Staff Report

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Lahontan Regional Board
Petroleum Hydrocarbon Cleanup Approach For Soils

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California Regional Water Quality Control Board, Lahontan Region
15428 Civic Drive, Suite 100
Victorville, CA 92392

Prepared by: Jehiel Cass, Associate Engineer

Reviewed by: Cindi Mitton, Senior Engineer
Hisam Baqai, Supervising Engineer
Robert Dodds, Assistant Executive Officer

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Staff Report

Petroleum Hydrocarbon Cleanup Approach For Soils

1. INTRODUCTION

The purpose of this Staff Report is to explain Regional Water Quality Control Board staff's (Board staff) recommended answer to the question, "*What is an appropriate cleanup approach and case closure criteria for petroleum hydrocarbon soils?*" Board staff recommend that the Regional Water Quality Control Board (Regional Board) accept the decision making process outlined in this Staff Report. If it meets with the Regional Board's approval, this information will be used by Board staff, responsible parties, dischargers, and other local regulatory agencies for determining when further action is required and in setting appropriate site specific soil cleanup levels within the Lahontan Region.

2. DISCUSSION

Board staff are tasked with making decisions on appropriate cleanup levels for petroleum hydrocarbons in soil. The legal requirements do not specify numerical cleanup standards for constituents that are allowed to remain in soil.

What is an appropriate cleanup level for contaminated soils? The Water Quality Control Plan by the Lahontan Region (Basin Plan) states that soil cleanup concentrations should be to background or to a concentration that is protective of water quality. Additionally, remaining contaminated soil must not pose a human health or ecological risk. The Lahontan Region has a wide variation in climate, average annual precipitation, average annual evapotranspiration rates, soil types, geology, water quality and land use. These conditions do not allow for a "one-size-fits-all" cleanup number.

Certain other regulatory agencies (California state and local as well as other states) take a "health-risk" based approach to soil cleanup levels. The State Water Resources Control Board (SWRCB) is developing a policy (still in draft) for petroleum hydrocarbon cleanup that may alter the Regional Board's current approach. For perspective, it is appropriate to describe the current approach Board staff uses for soil cleanup levels and receive input on proposed modifications to that approach.

The SWRCB issued the Leaking Underground Fuels Tank (LUFT) manual in 1989 that was intended to define a process to determine soil cleanup levels that are protective of water quality. The LUFT manual includes a table which was intended to assist in developing soil cleanup levels based on the leaching potential of selected petroleum hydrocarbon contaminants remaining in soil. The LUFT manual Table 2-1 is often referred to as a "look up" table for soil cleanup levels. In addition, the LUFT manual Table 2-2 allows a more detailed assessment of risk to water quality posed by contaminants in soil at a site. The LUFT manual Tables 2-3, and 2-4 through 2-7 are an environmental fate worksheet that may be used to evaluate soil concentrations higher than what Table 2-1 allows. The LUFT manual is criticized as being overly conservative in some situations with deeper ground water. This results in excessive remediation costs for sites that do not pose a threat to water quality or public health. In shallow ground water situations, the soil cleanup levels LUFT manual does not apply.

3. WHEN IS A REGIONAL BOARD STAFF DECISION REQUIRED?

Following are situations, grouped by program, where Board staff or Regional Board concurrence is sought in determining petroleum hydrocarbons remaining in soil.

