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ANALYSIS OF REMEDIATION ALTERNATIVES
SOIL AND GROUNDWATER CONTAMINATION
187 NORTH L STREET
Livermore, California

for: City of Livermore
Redevelopment Agency
1052 South Livermore Avenue
Livermore, CA 94550

Prepared by:

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December 22, 1989
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City of Livermore
Redevelopment Agency
1052 South Livermore Avenue
Livermore, CA 94550

Attention: Ms. Karen Majors
Redevelopment Coordinator

Subject: Analysis of Remediation Alternatives
Soil and Groundwater Contamination
at 187 North L Street
Livermore, California

Ladies and Gentlemen:

We are pleased to present the following analysis of remediation alternatives for the subject site. Petroleum contamination has been detected in soil and groundwater at the site. Since this is part of a planned redevelopment project to include a theater, bank, retail shops and parking, an evaluation of remediation alternatives is needed prior to acquiring this site.

We would be pleased to meet with Redevelopment Agency or City Staff to discuss our findings. Please call if you have any questions.

Sincerely,

WOODWARD-CLYDE CONSULTANTS

Albert P. Ridley, C.E.G.
Senior Consultant

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Enclosure

The assumed cleanup concentrations in Table 1 form the basis for evaluation of the remediation alternatives. They are based upon California Department of Health Services (DHS) Action Levels for groundwater and DHS guidelines for acceptable residual soil contamination.

Soil Excavation

Excavation of contaminated soil is limited by the size of the available site, the distance to adjacent structures, and the depth of contamination and depth to groundwater. Excavation using a backhoe may be feasible to depths of 20 to 25 feet depending upon the stability of the soil. Deeper excavations may be feasible using more space and using earth moving equipment such as a front end loader or dozer. The side slopes of the excavation will either need to be sloped at no steeper than about 1 to 1 (horizontal to vertical) or be supported by retaining structures, such as shoring or sheet piles.

At the site the soil contamination extends to a depth of 43 feet, where the groundwater table is encountered. Since the location of the contamination is close to L Street, it would be necessary to use shoring or sheet piles to support the slope adjacent to L Street to excavate to a depth of 43 feet. It is assumed that excavation will not be required below the water table, and that the regulatory requirement will be to remove soil with TPH greater than 100 ppm. The 100 ppm criteria would likely not apply in the deeper zone of average soil contamination nearer to the groundwater table where a 10 ppm or lower concentration might be required. The small size of the site limits the size of an excavation. The advantage of this method is that it is relatively quick and effective and has little environmental impact. While the waste site is permitted to accept such waste there would be some potential for petroleum vapors to impact the air during excavation and transport to the waste site.

(ones from LUFT guidelines)

Excavation and On-Site Bioremediation

Petroleum hydrocarbons in soil can be treated by bioremediation using naturally occurring soil microorganisms. This can be done on the surface by spreading the excavated contaminated soil over a large area to a depth of one or two feet and maintaining optimal conditions for the organisms by discing or rototilling, supplying fertilizers and irrigating the soil. Heap treatment (composting) can also be used where air is drawn through the soil piles using a series of slotted pipes and a vacuum pump. Commercially available organisms are available but there is little evidence to date to support the benefit of applying commercially produced organisms versus enhancing the naturally existing microorganisms. Both of these methods have been used in the San Francisco Bay Area with regulatory approval and with success.

At this site, if the extent of soil contamination is entirely within the site boundaries it may be feasible to excavate the contaminated soil and use some portion of the other property on the redevelopment block for bioremediation treatment. The same concerns exist with this alternative as with the excavation and off-site disposal alternative relative to the need to shore the sides of the excavation adjacent to L Street and the Railroad Right of Way. It is assumed that the volume of contaminated soil will be located within about a 50 foot diameter circle encompassing Well W-1 and will extend to a depth of 43 feet. The indicated volume would be about 3000 cubic yards of contaminated soil. Considering that the sides of the excavation will need to be sloped at least 45 degrees an additional volume of soil will need to be excavated to reach bottom of the contaminated soil mass. The side slope excavation could be about 15,000 cubic yards. An area about 200 feet by 200 feet would be needed to treat this volume of contaminated soil if it is spread in a 2 foot thick layer. A smaller area would be needed if a heap treatment (composite) method is used.

During excavation there is a potential for odors and organic vapors being released to the air over the site. In addition, if the soil is spread in a thin layer and is repeatedly disced there will likely be releases of vapors to the air over the treatment site. While the soil is being worked. The heap treatment method offers an opportunity to further control the release of vapors, since the pile does not have to be repeatedly disced. The pile will be covered with plastic and the vapors will be drawn through a vacuum system. The vacuum system can be equipped to remove organic vapors using an activated carbon filter system. The treated soil can be taken to a Class III waste site if the TPH concentrations are reduced to less than 100 ppm. This method has proven successful in reducing TPH levels from 1200 ppm to less than 100 ppm at a location in the San Francisco Bay Area. The treatment time is expected to range from two to six months.

Soil Vapor Extraction

Petroleum contamination in soil above the saturated zone can be treated to remove the volatile hydrocarbons by extraction of soil gas (the gas in the soil pores) using a vapor extraction system (VES). The extraction system consists of one or more small diameter extraction wells drilled into the vadose zone (the unsaturated zone of soil) above the groundwater table. A vacuum pump is used to draw soil gas from the extraction well(s). The removed vapors are either released into the air, if permitted, or are pumped through carbon canisters to remove the petroleum vapors prior to discharge to the atmosphere.

