14.9
	Alluvium	73.7	5.4	181	11.0
	Total	134	9.8	253	25.9
>1000 μg/l	Mt. Eden	10.5	13	30.7	57.2
	Alluvium	20.1	2.6	71	13.6
	Total	30.6	15.6	102	70.8
Total Mass in Groundwater		451	28	642	99

Notes:

1. This analysis excludes groundwater outside of the 400 μg/l isopleth downgradient of the Rocket Motor Production Area.

2. Totals have been rounded to 3 significant figures.

Because the vadose zone of the two-phase wells (Mt. Eden formation) is now saturated, the air inlet valves must be kept open to allow enough air flow through the well to lift the water. Consequently, this dilutes the vapors going to the catox unit. Although the groundwater concentrations have increased in these wells since 1977, the limited permeability of the Mt. Eden formation restricts groundwater flow and, therefore, the removal of contaminants.

A similar situation exists in the SVE wells, which are screened in the alluvium. The highest vapor concentrations formerly existed in the lower portion of the well screens. However, the rising water table has submerged this zone, causing the concentration of contaminants in the vapor stream going to the catox at the time of system startup to be approximately 10 times lower than the design levels. During the first six months of operation the concentration decreased further and the SVE system is currently removing only low-level, residual contamination from the vadose zone, as well as some VOCs that are evaporating from the groundwater. The total contaminant load to the catox unit is only 8 ppmv, at a flow rate of 200 scfm. This calculates to a total of approximately 100 lbs of contamination that has been removed from the vadose zone at the Burn Pit Area.

3.7 Recommendations

As described previously, the remediation system at the Burn Pit Area (BPA) was designed to extract and treat the most contaminated soil vapors and groundwater, thereby removing the soure and reducing the risk for further migration of contaminants. Because of the changes in the subsurface conditions this objective is not being fully met as shown by the data collected during the first six months of operation. The following modifications/ enhancements to the remediation system are recommended to help achieve the remedial objective in the Burn Pit Area:

- Investigate treatment alternatives, such as air sparging, to address the rise in water levels and enhance contaminant removal;

- Closely evaluate the effectiveness of continuing to operate the two-phase extraction system;
- Consider replacing the catox unit with activated carbon if influent levels do not increase; and
- Continue routine sampling and monitoring of the wells in the BPA to further evaluate the effectiveness of the system in achieving the remedial objectives.

The rationale for each recommendation is presented below.

Investigate Treatment Alternatives

A modification to the existing BPA extraction system is recommended to: 1) enhance the removal of contamination at the source, 2) create an extraction system that will be independent of the amount of rainfall and water level, and 3) shorten the cleanup timeframe and prevent further migration of contaminants.

As part of the investigation into treatment alternatives, an air sparging pilot study workplan is being developed and will be presented in the near future for agency review and approval. Proper design and analysis of the pilot study will allow an evaluation based on the following potential benefits:

- More rapid and effective removal of the aqueous-phase contaminant source in the Mt. Eden formation;
- Higher VOC destruction efficiency by catalytic oxidation (more concentrated vapors); and
- Shorter operating period for the catalytic oxidizer.

It is estimated that air sparging could increase the vapor influent concentrations entering the catox unit by a factor of four, which would increase the total average daily mass removal rate from 0.8 to 3.3 pounds/day.

Evaluate the Value of Continuing With Two-Phase Extraction

The screened zones of the two-phase extraction wells have been completely submerged by the elevated water table and no longer have any exposed vadose zone. Although the groundwater in these wells is relatively contaminated, it is necessary to allow ambient air into the well casing to create enough air flow through the well to lift water to the surface. However, this significantly dilutes the vapor stream, and reduces the contaminant removal rate to approximately 0.01 pounds of contaminant per day, or 4 pounds per year. If this is the case, then it may be prudent to discontinue operation of the two-phase wells until the water level decreases.

Replacement of the Catox Unit With Activated Carbon

If the influent vapors to the catox continue to remain at low concentrations, a passive treatment technology such as carbon adsorption rather than the catox unit may be more effective in removing the contamination from the vapor. This will decrease the power consumption required for treatment, and reduce the operating and maintenance requirements.

3.8 General Recommendations

In addition to the recommedations made to help achieve the remediation goals the following modifications to the monitoring program are recommended:

- Reduce the sampling frequency for treated water required by the RWQCB from weekly to monthly; and
- Modify the SCAQMD permit conditions to allow for operation of the catox unit without the HCl scrubber.

The rationale for each of these recommendations is presented below.

Reduce Sampling Frequency

Sample collection and analysis of treated water effluent from the air stripper and the BPA carbon vessels has been done on a weekly basis since system startup. All results have indicated that there is no detectable contamination in the treated water and all parameters have been consistently below the permitted discharge levels specified in the RWQCB Waste Discharge Requirements. Based on these results it is recommended that the sampling and monitoring of treated water be performed on a monthly basis instead of weekly.

Modify SCAQMD Permit

Prior to implementing any of the recommendations discussed in Section 3.7, the SCAQMD permit conditions must be formally amended to reflect the proposed changes. In addition it is recommended that the potential be discussed for amending the permit conditions (Numbers 16-19) which currently require the HCl scrubber to be in operation whenever the catox unit is operating. At the current influent vapor concentrations only low levels of HCl are being created. If concentrations remain at this current level it is recommended that the HCl scrubber be disconnected, thereby significantly reducing operating costs of the system without jeopardizing the remediation goals.