12.0 DEVELOPMENT AND SCREENING OF ALTERNATIVES

Technologies that remain for consideration following the screening process in Sections 10.0 and 11.0 are assembled to form definitive remedial action alternatives in this section. These alternatives are designed to address the specific site requirements for aquifer remediation.

The alternatives that will be discussed are as follows:

- Alternative 1 - No Action (Monitoring)
- Alternative 2 - Aqueous GAC with Municipal End Use
- Alternative 3 - Air Stripping with Off-Gas Treatment and Municipal End Use
- Alternative 4 - Advanced Oxidation (Ozone/Peroxide) with Municipal End Use
- Alternative 5 - Aqueous GAC with Reinjection
- Alternative 6 - Aqueous GAC with Surface Drainage

Alternatives 2 through 6 utilize four existing municipal wells and one new extraction well at the Newmark Wellfield, and four new extraction wells at the plume front. Flow rates of municipal wells located between the Newmark Wellfield and the plume front will be adjusted during the life of the remedial action to optimize contaminant capture. Development of the extraction scenario used to develop alternatives is discussed in detail in Section 13.1.

The single extraction scenario is used in combination with each of three treatment alternatives (Aqueous GAC, Air Stripping, and Advanced Oxidation), and with three methods of disposal (Municipal End Use, Surface Drainage and Reinjection). These treatment and disposal options can be used in a number of combinations; alternatives presented in this section were chosen based on discussions with the EPA and limited to only those alternatives that were most appropriate.

The same treatment processes were used for both the Newmark Wellfield and plume front groundwater treatment systems for alternatives that include treatment. However, this analysis does not preclude using a combination of suitable treatment options for the Newmark Wellfield and plume front treatment systems. It should be noted that the City of San Bernardino is currently operating an air stripping system at the Newmark Wellfield. This facility could be modified to accept all extracted water in the north. An alternative, incorporating the City air strippers was not developed because the system does not currently have off-gas treatment and the EPA requires that air strippers cannot emit contaminants. Modifications to the air strippers would include addition of a GAC vapor phase off-gas treatment process and changes to the air to water ratio to optimize off-gas treatment. If the existing facility can be modified, a reduction in the schedule and associated costs may be possible.

It is expected that the City of San Bernardino can accept all groundwater treated by both remedial systems into the municipal water supply for analysis purposes. For the purposes of this document, all pumping costs are included; however, O & M costs will be negotiated at a later date. Alternative 5 is developed using injection well disposal in case the City cannot accept the treated groundwater into the municipal system. Also, Alternatives 2, 3, 4, and 6 incorporate surface water disposal if the City only accepts some of the treated groundwater. Partial municipal use could occur during wet seasons of the year.

Remedial alternatives are evaluated and screened on the basis of effectiveness, implementability, and cost. Each screening criterion is discussed below.

Effectiveness - Each alternative is evaluated in terms of its effectiveness in protecting human health and the environment through reductions in toxicity, mobility, and/or volume of the contaminated groundwater.

Short-term effectiveness considers risk of exposure during the construction and implementation period. Long-term effectiveness considers the permanence of remediation after remedial action is complete.

Implementability - Implementability measures the technical and administrative feasibility to construct, operate, and maintain a remedial alternative.

Technical feasibility refers to availability, and ability to construct, operate, maintain, and monitor the alternative. The alternative's ability to meet regulations until a remedial action is complete is also considered.

Administrative feasibility refers to ability to obtain approvals from other offices and agencies, and availability of treatment, storage, and disposal services. Availability of specific equipment and technical specialists is also considered.

Cost - Absolute accuracy of cost estimates is not essential. Comparative estimates with relative accuracy are required to identify aspects of an alternative that will control cost, based on prior estimates, site-cost experience, and engineering judgement. The estimate is to include O&M costs after the remedial action is complete. Potential future remedial action costs are also to be considered.

12.1 ALTERNATIVE 1: NO ACTION (MONITORING)

The No Action alternative provides a baseline against which other alternatives are evaluated. This alternative includes quarterly sampling and water level monitoring of existing monitor and municipal wells, recording of pumping volumes versus time, and as appropriate, computer modelling to assess movement of the contaminant plume.

Effectiveness - The No Action alternative does not satisfy the statutory requirement of protectiveness of human health and the environment, and does not materially reduce potential risk of direct human contact with contaminated groundwater. Because this alternative does not remove or contain contaminants at the site, there is no reduction in toxicity, mobility, or volume. It would not attain the Remedial Action Objectives of reducing TCE and PCE to levels below 5 ppb, and migration of the groundwater contaminant plume would continue. Current knowledge suggest that time, well over fifty years, would be required for natural processes to reduce the levels.

Short-term effectiveness is high because installing monitor wells is a common and safe procedure. Long-term effectiveness is low because residual contaminants are not removed from the aquifer. Proper health and safety (H&S) procedures will be followed when new wells are installed and during quarterly sampling events to reduce potential health risks during this very limited exposure time.

Implementability - The No Action alternative is technically feasible because continuous monitoring of wells is common practice. Groundwater analysis is available from commercial laboratories, and associated technologies are well established.

Administrative implementability is poor because No Action does not meet Remedial Action Objectives by itself. Public and government approval is difficult to attain because there is no remediation.

Cost - The present worth estimated cost for Alternative 1 is approximately $3.5 million, and details are presented in Section 13.0.

Evaluation - The No Action alternative will be retained for detailed analysis as required by the NCP.

12.2 ALTERNATIVE 2: AQUEOUS GAC WITH MUNICIPAL END USE

This alternative uses groundwater extraction wells placed on-site and off-site to maximize plume capture and to control contaminant migration. The location and design of the production well-extraction well network will be developed in the remedial design. Groundwater will be pumped through underground piping to the aqueous GAC treatment system, the location of which will be determined during remedial design. Depending on the quality of the pumped water, pretreatment may be required to remove suspended solids and fine silts. Treated groundwater will be pumped to the municipal water supply system.

A schematic process diagram of an aqueous GAC system is shown in Figure 12-1.

Effectiveness - This alternative controls current and potential risks to human health and the environment by reducing toxicity, mobility, and volume of contaminants. A high degree of effectiveness also results

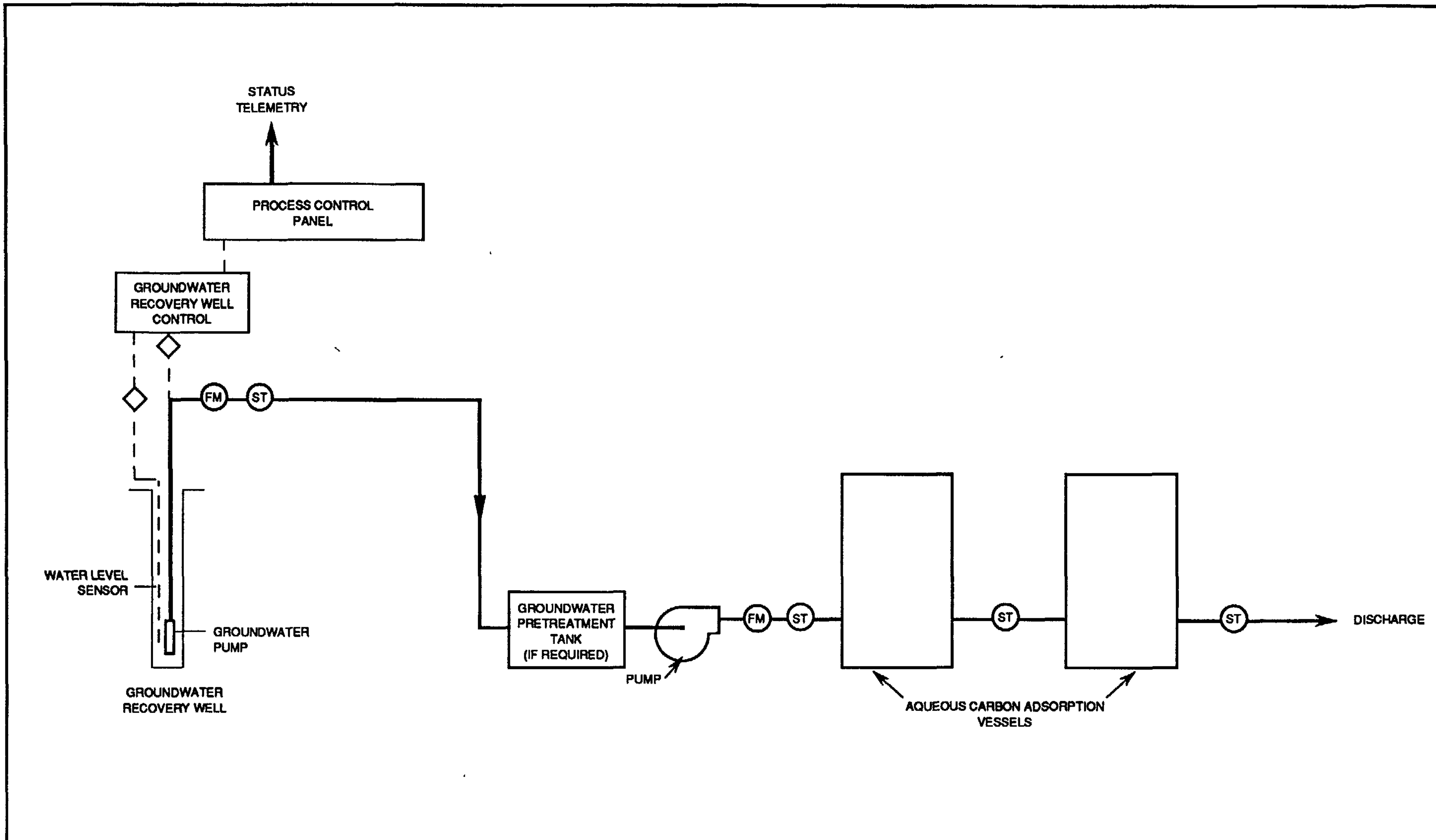

Figure 12-1
Aqueous Phase Carbon Adsorption System Conceptual Drawing
Newmark Groundwater Superfund Site
Newmark Operable Unit RI/FS Report

LEGEND

Symbol	Meaning
ST	SAMPLING PORT
FM	FLOW METER
◇	SYSTEM SHUT-OFF SENSOR

because the system does not produce air discharges and contaminants are removed from the site and regenerated.

