Spring 1996

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An Analysis of Remediation Alternatives in an Attempt to Establish an Effective Hydrocarbon-Contaminated Soils Remediation Program at the Yucca Mountain Site Characterization Project (YMP)

A Thesis submitted in partial satisfaction of the requirement for the degree of Bachelor of Arts in Environmental Studies UNIVERSITY OF NEVADA Las Vegas by Marc A. Gonzales

Spring 1996

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ABSTRACT

An analysis of Remediation Alternatives in an Attempt to Establish an Effective Hydrocarbon-Contaminated Soils Remediation Program at the Yucca Mountain Site Characterization Program (YMP)

by

Marc A. Gonzales

An analysis of six (6) soil remediation alternatives was completed in attempt to establish an effective hydrocarbon-contaminated soils remediation program at the Yucca Mountain Site Characterization Program (YMP). The remediation alternatives analyzed included: no remediation, on-site incineration, off-site incineration, in-situ bioremediation, ex-situ bioremediation, and excavation and disposal.

Variables considered in the evaluation process included cost of contaminated soil transportation, treatment costs, future liability, and success of remediating the contaminated soils to below regulatory thresholds. The analysis concluded in the recommendation of an on-site ex-situ bioremediation treatment facility (BTF) to remediate hydrocarbon-contaminated soils at the YMP. The selection was based on the low treatment costs provided by the technology, the ability to treat the contaminated soils on-site, and the success of the technology to treat contaminated soils to below regulatory thresholds.

The BTF will be established to treat YMP hydrocarbon-contaminated soils that originated from operational, historical, and abandoned hydrocarbon releases. Prior to submission for treatment, the...
contaminated soils must be qualified either through process knowledge or analytical sampling.

Through this qualification process, hazardous wastes will entirely be excluded from the contaminated soils wastestream. In addition, the BTF will initially be operated in test mode in order to evaluate the effectiveness of the treatment technology and to develop a baseline remediation schedule. To that end, the BTF is expected to be expanded as site characterization continues at the YMP and ultimately function as an effective hydrocarbon-contaminated soils remediation program.
I. INTRODUCTION

The remediation of hydrocarbon-contaminated soils has quietly developed a niche in the waste management arena. Through technical advances in remediation methods many possibilities are available to the waste manager. The methods range from high temperature thermal treatments to engineered biotreatment. Since remediation costs are not uniform, it is vital that the waste manager evaluate each remediation method available and determine which is most cost-effective. In addition the waste manager should also consider to what extent each remediation method removes waste liability. Because environmental regulations have a tendency to become more restrictive with time, the liability concern may perhaps be the most significant concern in the evaluation process.

As a result of past drilling and current site characterization activities, numerous locations at the YMP site have been contaminated with various hydrocarbons. In general, most of these hydrocarbons include diesel fuel and lubricating oils. Due to the increased awareness of the impacts of environmental contamination, the YMP has decided to establish a proactive waste management program designed to remediate existing and future hydrocarbon-contaminated soil locations. This paper provides an analysis of the various remediation alternatives that the YMP considered in attempting to establish an effective program for the remediation of its hydrocarbon-contaminated soils.
In addition, this paper provides a detailed description of the remediation method the YMP selected and describes how this alternative will be used to meet the goals of remediating hydrocarbon-contaminated soils at the YMP. Section II and III of this paper introduce the YMP facility and provide a history of hydrocarbon-contaminated soil generation at the YMP, respectively. Section IV describes the various regulations that apply to remediating hydrocarbon-contaminated soils. Section V provides a description of the remediation alternatives considered by the YMP. Finally, Section VI provides a detailed description of the alternative the YMP chose to remediate its hydrocarbon-contaminated soils.

II. YMP BACKGROUND AND FACILITY DESCRIPTION

With the passage of the Nuclear Waste Policy Act (NWPA) in 1982, and amended in 1987, Congress directed the U.S. Department of Energy (DOE), through its Office of Civilian Radioactive Waste Management (OCRWM), to evaluate the suitability of Yucca Mountain in Nevada for the permanent disposal of the nation's commercial spent nuclear fuel and high-level radioactive waste. The site characterization studies being conducted and planned at Yucca Mountain include a variety of geological, mechanical, thermal, chemical, as well as environmental studies, that will determine whether the site has the conditions necessary to isolate nuclear waste from the environment.

Currently, numerous studies are being completed within a large-diameter tunnel that extends many
miles into Yucca Mountain (i.e. the Exploratory Studies Facility). In addition, the YMP conducts small-scale hydrological, ecological, archaeological field studies; and monitors the meteorological, radiological, and air-quality conditions at Yucca Mountain (YMP/91-35, 1996).

The Yucca Mountain Site is situated on the southwestern boundary of the Nevada Test Site (NTS) and includes adjoining lands administered by the U.S. Air Force and the Bureau of Land Management. In general, YMP activities are completed in Area 25 of the NTS. The site is located in Nye County, Nevada, approximately 100 miles northwest of the city of Las Vegas, Nevada (see Appendix II-1).

Located in the southern Great Basin of the Basin and Range Province, the regional setting of the Yucca Mountain Site may be generally characterized as consisting of linear mountain ranges separated by intervening valleys with ephemeral streams or rivers. Four major groups of rocks comprise the mountain ranges and basins in the region of the site (DOE, 1986). The first and oldest, Precambrian crystalline rock, is not exposed at Yucca Mountain but may occur beneath the site at great depth. The second, sedimentary rock is many thousands of feet thick and is overlaid in many places by the third group, volcanic tuff of the Tertiary age. The fourth group, Quaternary deposits, is represented at Yucca Mountain by alluvium derived from the erosion of the nearby hills of sandstone and volcanic rock (YMSCO, 1995)
Free-flowing water does not exist at or near the Project site. All drinking water is pumped from groundwater sources. Recharge results from precipitation falling at higher elevations to the north. After percolating from the surface through the unsaturated zone that overlies the water table, water generally flows south and southwest (YMSCO, 1995). Typical of southwestern deserts, the climate of the Yucca Mountain region is characterized by limited precipitation, low relative humidity, and considerable solar radiation. From December 1985 through December 1994, average precipitation at the YMP averaged 4.53 inches. Average summer temperatures have ranged from a low of 71.6 °F to a high of 89.6 °F. Average winter temperatures have ranged from a low of 37.6 °F to a high of 50 °F (YMSCO, 1995).

Typical of desert regions, plant life at the YMP is considered generally sparse. At lower elevations creosote bush/bursage comprise the vegetation communities. The middle elevations are characterized by boxthorn/hopsage. At still higher locations on the nearby Nevada Test Site (NTS), sagebrush, pinyon pines, and junipers dominate (YMSCO, 1995).