- UST cases where the Regional Board is the lead agency and case closure may be appropriate.
- UST cases where a Local Oversight Program (LOP) agency is the lead agency. Kern and San Bernardino Counties are the only LOP agencies in the Lahontan Region. A LOP agency must notify the Regional Board of its intent to close an UST case. The Regional Board has 30 days to respond with concurrence or non-concurrence. A lack of response means concurrence.
- UST cases where a Local Implementing Agency (LIA) is the lead agency. In the Lahontan Region, all other counties and the Cities of Victorville and Hesperia are LIAs. On "soil only"[1] cases, these agencies make their case closure decisions independently. LIAs are not required to notify the Regional Board but often ask for Board staff guidance in making closure decisions;
- Sites in the Spills, Leaks, Investigations and Cleanup Program (including both the cost recovery program and other spill areas) in which the Regional Board is the lead agency. Many accident and spill site cleanups are overseen by local agencies that may or may not seek Regional Board concurrence in making closure and "No Further Action"[2] decisions;
- Sites that fall into the Regional Board permitting authority where Waste Discharge Requirements are adopted or a Waiver is issued. This includes soil treatment facilities or activities that result in concentrations of petroleum hydrocarbons discharged to or remaining in soil; and
- Sites that are conducting site investigation and cleanup under Federal Comprehensive Environmental Response, Compensation, Liability Act Authority, also known as CERCLA. These sites include Department of Defense facilities where soil cleanup levels may be established in a Record of Decision or similar document.

4. WHAT CONDITIONS TRIGGER A SOIL CLEANUP DECISION?

Soil cleanup decisions fall into one of two categories;

- ***In-situ soil*** that will remain in place in the vicinity of a spill or release (e.g. highway traffic spill or release from an UST that is under a building), and
- ***Ex-situ treated soil*** that will remain at the treatment site location or disposed to some other area (e.g., excavated soil that is remediated in a waste treatment pile that will remain on site or be disposed at some other location).

5. WHAT LEGAL REQUIREMENTS APPLY?

The California Water Code § 13304 provides the Regional Board's authority to require cleanup and abatement of conditions of actual or threatened ground water pollution. Soils contaminated with petroleum hydrocarbons either are the conduit through which underlying pollution migrated or may be the source that continues to threaten ground waters with future pollution by leaching, percolation, or vapor migration.

The Basin Plan page 4.2-5 states that "*The Regional Board will determine soil cleanup levels for the unsaturated zone based on threat to water quality....If it is unreasonable to clean up soils to*

[1] "soil only" refers to cases where only the soil is contaminated and there is no ground or surface water impacts.

[2] "No Further Action" refers to situations where the agency will not require further cleanup or regulatory action.

background concentration levels, the Regional Board may consider site-specific recommendations for soil cleanup levels above background provided that applicable ground water quality objectives are met and health risks from surface or subsurface exposure meet current guidelines."

General requirements to conduct clean up are also found in Title 23, California Code of Regulations, Chapter 16 § 2724-2728 (UST regulations) and Chapter 15 § 2522(a) & § 2550.10 (waste disposal to land regulations). Additionally, State Board Resolution No. 92-49 § III.G. Explicitly states that "*dischargers are required to cleanup and abate the effects of discharges in a manner that promotes attainment of either background water quality, or the best water quality which is reasonable if background levels of water quality cannot be restored*". The State Board interprets this section of State Board Resolution No. 92-49 as applicable to soil as well as ground water. While soil cleanup to background is not specified, soils must be cleaned up such that ground water is restored to background, or to the best water quality that is reasonable if background can not be restored.

6. WHAT ARE THE CONSTITUENTS OF CONCERN?

Petroleum hydrocarbons are composed of over 70 constituents with a carbon content ranging from C_2 to over C_{30}. The primary constituents of concern associated with petroleum hydrocarbons are the lighter fraction volatile components. Petroleum hydrocarbons with a carbon content of greater than C_{15} have generally a very low solubility in water. Emphasis is placed on the most toxic constituents, **benzene, ethylbenzene, toluene, and xylene**, referred to as **BTEX**. Benzene is a known carcinogen, ethylbenzene, toluene and xylene are toxic but have been identified as carcinogens. BTEX compounds are in a class of compounds known as **volatile organic compounds**. Volatile organic compounds are typically smaller molecules and more mobile in the environment than other compounds that are found in petroleum products. Fuel compounds tend to degrade aerobically (in the presence of oxygen). Typically, the total lump sum amount of petroleum hydrocarbons (or a fraction thereof) may be measured analytically as **total petroleum hydrocarbons**, or TPH. Generally, the analysis is compared to a known standard, such as gasoline, diesel, jet fuel, kerosene, waste oil, hydraulic oil, or crude oil. Of course, the exact composition of a petroleum spill varies with the parent material used and the age of the release.