Potential of short-term risks to construction crews and implementation personnel is low because there is a minimal opportunity for direct contact with contaminated groundwater. Handling of spent carbon and the off-site incineration process of carbon disposal poses some threat to human health. This can be managed by implementing proper Health and Safety (H&S) procedures.

Long-term effectiveness is high because contaminants have been removed from groundwater after implementation of the remedial action. There are only minor resulting residuals remaining after treatment, which are VOCs that combine with organic carbon in the soil.

Implementability - This alternative is highly implementable. It is considered to be a standard remedial approach in the industry and is relatively easy to construct, operate, and maintain. Also, removal and regeneration of carbon is a common service provided by many vendors.

Administratively, regulatory approval for extraction and treatment systems is expected to be relatively easy to obtain. Acceptance from the City of San Bernardino is required to permit the municipal water supply end use option. Compliance with any additional requirements, such as a monitoring program, discharge permits, or a remediation progress evaluation may be required.

Cost - The present worth estimated cost for Alternative 2 is approximately $49.9 million, and details are presented in Section 13.0.

Evaluation - The aqueous GAC with municipal end use alternative will be retained for detailed analysis because of its effectiveness in reducing mobility, toxicity, and volume of contaminants.

12.3 ALTERNATIVE 3: AIR STRIPPING WITH OFF-GAS TREATMENT AND MUNICIPAL END USE

Aspects of this alternative are similar to those of the previous alternative. Groundwater extraction wells are used which pump groundwater through underground piping to the air stripper treatment system. Off-gases are treated using vapor phase GAC. Treated groundwater is then pumped to the municipal water supply system.

A schematic process diagram of an air stripping system with vapor phase GAC off-gas treatment is shown in Figure 12-2.

Effectiveness - This alternative reduces toxicity, mobility, and volume of contaminants. The high degree of effectiveness is achieved as a result of vapor phase contaminants being collected, removed from the site, and destroyed in the carbon regeneration process.

Potential of short-term risks to construction crews and implementation personnel is low because there is will be very limited direct contact with highly contaminated groundwater. Handling of spent carbon and the off-site incineration process of carbon disposal poses some threat to human health. This can be managed by implementing proper H&S procedures.

Long-term effectiveness is high because contaminants have been removed from groundwater after implementation of the remedial action. Resulting residuals consist of VOCs adsorbed to organic carbon in the soil.

Implementability - This alternative is highly implementable. It is considered to be a standard remedial approach in the industry and is relatively easy to construct. Maintenance of air stripper and GAC treatment units requires monitoring the control systems regularly to ensure it is operating to full capability. Removal and regeneration of activated carbon is a common service provided by many vendors.

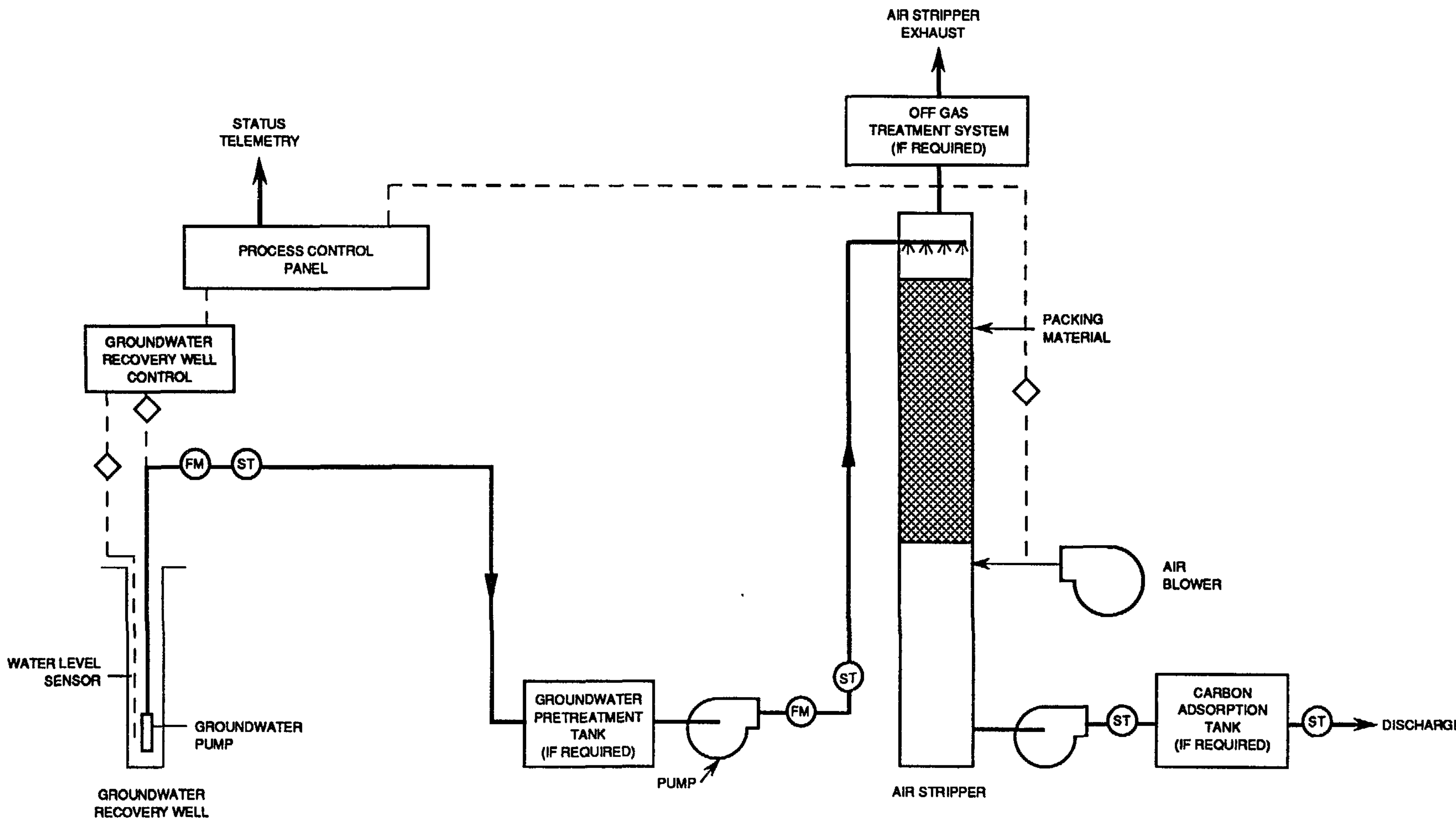

Figure 12-2
Air Stripper System Conceptual Drawing
Newmark Groundwater Superfund Site
Newmark Operable Unit RI/FS Report

LEGEND	
ST	SAMPLING PORT
FM	FLOW METER
◇	SYSTEM SHUT-OFF SENSOR

Administratively, it is typically more difficult to obtain permits for an sir stripper system because approval for off-gas treatment system is required.

Cost - The present worth estimated cost for Alternative 3 is approximately $47.9 million, and details are presented in Section 13.0.Evaluation - The air stripping with vapor phase GAC off-gas treatment and municipal end use alternative will be retained for detailed analysis because of its effectiveness and ease of installation.

For purposes of this FS, conventional (GAC) technology will be carried through, but an innovative technology demonstrated to be as effective as GAC (and within reasonable cost range) would be considered equivalent.

12.4 ALTERNATIVE 4: ADVANCED OXIDATION (OZONE/PEROXIDE) WITH MUNICIPAL END USE

As with previous alternatives, this alternative includes groundwater extraction wells to pump groundwater through underground piping to the ozone/peroxide advanced oxidation treatment system. Treated groundwater is then pumped to the municipal water supply system.

A schematic process diagram of an Advanced Oxidation (Ozone/ Peroxide) treatment system is shown in Figure 12-3.

Effectiveness - This alternative is not a fully proven destructive technology for large systems to reduce toxicity, mobility, and volume of contaminants. The process can produce hazardous by-products if incomplete oxidation occurs. A high degree of effectiveness is achieved if complete oxidation occurs, whereby contaminants are destroyed and treatment residuals are not produced.

Potential of short-term risks to construction crews and implementation personnel is low because there is a low risk of direct contact with contaminated groundwater. Handling of strong oxidants poses some threat to human health, which can be managed by implementing proper H&S procedures.