III. HISTORY OF HYDROCARBON-CONTAMINATED SOILS AT THE YMP

As a result of exploratory drilling, and other early Yucca Mountain Site selection processes, numerous locations in Area 25 of the Nevada Test Site (NTS) have been contaminated with various petroleum
hydrocarbons, including diesel fuel and lubricating oils. From approximately 1987 through 1990, Area 25 of the NTS was under hydrologic investigation by the OCRWM Nevada Nuclear Waste Storage Investigation (NNWSI) Project. As a function of the NNWSI Project it is estimated that approximately 239 boreholes were drilled in Area 25. Of the 239 boreholes drilled, 58 boreholes have been inspected by the OCRWM Management and Operating Contractor Environmental Programs Department (M&O EPD) for incidence of soil contamination. The M&O EPD inspection findings indicated that 29 of the 58 borehole locations included hydrocarbon-contaminated soil (Estes, 1994).

As formal YMP activities proceeded through the 1990's it was not uncommon to discover locations of abandoned petroleum releases. In general, these locations were former sites of drilling equipment and fuel storage areas. In November 1991 a several hundred gallon diesel fuel release occurred at the Drilling Subdock in Area 25 of the NTS. During the cleanup phase of this release, historic hydrocarbon-contaminated soil was encountered from an abandoned petroleum release at the site. The total remediation of the site resulted in the removal of 700 cubic yards of hydrocarbon-contaminated soil. Most recently, operational releases associated with construction of the Exploratory Studies Facility (ESF) at the YMP have generated the majority of hydrocarbon-contaminated soils. In May 1995 an estimated 57 gallons of lubricating oil was released onto the soil in the ESF construction pad.
The release was the result of a ruptured seal on an oil dispensing unit; approximately 10 cubic yards of hydrocarbon-contaminated soil was excavated from the site.

Current YMP directives involving site characterization activities stress a level of environmental stewardship more rigorous than of the past. The concept being, that most potential sources of hydrocarbon contamination are controlled, mitigated, and managed in such a manner as to preclude all but the most unusual events from releasing contaminants to the environment. Yet, as noted above, historical and abandoned activities were not managed in such a manner. Therefore the YMP is faced with establishing a management strategy that provides for the successful remediation of historical, abandoned, and operational contaminated sites. Appendix III-1 lists NNWSI boreholes that are possible sites of historical petroleum releases. Appendix III-2 through III-4 lists the hydrocarbon releases that occurred at the YMP during the years 1992 through 1994, 1995, and 1996, respectively.

IV. HYDROCARBON-CONTAMINATED SOIL REGULATIONS

With the passage of the Nuclear Waste Policy Act (NWPA) in 1982, and amended in 1987, Congress directed the U.S. Department of Energy (DOE), through its OCRWM, to evaluate the suitability of Yucca Mountain in Nevada for the permanent disposal of the nation's commercial spent nuclear fuel and high-level radioactive waste. Many site characterization activities require the use of materials, and
the disposal of wastes, that are regulated by federal, state, and local laws, as well as policies and procedures developed by the YMP (YMP/91-35, 1996). A description of the compliance regulations that apply to the remediation and management of hydrocarbon-contaminated soils at the YMP follow below.

Published in October 1987 the Nevada Division of Environmental Protection (NDEP) Hydrocarbon Cleanup Policy was developed in response to the increasing number of leaking underground storage tanks and other spillage which had resulted in significant amounts of hydrocarbon contaminated soils. The Policy applies only to contamination due to hydrocarbons, including petroleum releases, which are determined to be non-hazardous based upon the guidelines outlined in 40 Code of Federal Regulations (CFR) Part 261 (State of Nevada, 1987). As a result of having no nationally defined criteria limits for the detection, sampling, and cleanup of petroleum contaminated problems, the NDEP implemented their Cleanup Policy through state regulations.

Nevada Administrative Code (NAC) 445A.347, Notice Required, and NAC 459.9973, Action by Division when excessive Petroleum is Present in Soil, require that releases of petroleum products exceeding 25 gallons, or discovered on or in groundwater, or in at least three cubic yards of soil in a concentration exceeding 100 parts per million (ppm), be reported within one day to the Nevada
Division of Emergency Management, the NDEP, and if applicable, the National Response Center.

Within 45 days of State confirmation of initial notification of a release, NAC 445A.347 requires the generator of the release to submit a 45-Day report of the incident to the State of Nevada with plans for remediation of the site. After acceptance of the report by the State of Nevada, and completion of remediation, a Final Closure Report must be submitted to the State of Nevada (YMP/91-35, 1996).

The NDEP requires that all reportable incidents, where soil or water is contaminated with hydrocarbons, undergo analytical sampling to include, at a minimum, Environmental Protection Agency (EPA) Method 8015, Total Petroleum Hydrocarbons (TPH) modified for diesel/oil/gasoline.

In addition, NDEP requires soil removal if analytical results indicate the presence of TPH in concentrations exceeding 100 ppm. Also, and with NDEP approval, excavated hydrocarbon-contaminated soils which are not hazardous wastes may be disposed of in a NDEP recognized Class I, Class II, or Class III sanitary solid waste landfill (State of Nevada, 1987).

In accordance with Section 113 (a) of the NWPA, as amended, the YMP is required to complete site characterization activities in a manner that minimizes, to the maximum extent practicable, any significant adverse environmental impacts. To that end, the YMP has formalized the hydrocarbon release notification process with the development of work instruction, NWI-EPD-002, Release.
Reporting, and Response Actions. In addition, the YMP procedures for managing hydrocarbon-contaminated soils at the YMP are contained in the soon to be published NAP-EP-002, Management of Hydrocarbon-Contaminated Soils.

V. YMP HYDROCARBON-CONTAMINATED SOIL REMEDIATION ALTERNATIVES

In the past, the YMP remediated hydrocarbon-contaminated soils through excavation and transport to permitted off-site treatment locations. In Fiscal Year (FY) 1994, however, because of a decreased YMP environmental programs budget the propensity to accumulate 55 gallon metal drums containing excavated hydrocarbon-contaminated soil from operational releases became a common practice.

Notwithstanding, the environmental stewardship in the YMP was still apparent as the M&O EPD kept a electronic database on the status of each drum and performed periodic surveillances on the drum storage area. Yet the fiscal resources provided by OCRWM to remediate the soils were not available.

In an effort to remove the unsightly drums from the site and provide a long-term solution to project derived hydrocarbon-contaminated soils, the YMP decided to consider a variety of soil remediation alternatives. As a result of a limited budget and nature of hydrocarbon-contaminated soil generated, the YMP decided only to consider the following remediation alternatives: 1) No remediation, 2) On-site/Off-site incineration, 3) In-situ/Ex-situ bioremediation, and 4) Excavate and Disposal.
The no remediation alternative includes negotiation with the NDEP wherein hydrocarbon-contaminated soil remediation is not pursued. In this case, the NDEP provides relief from standard forms of soil remediation contained in the Hydrocarbon Cleanup Policy. Through discussions with private parties that have successfully used the no action alternative to solve hydrocarbon-contaminated soil problems, the YMP learned that only under certain well defined conditions will the NDEP consider this alternative. These conditions include: depth to groundwater, distance to irrigation or drinking water wells, type of soil, annual precipitation, type of contaminant released to the soil, extent of contamination, present and potential land use, preferred routes of migration, locations of structures and impediments, the potential for a hazard related to fire, vapor or explosion; and any other factor that is specific to a site as determined by the NDEP. For recent operational releases (i.e. accidental petroleum release or small fuel drips from equipment) much of the information required above will be readily accessible. Yet for historical or abandoned releases this information will have to be researched, and in most cases, extensive characterization of the contaminated location will be required. Such characterization often involves that sample holes be drilled or augered and samples be taken for analysis at various depths and distances from a central reference point. In many cases, a characterization activity of this type will cost a substantial portion of what an excavation and off-site
remediation treatment activity commonly cost, without eliminating any of the liability associated with hydrocarbon-contaminated soils. Further, the quality of some site characterization activities may be compromised by leaving contaminants in place. For example, hydrocarbon-contaminated soil not remediated at a location close to a critical hydrological sampling site may attach variables to the analytical data that render the results inconclusive.