Other constituents of concern are the semi-volatile compounds such as **naphthalene**. Semi-volatile compounds may contain **poly nuclear aromatics** (PNAs) which are carcinogenic but fairly immobile. **Heavy metals** may be present in waste oil, such as **lead**, **chromium** or **zinc**. Gasoline **additives** such as oxygenates (**methyl tertiary butyl ether**, known as MTBE) or **ethylene dibromide** (EDB) may be released with a spill and are also of concern. During active soil bioremediation, either in-situ or ex-situ treatment, nutrients are added to promote the bioremediation process, such as **nitrate** or **phosphate**. These nutrients are constituents of concern if they become mobile to ground water in concentrations greater than water quality objectives.

7. WHAT ARE THE REGULATORY SOIL CLEANUP CRITERIA?

The Basin Plan and State Board Resolution No. 92-49 contain the regulatory cleanup criteria for soils. The criteria are presented in a narrative fashion and indicate that soil cleanup to background concentrations should be evaluated. If soil cleanup to background concentrations is unreasonable, then cleanup must be to a level that will not threaten water quality above background levels. This criteria implies that natural attenuation of soils in the vadose zone may be considered in establishing soil cleanup levels. Additionally, the cleanup approach must consider human and ecological health concerns.

8. WHAT FACTORS AFFECT SOIL CLEANUP LEVELS?

There are many factors that must be considered when evaluating the impact of leaving contamination in place at levels above background. The extent that these factors are quantified varies with the magnitude of the release. The data needed to make remediation and cleanup level decisions for a spill of one quart of motor oil are different than for a large gasoline leak. These include but are not limited to:

- product physical properties;
- mass of product remaining;
- area and volume of affected soil remaining;
- soil type and soil physical properties;
- type of petroleum hydrocarbon product (gas, diesel, crude);
- depth to ground water and depth to highest ground water;
- rainfall amount frequency and duration;
- contaminant leaching potential;
- presence of a fluctuating water table that may allow a smear zone;
- beneficial uses of water;
- distance and location of surface water;
- presence and type of cap (concrete, asphalt, foundation, etc.);
- location of site and land use type; and
- vapor migration potential.

9. HOW ARE SOIL CLEANUP CONCENTRATIONS SET?

On December 8, 1995, the Executive Officer of the SWRCB issued a letter indicating that cleanup oversight agencies should "aggressively close low risk soil only cases". Board staff interpret "low risk" to mean that soil cleanup concentrations remaining at closure pose a low risk to human health and ecological receptors and a low risk of impacting the water resources of the State (both surface and ground water) in accordance with the Basin Plan.

9.1. Cleanup to Background

For petroleum product organic compounds, Board staff generally, consider background to be "non-detectable". In situations with a prior release or with elevated naturally occurring organic material in the soil, it may be important to establish background soil concentra-tions that are above detection limits. Appropriate statistical methods should be reviewed by Board staff on a case-specific basis. In order to meet the Basin Plan criteria, supporting information is necessary to justify that it is technically or economically infeasible to clean up a release to background levels.

9.2. Cleanup Levels Above Background that are Protective of Water Quality Objectives

To evaluate an appropriate petroleum hydrocarbon soil concentration that may remain above background concentrations, a number of methods are used by Board staff. In order to justify that soil contaminant concentrations will not adversely impact water resources above the water quality objectives specified in the Basin Plan, supporting information such as outlined below must be provided. Board staff are aware that petroleum degrades biologically in the environment. The degree of biodegradation will vary with each site. Thus the reliance on biodegradation to reduce soil concentrations must be evaluated on a site specific basis.