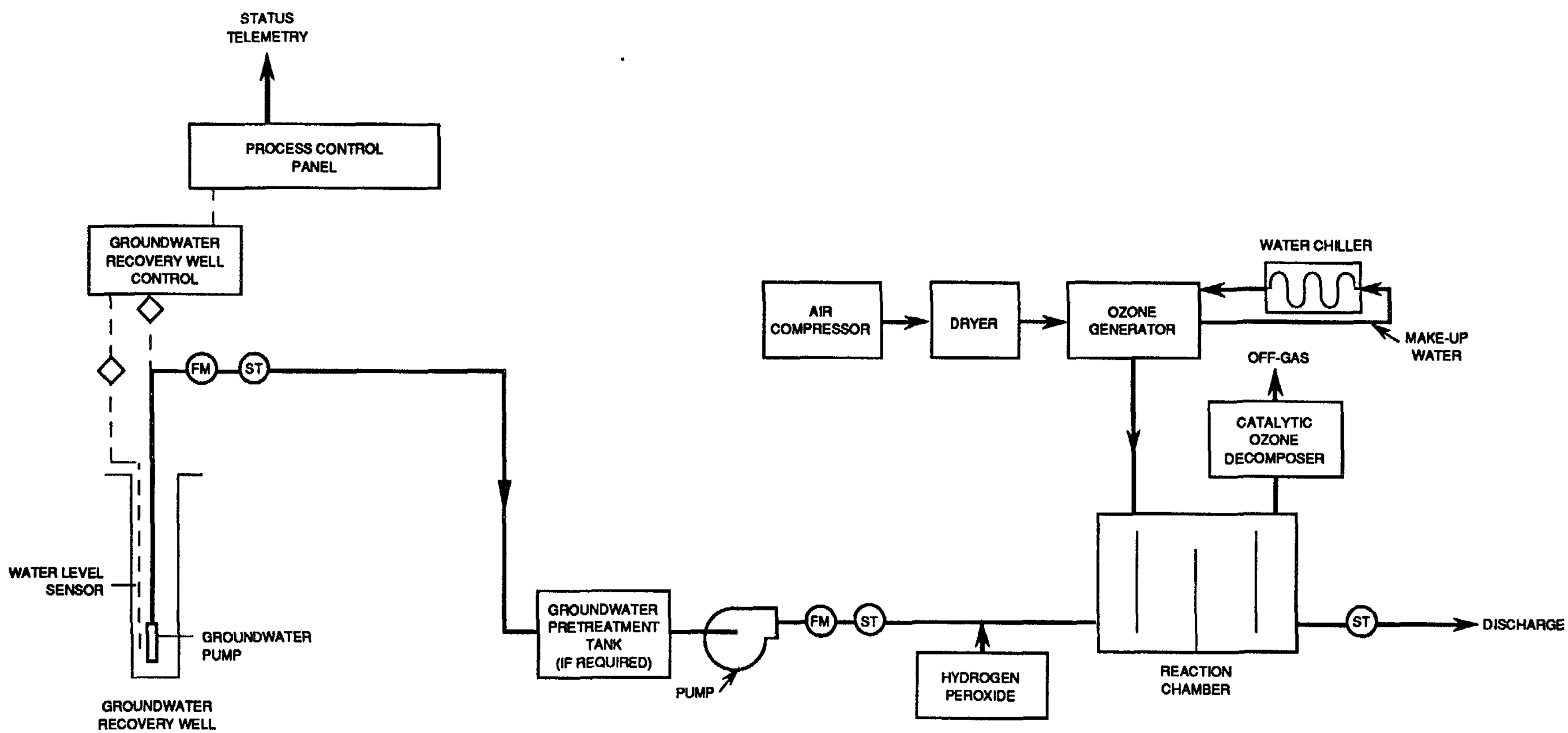

Figure 12-3
Advanced Oxidation System Conceptual Drawing
Newmark Groundwater Superfund Site
Newmark Operable Unit RI/FS Report

LEGEND	
(ST)	SAMPLING PORT
(FM)	FLOW METER
◇	SYSTEM SHUT-OFF SENSOR

Long-term effectiveness is high because contaminants are destroyed on-site.

Implementability - This alternative is technically feasible, is considered to be an innovative remedial approach, and is relatively easy to construct. Maintenance of the advanced oxidation treatment unit requires monitoring the control systems regularly to ensure it is operating to full capability.

Regulatory approval for extraction and treatment systems is expected to be relatively easy to obtain. Acceptance from the City of San Bernardino needs to be attained to permit the municipal water supply end use option. Compliance with any additional requirements, such as a monitoring program, discharge permits, or a remediation progress evaluation may be required. The necessary equipment and personnel to implement this alternative are available.

Cost - The present worth estimated cost for Alternative 4 is approximately $61.0 million, and details are presented in Section 13.0.

Evaluation - The advanced oxidation with municipal end use alternative will be retained for detailed analysis because of its potential effectiveness in destruction of contaminants.

12.5 ALTERNATIVE 5: AQUEOUS GAC WITH REINJECTION

This alternative is identical to Alternative 2, which includes extraction wells, underground piping, and aqueous GAC system. But here, treated groundwater will be discharged into injection wells. These will be located and screen placement designed based on modeling results during remedial design.

Effectiveness - This alternative reduces toxicity, mobility, and volume of contaminants. As with Alternative 2, a high degree of effectiveness results from the system not producing air discharges, and from contaminants being collected, and removed from the site, during the carbon regeneration process. Injection wells replenish the groundwater with treated water which aids in controlling the contaminant plume.

Potential of short-term risks to construction crews and implementation personnel is low because there will be very limited direct contact with highly contaminated groundwater. Handling of spent carbon and the off-site incineration process of carbon disposal poses some threat to human health but this can be managed by implementing proper H&S procedures.

Long-term effectiveness is high because contaminants will be removed from groundwater after implementation of the remedial action, and only minor residuals will remain.

Implementability - This alternative is highly implementable. It is considered to be a standard remedial approach in the industry and is relatively easy to construct and operate. Removal and regeneration of carbon is a common service provided by many vendors. Injection wells typically need additional maintenance to prevent restricted water flow due to plugging or fouling of the wells.

Administratively, regulatory approval for extraction and treatment systems is expected to be relatively easy to obtain. Approval is required for the installation of injection wells used for disposal.

Cost - The present worth estimated cost for Alternative 5 is approximately $48.1 million, and details are presented in Section 13.0.

Evaluation - The aqueous GAC with reinjection alternative will be retained for detailed analysis because it provides another effective end use method if disposal to the municipal water supply is not possible.

12.6 ALTERNATIVE 6: AQUEOUS GAC WITH SURFACE DRAINAGE

This alternative is also identical to Alternative 2, which includes extraction wells, underground piping, and aqueous GAC system. The exception is that treated groundwater will be discharged by surface drainage in pre-determined off-site locations.

Effectiveness - This alternative reduces toxicity, mobility, and volume of contaminants. As with Alternative 2, a high degree of effectiveness results from the system not producing air discharges. Contaminants are collected, removed from the site, and destroyed in the carbon regeneration process.

Potential of short-term risks to construction crews and implementation personnel is low because there will be very limited direct contact with highly contaminated groundwater. Handling of spent carbon and the off-site incineration process of carbon disposal poses some threat to human health but this can be managed by implementing proper H&S procedures.

Long-term effectiveness is high because contaminants have been removed from groundwater after implementation of the remedial action. There are only minor resulting residuals after treatment, which are VOCs that combine with organic carbon in the soil.

Implementability - This alternative is highly implementable, and is easy to construct and operate. Removal and regeneration of carbon is a common service provided by many vendors.

Regulatory approval for extraction and treatment systems is expected to be relatively easy to obtain. An NPDES permit will be needed for surface drainage disposal but it is believed the permit can be obtained. Compliance with any additional requirements, such as a monitoring program, or a remediation progress evaluation may be required.

Cost - The present worth estimated cost for Alternative 6 is approximately $36.5 million, and details are presented in Section 13.0.

Evaluation - The aqueous GAC with surface drainage alternative will not be retained for detailed analysis. Instead, surface drainage and municipal end use will be combined for flexibility.

12.7 EVALUATION SUMMARY

Alternative 1, the No Action alternative, will be carried through to detailed analysis, in accordance with the NCP.

Alternatives 2 through 5 inclusive, will also be carried to detailed analysis because all of these treatment systems would meet the Remedial Action Objectives.

Table 12-1 summarizes the results for alternatives evaluated in this section.

Table 12-1

SCREENING OF GROUNDWATER ALTERNATIVES
Newmark Site

ALTERNATIVE	EFFECTIVENESS	IMPLEMENTABILITY	APPROX. COST
Alternative 1: No Action	▪ Protection of human health and the environment: Poor ▪ Reduction of contaminant toxicity, mobility or volume: Poor ▪ Short-term: Good ▪ Long-term: Good	▪ Technical: Excellent ▪ Administrative: Poor	$3.5 million
Alternative 2: Aqueous Granular Activated Carbon (GAC) with Municipal End Use	▪ Protection of human health and the environment: Excellent ▪ Reduction of contaminant mobility, toxicity or volume: Excellent ▪ Short-term: Good ▪ Long-term: Excellent	▪ Technical: Excellent ▪ Administrative: Excellent	$49.9 million
Alternative 3: Air Stripping with Vapor Phase Off-Gas Treatment and Municipal End Use	▪ Protection of human health and the environment: Excellent ▪ Reduction of contaminant toxicity, mobility or volume: Excellent ▪ Short-term: Good ▪ Long-term: Excellent	▪ Technical: Excellent ▪ Administrative: Good	$47.9 million
Alternative 4: Advanced Oxidation (Ozone/Peroxide) with Municipal End Use	▪ Protection of human health and the environment: Good ▪ Reduction of contaminant toxicity, mobility or volume: Good ▪ Short-term: Good ▪ Long-term: Good	▪ Technical: Good ▪ Administrative: Excellent	$61.0 million
Alternative 5: Aqueous GAC with Reinjection	▪ Protection of human health and the environment: Excellent ▪ Reduction of contaminant toxicity, mobility or volume: Excellent ▪ Short-term: Good ▪ Long-term: Excellent	▪ Technical: Good ▪ Administrative: Good	$48.1 million
Alternative 6: Aqueous GAC with Surface Drainage	▪ Protection of human health and the environment: Excellent ▪ Reduction of contaminant toxicity, mobility or volume: Excellent ▪ Short-term: Good ▪ Long-term: Good	▪ Technical: Good ▪ Administrative: Moderate	$36.5 million

(shaded) Alternative that is screened out.