Perhaps the most significant concern associated with the no action alternative is that regulations have a tendency to become more restrictive with time. For instance, the acceptable abandonment of a hydrocarbon-contaminated location at one point in time may not be so in the future. As an example of such a predicament, many hazardous waste landfills that at one point in time were legally permitted and in compliance with all applicable regulations are now considered to be in violation of hazardous waste disposal laws and must be remediated, often at great expense to those who used the facility in good faith.

Incineration treatment of hydrocarbon-contaminated soils is used to accomplish the removal of volatile or combustible organic matter from the soil. Incineration utilizes high temperatures, usually in excess of 1600°F to either directly destroy organic matter contained in the soil or to drive the organic matter off and combust them in a separate treatment chamber (Manahan, 1991). In general, the incineration
method consists of either utilizing a fixed apparatus or mobile station unit containing some form of combustion chamber and ancillary equipment such as belt conveyors, bag houses, scrubbers, afterburners, and heat exchangers (Wirtz, 1994).

Thermal treatment, such as incineration, offers essentially complete destruction of the original organic waste. Destruction and removal efficiency achieved for wastestreams incinerated in a properly operated incinerator often exceeds the 99.99 percent required by hazardous waste laws for most hazardous wastes (NDEP Environmental Managers Review Manual, 1995). Although hydrocarbon-contaminated soils are not hazardous wastes it is assumed the efficiency of organic waste destruction provided by incineration will generally remain the same for the soils because in most cases hazardous wastes do not offer the same type of waste homogeneity. Further, in many cases, incineration allows for material recovery. In hydrocarbon-contaminated soils treatment, materials recovery is accomplished by thermally treating the excavated contaminated soils and then processing the treated soils back to the original excavation site. Also, relative mobility of some incineration equipment allows the units to be moved from one contaminated location to another (Wirtz, 1994).

As a result of large capital expenses associated with permitting and purchasing or leasing incineration equipment, the incinerator will be required to be in constant use in order to be cost effective.
Notwithstanding any major equipment failures, the incinerator will also require extensive preventative maintenance in order to ensure its effectiveness in meeting regulatory compliance thresholds, such as air pollution control effluents. Further, in discussions with incinerator contractors the YMP learned that soil incinerators are capable of reducing TPH concentrations in soil to "non-detect" levels. To that end, the incinerator contractors were unable to quantify the limits of the analytical approach, as such the term "non-detect" is of limited value. Yet, in general, incineration units are capable of reducing contaminants to the low ppm range (Wirtz, 1994). In addition, and as a result of the treatment technology, permitting an incineration unit may sometimes be a long and detailed process.

On-site incineration of hydrocarbon-contaminated soils at the YMP would include obtaining the appropriate operating permits, leasing incineration treatment equipment, employing the services of off-site incineration treatment contractors, and ensuring that recovered soils were below the NDEP 100 ppm soil threshold. Discussions with incineration contractors regarding the applicability of employing on-site soil incineration at the YMP resulted in a cost schedule that contained extremely expensive capital costs. The costs associated with transporting, mobilizing, and demobilizing the incinerator is approximately $15,000. In addition, the hydrocarbon-contaminated soil treatment costs range from $25.00 per ton to $28.00 per ton; soil treatment throughput of the incinerator is 150 tons (Wirtz,
Off-site incineration of YMP hydrocarbon-contaminated soil would include excavation of contaminated locations, backfill of the excavation with imported fill, verifying pre-acceptance documents for the soil wastestream from the treatment facility, transporting excavated soils to the treatment facility, and ensuring that the excavated soils have been successfully treated. In general, proof of soil treatment is provided by the treatment facility through a signed certificate of treatment. The costs of transport to the off-site incinerator is approximately $35.00 per ton and an additional $35.00 per ton to complete the soil treatment process. Also, for an additional $35.00 per ton the treated soil may be returned to the site for use as fill in the original excavation (Wirtz, 1994).

Bioremediation refers to the alteration or optimization of environmental factors that stimulate microbial biodegradation activity. Biodegradation activity is defined as the breakdown of organic compounds by living organisms resulting in the formation of carbon dioxide and water (Hoppel and Hinche, 1994).

Ex-situ bioremediation refers to the treatment method wherein contaminated soil or groundwater is removed from the impacted site and treated. Ex-situ bioremediation normally is completed in a reactor or treatment cell, and in the presence or absence of oxygen, with introduced microorganisms providing the metabolizing activity necessary to degrade the hydrocarbons to a low TPH concentration (NDEP...
Environmental Manager Review Manual, 1995). As a result of the process provided by ex-situ
treatment, wastestreams destined for treatment are not confined to straight chain carbon organics. In
many cases ex-situ treatment may be utilized to successfully remediate organics such as pesticides,
herbicides, formaldehyde, and phenols (NDEP Environmental Manager Review Manual, 1995). In
general, in-situ bioremediation is employed at sites having soil or groundwater contaminated with
readily biodegradable organics (NDEP Environmental Manager Review Manual, 1995). Alkanes,
alkylaromatics, and aromatics of the carbon 10 to carbon 12 straight chain range are the most highly
biodegradeable (Dragun, 1988). The in-situ process employs the contaminated location’s naturally
occurring soil microorganisms to remediate the contaminant. In this case, the carbon derived from the
petroleum substrate serves as the energy source and is aerobically metabolized by the microbe

Most recently the YMP has primarily employed the ex-situ bioremediation method to remediate its
hydrocarbon-contaminated soils. Since 1994, Environmental Technologies (ET) of Nevada has
provided ex-situ bioremediation treatment services to the YMP. The ET bioremediation landfarm is
located in the Apex Industrial Area, approximately 45 miles north of Las Vegas. Hydrocarbon-
contaminated soils must meet certain qualifications prior to being accepted by ET for bioremediation.
It must be determined that only permitted hydrocarbon materials are present and that no hazardous waste constituents occur in the soils. Such determination is accomplished with a detailed pre-acceptance policy that includes analytical sampling and process knowledge of the wastestream. ET requires the following analysis to be completed prior to acceptance for treatment: EPA Method 8015 (TPH modified for gas/oil/diesel), Method 8260 (Volatile Organic Compounds), Method 6010A (8 RCRA Metals), and exposing a representative sample of the contaminated soil to a culture of the bacterial consortia to be used in the remediation process, to determine the level of toxicity to the organisms (YMP FISA, 1994). Process knowledge of the wastestream generally refers to waste generating information (e.g. chemicals used in manufacturing process) to complete waste characterization.