- *Leaching Potential Methods*

Jon Marshak with the Central Valley Regional Board developed the Designated Level Method in 1989. An Attenuation Factor Method was developed by Yue Rong with the Los Angeles Regional Board in 1995. The Santa Ana and San Diego Regional Boards use leaching potential information obtained from modifications of the US EPA Toxicity Characteristic Leaching Potential (TCLP) method. Deionized water is typically substituted as the leaching agent. TCLP results, along with the other factors listed in section 8, above, may be sufficient to demonstrate that water quality will be protected.

- *Vadose Zone Flow and Transport models*

There are numerous computer vadose zone transport models available (Wilson, Everett & Cullen, Lewis Publishers, 1995). The more common models are VLEACH and SESOIL and there are both pros and cons to the use of these types of models. Collecting the information necessary to use the model may be expensive, the model may not reasonably reflect actual site conditions, and sometimes results in overly conservative results. Vadose zone models may not accurately predict the fate and transport of hydrocarbons in soil over time, but may be a good indicator of whether hydrocarbons will reach ground water at all. The results of a computer model may be used as supporting information to demonstrate that water quality will be protected.

- *Best Professional Judgment*

In most cases, Board staff apply empirical data and experience from previous sites to use Best Professional Judgment in determining appropriate site specific soil cleanup levels that are protective of water quality. Board staff experience in the Lahontan Region is that sites with lighter fractions of petroleum hydrocarbons (C_1 - C_{15}) in dry climates should have at least a 50 foot separation from the highest historical ground water table. Sites with heavier fractions of petroleum hydrocarbons (greater than C_{20}) generally have minimal impact on water quality. In areas having wet climate with ground water within 10 feet of the surface, any concentration of petroleum hydrocarbons left in the vadose zone will likely impact water quality. Using Best Professional Judgment allows unique, site specific conditions to be evaluated and considered for each case.

9.3. Human Health and Ecological Risk Considerations

Historically, Board staff has not emphasized individual site specific human health risk assessments because exposure to humans may not be occurring (no wells impacted) even though the water resource is impacted or threatened. When a site-specific *quantitative* human or ecological risk assessment is prepared, Board staff may defer technical review to other agencies with expertise for review (local health departments, Cal-EPA Department of Toxic Substances Control, Cal-OSHA, Cal-EPA Office of Environmental Health Hazard Assessment, Department of Health Services).

Board staff requests information to perform a *qualitative* risk assessment. This information may be an evaluation of soil gas concentrations to determine if vapor migration is a concern, or identification of the location of nearest wells to determine if drinking water impacts is expected. Prior to granting UST case closure, Board staff will assess site conditions and make a qualitative determination that there are no human health risks.

Recently, the SWRCB has sponsored statewide training to use the "Risk Based Corrective Action", (RBCA), process developed by the Association for Testing and Materials or ASTM.

The RBCA is appropriate for determining human health threats but does not effectively evaluate ecological threats. The "Risk Assessment Guidance for Superfund Sites" protocol developed by the US EPA is more rigorous and requires more information. While human and ecological risks must be evaluated, existing State and Regional Board criteria do not specify that case closure be made on the basis of risk alone.

10. WHAT ARE SOME ACTUAL SOIL CLEANUP NUMBERS?

Attached are a number of tables to illustrate actual soil cleanup concentrations that have been specified in Waste Discharge Requirements, allowed to remain in place at the time an UST case is closed, or where spills to ground have occurred. In general, Board staff has first requested that soil be cleaned up to background in accordance with the Basin Plan. In cases where cleanup to background is impractical, Board staff has used the general guidance found in the LUFT manual, Table 2-1. Board staff is now recognizing that there are cases where soil cleanup numbers higher than the LUFT manual (Table 2-1) will still be protective of the water quality beneficial uses that are specified in the Basin Plan. Following is a discussion of the attached tables.