13.0 DETAILED ANALYSIS OF ALTERNATIVES

Five alternatives that remain following screening in Section 12.0 are analyzed in detail in Section 13.0 according to nine criteria. These criteria address a more detailed analysis of effectiveness, implementability, and cost than the evaluation completed during development and screening of alternatives.

After detailed analysis, alternatives are compared to evaluate relative performance in relation to each specific criterion. This comparison will be used by the EPA as the basis for selecting a preferred alternative.

TCE and PCE concentrations used for development of treatment alternatives are based on the analytical data obtained from municipal wells in the Newmark study area. The groundwater quality data have been obtained since 1980 and are discussed in Section 5.3. TCE and PCE reached peak concentrations from 1985 to 1987. Since then, a declining trend is observed for a majority of the wells. To determine an optimum design concentration, the data obtained from 1988 to present is used. The average concentration of TCE and PCE for this duration is 4.8 ppb and 27.7 ppb with standard deviation of 3.3 ppb and 20.8 ppb, respectively. Concentrations of 10 ppb and 75 ppb for TCE and PCE, respectively, were used to develop alternatives because these concentrations are approximately half the way between average and maximum concentrations seen at the site.

If concentrations increased, carbon usage rates would increase, reducing the time between carbon regenerations. Recycling effluent can be used to reduce influent concentrations with an air stripping system if concentrations exceed the capabilities of the stripper.

Apart from TCE and PCE, the following are the VOCs and their concentrations that were detected during recent analysis of groundwater in Newmark (see Table 5-3): Methylene Chloride (0.2 ppb), 1,1 dichloroethane (1 ppb), cis-1,2 Dichloroethene (3 ppb), Chloroform (0.2 ppb), 1,2 Dichloropropane (0.2 ppb), Dichlorofluoromethane (7 ppb), Trichlorofluoromethane (12 ppb), and Carbon Tetrachloride (0.7

ppb). Since the concentrations of these VOCs are below drinking water standards, they are only evaluated for their possible secondary affects on the groundwater treatment technologies.

13.1 DEVELOPMENT OF EXTRACTION SCENARIOS

13.1.1 Introduction

This Section describes nine extraction scenarios that were simulated using the project flow model. The extraction scenarios were simulated for the purpose of comparing the efficiency and feasibility of remediation extraction systems for the Newmark plume.

In evaluating extraction scenarios, it was assumed that TCE and PCE travel at the same velocity as the groundwater. This simplification was necessary because the modeling software is only capable of calculating groundwater velocities, not contaminant velocities. This assumption is reasonable because, as shown in Section 13.2 of Appendix M, the retarded velocities for TCE and PCE are not substantially different from the groundwater velocities. The project flow model briefly described in Subsection 13.1.3 served as the basis for the extraction scenario simulations. More detail describing the development of the extraction scenarios can be found in Appendix M.

13.1.2 Extraction Scenarios and Extraction Regions

A total of nine extraction scenarios were simulated. The extraction scenarios consisted of extraction areas located in one or any combination of four extraction regions of the Newmark plume, with the exception of extraction scenario no. 9. The extraction area locations determined in each of the extraction scenarios are for analysis only. The exact locations of extraction areas will be identified during the design phase. Extraction scenario no. 9 was simulated without using any additional extraction areas, other than the existing water-supply wells. The extraction regions of the Newmark plume were:

- Downgradient edge of the Newmark plume;

- Middle of the Newmark plume (adjacent to the eastern edge of Shandin Hills);
- Newmark Wellfield; and
- Centerline of the southern half of the Newmark plume.

The downgradient edge of the Newmark plume was chosen as the extraction region for the main purpose of preventing further downgradient migration of the Newmark plume. The middle of the Newmark plume was chosen as an extraction region because it was a strategic location for narrowing the width of the Newmark plume and dividing it into two plumes that could be remediated independently. The Newmark Wellfield was chosen as an extraction region because it was a suspected source area for the Newmark plume that could be remediated separately from the remainder of the Newmark plume. The centerline of the Newmark plume was chosen as an extraction region for the purpose of remediating the southern half of the Newmark plume in one efficient system of extraction wells. Figure 13-1 shows the study area with the estimated location of the plume and the extraction scenario regions.

The nine extraction scenarios were:

- Extraction scenario no. 1 was simulated for a duration of 5 years using extraction areas located at the downgradient edge of the Newmark plume;
- Extraction scenario no. 2 was simulated for a duration of 5 years using extraction areas located in the Newmark Wellfield;
- Extraction scenario no. 3 was simulated for a duration of 5 years using extraction areas located in the middle of the Newmark plume;
- Extraction scenario no. 4 was simulated for a duration of 5 years using extraction areas located along the centerline of the Newmark plume;

- Extraction scenario no. 5 was simulated for a duration of 35 years using extraction areas located at the downgradient edge of the Newmark plume;

- Extraction scenario no. 6 was simulated for a duration of 35 years using extraction areas located at the downgradient edge of the Newmark plume and in the Newmark Wellfield;

- Extraction scenario no. 7 was simulated for a duration of 35 years using extraction areas located at the downgradient edge of the Newmark plume, in the Newmark Wellfield, and in the middle of the Newmark plume;

- Extraction scenario no. 8 was simulated for a duration of 35 years using extraction areas located along the centerline of the southern half of the Newmark plume and in the Newmark Wellfield of the Newmark plume; and

- Extraction scenario no. 9 was simulated for a duration of 35 years using only the existing municipal wells.

Extraction scenarios no. 1 through 4 were simulated for a short-time span of 5 years and were simulated for each of the four extraction regions. The first four extraction scenarios were preliminary scenarios simulated for the purpose of quickly estimating the number of extraction areas (with their locations and pumping rates) that would be required to capture the Newmark plume at each of the four extraction regions.

Extraction scenarios no. 5 through 8 were simulated for 35 years using combinations of the extraction area locations for the four extraction regions. Extraction scenarios no. 5 through 8 were final scenarios simulated for the purpose of comparing the efficiency and feasibility of extraction systems for remediating the Newmark plume.

Extraction scenario no. 9 was simulated for 35 years using just the existing water-supply wells. This extraction scenario was also known as the No Action scenario. Extraction scenario no. 9 was used to:

PARTIALLY SCANNED
OVERSIZE ITEM (S)

See Document # 2025203
for partially scanned image(s).

PLATE 1

For complete version of oversize document(s),
see paper copy.

OVD-parent

- Estimate the position of the Newmark plume 35 years from January 1986;

- Evaluate whether any existing municipal wells within the Newmark plume had an influence and could be utilized as possible extraction areas for the Newmark plume; and

- Calculate groundwater velocities for three areas of the Newmark plume.

Information from extraction scenario no. 9 was also used for estimating the time required to remediate the Newmark plume. The remediation times were estimated based on the groundwater velocities calculated for the three areas of the Newmark plume. The calculations of the remediation times are described in Section 14.0 of Appendix M and summarized in Subsection 13.1.4.

Several simulations were made before the final simulation for each extraction scenario was achieved. A description of objectives, data, procedures and results for each extraction scenario are found in Sections 4.0 through 12.0 of Appendix M.

Extraction scenarios no. 6 through 9 will be summarized in this section. Extraction scenarios no. 1 through 4 will not be summarized in this section since they were only preliminary simulations to extraction scenarios no. 5 through 8. Extraction areas located in the Newmark Wellfield are considered a vital part of the remediation extraction system and since extraction scenario no. 5 does not contain extraction areas in the Newmark Wellfield, it is not seriously being considered as an efficient and feasible remediation extraction system. Therefore, extraction scenario no. 5 will not be summarized in this section.

13.1.3 <u>Review of Project Flow Model</u>

The project flow model serves as the basis for the extraction scenario simulations. Development of the project flow model consisted of several processes:

- Development of the conceptual model
- Definition of the model area
- Preparation of the input data
- Definition of the grid system
- Calibration of the steady-state and transient-state flow models

Development of the conceptual model and definition of the model area are described in Section 1.4 of Appendix J. Preparation of the input data and boundary conditions for the transient-state flow model (which eventually becomes the project flow model) is described in Section 2.4 of Appendix J. The final input data used in the project flow model is described later in this section. Details on the calibration of the steady-state and transient-state flow models can be found in Sections 2.2 and 2.5 of Appendix J. A brief description on the calibration of the steady-state and transient-state models as they pertain to the project flow model and the extraction scenario simulations is given below.