Once accepted by ET, the hydrocarbon-contaminated soils may be transported to the facility for treatment. The facility consists of 15 cells, each capable of remediating 3,000 tons of contaminated soil. The screened soil is placed into each cell to a depth of 18 inches. The cells consist of a permeable layer of random fill, upon which the contaminated soil is placed. The cells are watered with automated sprinkling systems, and the soil is periodically tilled to maintain aerobic conditions. A bacterial consortia and nutrients are added when the soil is tilled. Bacterial plate counts are
periodically taken to ascertain vigor and viability of the microbial populations, and TPH analyses are
used to determine effectiveness and endpoint of the remediation process (YMP FISA, 1994).

In general, landfarming bioremediation approaches, like ET's, are effective in reducing the TPH
concentration of hydrocarbon-contaminated soils to the low ppm range. Normally, if pre-treatment
TPH concentrations of the soil are less than 10,000 ppm landfarming is considered a very effective
remediation method. Yet, if pre-treatment TPH concentrations of the soil exceeds 50,000 ppm,
landfarming is considered ineffective because toxic or inhibitive conditions exist and prevent bacterial
consortia growth (EPA, 1995). Since the NDEP TPH cleanup threshold is 100 ppm, ET's landfarm is
capable of meeting current standards and likely to be within any future regulatory compliance
modifications. Although the ET landfarm alternative offers attractive characteristics, such as effective
treatment of hydrocarbon-contaminated soil and convenience of immediate removal of contaminated
soil from the YMP site, it remains a costly treatment method and a possible public concern.

Using data from previous shipments of hydrocarbon-contaminated soil to the ET landfarm, pre-
treatment transportation of the soil costs $30.00 per ton and treatment of the soil cost an additional
$28.00 per ton (Wirtz, 1994). Also, and under the most extraordinary circumstances, the possibility
exists that the general public may come into contact with YMP derived hydrocarbon-contaminated soil
during the ET transportation and treatment processes. In general, since human health effects are not commonly associated with exposure to hydrocarbon-contaminated soils the YMP considered more closely the public perception attribute of transporting waste materials off the NTS. Because the YMP is considered a high profile project by residents of southern Nevada, the off-site activities associated with the ET landfarm were considered negatively in the YMP’s remedial alternative evaluation (Wirtz, 1994).

The YMP considered using in-situ bioremediation treatment because of the treatment’s general effectiveness in removing petroleum contaminants similar to the ones contained in YMP soils, the treatment process would not require soils to be removed from the YMP site, and the estimated treatment costs would be low. Results of applied natural in-situ bioremediation performed at a former Leaking Underground Storage Tank site indicated that this method was effective in removing petroleum products from soils. The site lithology was composed of sandy clays, and included approximately 8,900 cubic yards of petroleum-contaminated soil. Prior to in-situ treatment, TPH soil concentrations exceeded 1,000 ppm. After 80 days of treatment, TPH concentrations were reduced to less than 50 ppm (Autry and Ellis, 1992). As a result of many factors affecting the cost of remediation, in-situ bioremediation costs are not easily generalized. For the same site conditions and
contaminant distribution, the cost of bioremediation can vary significantly depending on the specific
design. For instance, incorporating recovery and injection wells will increase the capital costs but may
reduce the operating and maintenance costs by reducing the total time of remediation (Norris, 1994).

Since the YMP in-situ treatment alternative will be bioremediating light petroleum product
contamination on a small-scale, preliminary estimates for in-situ treatment were significantly less than
the remedial alternatives under consideration.

The ability of microbes to consume specific organic pollutants depends on a variety of factors. These
factors may be considerable barriers in the success of remediating a petroleum-contaminated location.

One of the prominent limiting factors is the host soil biochemical cycle. This refers to the soil's
ability to breakdown the contaminant's primary chemical composition. In-situ bioremediation failure
may occur when the concentration of the contaminant is at a level that is toxic to the indigenous soil
microbes, or if the degradation process is exceeded by another biochemical cycle that may be
potentially harmful to the environment (Pierzynski, Sims, & Vance, 1994). Another complicating
factor to consider is the inability of the in-situ treatment to remove contaminants to low TPH
concentrations. Here, even under optimal biodegradation conditions, microbes may be unable to
remove contaminants to regulatory or health-based levels. This results primarily from the microbes
inability to control their metabolic reactions (Committee on In-situ Bioremediation, 1993). Therefore, in order to fully determine optimal in-situ bioremediation conditions, hydrocarbon-contaminated locations need to be fully characterized. This characterization consists of performing representative soil sampling on the contaminated site and initiating appropriate laboratory analyses on the samples.

The primary analytical criteria used include TPH concentration, moisture holding capacity, air permeability, pH, biodegrability, and mineral nutrient content (Fogel, Findlay, & Moore, 1989). In preliminary designs the YMP in-situ approach would include a small-scale test treatment cell.

Therefore, it is anticipated that initial characterization of soil parameters, as discussed above, will be one-time costs. However, if the in-situ approach is applied on a larger scale and at different contaminated soil locations, costs will be competitive with other remedial alternatives mentioned in this paper.

The Nevada Bureau of Air Quality (BAQ) issued the BAQ Permitting Guidance for Remediation of Hydrocarbon-Contaminated Soils in order to describe Nevada's air quality permitting process that is associated with remediation of hydrocarbon-contaminated soils. Although the BAQ Guidance is generally concerned with soil remediation treatments that employ incineration technology that may produce negative air quality impacts it requires, at a minimum, that an air quality operating permit be
obtained before in-situ treatment begins at a location. Further, a BAQ operating permit is required for each treatment reactor or cell, the fee for a BAQ permit is $250.00 (NDEP BAQ, 1995). Specifically favorable to in-situ bioremediation are the benefits of destroying the hydrocarbon contaminants in place and the low profile of the remedial process. Generally, liability is not an issue because the contaminant wastestream is entirely remediated. To that end, the YMP favorably considered the in-situ bioremediation alternative as its solution to meeting its commitment to provide hydrocarbon-contaminated soil remediation.

The excavation and disposal alternative consists of excavating hydrocarbon-contaminated soils and disposing them in a state permitted Class I, Class II, or Class III landfill. Under this remediation method the YMP would excavate, transport, and dispose of hydrocarbon-contaminated soils in the NTS Area 6, Class III Hydrocarbon Land Disposal Unit (HLDU). Owned by the DOE, and operated by Bechtel, Nevada Inc., the HLDU is exclusively used for the disposal of hydrocarbon burdened soil or debris. Prior to disposing of hydrocarbon-contaminated soils in the HLDU, the soils are characterized using process knowledge, sampling and analysis, or a combination of both. Next, the soils are transported to the HLDU under a Bill of Lading. The Bill documents the generator of the soil, amount transported, and that the soil has been surveyed from radioactive contamination. Upon
receipt, the HLDU operator inspects the load and notes in the HLDU log book all pertinent information or discrepancies associated with the load. The disposal process includes spreading the soils into a layer which will not exceed one foot in thickness prior to compaction. Landfill compactors (i.e. heavy equipment sheep foot roller) will then be used to compact the soil. In general, the number of layers incorporated into the landfill will be dependent upon the amount of soil delivered for disposal (DOE EPD, 1995). The HLDU is monitored to detect liquid movement through the use of three neutron monitoring bore holes. A 100 percent change of the average neutron count in any neutron borehole will require notification of the NDEP. In addition, the HLDU submits a landfill status report and neutron monitoring report annually to the NDEP (WOD, 1994).