Table A (Adopted Waste Discharge Requirements) shows how the LUFT manual was used to set soil concentrations for treatment facilities based on threat to water quality. The Ft. Irwin and Bishop landfills have a similar depth to ground water and climate. Treated soil from the TPS facility has an unrestricted use, hence the low cleanup levels. Limits for the Victorville and Barstow landfills are newly developed based on an attenuation factor method

Table B (Closed UST Cases) shows cleanup levels used at typical UST sites, both in the North and South Lahontan Basin. Soil cleanup concentrations in the wet climates with shallow ground water are much lower than cleanup concentrations used in the dry climates with deeper ground water.

Table C (Spill Sites) shows how practical considerations were used to allow higher concentrations to remain in soil after excavation removed the largest mass of petroleum hydrocarbons in soil. Both railway sites were along the Mojave River. It is also evident from Board staff experience that a quick initial spill response by excavating impacted soil to remove the hydrocarbon source will have the best long term impact.

11. PETROLEUM HYDROCARBON CLEANUP APPROACH FOR SOILS

This section describes guidelines for when "No Further Action" is required when petroleum hydrocarbons remain in soil at sites within the Lahontan Region. This guidance is narrative in format, specifying no numerical criteria, because of the wide range of site conditions and circumstances within the Lahontan Region.

11.1. Cleanup to background or concentrations protective of water quality

An evaluation is necessary to demonstrate that cleanup of petroleum hydrocarbons in soils to background conditions was considered and is not reasonable as being necessary to achieve water quality objectives. Then, soil cleanup concentrations above background may be site specific based on threat to water quality.

11.2. Site assessment is complete

A complete site assessment must determine with reasonable certainty the full vertical and lateral extent of petroleum hydrocarbons in soil. The site assessment should be capable of determining whether threatened pollution of ground water remains. For gasoline station sites, MTBE concentrations in soil should be evaluated. Future remedial action decisions will

be made based on this information. Board staff specifies no specific protocol for conducting a site assessment as numerous reference sources are available. All technical reports must be signed by a California Registered Civil Engineer, Geologist, or Certified Engineering Geologist. For small spills it may be more practicable to excavate all contaminated soil rather than conduct a site assessment. The site assessment must provide information and data to evaluate the economic and technical feasibility of cleaning up soils to background. It may be necessary to collect water samples in areas with shallow ground to show that the site is a "soil only" site.

11.3. No free draining product remains

Depending on the size and source of the spill or release, liquid and gaseous phase petroleum hydrocarbons may remain mobile for long periods of time, threatening to pollute ground water. The soil holding capacity varies and is a function of soil properties, other site conditions and the depth to ground water. A paint filter test, or similar method may be used to demonstrate soil holding capacity.

11.4. No leaching that adversely affect beneficial uses of water

The ability of petroleum hydrocarbons to leach from soil is also a function of many parameters. Compounds with more volatile constituents are more leachable than compounds with heavier chain hydrocarbons. Leaching potential may be evaluated using a) Best Professional Judgment, b) attenuation factor methods, c) leaching potential tests using de-ionized water or by d) a vadose zone computer model simulations with site specific data to support recommendations that water quality will not be affected by contaminants remaining. Consideration should be given to fractional characterization of the total petroleum hydrocarbon compounds to assist in fate and transport evaluation of petroleum hydrocarbons in soil. Climate (e.g., rainfall conditions) and fluctuating ground water tables that re-dissolve petroleum hydrocarbons into ground water, must be considered. Higher concentrations of petroleum hydrocarbons may remain near the surface if sufficient soil attenuation capacity exists to protect ground water.

11.5. A 50/25 foot separation remains

Board staff experience in the Lahontan Region is that sites with lighter fractions of petroleum hydrocarbons (C_1 - C_{15}) in dry climates that have at least a 50 foot separation from the highest historical ground water table typically do not threaten water quality objectives for ground water. Similarly, sites with heavier fractions of petroleum hydrocarbons (heavier than C_{20}) typically do not threaten water quality if there is at least a 25 foot separation to the highest historical ground water. Sites that meet this criteria are allowed to have higher soil concentrations remaining at closure.