Prior to installation, a test should be conducted to evaluate the amount of petroleum vapors that can be removed during a specific time period for design of the system. This test at the subject site would involve installation of two 2-inch diameter wells extending to the top of the groundwater table. One well would be drilled near the center of the soil contamination area (near well W-1) and would be attached to a portable vacuum pump. A second well would be installed near the north property line to detect soil vapor pressure changes during the test. The test would be run for about 24 hours. Each of the existing groundwater monitoring wells would be used to detect pressure changes in the soil to evaluate the lateral distance affected by the vacuum applied to the extraction well. Based upon this test a production extraction system could be designed and installed on the site. It would most likely require about two parking spaces of area for the vacuum pump and carbon canisters. The carbon canisters could be two 55 gallon drum units for a small system, or two 1000 pound carbon canisters for a larger system. When the sorption capacity had been reached the spent carbon would be returned to the supplier for regeneration. The regeneration process is at a permitted facility and involves removal and incineration of the sorbed vapors. Since the regeneration facility is actively regenerating carbon from other sites, the increased impact of the waste from the VES at this site would not be considered significant. It is anticipated that the vapor extraction system would operate for at least one year prior to performing a verification drilling program.

GROUNDWATER REMEDIATION

In-Situ Bioremediation Closed Loop Approach

In-situ bioremediation closed loop approach would involve treatment of both soil and groundwater using bioremediation techniques. The system would consist of one or more groundwater extraction wells and a grid of injection wells. The extracted water would be pumped to an above-ground tank where oxygen, nutrients, and heat would be added to the water. This mixture would be metered into the injection wells to increase and maintain the in-situ bacteria and microorganism population necessary to remediate the soil and groundwater in the subsurface. This method may require substantial initial documentation (a pilot study) before regulatory agency approval in the San Francisco Bay Area, however it has been permitted and used successfully in Southern California and at a Montana Superfund Site. The relative costs are generally less than VES and groundwater extraction and treatment using carbon filters. At least one year might be needed to complete the remediation of the soil and groundwater. Depending upon the effectiveness a second year might be needed to reach the desired cleanup levels. The pumps and above ground tanks would occupy space equivalent to about 2 parking spaces.

Groundwater Extraction and Treatment

Groundwater extraction and treatment is a proven technology that has been used for many years for treatment of petroleum contaminated groundwater. This involves installation of one or more wells in the contaminated aquifer, to be used for pumping and extraction of groundwater to be treated on the surface in a treatment plant.

For the subject site it is assumed that a minimum of two extraction wells would need to be installed. One well would be installed near the center of the groundwater contamination, while a second well would be installed downgradient within the contaminant plume to provide additional lateral coverage. The wells would have 4 inch or greater diameter casing and would be screened several feet above the groundwater level to provide an opportunity to extract floating product. The water would be pumped first through an oil-water separator drum and then through granulated activated carbon filters to be released to the sanitary sewer. The carbon would be replaced as needed to achieve the allowable concentrations in the discharged water.

The cost of operations would depend upon the amount of petroleum product in the groundwater. Typical systems for this type of application can be brought in as a prefabricated unit on a trailer. The system would occupy about 3 parking spaces. As the contaminant concentrations in the groundwater decrease, the operations costs will decrease.

RELATIVE FEASIBILITY

Soil Remediation

1- Excavation and Hauling to a Class I or II Waste Site. If the soil contamination is assumed to extend to a depth of 43 feet and in a 50 foot circle around well W-1, there will be insufficient distance to provide a 45 degree excavation slope to L Street and to the Railroad Right of Way during soil excavation (50 feet from W-1 to L Street and 60 feet from W-1 to the rail line). Therefore construction of some form of retaining walls will be needed. The usual method of supporting temporary excavations is sheet piles, or driven steel H piles with wood lagging in between the piles. These walls will need to support the full 43 foot high excavation for the time the excavation is open. A ramp would probably be excavated westward towards the open part of the redevelopment property on the west side of 187 North L Street to provide access for excavation equipment, such as a dozer with a loader bucket, or a rubber tired front end loader. The soil would be loaded onto trucks and hauled to a Class I or II waste site for disposal depending upon TPH concentration. Clean excavated or import soil would be placed and properly compacted in the excavation to refill it to original grade.

The relatively positive factors of this method of soil remediation are: 1) it is a physical removal of the contamination that can be visually and analytically documented, 2) is will require less time than other methods, and 3) is would provide 43 feet of clean soil which would provide few restrictions for construction.

The relatively negative factors of this method of soil remediation are: 1) soil excavation is limited by the property boundaries at L Street and the Railroad Right of Way, and if soil contamination extends under the street or rail line, then excavation will need to be extended necessitating the removal and later replacement of the street or the rail line. 2) the relative cost is higher than other methods, and 3) the excavation will be highly visible, will impact the schedule of construction on other portions of the site, and may release volatiles to the air.

2- Excavation And On-Site Bioremediation. The soil excavation methods would be the same as described above, but the excavated soil with petroleum contamination would be treated on site prior to removal to a Class I Waste site. The soil could be treated either in a 2 foot layer, or in large piles. The thin layer method would involve adding nutrients and water and then discing the soil periodically. The soil would be covered with plastic This method might require several months to reach the 100 ppm cleanup level for petroleum hydrocarbons. The soil could then be removed to a Class III Waste site as non-hazardous soil. The heap method would involve placing perforated pipes in the soil as the soil is placed in the pile. Nutrients (fertilizer) and water would be added to the soil and then a layer of plastic would be placed over the soil pile to control heat loss and protect the soil from wind and erosion. A vacuum pump would draw air through the pipes and thus increase oxygen availability in the pile and promoting the microbial activity. The bioremediation of the soil might require several months to reach the 100 ppm cleanup level for petroleum hydrocarbons. The soil would then be removed to a Class III waste site following verification testing.

The positive factors of this bioremediation approach are: 1) bioremediation will reduce the petroleum hydrocarbon content to below the concentration that is considered a hazardous waste (100 ppm), therefore no hazardous waste will be removed from the site, 2) the method can be physically and analytically documented, and 3) the relative costs will be less than for off-site disposal of the contaminated soil because the soil can be hauled to a Class III waste site as non-hazardous soil.