Discussions with Bechtel regarding transportation and disposal of hydrocarbon-contaminated soil in the HLDU from the YMP resulted in the following. Transportation of the soil is approximately $50.00 per ton and the cost for disposal is an additional $11.00 per ton. From a fiscal perspective the HLDU is certainly one of the least expensive remedial alternatives. Yet, as mentioned earlier, this alternative does not remove any potential liability since the hydrocarbon contaminants are not treated nor removed from the soil. Further, the disposal of hydrocarbon soils to the environment without prior treatment, although legal, does not follow the spirit of environmental stewardship the YMP is
Appendix V-1 is a summary of the hydrocarbon-soil remediation alternatives that were evaluated by the YMP. The remediation alternatives correspond to the following alphabetical designations: A) No remediation, B) On-site incineration, C) Off-site incineration, D) Ex-situ bioremediation, E) In-situ bioremediation, and F) Excavation and Disposal.

VI. ON-SITE EX-SITU BIOREMEDIATION TREATMENT AT THE YMP

After careful evaluation of the remedial alternatives discussed in this paper, the YMP considered on-site ex-situ bioremediation treatment as the technique to remediate YMP derived hydrocarbon-contaminated soils. On-site ex-situ bioremediation was considered the most suitable in that: 1) the estimated cost were within fiscal constraints, 2) the soils would remain on site, 3) the process would be under control of the YMP, and 4) treatment costs would diminish as the system and techniques became more efficient. All of these factors are important is selecting a suitable strategy for dealing with hydrocarbon-contaminated soils. Unlike disposal, where contaminated soil is simply relocated, bioremediation actually works to destroy the contaminants to non-hazardous components (i.e. carbon dioxide and water). Further, since the YMP will initially operate a small ex-situ treatment cell, an estimate of the limitations and effectiveness of the treatment's operation will be learned. Although, the
ex-situ treatment alternative was discussed in terms of ET's landfarm. Principal costs and remedial
techniques were extrapolated from ET's landfarm to the design of on-site ex-situ treatment at the YMP.

The YMP's initial approach of ex-situ soil remediation will consist of an above-ground, soil-pile
bioreactor, capable of treating 44 cubic yards of soil at a time (Wirtz, 1995). The YMP has
designated the treatment location as the Bioremediation Test Facility (BTF). The proposed location
for the facility is approximately 1/2 mile south and east of well J-13 in Area 25 of the NTS
(Appendix VI-1). Only soil that is completely characterized will be accepted for bioremediation
treatment. An acceptance package will be submitted to the OCRWM M&O EPD prior to transport of
contaminated soil to the BTF. The package will identify the contaminant(s), point of origin, and
demonstrate through process knowledge or analytical sample results that the soil is free of hazardous
waste components.

Initially, the BTF will include a treatment cell 50 feet long and 12 feet wide having the capacity to
treat a soil layer approximately 24 inches deep. The cell will be covered with an impermeable plastic
liner and subsequently covered with a network of perforated pvc sewer pipes. The pipes will provide
aeration and drainage capabilities to the soil pile. The pipes will then be overlain with geotextile
material (e.g. mesh cloth) that will exclude dirt and rock from interfering with the pipes. The
contaminated soil will be placed on the geotextile material, and a network of small diameter drip-watering tubes attached to a water manifold pipe will be placed across the soil pile. The pile will then be covered and allowed to initiate the biodegradation process (Wirtz, 1995). Preliminary arrangements include OCRWM M&O personnel operating all functions of the BTF. A side view of the BTF's conceptual design of is presented on Appendix VI-2.

As a result of the experimental nature of the BTF, critical parameters that relate to the effectiveness and efficiency of the remedial process will be assessed. These parameters include: microbial determinations, moisture and temperature determinations, oxygen determinations, and TPH determinations. In order to determine degradation rate and end-point capability of indigenous microbial species, soil samples will be periodically taken for the preparation of bacterial plate counts.

The concentration of total heterotrophic organisms will be determined. Progress of the degradation process is indicated by an increase in number or organisms as nutrients and hydrocarbon substrate are metabolized. A decrease in the number of organisms indicates that an endpoint has been reached.

Soil/water regimens and nutrient availability are often the more sensitive variables in determining optimal hydrocarbon degradation rate for any particular bio-treatment system. The BTF is expected to focus on three moisture levels (30-40%), 45-55%, and 60-70%). In addition, the BTF will be
instrumented with soil moisture and temperature probes that will enable target levels of these parameters to maintained at optimal levels. As a result of the short diffusive path of the pile (24 inches), BTF oxygen levels are not anticipated to vary significantly. If BTF design is manipulated, the addition of oxygen releasing compounds may be added to accelerate the degradation process (Wirtz, 1995). In order to determine the presence or absence TPH concentrations of the treated soil, samples will be removed from each treated batch and analyzed using EPA Method 8015. In addition, and as required by BAQ Guidelines, air TPH samples will be taken from the evapotranspiration stream for analysis.

Currently, the BTF is still in a pre-construction phase. The facility design has been approved by OCRWM hierarchy and a BAQ operating permit for BTF use has been issued. However, recent YMP budget decreases, and subsequent staff reductions, have moved the milestone for establishing and operating the BTF to the early part of Fiscal Year 1997 (October-November 1997). In the interim, the YMP has utilized ET's landfarm to remediate all YMP derived hydrocarbon-contaminated soils.

VII. CONCLUSION

After a thorough evaluative process that considered variables such as cost and liability, the YMP decided to approach the remediation of its hydrocarbon-contaminated soils through the development of
an on-site bioremediation facility. In design, the preferred method appears to satisfy the goal of
establishing a waste management strategy designed to remediate existing and future hydrocarbon-
contaminated soils. Yet, the method can only be effective if it is implemented. Because of recent
OCRWM budget constraints the YMP has become increasingly conservative in dedicating funds to
operate innovative waste management approaches like the BTF. As a result, the BTF is still months
from being operable.

In completing this research, I found that the YMP utilized a simple and effective strategy in
establishing a waste management approach to remediating its hydrocarbon-contaminated soils. The
YMP considered its site and fiscal limitations, and made a rational decision to develop a remedial
strategy that sought to destroy the hydrocarbon contaminants rather than just simply move them to
another location. Yet, the YMP hydrocarbon-contaminated soil waste management strategy does not
go without some unresolved problems. The historical and abandoned contaminated locations
mentioned in Section III have not been completely characterized or reported to the State of Nevada.