The steady-state flow model was simulated and calibrated for the time period between January 1982 to January 1986. The input data and boundary conditions are described in Section 1.5 and 2.3 of Appendix J. The transient-state flow model was simulated and calibrated for the time period between January 1986 to December 1990. The input data and boundary conditions, resulting from the calibration of the steady-state flow model, were used as the initial conditions for the transient-state flow model. Some of the input data and boundary conditions (i.e., transmissivities, recharge values) were refined in order to calibrate the transient-state flow model. The calibrated transient-state flow model then became the project flow model, which was used for simulation of the extraction scenarios. The measured recharge, streamflow, pumpage, and head values for this time period were used in the extraction scenario simulations.

MODFLOW (McDonald and Harbaugh 1988) was the groundwater flow program used to simulate the groundwater flow for the Newmark model area. PATH3D (Zheng 1991) and SURFER (Golden Software, Inc. 1990) were used as post-processors for the MODFLOW output data. PATH3D, a groundwater path and travel-time program, utilized the input data and unformatted head files of MODFLOW simulations to:

- Create contours of the calculated heads;

- Simulate the pathlines of imaginary particles placed in various areas of the Newmark plume; and

- Delineate capture-zones for each extraction scenario.

SURFER (Golden Software, Inc. 1990) is a graphics program, which utilizes the head contour files created by PATH3D to produce plots displaying the head contours, particle pathlines and locations of the extraction areas.

13.1.4 Results of the Extraction Scenarios and Remediation Times

Velocities of the Groundwater and TCE and PCE in the Groundwater

Extraction scenario no. 9 (No Action scenario) was simulated for 35 years without using any additional extraction areas, other than the existing municipal wells. Pathlines were created for three sets of imaginary particles that totalled 50 imaginary particles. Set 1 contained six imaginary particles that were placed upgradient to the Newmark Wellfield wells in a north/south oriented line. Set 2 contained seven imaginary particles that were placed approximately half-way between the Newmark Wellfield and the middle area of the Newmark plume, in a north/south oriented line. Set 3 contained 37 particles that were placed along the outer perimeter of the bottom two-thirds of the Newmark plume. Table 25 of Appendix M gives the locations of the imaginary particles. This scenario was used to calculate an average groundwater velocity that could be used in the estimation of remediation times for the Newmark plume. Figures 13-2 and 13-3 display the head contour plots for layers 1 and 2, respectively. These figures also display the extraction areas and the imaginary particles with their pathlines.

For the first step in the calculation of the remediation times, groundwater velocities were calculated for three areas of the Newmark plume and then averaged together. Section 12.3 in Appendix M elaborates on the groundwater velocity calculations. The average groundwater velocity equaled 355.9 ft/yr, which appears to be the best estimate available using the existing information.

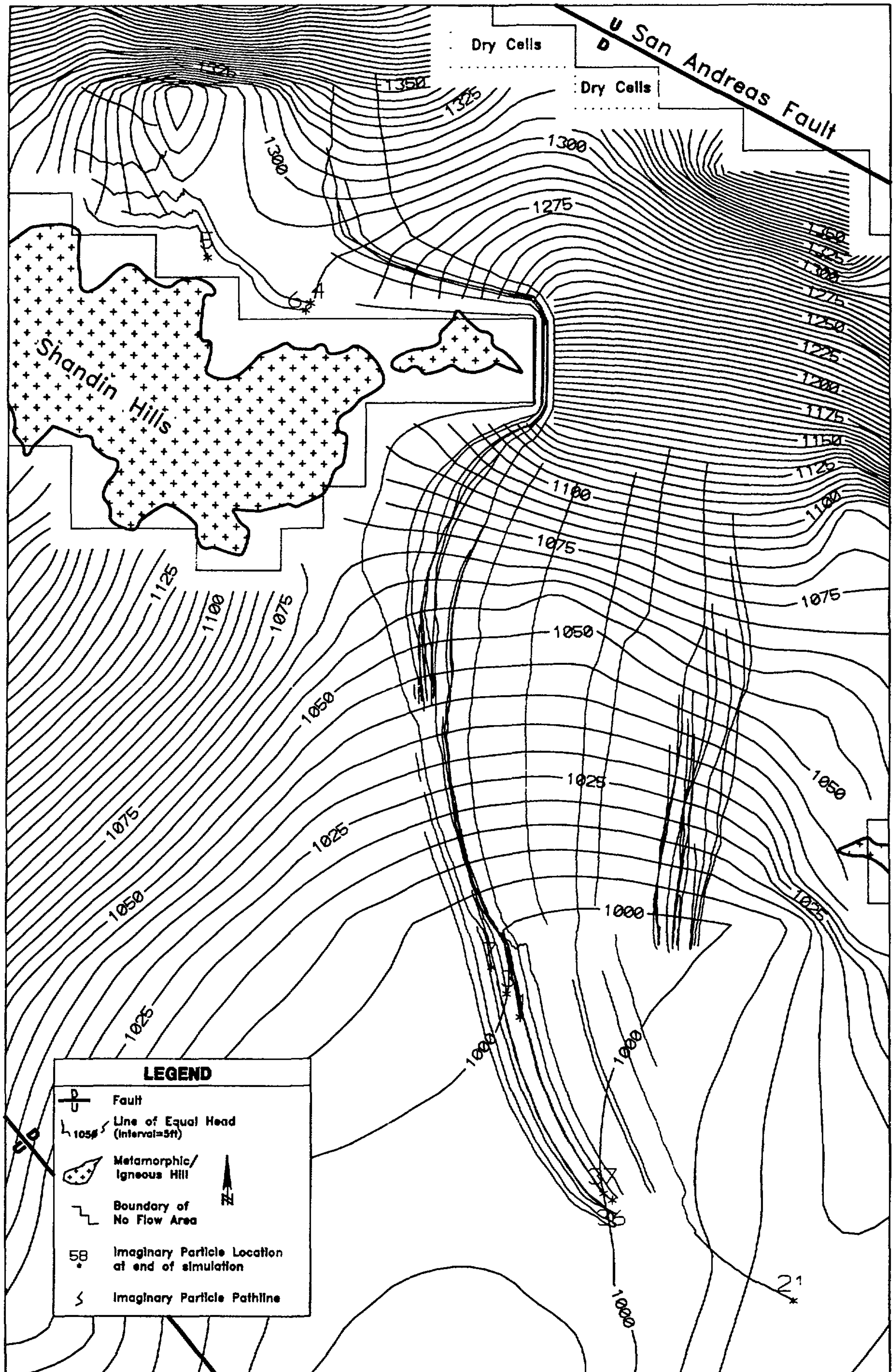

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FIGURE 13-2
HEAD CONTOUR AND PATHLINE PLOT FOR EXTRACTION SCENARIO NO. 9, LAYER 1 (UPPER AQUIFER)

0' 1000' 2000'
SCALE IN FEET

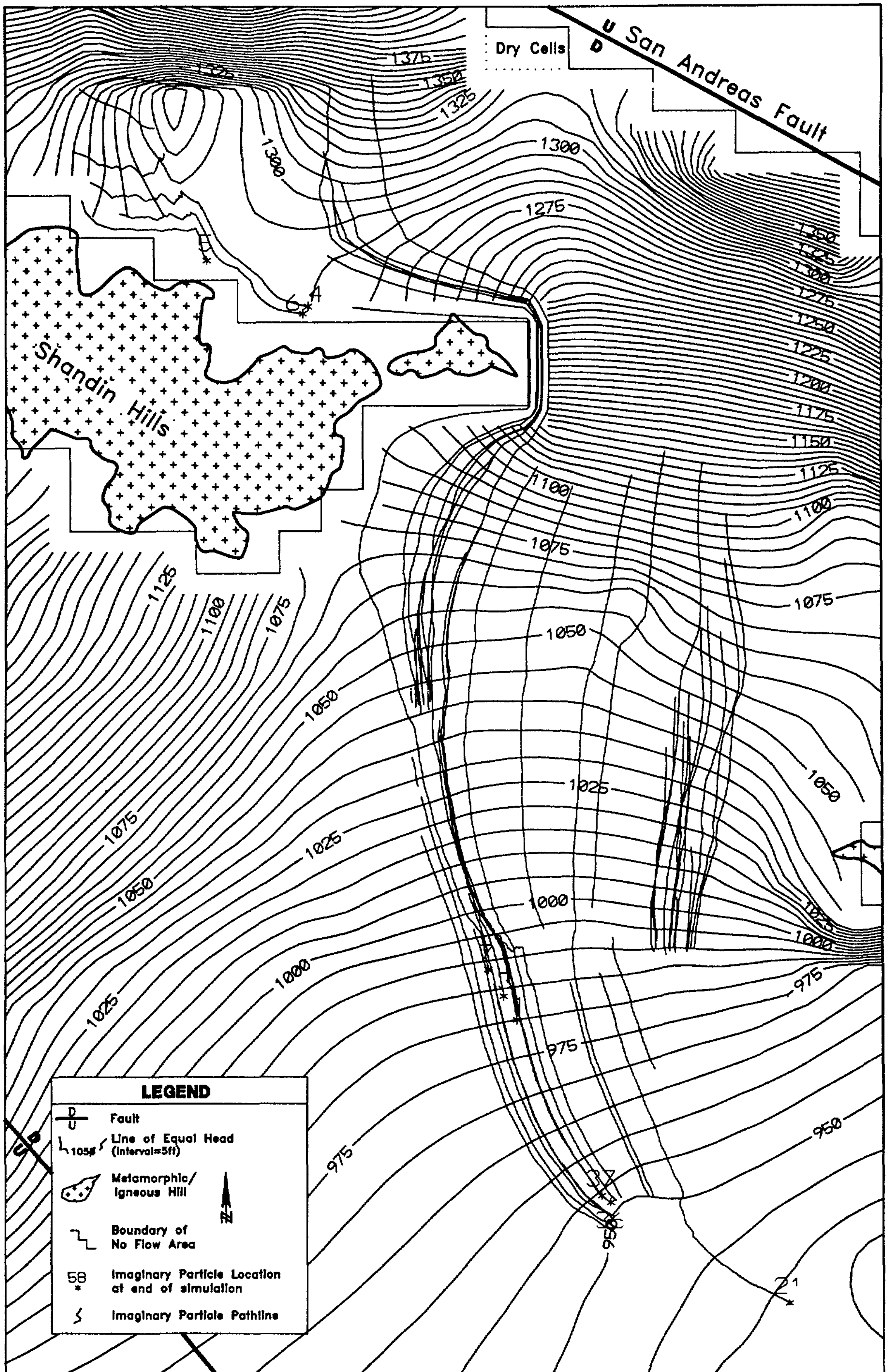

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FIGURE 13-3
HEAD CONTOUR AND PATHLINE PLOT FOR EXTRACTION SCENARIO NO. 9, LAYER 2 (LOWER AQUIFER)