The negative factors of this method are: 1) a large portion of the block will be needed for treating the soil for a number of months which will interfere with the site development, 2) the spreading and discing operation could result in possible petroleum odor releases to the air when the soil is uncovered, 3) stockpiled soil in the heap method would be visible from many off-site locations, and if the heap (compost) method is used unless a carbon filter is used, on the vacuum system, odors and gases would be released to the air, 4) achievement of target cleanup concentrations in a reasonable time is likely, but cannot be assured.

3-Soil Vapor Extraction. Extraction of soil vapors involves use of existing wells and installation of one or more vapor extraction wells. A field test would be performed to evaluate the effectiveness of the method for the site. The results would be used to design the system, which includes locating the extraction well(s) selecting the size of piping and pumps and associated equipment. To reduce emissions to the air the extracted vapors would be pumped through a granular activated carbon filter before release to the air. The extraction wells would consist of 2-inch diameter PVC well casing with at least a 20 foot long perforated section surrounded by pea gravel. The production pump and filter could be located at some distance from the well with piping buried under the surface for minimum site disturbance. Granular activated carbon would be returned to the supplier for regeneration. It is difficult to estimate the length of time needed to complete the soil remediation until the field tests are completed and additional soil contamination data is available to estimate the amount of petroleum products in the soil. Several years of system operation should be anticipated.

The positive factors for this method of soil remediation are: 1) there will be minimal disruption of existing surface uses of the site, 2) since a large area will not be needed for excavation and treatment there will be little impact on the planned construction schedule or planned locations of structures, 3) the relative cost will likely be less than excavation methods for treating the same volume of soil, 4) gas extraction may promote in-situ biological degradation of the soil contaminants by providing soil microorganisms with oxygen while removing carbon dioxide and 5) emissions to the air can be mitigated by the use of granular activated carbon filters.

ANALYSIS OF REMEDIATION ALTERNATIVES
SOIL AND GROUNDWATER CONTAMINATION
187 NORTH L STREET
LIVERMORE, CALIFORNIA

INTRODUCTION

Exploration at the subject site has detected petroleum contamination in both soil and groundwater. The site, at 187 North L Street, is about 200 feet long and 100 feet wide and is located on the west side of L Street and the south side of the Western Pacific Railroad right of way. Since this site is proposed to be included as part of the redevelopment of the entire Railroad Avenue block, west of L Street to N Street, and north of Railroad Avenue, for a theatre, bank, and retail shops, the Redevelopment Agency needs an analysis of remediation alternatives prior to making decisions about acquiring the site. The planned development of the block is shown on the attached site plan, by Jerry Loving, Architect, dated August 3, 1989 (Figure 1). This study is also intended to provide technical data to assess whether or not a Mitigated Negative Declaration is appropriate for this site.

SCOPE OF WORK

Available soil and groundwater contamination data were reviewed to estimate the type and possible magnitude of site contamination. The existing information included two reports prepared by WCC describing the results of soil exploration and groundwater exploration at the site. These reports were dated April 7, 1989 and July 10, 1989 (WCC 1989A and WCC 1989B). The planned use of this site as paved parking for retail stores was also considered (Figure 1). Using this data, and assumptions about the possible extent of contamination, potential remediation alternatives have been identified and analysed for their relative feasibility and environmental impact.

SITE CONTAMINATION

The soil samples from Well W-1, in the vicinity of four former underground fuel storage tanks, contained total petroleum hydrocarbons (TPH as gasoline) ranging from 1,200 parts per million (ppm) at 15 feet to 16,000 ppm at 40 feet below the surface. Up to 1,500 ppm TPH (as diesel) was detected in soil from Well W-1 at a depth of 40 feet. Exploratory borings drilled to depths of 25 feet at the location of three former underground tanks (Figure 1) yield soil samples with detectable TPH as gasoline up to 220 ppm at 25 feet (B-1). Soil from boring B-5 near an existing underground fuel storage tank contained detectable TPH as gasoline at only 1.9 ppm. The soil contamination, therefore appears to be concentrated in the immediate vicinity of the former tanks near W-1. It is likely that the petroleum contaminated soil extends downward in a zone under the former tank and then spreads laterally in the soil horizon above the groundwater level at a depth of about 43 feet. No significant petroleum contamination was detected in soil from two wells (W-2, and W-3) located about 150 feet west of W-1. About 1.2 ppm TPH as gasoline was detected at 5 feet in W-2, and 12 ppm TPH was detected at 50 feet in W-3, with no detection at other depths in those wells.

The greatest petroleum contamination in groundwater was found in well W-1, where 300,000 parts per billion (ppb) TPH as diesel, 210,000 ppb TPH as gasoline, 29,000 ppb benzene, 30,000 ppb toluene, 5,400 ppb ethyl benzene, and 24,000 ppb xylenes are detected. The concentrations of these contaminants decrease significantly in the downgradient direction at W-3, with detection of 2,200 ppb TPH as diesel, 11,000 ppb TPH as gasoline, 290 PPB benzene, 120 ppb toluene, 150 PPB ethyl benzene, and 140 ppb xylenes.

In well W-2 no diesel was detected, and 360 ppb TPH as gasoline was detected, with 6.7 ppb benzene, 2.1 ppb toluene, 0.47 ppb ethyl benzene, and 1.3 ppb xylenes.