Although the soils from these locations, if qualified, could be remediated at the BTF, the complexity
associated with determining the process knowledge or developing the appropriate analytical sample
plans for these locations would be great. In an effort to resolve this dilemma, the YMP is considering
a waste management approach that will remediate historical or abandoned sites based on severity of contamination. Severity of contamination will be established through analytical sampling (Estes, 1994). At the time of this writing, there have been no further developments in the historical or abandoned waste management approach.

In closing, the YMP should be commended for recognizing the problems associated with the remediation of its hydrocarbon-contaminated soils and for choosing such a benign technology for treating its contaminated soil wastestream. The YMP's bioremediation strategy not only provides relief from other costly remediation methods but also removes the critical element of liability.
APPENDIX II-1
FOC = Field Operations Center
SMF = Sample Management Facility
EG&G = EG&G Trailers
HRF = Hydrological Research Facility
RAD = Radiation Services Facility
MET = Meteorological Facility
SBD = Subdock
CBP = Concrete Batch Plant
PCY = Precast Yard

Yucca Mountain Site Characterization Project
Major Hazardous Materials Storage Locations

Location Map

Nella Air Force Range
Nevada Test Site

EG&G

YMP-95-026.2
APPENDIX III-1
### Possible Historic Release Sites

<table>
<thead>
<tr>
<th>NEUTRON</th>
<th>WATER TABLE</th>
<th>UNSATURATED ZONE</th>
<th>OTHER</th>
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<tr>
<td>USW UZ N 6**</td>
<td>USW WT 1*</td>
<td>USW UZ 1**</td>
<td>U 25 S H 24*</td>
</tr>
<tr>
<td>USW UZ N 24</td>
<td>USW WT 2*</td>
<td>USW UZ 6**</td>
<td>U 25 S H 21*</td>
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<td>USW UZ N 25</td>
<td>UE 25 WT 3**</td>
<td>USW UZ 8**</td>
<td>U 25 S 1*</td>
</tr>
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<td>USW UZ N 26</td>
<td>UE 25 WT 4**</td>
<td>USW UZ 13**</td>
<td>U 25 S 13*</td>
</tr>
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<td>USW UZ N 27</td>
<td>UE 25 WT 5</td>
<td>USW UZ 8**</td>
<td>UE 25 H 1</td>
</tr>
<tr>
<td>USW UZ N 46</td>
<td>UE 25 WT 14**</td>
<td>USW UZ 6**</td>
<td>UE 25 C COMPLEX**</td>
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<td>UE 25 WT 15</td>
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<td>USW H 1*</td>
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<tr>
<td>USW UZ N 48</td>
<td>UE 25 WT 16**</td>
<td></td>
<td>USW H 3*</td>
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<tr>
<td>USW UZ N 49</td>
<td>UE 25 WT 17**</td>
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<td>USW H 4**</td>
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<tr>
<td>USW UZ N 50</td>
<td>UE 2 WT 18**</td>
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<td>USW H 5**</td>
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<td>USW UZ N 51*</td>
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<td></td>
<td></td>
<td>USW G 2**</td>
</tr>
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<td></td>
<td></td>
<td>BLDG 4222 UST*</td>
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<td>USW UZ N 98</td>
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</table>

* a release has been noted
** a release has been noted- possibly reportable.
APPENDIX III-2
### 1992-1994 YMP STATE REPORTABLE HYDROCARBON RELEASES