For the second step in the calculation of the remediation times, retardation factors in relation to the Newmark plume area were estimated for TCE and PCE in the groundwater system. The estimated retardation factors for TCE and PCE were 1.91 and 2.75, respectively. The average groundwater velocity divided by the TCE and PCE retardation factors yielded average TCE and PCE velocities in the groundwater of 186.3 and 129.4 ft/yr, respectively. Section 13.2 of Appendix M elaborates on the calculations for the retardation factors and velocities of TCE and PCE in the groundwater.

Since PCE travels at a slower velocity than TCE, the retarded velocity for PCE was used for estimating the remediation times under worst-case conditions. The average groundwater velocity was used for estimating the remediation times under best-case conditions. The remediation times equalled the centerline distance for a designated area of the Newmark plume divided by the velocity of either the groundwater or the PCE in the groundwater. The following subsections summarize the estimated remediation times for extraction scenario nos. 6 through 8.

<u>Extraction Scenario No. 6</u>

Extraction scenario no. 6 consisted of three extraction areas located at the downgradient edge of the Newmark plume and five extraction areas located in the Newmark Wellfield, four of which were the existing Newmark Wellfield wells (extraction area nos. 1 through 4 in Figures 13-4 and 13-5). Extraction scenario no. 6 was simulated for 35 years. Pathlines were created for 68 imaginary particles. Sixty-eight imaginary particles were placed along the outer perimeter of the Newmark plume, from upgradient of the Newmark well area to the downgradient edge of the Newmark plume. Table 17 of Appendix M gives the locations of the imaginary particles.

The extraction areas for the Newmark Wellfield successively captured the imaginary particles placed upgradient of the Newmark Wellfield. Also, some imaginary particles placed downgradient of the Newmark Wellfield were captured by the extraction areas. The pumping rate for the added extraction area was 800 gpm throughout the entire 35-year simulation. Normal pumping rates for the time period between January 1986 through December 1990 were used for the Newmark Wellfield wells and are repeated in 5-year intervals throughout the entire 35-year simulation.

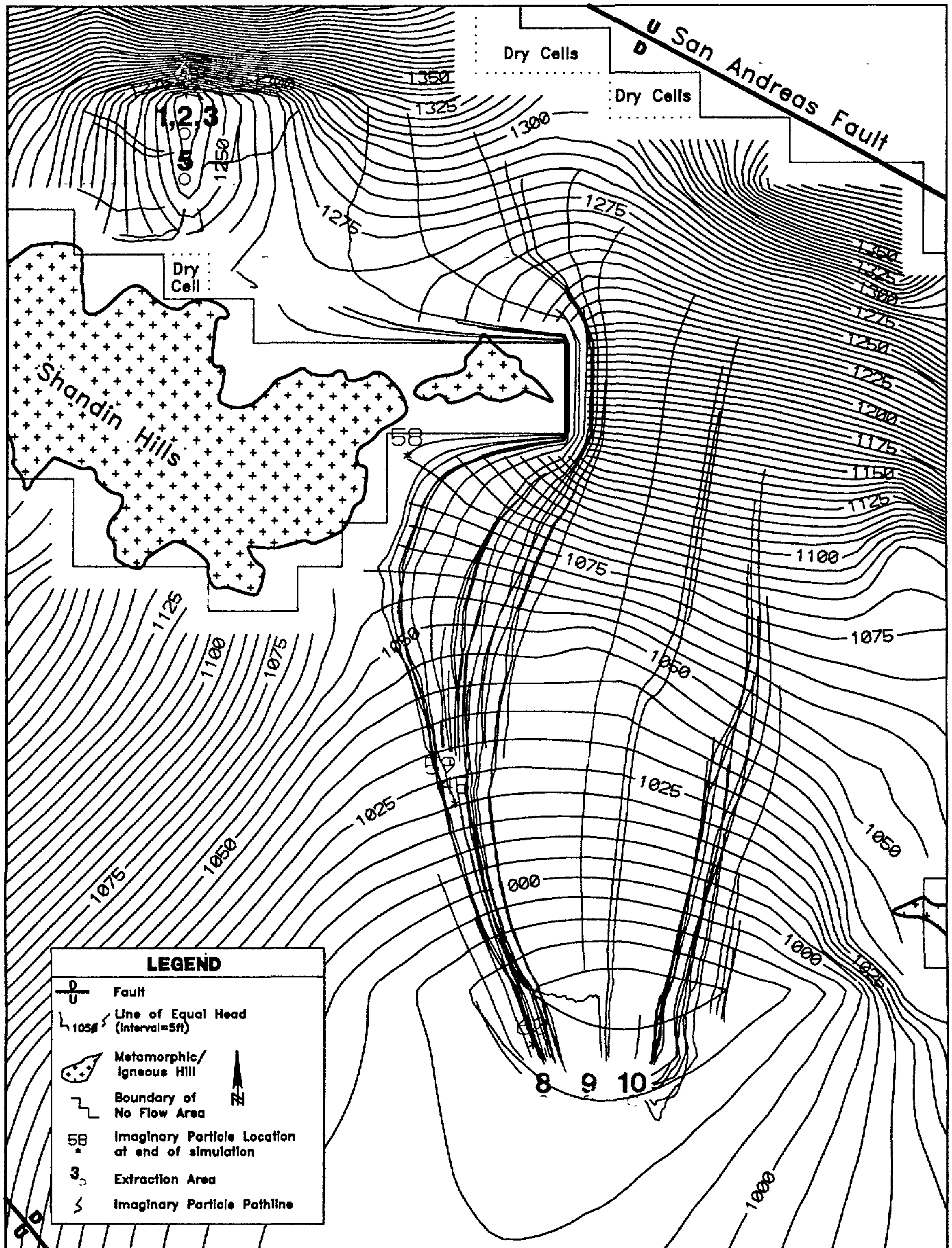

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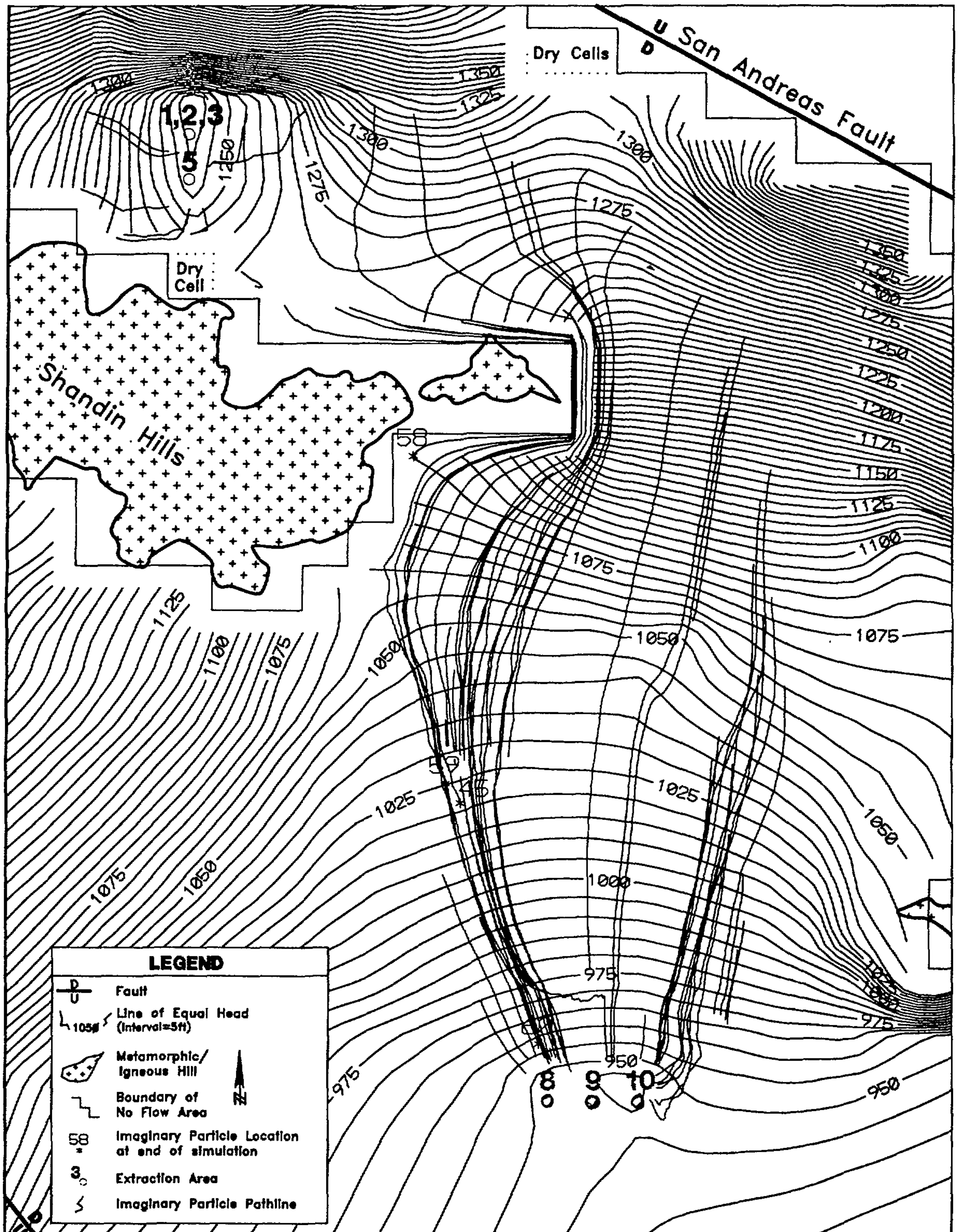
FIGURE 13-4
HEAD CONTOUR AND PATHLINE PLOT OF EXTRACTION SCENARIO NO. 6, LAYER 1 (UPPER AQUIFER)