The depth of groundwater contamination is not known. It is assumed that the groundwater contaminated with petroleum products at this site is within a zone that is less than 100 feet in depth, since the petroleum would normally tend to float on the surface of the groundwater and have a limited depth of dissolved product as long as there is no significant downward flow of groundwater. Wells drilled to date have encountered a clay layer beneath the shallow contaminated groundwater bearing zone. This clay layer could retard downward migration of contaminants. Drilling through the clay layer might present a risk of release of contaminants to deeper zones. The lateral extent of the plume of shallow contaminated groundwater is assumed to be of limited extent in the downgradient direction (northwest) from the site. The lateral extent of groundwater contamination is assumed to extend about an additional 150 to 200 feet beyond the downgradient edge of the property in a northwest direction. Additional exploration will be needed to evaluate this assumption.

SOIL REMEDIATION ALTERNATIVES

Soil containing petroleum hydrocarbons can be remediated using techniques that have proven effective and have been used successfully at other sites in the San Francisco Bay Area. These methods include excavation and removal of the contaminated soil to an approved waste site, excavation and on-site bioremediation using natural soil bacteria and removal to a waste disposal site, in-situ bioremediation , or in-situ vapor extraction. Each of these methods have limitations as to their feasibility for certain site conditions. Their relative costs, and environmental impact may also vary. Each of these methods will be discussed below in an effort to provide a basis for selection of the alternative that achieves the goal of cost effective remediation of the contaminated soil with the least environmental impact.

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The negative factors for this method of soil remediation are: 1) the vapor extraction system will need to operate for a relatively long time as compared to the excavation method, 2) there is some uncertainty as to how long the system will need to operate and how much activated carbon will need to be removed and regenerated at the supply facility, 3) the operating cost may continue over a number of years after the site is developed, 4) timely achievement of low residual concentrations may be difficult for diesel contaminated soil.

Groundwater Remediation

1-Groundwater Extraction and Carbon Filter Treatment. Contaminated groundwater could be extracted using extraction well(s), treated using a granular activated carbon filter system. After the treatment it could be discharged to the sanitary sewer. At least one extraction well would need to be constructed with a screened section extending into the contaminated groundwater zone. The well casing would be at least 4 inches in diameter and would have a submersible pump installed which would pump water to the treatment plant. The treatment facility would have at least two granular activated carbon filters in series, and a holding tank to allow monitoring water prior to discharge to the sanitary sewer. Prior to installation of the system, aquifer tests (slug tests or pump tests) would need to be conducted to test the conductivity of the groundwater bearing zone. The results of pumping or slug tests in the existing wells on site would be used to select the number and location of wells, size of pumps, and size of the treatment system. Groundwater discharge would be monitored during start up and on a regular schedule during remediation. The granular activated carbon filters would be emptied and refilled as they reach their capacity to remove petroleum from the water. The spent carbon would be returned to the supplier for regeneration. This groundwater pumping and treatment activity might continue for several years. It is anticipated that the granular activated carbon filters would need to be repacked at progressively longer intervals as remediation progresses. During this pumping process groundwater would be sampled from a select number of groundwater monitoring wells to monitor the effectiveness of the remediation.

The positive factors for this method of groundwater remediation are: 1) it provides a means to draw contaminated groundwater from both under the site and off site without impacting the surface activities, 2) groundwater contaminants are not released to the air, but are removed from the site and are destroyed by incineration, 3) it is compatible with the continued use of the site for present activities, or for the planned development of the site.

The negative factors for this method of groundwater remediation are: 1) a relatively long time period (years) will be needed to reach the cleanup levels for groundwater, 2) the pump and filter system will occupy the equivalent of 2 to 4 parking spaces which will impact the site development, 3) there are some uncertainties about the duration, operational cost, and ultimate effectiveness of the system.

2-Groundwater Extraction , Bioremediation, and Re-Injection. The groundwater extraction methods would be essentially the same as for 1-above. However, the groundwater would be held in a tank on the surface where nutrients, heat, and oxygen would be added to the water prior to reinjection into the groundwater treatment zone. Indigenous microorganisms presumed to be present in the groundwater will flourish as a result of nutrient and oxygen addition and some degree of petroleum reduction in the water in the holding tank will take place prior to re-injection. The injection wells would be constructed similar to the extraction wells, but would be connected at the surface by pipes to inject water directly to the by gravity ground or would be re-injected in a gravity system in a gravel filled trench. The extracted water would be sampled to evaluate the effectiveness of the remediation process. The duration of this method (2) would be expected to be shorter than Option 1, above.

The positive factors for this type of remediation are: 1) remediation is performed on site, and no hazardous wastes are removed from the site, 2) the time to remediate the groundwater is anticipated to be less than using granular activated carbon filters, 3) the remediation process will also assist in remediating soil contamination by introducing oxygen, nutrients and microorganisms to the contaminated soil layer; and also allowing activation of existing microorganisms in the soil.

The negative factors for this type of remediation are: 1) the start up and operations are more labor intensive than pumping and treating with carbon filters, 2) the startup costs probably are slightly higher than for carbon filter methods, 3) there may be difficulty in obtaining permission from the Regional Water Control Board to re-inject treated groundwater, and 4) the duration of treatment is difficult to assess.

POSSIBLE ENVIRONMENTAL IMPACTS

Soil Remediation

1-Excavation and Removal to Class I or II Waste Site. As in normal excavations there would be increased noise from excavating equipment, and there would be dust from the excavated soil. During excavation of the petroleum contaminated soil there is a potential for release of petroleum vapors to the air, both from the pit and from the stockpile of contaminated soil awaiting removal. The odors and vapors could move with the wind to off site locations. The vapors could also be released to the air during transport in trucks to the waste site. Excavation would create a hole that would be a visual impact for the site until backfilled.

2-Excavation and On-Site Treatment by Bioremediation. The same potential impacts exist for the excavation effort as in optional 1 above. The potential for vapors and odors to enter the air would be relatively high while the contaminated soil is spread and disced at the site. The heap treatment has a lower potential to impact the air with odors and vapors because covering the pile with plastic would reduce uncontrolled releases of vapors to the air, and the piles would not need to be re-worked. The potential release of odors and vapors from trucks during hauling to a Class III Waste Site would be minor since most vapors would have been degraded during the bioremediation on the site. The excavation and stockpiles of contaminated soil would provide a visual impact for the site during remediation activities.