**01-Apr-96**

<table>
<thead>
<tr>
<th>NDEM REPORT #</th>
<th>INITIAL NOTIFICATION</th>
<th>SPILL LOCATION</th>
<th>MATERIAL RELEASED</th>
<th>45 DAY REPORT SENT</th>
<th>SOIL EXCAVATED</th>
<th>FINAL REPORT SENT</th>
<th>COMMENTS</th>
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<tbody>
<tr>
<td>H911122A</td>
<td>11/22/92</td>
<td>Subdock</td>
<td>Diesel Fuel</td>
<td>1/22/92</td>
<td>300 cu. yds</td>
<td>8/18/94</td>
<td>CLOSED</td>
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<tr>
<td>H920401F</td>
<td>4/1/92</td>
<td>UZ-1</td>
<td>Diesel Fuel</td>
<td>1/8/93</td>
<td>1400 cu yds</td>
<td>8/12/94</td>
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<tr>
<td>H921110D</td>
<td>11/10/92</td>
<td>NRG-6</td>
<td>Hydraulic Fluid</td>
<td>12/31/92</td>
<td></td>
<td>10/19/94</td>
<td>CLOSED</td>
</tr>
<tr>
<td>H921211D</td>
<td>12/11/92</td>
<td>J-13</td>
<td>Hydraulic Fluid</td>
<td>1/22/93</td>
<td>12/11/92; 1.2 cu. yds</td>
<td>5/1/95</td>
<td>CLOSED</td>
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<td>NDEM REPORT #</td>
<td>INITIAL NOTIFICATION</td>
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<td>H930127B</td>
<td>1/27/93</td>
<td>C-Well Complex</td>
<td>Diesel Fuel</td>
<td>3/24/93</td>
<td>1200 cu. yds</td>
<td>9/1/95</td>
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<td>2/17/93</td>
<td>Borrow Pit Area # 1</td>
<td>Diesel Fuel</td>
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<td>2 cu. yds</td>
<td>3/15/95</td>
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<td>H930226B</td>
<td>2/26/93</td>
<td>N end of Subdock</td>
<td>Diesel Fuel</td>
<td>4/15/93</td>
<td>none</td>
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<tr>
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<td>H930315C</td>
<td>3/16/93</td>
<td>ESF</td>
<td>Antifreeze</td>
<td>5/19/93</td>
<td>3/16/93; &lt; 1 cu. yd.</td>
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<td>Soil sent to ET on 8/24/95.</td>
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<td>H930325E</td>
<td>3/25/93</td>
<td>Bldg 4222</td>
<td>Diesel Fuel</td>
<td>6/7/93</td>
<td>none</td>
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<td>Pending Further Action (Dave Madsen)</td>
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<td>H930526D</td>
<td>5/26/93</td>
<td>ESF</td>
<td>Hydraulic Fluid</td>
<td>7/23/93</td>
<td>5/26/93; &lt; 1 cu. yd</td>
<td>8/15/94</td>
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<td>NDEM REPORT #</td>
<td>INITIAL NOTIFICATION</td>
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<td>H941229H</td>
<td>12/29/94</td>
<td>Borrow Pit Area # 1</td>
<td>Hydraulic Fluid</td>
<td>2/3/95</td>
<td>12/20/94: 7.2 cu. yds</td>
<td>11/3/95</td>
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<tr>
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<tr>
<td>1/6/95</td>
<td>Unleaded gas</td>
<td>8 gal</td>
<td>1/2 mile East of the pre-cast yard</td>
<td>&lt; 1 cubic yard</td>
<td>John West (REECo)</td>
<td>N/A</td>
<td>Release result of GSA vehicle gas leak</td>
</tr>
<tr>
<td>2/7/95</td>
<td>Diesel fuel</td>
<td>8 gal</td>
<td>REECo Drilling Subdock (Area 25)</td>
<td>1.36 cubic yards</td>
<td>John West (REECo)</td>
<td>N/A</td>
<td>Release result of NTS/Fuel &amp; Lube tank overfill</td>
</tr>
<tr>
<td>2/8/95</td>
<td>Diesel fuel</td>
<td>20 gal</td>
<td>ESF PAD</td>
<td>6.2 cu. yds.</td>
<td>John West (REECo)</td>
<td>H950208E</td>
<td>Release result of dropped fuel drain plug</td>
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<tr>
<td>3/16/95</td>
<td>Hydraulic fluid</td>
<td>45 gal</td>
<td>Water Fill Station # 1</td>
<td>20 cu. yds.</td>
<td>John West (REECo)</td>
<td>H950316C</td>
<td>Release result of ruptured hydraulic hose</td>
</tr>
<tr>
<td>DATE OF RELEASE</td>
<td>MATERIAL RELEASED</td>
<td>VOLUME RELEASED</td>
<td>RELEASE LOCATION</td>
<td>SOIL EXCAVATED</td>
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<td>3/16/95</td>
<td>Antifreeze</td>
<td>6 gal</td>
<td>Water Fill Station # 2</td>
<td>2.7 cu. ft</td>
<td>John West (REECo)</td>
<td>H950316D</td>
<td>Release result of vehicle rollover accident</td>
</tr>
<tr>
<td>3/23/95</td>
<td>Automatic Transmission Fluid</td>
<td>2-5 gal</td>
<td>Jackass Flat Rd @ Skull Mtn</td>
<td>&lt; 1 cubic yard</td>
<td>John West (REECo)</td>
<td>N/A</td>
<td>Release result of 3 car accident</td>
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<td>4/10/95</td>
<td>Antifreeze</td>
<td>17 gal</td>
<td>Borrow Pit # 1</td>
<td>1.34 cu. yds</td>
<td>John West (REECo)</td>
<td>H950410D</td>
<td>Release result of hole in vehicle radiator.</td>
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<td>4/14/95</td>
<td>Hydraulic fluid</td>
<td>2-5 gal</td>
<td>ESF access road</td>
<td>&lt; 1 cubic yard</td>
<td>John West (REECo)</td>
<td>N/A</td>
<td>Release result of D-9 Cat hose leak</td>
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<tr>
<td>DATE OF RELEASE</td>
<td>MATERIAL RELEASED</td>
<td>VOLUME RELEASED</td>
<td>RELEASE LOCATION</td>
<td>SOIL EXCAVATED</td>
<td>CONTACT</td>
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<tr>
<td>4/21/95</td>
<td>Diesel fuel</td>
<td>15-20 gal</td>
<td>U-Z 4 Drill Site</td>
<td>2.18 cu. yds.</td>
<td>John West (REECo)</td>
<td>N/A</td>
<td>Release result of faulty hose coupler on fuel tank</td>
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<tr>
<td>5/20/95</td>
<td>15w-40 Lube Oil</td>
<td>57 gal</td>
<td>ESF Pad</td>
<td>10.3 cu. yds.</td>
<td>Dave Wayman (Kiewitt/PB)</td>
<td>H950522B</td>
<td>Release result of ruptured oil seal on oil unit.</td>
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<td>6/16/95</td>
<td>Hydraulic Fluid</td>
<td>24 gal</td>
<td>Muck Storage Pad</td>
<td>40 cu. yds.</td>
<td>John West (REECo)</td>
<td>H960616D</td>
<td>Release result of ruptured hydraulic hose</td>
</tr>
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<td>DATE OF RELEASE</td>
<td>MATERIAL RELEASED</td>
<td>VOLUME RELEASED</td>
<td>LOCATION</td>
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<tr>
<td>6/21/95</td>
<td>Hydraulic Fluid</td>
<td>34 gal</td>
<td>ESF Tunnel (TBM Station 10 + 33-70)</td>
<td>None</td>
<td>Dave Wayman (Kiewitt/PB)</td>
<td>N/A</td>
<td>Release result of TBM rock drill fitting failure</td>
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<tr>
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<td>ISO 220 Lube Oil</td>
<td>40 gal</td>
<td>ESF Tunnel (TBM Station 11+16)</td>
<td>None</td>
<td>Dave Wayman (Kiewitt/PB)</td>
<td>N/A</td>
<td>Release result of TBM lube system fitting failure</td>
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<tr>
<td>8/22/95</td>
<td>Diesel fuel</td>
<td>34-50 gal</td>
<td>ESF Pad</td>
<td>48 cubic yards</td>
<td>John West (REECo)</td>
<td>H950823E</td>
<td>Tank hose failure released qty of diesel in berm</td>
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<tr>
<td>8/25/95</td>
<td>Waste compressor oil</td>
<td>1 gal</td>
<td>SD-7</td>
<td>&lt; 1 cubic yard</td>
<td>John West (REECo)</td>
<td>N/A</td>
<td>Release result of drum # 583-234 rupture</td>
</tr>
<tr>
<td>DATE OF RELEASE</td>
<td>MATERIAL RELEASED</td>
<td>VOLUME RELEASED</td>
<td>RELEASE LOCATION</td>
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<td>8/31/95</td>
<td>Lube Oil</td>
<td>20 gal</td>
<td>ESF Pad</td>
<td>&lt; 1 cubic yard</td>
<td>Dave Wayman [K/PB]</td>
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<td>Release result of Lube Oil Truck spill at ESF Pad</td>
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<td>9/4/95</td>
<td>Diesel Fuel</td>
<td>5 gal</td>
<td>ESF Access Road</td>
<td>&lt; 1 cubic yard</td>
<td>Dave Wayman [K/PB]</td>
<td>N/A</td>
<td>Release result of Heavy Eqpt. leak at ESF access road.</td>
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<td>9/25/95</td>
<td>Lube Oil</td>
<td>80 gal</td>
<td>ESF Tunnel [TBM Station 18 + 65]</td>
<td>2.5 cu. yds</td>
<td>Dave Wayman (Kiewitt/PB)</td>
<td>N/A</td>
<td>Release result of oil pump failure. Majority of impact was to muck that accumulated on invert.</td>
</tr>
<tr>
<td>11/8/95</td>
<td>Hydraulic Fluid</td>
<td>10-15 gal</td>
<td>E of Tunnel tracks on the ESF Pad by White Tent</td>
<td>2.2 cu. yds.</td>
<td>John West [P/KW]</td>
<td>N/A</td>
<td>Release result of Crane # RTC-8028 hose rupture</td>
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<tr>
<td>DATE OF RELEASE</td>
<td>MATERIAL RELEASED</td>
<td>VOLUME RELEASED</td>
<td>LOCATION</td>
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</tr>
<tr>
<td>11/9/95</td>
<td>Hydraulic Fluid</td>
<td>12 gal</td>
<td>SD-7</td>
<td>1.4 cu. yds.</td>
<td>John West [P/KW]</td>
<td>N/A</td>
<td>Release result of Hydraulic unit equipment leak to berm</td>
</tr>
<tr>
<td>11/17/95</td>
<td>Unleaded Gasoline</td>
<td>5-10 gal</td>
<td>FOC West Parking lot</td>
<td>None</td>
<td>Joel Wang [Lawrence BL]</td>
<td>N/A</td>
<td>Release result of gas tank leak on P.O.V. NV lic # 902GLX</td>
</tr>
<tr>
<td>1/23/96</td>
<td>Hydraulic Fluid</td>
<td>5 gal</td>
<td>Precast Yard</td>
<td>&lt; 1 cu. yard</td>
<td>J.W. Witt [K/PB]</td>
<td>N/A</td>
<td>Ruptured wheel line on truck # 81704</td>
</tr>
<tr>
<td>1/24/96</td>
<td>Hydraulic Fluid</td>
<td>4 gal</td>
<td>Precast Yard</td>
<td>&lt; 1 cu. yard</td>
<td>J.W. Witt [K/PB]</td>
<td>N/A</td>
<td>Ruptured hydraulic line on veh. # 81703</td>
</tr>
<tr>
<td>DATE OF RELEASE</td>
<td>MATERIAL RELEASED</td>
<td>VOLUME RELEASED</td>
<td>RELEASE LOCATION</td>
<td>SOIL EXCAVATED</td>
<td>CONTACT</td>
<td>NDEM REPORT #</td>
<td>COMMENT</td>
</tr>
<tr>
<td>-----------------</td>
<td>-------------------</td>
<td>-----------------</td>
<td>------------------</td>
<td>----------------</td>
<td>---------</td>
<td>--------------</td>
<td>---------</td>
</tr>
<tr>
<td>2/7/96</td>
<td>Hydraulic Fluid</td>
<td>23 gal</td>
<td>Alcove 5</td>
<td>&lt; 1 cu. yard</td>
<td>John West (K/PB)</td>
<td>N/A</td>
<td>Broken Hydraulic line on Alpine Jumbo Miner. Impacted muck</td>
</tr>
<tr>
<td>2/28/96</td>
<td>Hydraulic Fluid</td>
<td>15 gal</td>
<td>Alcove 1</td>
<td>&lt; 1 cu. yard</td>
<td>John West (K/PB)</td>
<td>N/A</td>
<td>Broken Hydraulic line on Alpine Miner (AP-75)</td>
</tr>
<tr>
<td>3/22/96</td>
<td>Diesel Fuel</td>
<td>TBD</td>
<td>TBD</td>
<td>TBD</td>
<td>John West (K/PB)</td>
<td>TBD</td>
<td>Operator error while refueling equipment released quantity of diesel</td>
</tr>
</tbody>
</table>
APPENDIX III-4
# CY1996 YMP Hydrocarbon Releases