11.6. There is no vapor migration potential

If soil BTEX concentrations are less than the LUFT Table 2-1 recommendations, vapor migration is expected to be minimal. If volatile constituent concentrations are higher (e.g. greater than two orders of magnitude above the LUFT Table 2-1), information and data from a soil gas survey must assure there is no vapor migration potential. Vapor migration is of concern in areas with shallow ground water, in areas with a low total soil organic carbon content (sands and glacial tills), in cases with a higher fraction of volatile constituents remaining than heavier compound, and in cases that are borderline in respect to the separation criteria.

11.7. Risk

A qualitative assessment must be performed for each site to evaluate threat to ground water, human health or ecological receptors. The results of a quantitative risk assessment may be used for contaminant fate and transport analysis and to demonstrate that the site does not pose an unacceptable human health risk.

11.8. Soil Remediation

Sites that do not meet the above criteria must take actions to meet the requirements of State Board Resolution No. 92-49, Section III.G. That requirement is for cleanup and abatement of the effects of discharges in a manner that promotes attainment of background water quality or the best water quality that is reasonable. Such actions include, but are not limited to, active cleanup measures (e.g. bioventing, soil vapor extraction, thermal oxidation/desorption, etc.), source removal such as excavation, site controls such as capping or long term monitoring of natural bioattenuation processes.

11.9. Documentation

A Case Closure summary table is to be used to document site conditions remaining at closure. When contaminants remain onsite, a description should be provided clearly presenting the rationale for closure and showing that site conditions are protective of human health, ecological receptors and water quality. For cases with petroleum hydrocarbons remaining in soil, the Case Closure summary table will be sent to the SWRCB staff for entry into a database required by SB 562.

12. Conclusions

Board staff recommends the approach described above for “soil only” petroleum hydrocarbon cases. This approach is consistent with the Basin Plan and other State plans and policies. This approach takes into account the different climatic and hydrogeologic regimes found in the Lahontan Region. This approach also providesflexibility to responsible parties, Board staff and local regulatory agencies in determining appropriate soil cleanup concentrations for petroleum hydrocarbons.

At certain sites, a significant quantity of petroleum hydrocarbons may remain in soil and not threaten water quality. Board staff experience has shown that no further action may be appropriate in cases where ground water at the site may be deep or the remaining petroleum hydrocarbons in soil may be generally low. In these cases, Board staff may require a Risk Assessment to calculate both risks to human and ecological receptors as well as threat to water quality posed by contaminants remaining.

According to the approach described in this Staff Report, the Executive Officer or Assistant Executive Officer will sign Case Closure letters for these *low-risk* “soil only” cases. By the implementation of the approach recommended, here many low risk soil cases can be closed allowing more time for Board staff to focus on cases that pose a greater threat to water quality.

13. TABLES

13.1. Table A (Adopted Waste Discharge Requirements)

13.2. Table B (Closed UST Cases)

13.3. Table C (Spill Sites)

13.4. LUFT Manual Table 2-1

Table A (Adopted Waste Discharge Requirements)

Facility	TPHg (ppm)	TPHd (ppm)	benzene (ppm)	Toluene (ppm)	ethylbenzene (ppm)	xylene (ppm)	VOC Sum (ppm)	EDB (ppm)	Facility Type	Waste Disposal Location	Depth to Ground water
Bishop-Sunland Landfill	100	1000	0.1	0.1	0.1	0.1	NS	NS	landfill treatment unit	treated soil goes back to landfill then used for daily cover	70-130
Ft. Irwin Landfill	100	1000	0.1	0.1	0.1	0.1	NS	NS	landfill treatment unit	treated soil goes back to landfill then used for daily cover	≅ 100 feet
TPS	10 ppm for all TPH		0.1	0.1	0.5	0.5	0.1	.05	thermal treatment unit	unrestricted use of soils	>120 feet
Victorville Landfill	100 times the method detection limit for the organics specified in the Operations Plan								Sludge Drying Beds	dry sludge is returned to landfill then used for daily cover	≅200 feet
Barstow Landfill	1000 times the method detection limit for the organics specified in the site Operations Plan								Sludge Drying Beds	dry sludge is returned to landfill then used for daily cover	>900 feet