3-Soil Vapor Extraction. If the extracted soil vapors are allowed to be discharge to the air untreated, there would be a direct impact on air quality and odors over the site and downwind of the site. If granular activated carbon filters are used but become saturated during operations, there is a potential for releases of vapors and odors to the air over the site. During construction of the wells and installation of the vapor extraction plant there may be some increased noise from construction equipment.

Groundwater Remediation

1-Groundwater Extraction and Carbon Filter Treatment. If carbon filters become saturated there is a potential for release of petroleum contaminants to the sanitary sewer. During installation of wells and installation of treatment equipment there may be some increased noise from construction equipment.

2-Groundwater Extraction, Bioremediation, and Re-Injection. There is some potential for release of petroleum vapors to the air from the surface holding tank used to introduce nutrients and oxygen to the extracted water. As above, there could be an increase in noise during installation of wells and treatment equipment.

MITIGATING MEASURES

Soil Remediation

1-Excavation and Removal to a Class I Waste Site. To limit noise the excavation equipment could be equipped with noise suppression mufflers. Excavation operations could be limited to normal daytime hours. It is anticipated that the noise of excavation would be no greater than for normal site grading for construction. Dust suppression measures (by watering the area during excavation) could be included to mitigate potential dust. The release of petroleum vapors from excavated contaminated soil could be mitigated by covering the soil with a vapor barrier of plastic sheeting. Plastic covering could also be used to cover loads of contaminated soil on trucks transporting soil to the waste site. Air monitoring could be performed on the upwind and downwind side of the excavation to test for emissions of petroleum vapors to the air. If vapor concentrations exceed allowable concentrations the sides and bottom of the excavation could be covered with a temporary plastic vapor barrier.

2-Excavation and On-Site Bioremediation. The mitigating measures outlined above in Option 1 could also be used for dust, noise, and vapor emissions control for this method. For heap treatment the pile could be covered with a plastic vapor barrier to reduce emissions of vapors, and the vacuum pump emissions could be discharged through a carbon filter system to control emissions of vapors. For the thin layer method soil could be covered with plastic between discing to reduce dust and vapor emissions.

3-Soil Vapor Extraction. The impacts of noise from drilling wells could be reduced by use of mufflers on equipment and drilling during daytime hours. The carbon filter system could be designed with the carbon filters in series so if the first carbon canister became saturated a second canister would treat the vapors that passed through the first canister. The design and operation of the extraction system would provide for sampling and testing of gases discharged from each carbon canister to evaluate breakthrough, and allow for timely replacement of carbon to prevent inadvertent release of vapors to the air.

Groundwater Remediation

1-Groundwater Extraction and Carbon Filter Treatment. The impacts of noise from drilling wells could be reduced by use of mufflers on equipment and drilling during daytime hours. As described above in Option 3 the granular activated carbon filter canisters could be constructed in series so that breakthrough of one canister could be detected and the next cannister would remove petroleum contaminants not removed by the previous canister. Carbon canisters could be replaced easily and quickly without affecting the operations. A program of sampling of discharged water and water at extraction points and intermediate points in the system would evaluate the systems effectiveness and prevent the potential discharge of petroleum contaminants to the sanitary sewer.

2-Groundwater Extraction, Bioremediation and Re-injection. The potential for release of vapors from the on site holding tank could be mitigated by covering the tank and controlling air into and out of the tank with valves. The potential for re-injecting water with chemical parameters that could impact the groundwater quality could be mitigated by careful selection and control of nutrients of such that they are not potentially damaging to the groundwater quality. Testing of water to be re-injected would also reduce the potential for re-injecting water that could impact groundwater quality.

RELATIVE COSTS

The estimated relative costs for each treatment option are presented in Table 2. These costs are intended for comparison only and are not based upon site specific data. Additional site exploration and testing will be needed to establish the extent of soil and groundwater contamination to better estimate the remediation costs.

Soil Remediation

1-Soil Excavation and Hauling to Class I or II Waste Site. If it is assumed that about 3,000 cubic yards of contaminated soil will need to be excavated and removed to a Class I or II waste site. The estimated costs are be about $1,475,000. This estimate assumes that the cost of hauling and disposal at a Class I or II waste site will be about $350 per cubic yard. The cost of placing imported clean soil will be about $15 per cubic yard, and the cost of excavating excess soil for side slopes and replacing it will also be about $15 per cubic yard. The cost of shoring(sheet piles or "H" piles and logging) will be at least $50,000, and WCC fees will be about $100,000.

2-Soil Excavation and On-Site Bioremediation. For excavating and treating about 3,000 cubic yards of contaminated soil the estimated costs are about $935,000. This cost assumes that shoring, and importing of clean fill and replacing excavated clean soil will be the same as in Option 1 above. The treatment costs will be about $120 per cubic yard, and disposal at a Class III waste site will be about $50 per cubic yard.

3-Soil Vapor Extraction. The soil vapor extraction option could cost about $360,000. This cost assumes that about 300 to 1,000 gallons of petroleum hydrocarbons are contained in the contaminated soil, and that they can be removed by vapor extraction methods. Several test wells will need to be installed as part of a feasibility test which would cost about $30,000, assuming two extraction wells. Designing and installing the vapor extraction system could cost about $80,000. Preparation of a Work Plan and testing of soil and vapors to document the effectiveness of the vapor extraction would cost about $100,000. The work plan would be prepared prior to installation of the vapor extraction system, and the documentation of effectiveness would be performed after one or more years of operation of the system. Operation for the first year could cost about $100,000, and the second year is expected to be about half of the first year costs ($50,000). These operations costs assume about 20,000 pounds of carbon will be used during the first year, and 10,000 pounds will be used during the first year, and 10,000 pounds will be used during the second year. The costs or the need for a third year or subsequent of operations cannot be estimated with existing data.