**01-Apr-96**

<table>
<thead>
<tr>
<th>DATE OF RELEASE</th>
<th>MATERIAL RELEASED</th>
<th>VOLUME RELEASED</th>
<th>RELEASE LOCATION</th>
<th>SOIL EXCAVATED</th>
<th>CONTACT</th>
<th>NDEM REPORT #</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/23/96</td>
<td>Hydraulic Fluid</td>
<td>5 gal</td>
<td>Precast Yard</td>
<td>&lt; 1 cu. yard</td>
<td>J.W. Witt (K/PB)</td>
<td>N/A</td>
<td>Ruptured wheel line on truck# 81704</td>
</tr>
<tr>
<td>1/24/96</td>
<td>Hydraulic Fluid</td>
<td>4 gal</td>
<td>Precast Yard</td>
<td>&lt; 1 cu. yard</td>
<td>J.W. Witt (K/PB)</td>
<td>N/A</td>
<td>Ruptured hydraulic line on veh. # 81703</td>
</tr>
<tr>
<td>2/7/96</td>
<td>Hydraulic Fluid</td>
<td>23 gal</td>
<td>Alcove 5 (Underground)</td>
<td>&lt; 1 cu. yard</td>
<td>John West (K/PB)</td>
<td>N/A</td>
<td>Broken Hydraulic line on Alpine Jumbo Miner.</td>
</tr>
<tr>
<td>2/28/96</td>
<td>Hydraulic Fluid</td>
<td>15 gal</td>
<td>Alcove 1 (Underground)</td>
<td>&lt; 1 cu. yard</td>
<td>John West (K/PB)</td>
<td>N/A</td>
<td>Broken Hydraulic line on Alpine Miner (AP-75)</td>
</tr>
<tr>
<td>3/22/96</td>
<td>Diesel Fuel</td>
<td>TBD</td>
<td>TBD</td>
<td>TBD</td>
<td>John West (K/PB)</td>
<td>TBD</td>
<td>Operator error while refueling equipment</td>
</tr>
</tbody>
</table>
### SUMMARY OF HYDROCARBON-CONTAMINATED SOIL REMEDIATION ALTERNATIVES

<table>
<thead>
<tr>
<th>ALTERNATIVE</th>
<th>CLEANUP LEVEL</th>
<th>TRANSPORT COSTS</th>
<th>TREATMENT COSTS</th>
<th>LIABILITY REMOVED</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>No</td>
</tr>
<tr>
<td>B</td>
<td>&lt; 10 ppm</td>
<td>$15,000 Set Up</td>
<td>$28.00/Ton</td>
<td>Yes</td>
</tr>
<tr>
<td>C</td>
<td>&lt; 10 ppm</td>
<td>$35.00/Ton</td>
<td>$35.00/Ton</td>
<td>Yes</td>
</tr>
<tr>
<td>D</td>
<td>&lt; 50 ppm</td>
<td>$30.00/Ton</td>
<td>$28.00/Ton</td>
<td>Yes</td>
</tr>
<tr>
<td>E</td>
<td>&lt; 50 ppm</td>
<td>None</td>
<td>*$25.00/Ton</td>
<td>Yes</td>
</tr>
<tr>
<td>F</td>
<td>None</td>
<td>$50.00/Ton</td>
<td>$11.00/Ton</td>
<td>No</td>
</tr>
</tbody>
</table>

A = No Remediation  
B = On-site Incineration  
C = Off-site Incineration  
D = Ex-situ Bioremediation  
E = In-situ Bioremediation  
F = Excavation and Disposal  

* Estimated Costs of In-situ bioremediation
Figure 1. Regional View of Bioremediation Cell
APPENDIX VI-2
Side View

4" diameter non-perforated PVC attached to perforated vent system

Perforated vent pipe 4" diameter open on both ends, running along top of pile

Movement of air

Place cover over assembled pile, fix in place with sandbags

Air sample port
Hose clamp
Stabilizer post (2 ea)

Pole-Berm
Vent pipe
Geotextile
Liner

50'
WORK CITED


Waste Operations Department, Nonradioactive Waste Section [WOD] (1994). Operation and maintenance plan for the nevada test site class III landfill in area 6 for the disposal of hydrocarbon burdened soil and debris. Unpublished manuscript.