SCALE IN FEET



URS CONSULTANTS	2710 GATEWAY OAKS DR. SUITE 250 NORTH SACRAMENTO, CA 95834 (916) 929-2346	NEWMARK GROUNDWATER SUPERFUND SITE, NEWMARK OPERABLE UNIT RI/FS REPORT	**FIGURE 13-6** HEAD CONTOUR AND PATHLINE PLOT OF EXTRACTION SCENARIO NO. 6, LAYER 2 (LOWER AQUIFER)	0' 1000' 2000' SCALE IN FEET

The three extraction areas, located at the downgradient edge of the Newmark plume, successively captured all imaginary particles that reached the downgradient edge of the Newmark plume. Four of the imaginary particles, that remained upgradient of the downgradient edge of the Newmark plume, were migrating downgradient within the capture zone of the downgradient extraction areas. The total pumping rate for the three downgradient extraction areas equaled 7,000 gpm throughout the entire 35-year simulation. Figures 13-4 and 13-5 display the head contour plots for layers 1 and 2, respectively. These figures also display the extraction areas and the imaginary particles with their pathlines.

Remediation times were estimated for the Newmark plume area extending from the Newmark Wellfield to the downgradient edge of the Newmark plume. Remediation times were estimated under best-case conditions and worst-case conditions. Best-case conditions are described as TCE and PCE traveling at the same velocity of the groundwater and worst-case conditions are described as TCE and PCE traveling at a retarded velocity. Table 13-1 summarizes the estimated remediation times for best-case and worst-case conditions and the number, street locations and pumping rates of the extraction areas for extraction scenario no. 6.

<u>Extraction Scenario No. 7</u>

Extraction scenario no. 7 consisted of three extraction areas located at the downgradient edge of the Newmark plume, five extraction areas located in the Newmark Wellfield (four of which were the existing Newmark Wellfield wells), and two extraction areas located adjacent to the northeast edge of Shandin Hills (middle area of Newmark plume). Extraction scenario no. 7 was simulated for 35 years. Pathlines were created for 68 imaginary particles. Sixty-eight imaginary particles were placed along the outer perimeter of the Newmark plume, from upgradient of the Newmark Wellfield to the downgradient edge of the Newmark plume. Table 20 of Appendix M gives the locations of the imaginary particles.

Extraction areas placed at the three regions of the Newmark plume successively captured all imaginary particles placed along the outside perimeter of the Newmark plume. The extraction areas for the Newmark Wellfield captured the imaginary particles placed upgradient and some of the imaginary particles placed downgradient of the Newmark Wellfield. The pumping rate for the added extraction

Table 13-1

Summary of Extraction Scenario No. 6

Extraction Area	Approximate Location	Pumping Rate (gpm)	Remediation Time (yrs)	
			Best-case[a]	Worst-case[b]
Downgradient Edge of Newmark Plume				
8	on Arrowhead Ave.; 150' S/of 14th St.	2,000		
9	200' E/of Mt. View Ave.; 300' N/of Wabash St.	2,000		
10	250' E/of Sierra Way; on 14th St.	3,000		
Newmark wellfield of Newmark Plume				
Newmark 1[c]	NE corner of A St. & Western Ave.	0 to 2,910[d]	Remediation from Newmark wellfield to edge of Newmark plume	
Newmark 2[c]	175' S/of Reservoir Dr.; 40' W/of Magnolia Dr.			
Newmark 3[c]	95' N/of 42nd St.; 280' E/of Western Ave.			
Newmark 4[c]	65' S/of Reservoir Dr.; 50' E/of Western Ave.	0 to 1,585[e]		
5	450' W/of 4th St.; 500' S/of 42nd St.	800	60.8	167.3

[a] Remediation time is calculated using the average velocity of the groundwater.
[b] Remediation time is calculated using the average velocity of PCE in the groundwater.
[c] Existing water-supply well.
[d] Total pumping rate range for Newmark 1,2 & 3 for 1986 through 1990 was used in the 5-year simulation.
[e] Pumping rate range for Newmark 4 for 1986 through 1990 was used in the 5-year simulation.

area was 800 gpm throughout the entire 35-year simulation. Normal pumping rates for the time period between January 1986 through December 1990 were used for the Newmark Wellfield wells and repeated in 5-year intervals throughout the entire 35-year simulation. The two extraction areas adjacent to the northeast edge of Shandin Hills captured the upgradient imaginary particles that were not captured by the extraction areas at the Newmark Wellfield. The total pumping rate for the two middle extraction areas equaled 4,000 gpm throughout the entire 35-year simulation.

The three extraction areas, located at the downgradient edge of the Newmark plume, successfully captured all imaginary particles that reached the downgradient edge of the Newmark plume. The total pumping rate for the three downgradient extraction areas equaled 7,000 gpm throughout the entire 35-year simulation. Figures 13-6 and 13-7 display the head contour plots for layers 1 and 2, respectively. These figures also display the extraction areas and the imaginary particles with their pathlines.

Best-case and worst-case remediation times were estimated for the Newmark plume area extending from the Newmark Wellfield to the middle area of the Newmark plume. Also, best-case and worst-case remediation times were estimated for the Newmark plume area extending from the middle area to the downgradient edge of the Newmark plume. Table 13-2 summarizes the estimated remediation times for best-case and worst-case conditions and the number, street locations and pumping rates for the extraction areas for extraction scenario no. 7.

Extraction Scenario No. 8

Extraction scenario no. 8 consisted of three extraction areas located along the centerline of the lower end of the Newmark plume and five extraction areas located in the Newmark Wellfield, four of which were the existing Newmark Wellfield wells. Extraction scenario no. 8 was simulated for 35 years. Pathlines were created for 68 imaginary particles. Sixty-eight imaginary particles were placed along the outer perimeter of the Newmark plume, from upgradient of the Newmark Wellfield well area to the downgradient edge of the Newmark plume. Table 23 of Appendix M gives the locations of the imaginary particles.