Groundwater Remediation

1-Groundwater Extraction and Carbon Filter Treatment. The relative costs to install two extraction wells and a carbon filter treatment system could be about $290,000. This cost assumes that $10,000 would be needed to install two 4-inch diameter extraction wells, and $30,000 would be needed to prepare a design report. The costs to install a treatment system would be about $100,000. Operation for one year could be about $100,000, and for a second year could be about $50,000. These operations costs assume the use of 16,000 pounds of carbon for the first year, and 8,000 pounds of carbon for the second year. The costs or the need for a third year of operation cannot be estimated with the existing data.

2-Groundwater Extraction and Bioremediation and Re-Injection. The relative costs to extract, bioremediate and re-inject groundwater could be about $295,000. That cost assumes that two extraction wells and eight injection wells will need to be installed at a cost of about $125,000. Design studies would be about $50,000. Construction, assembly, and installation of the bioremediation system will cost about $50,000. Operation costs are estimated to cost about $70,000 for the first year. This operating cost assumes about one day per week of maintenance for the first year. The costs for a second and subsequent years of operations cannot be estimated with the existing data.

SITE CHARACTERIZATION STUDIES

Prior to design or implementation of site remediation, site characterization studies are needed to satisfy the requirements of the Alameda County Department of Environmental Health. The extent of groundwater contamination should be explored to provide a basis for design of a groundwater remediation program. That program might include soil borings and groundwater monitoring wells as suggested below.

At least three groundwater monitoring wells might be installed downgradient and possibly off-site at depths of about 50 feet to explore the lateral extent of shallow contamination in the downgradient direction. A fourth monitoring well should be installed between W-1 and the existing 1,000 gallon underground gasoline storage tank.

To explore evidence of possible contamination from a reported spill at the existing underground gasoline storage tank a boring might be drilled through the tank backfill and extended to groundwater at about 50 feet. Soil samples would be collected from the backfill and from regular depths below the bottom of the tank and be tested in the laboratory for TPH as gasoline, and BTEX. The boring could be converted to a groundwater monitoring well to obtain samples of groundwater for laboratory testing for gasoline and diesel. Fuel fingerprint tests would be conducted to compare detected petroleum contaminants in soil and groundwater to fuel in the storage tank. An upgradient groundwater monitoring well would also be constructed off-site on the adjacent property, to the southeast of 187 North L Street, to provide upgradient groundwater quality data.

Based on the soil and groundwater laboratory analyses developed during this site characterization study for petroleum products in soil and groundwater, the lateral extent of shallow contamination would be better estimated. That information could form the basis for design of the soil and groundwater remediation program. The site characterization data would be summarized in a report which could be submitted to the regulatory agencies.

If the site characterization data is satisfactory to the regulatory agency(s) then in-situ testing could be performed for the design of a groundwater extraction system and for a vapor extraction system. Pump tests or slug tests would be performed to evaluate the aquifer characteristics for the design of groundwater extraction wells. In addition, a vapor extraction test could be performed to evaluate the effectiveness of the vapor extraction method. The vapor extraction system could then be designed.

CONCLUSIONS

The following conclusions consider the planned site development as paved parking for retail stores, as shown in Figure 1. Available soil and groundwater information from previous studies, and our experienced with remediation of similar sites forms the basis for our conclusions.

Soil Remediation

As shown in Table 2 the relative cost for soil remediation indicate that the vapor extraction alternative is the most cost effective. While the soil vapor extraction method may require a longer period of time than excavation and removal of contaminated soil, or on-site above-ground bioremediation of contaminated soil, it would provide less impact use by Arrow Rentals to the existing and planned site developments (Figure 1) for parking and retail stores. In our opinion, vapor extraction also will meet the requirements for a mitigated negative declaration for this planned development.

Groundwater Remediation

The two groundwater extraction and treatment alternatives (Table 2), one using granular activated carbon filters, and the second using on-site bioremediation have similar estimated costs. However, the carbon filter method will be more easily permitted since it is a proven technology and it does not include re-injection of water into the shallow aquifer. A considerable amount of documentation would be required by the regulatory agencies, in particular the Regional Water Quality Control Board, to permit re-injection of treated groundwater. However, since the intent of this approach is to create a closed loop, where injected water is ultimately extracted, agency concerns may be minumized. In our opinion, both alternatives for groundwater remediation meet the requirements for a negative declaration for this planned development (Figure 1).

REFERENCES

Jerry Loving, Architect & Associates, Inc., 1988, drawing entitled "Site Plan, Village Square", dated August 3, 1988, Exhibit A received 8-16-89, S.P.A. #188-89.

Woodward-Clyde Consultants, 1989A, Consultants report entitled "Phase II Site Exploration Railroad Avenue Property, Livermore, California", dated April 7, 1989, prepared for City of Livermore Redevelopment Agency.

Woodward-Clyde Consultants, 1989B, Consultants report entitled "Phase III Environmental Exploration, 187 North L Street, Livermore, California", dated July 10, 1989, prepared for City of Livermore Redevelopment Agency.