List of Acronyms

ND	Not detectable
NS	Not sampled
TPHg	Total petroleum hydrocarbons gas phase
TPHd	Total petroleum hydrocarbons dissolved
TRPH	Total Recoverable Petroleum Hydrocarbons
VOC	volatile organic compounds in gasoline, solvents et.
EDB	ethylene dibromide
ppm	parts per million

Table B (Regional Board Lead UST Closures)

Facility	LUSTIS Site #	TPHg (ppm)	TPHd (ppm)	benzene (ppm)	toluene (ppm)	ethyl benzene (ppm)	xylene (ppm)	Comments	Depth to Ground water
Barstow Airport Hanger 2 & 3,	6B3600478T	21	5500	ND	ND	ND	ND	excavated soil , after excavation some contamination remained; however determined no threat of leaching	≅120 feet
Southland Corp. 7-11, Lancaster	6B190039IT	700	780	0.2	1.2	1.6	21	3 12,000 gallon gasoline storage tanks	80 feet
Chevron Service Station	6B1920069T	780	NS	1.8	18	9.4	55	unauthorized chemical released (Gasoline)	>200 feet
Lancaster Community Hospital	6B1900402T		3080	ND	ND	ND	0.6	Diesel piping leak	> 240 feet
China Lake NAWS Boiler Plant #4	6B1500365T	NS	1780 43000 (oil & grease	NS	NS	NS	NS	32,000 gallon UST was removed, contamination under tank warranted additional site characterization	150 feet
Myers Marine	6T0054A	ND	ND	ND	ND	ND	ND		4 feet
Tahoe City PUD	6T0165A	1	ND	0.011	0.009	0.077	0.480		13 feet
MWTC Lodge Site	6T0213A	ND	50	ND	ND	ND	ND		8 feet

List of Acronyms

ND	Not detectable
NS	Not sampled
TPHg	Total petroleum hydrocarbons gas phase
TPHd	Total petroleum hydrocarbons dissolved
TRPH	Total Recoverable Petroleum Hydrocarbons
VOC	volatile organic compounds in gasoline, solvents et.
EDB	ethylene dibromide
ppm	parts per million

Table C (Spills, Leaks, Investigations and Cleanup Sites)

Facility	TRPH (ppm)	Comments	Depth to Ground water
Santa Fe Railway	15,300-52800 ppm	Train derailment next to Mojave river. Approximately 3800 gallons of diesel spilled.. Contaminated soil was excavated. A small amount of contaminated soil still remains. Complete excavation would have undermined the track structure creating safety hazards. No further action taken.	20 40 Feet
Santa Fe Railway	ND	Locomotive fuel tank punctured by rocks. Spill consisted of 1000 gallons of diesel. 600 gallons were lost immediately, the other 400 were lost over the next 40 miles. Soil was excavated and removed. No further action taken.	20-40 Feet
There are approximately 110 examples of accidental spills or leaks in the last three years within the South Lahontan Basin in which the soil was excavated and removed and no further action was taken.			

List of Acronyms Used in Tables.

ND	Not detectable
NS	Not sampled
TPHg	Total petroleum hydrocarbons gas phase
TPHd	Total petroleum hydrocarbons dissolved
TRPH	Total Recoverable Petroleum Hydrocarbons
VOC	volatile organic compounds in gasoline, solvents et.
EDB	ethylene dibromide
ppm	parts per million