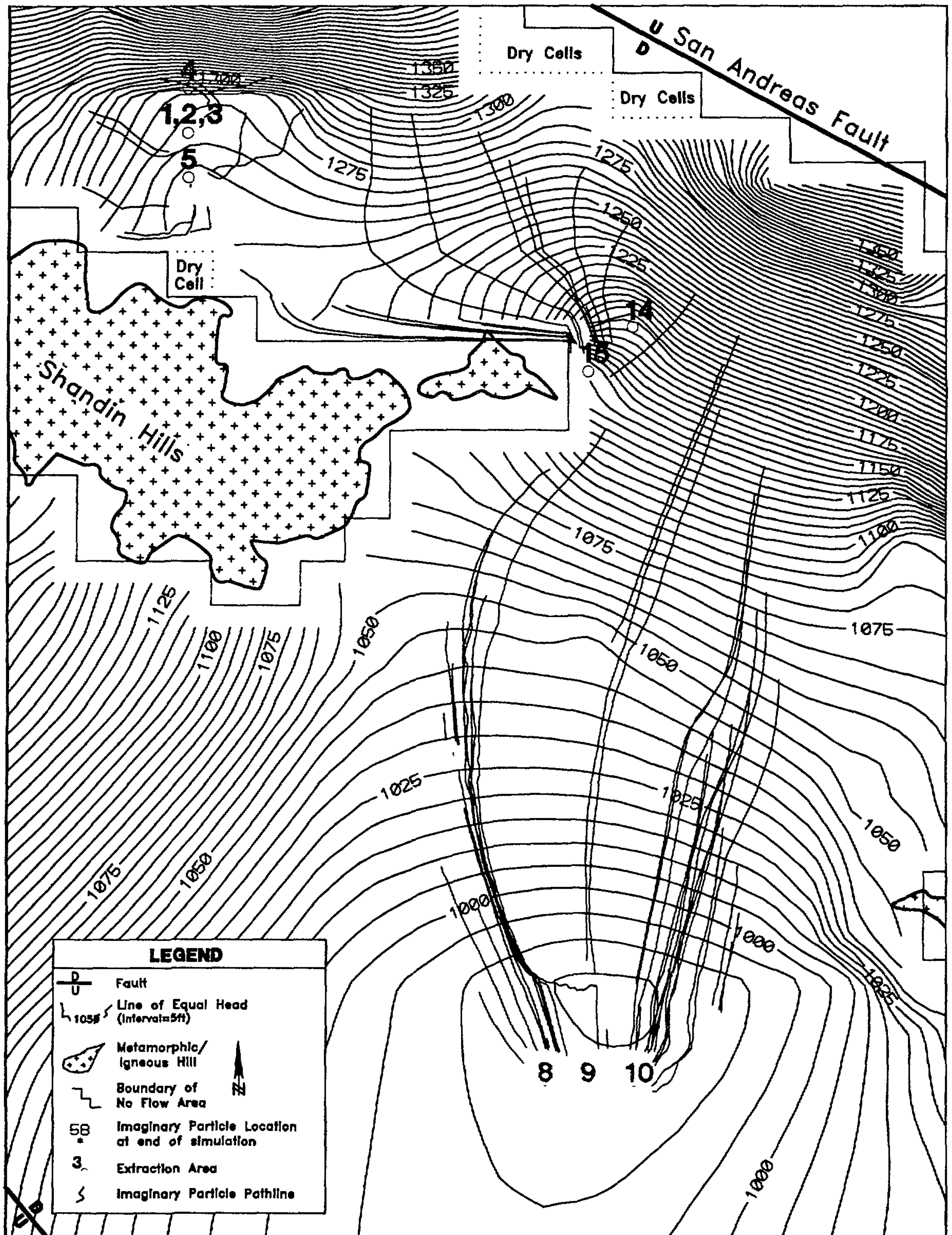


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FIGURE 13-6
HEAD CONTOUR AND PATHLINE PLOT OF EXTRACTION SCENARIO NO. 7, LAYER 1 (UPPER AQUIFER)

SCALE IN FEET

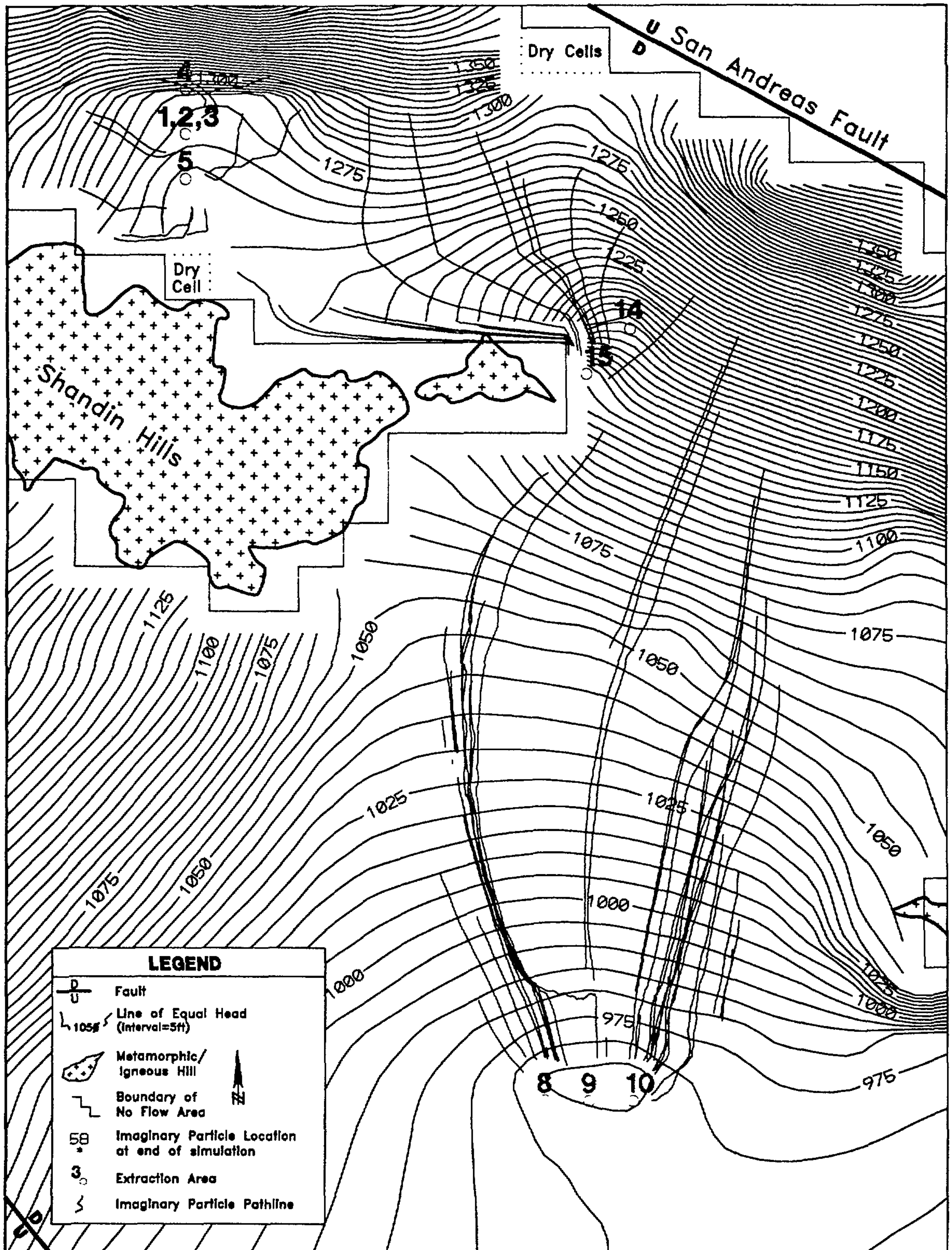

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FIGURE 13-7
HEAD CONTOUR AND PATHLINE PLOT OF EXTRACTION SCENARIO NO. 7, LAYER 2 (LOWER AQUIFER)

SCALE IN FEET

Table 13-2

Summary of Extraction Scenario No. 7

Extraction Area	Approximate Location	Pumping Rate (gpm)	Remediation Time (yrs)	
			Best-case[a]	Worst-case[b]
Downgradient Edge of Newmark Plume				
8	on Arrowhead Ave.; 150' S/of 14th St.	2,000		
9	200' E/of Mt. View Ave.; 300' N/of Wabash St.	2,000		
10	250' E/of Sierra Way; on 14th St.	3,000		
Newmark Wellfield of Newmark Plume				
Newmark 1[c]	NE corner of A St. & Western Ave.	0 to 2,910[d]	Remediation from Newmark wellfield to middle of Newmark plume	
Newmark 2[c]	175' S/of Reservoir Dr.; 40' W/of Magnolia Dr.			
Newmark 3[c]	95' N/of 42nd St.; 280' E/of Western Ave.			
Newmark 4[c]	65' S/of Reservoir Dr.; 50' E/of Western Ave.	0 to 1,585[e]		
5	450' W/of 4th St.; 500' S/of 42nd St.		23.3	64.1
Middle Area of Newmark Plume				
14	150' E/of Sierra Way; 200' N/of Ralston Ave.	2,000	Remediation from middle to edge of Newmark plume	
15	100' E/of Mt. View Ave.; 200' S/of 39th St.	2,000	37.5	103.2

a Remediation time is calculated using the average velocity of the groundwater.
b Remediation time is calculated using the average velocity of PCE in the groundwater.
c Existing water-supply well.
d Total pumping rate range for Newmark 1,2 & 3 for 1986 through 1990 was used in the 35-year simulation.
e Pumping rate range for Newmark 4 for 1986 through 1990 was used in the 35-year simulation.

The extraction areas for the Newmark Wellfield successively captured the imaginary particles placed upgradient and some of the imaginary particles placed downgradient of the Newmark Wellfield. The pumping rate for the added extraction area was 800 gpm throughout the entire 35-year simulation. Normal pumping rates for the time period between January 1986 through December 1990 were used for the Newmark Wellfield wells and repeated in 5-year intervals throughout the entire 35-year simulation.

The three extraction areas, located along the centerline, captured the upgradient imaginary particles that migrated and reached the centerline extraction areas. One of the imaginary particles, which had originated north of Shandin Hills, migrated around the east edge of Shandin Hills and stopped next to Shandin Hills. This imaginary particle was not captured by existing municipal wells. Several imaginary particles upgradient of the centerline extraction areas were captured by existing municipal wells.

Seven of the imaginary particles, placed on the southeastern downgradient edge of the Newmark plume and downgradient of the centerline extraction areas, were not pulled toward and captured by the centerline extraction areas. These seven imaginary particles migrated toward the south/southeast. One of these seven imaginary particles migrated southeast and out of the model area. The other six imaginary particles were captured by existing municipal wells: 17th Street well, 16th Street well, 7th Street well and Gilbert Street well. Figures 13-8 and 13-9 display the head contour plots for layers 1 and 2, respectively. These figures also display the extraction areas and the imaginary particles with their pathlines.

Best-case and worst-case remediation times were estimated for the Newmark plume area extending from the Newmark Wellfield to the downgradient edge of the Newmark plume. Table 13-3 summarizes the estimated remediation times for best-case and worst-case conditions and the number, street locations and pumping rates of the extraction areas for extraction area no. 8.