Table 1. ASSUMED CLEANUP CONCENTRATIONS

SOIL:

Total Petroleum Hydrocarbons	Less than 100 mg/kg (ppm) (3)

GROUNDWATER:

compound	cleanup concentration in µg/L (ppb)	
Benzene	1	(1)
Toluene	100	(2)
Ethylbenzene	680	(1)
Xylenes	1750	(1)

(1) 1989 DOHS Maximum Contaminant Levels

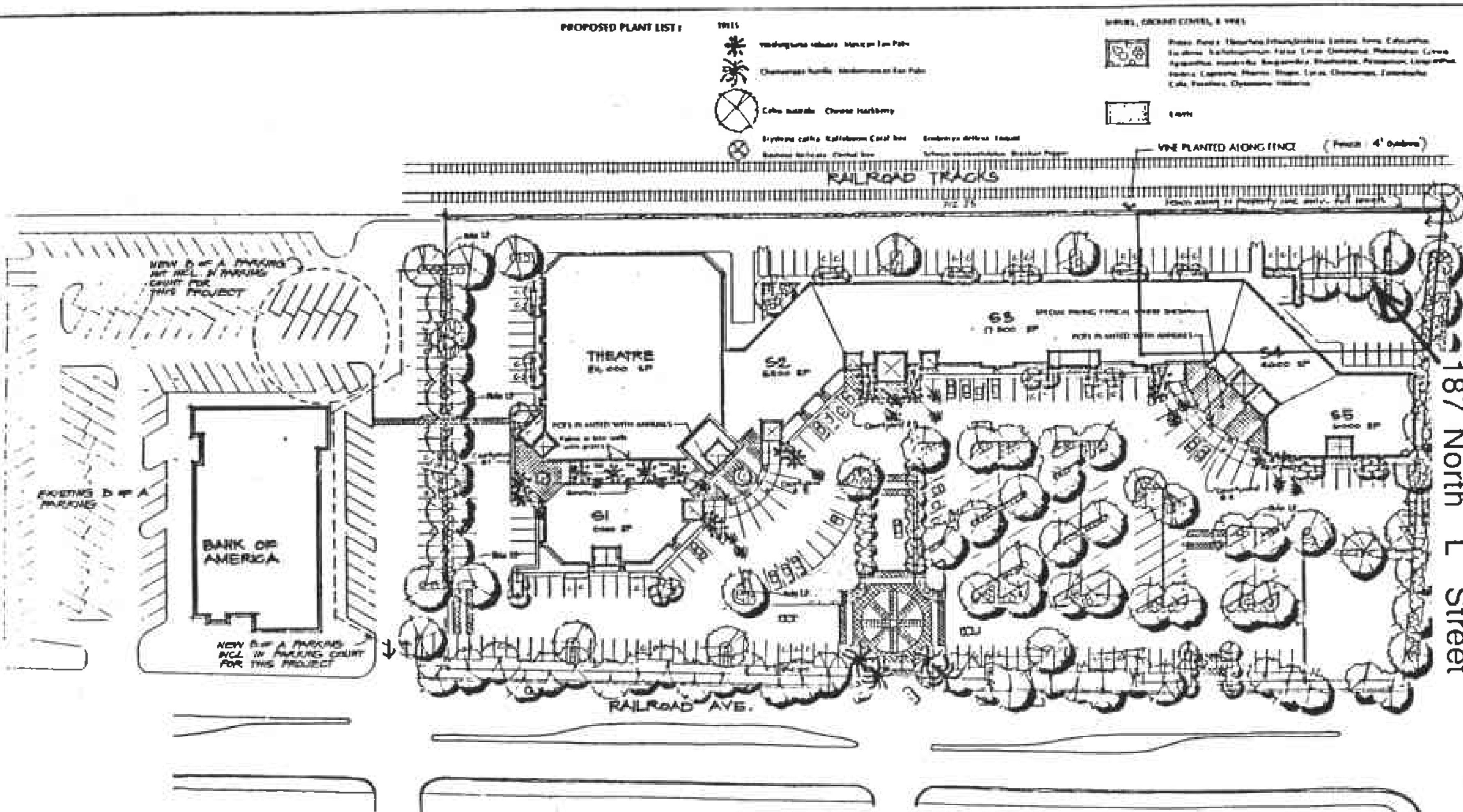
(2) California Drinking Water Limit

(3) DOHS Guidelines for residual soil contamination, will be lower concentration nearer to water table

Table 2. ESTIMATED RELATIVE COSTS FOR SITE REMEDIATION ALTERNATIVES

Soil Remediation	Estimated Costs
1-Excavate and Haul to Class I or II Waste Site	
Haul 3,000 cu. yd. at $350/yd.	$1,050,000
Place 3,000 cu. yd. of fill at $15/yd.	50,000
Remove and replace 15,000 cu. yds. at $15/yd.	225,000
Shoring (sheet piles or "H" piles and lagging)	50,000
WCC work plan, and documentation	100,000
TOTAL	$1,475,000
2-Excavate, On-site Bioremediation Haul to Class III Waste Site	
Excavate, treat 3,000 cu. yds. at $120/yd.	$360,000
Place 3,000 cu. yds. of fill at $15/yd.	50,000
Remove and replace 15,000 cu. yds. at $15/yd.	225,000
Shoring (Sheet piles, or "H" piles and lagging)	50,000
Haul 3,000 cu. yd. to Class III site at $50/yd.	150,000
WCC work plan, and documentation	100,000
TOTAL	$935,000
/ 3-Soil Vapor Extraction	
Site feasibility test	$30,000
Design and Install Vapor Ext. System	80,000
WCC work plan, and documentation	100,000
Operation for 1 year (20,000 lbs. of carbon)	100,000
Operation for 2nd year (10,000 lbs. of carbon)	50,000
Operation for 3rd year	?
TOTAL	$360,000
Groundwater remediation	
/ 1-Groundwater Extraction and Carbon Filter Treatment	
Design studies and report	$30,000
Installation of Extraction Well(s)	10,000
Installation of pumps and treatment system	100,000
Operation for 1 year (16,000 lbs. of carbon)	100,000
Operation for 2nd year (8,000 lbs. of carbon)	50,000
Operation for 3rd year	?
TOTAL	$290,000
2-Groundwater Extraction and Bioremediation and Re-Injection	
Design studies and report	$50,000
Install extraction and injection wells (two extraction and eight injection)	$125,000
Install Bioremediation System	50,000
Operation for 1 year	70,000
Operation for 2nd year	?
TOTAL	$295,000

Note: Above estimates do not include costs for site characterization investigation that will be required by regulatory agencies before the start of remediation. That cost could be about $80,000 to $100,000.



SITE PLAN / LANDSCAPE

PROJECT DATA

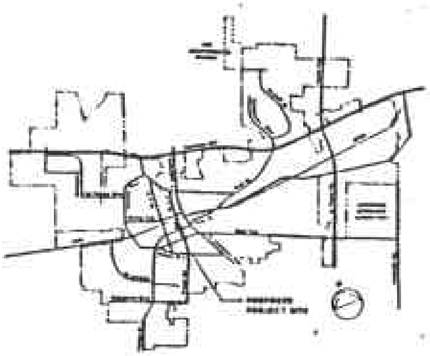
BUILDING AREA

THEATRE		20,000 SF
RETAIL SHOPS	S1–S5	40,000 SF
	TOTAL	60,000 SF

PARKING REQ'D

1600 SEATS	1 CAR/4 SEATS =	400
	1 CAR/400 SF =	100
	TOTAL	500
LESS SHARED (B OF A)		– 60
	SUBTOTAL	440
LESS 25% FOR DAY/ NIGHT SHARING		110
TOTAL REQ'D PARKING		330
TOTAL PROVIDED		345
STANDARD		275
COMPACT		60

N



VICINITY MAP NO SCALE

SITE PLAN

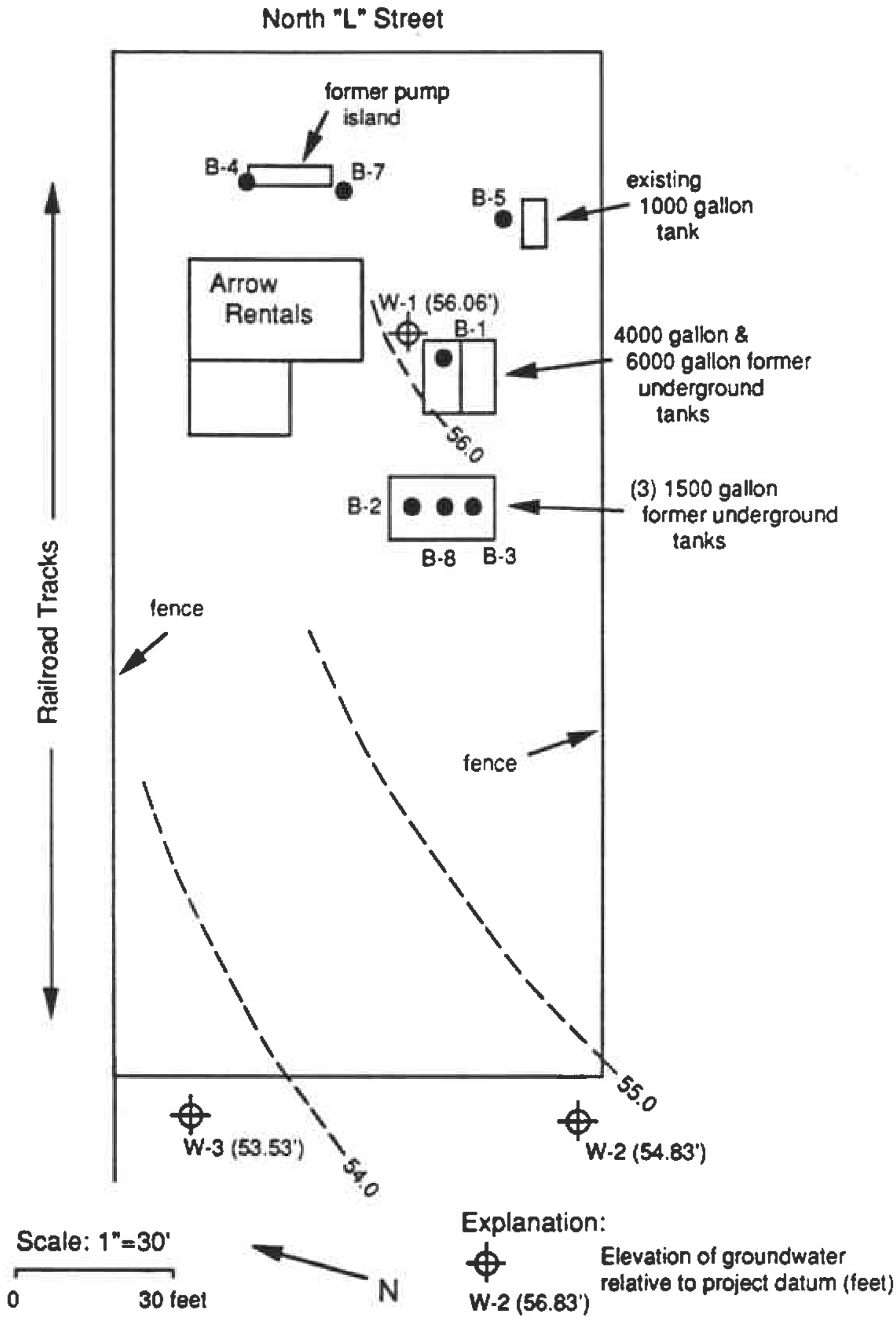
8810220A

Railroad Ave. Property

Woodward-Clyde Consultants

SITE PLAN

Figure 1



Project No. 8810220A	Railroad Ave. Property	Site Groundwater Gradient Map, 187 North L Street, Livermore, California	Figure 2
Woodward-Clyde Consultants			