"MAKING OLD OIL FIELDS SAFE FOR COMMERCIAL AND RESIDENTIAL DEVELOPMENT"

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INTRODUCTION

In our state, California, oil production peaked in 1953, when an average of more than one million barrels of oil per day was produced. From approximately 1861, when the first oil and gas wells were drilled in California, to the present, approximately 170,000 wells have been drilled. About 86,000 are still in use.

Over the years many oil and gas fields have been abandoned and, in the not too distant future, many more are likely to be abandoned. In places such as the Los Angeles Basin, at one time a prolific oil and gas producing area and now a densely populated urban area, homes and office buildings stand where oil derricks and pumping units once proliferated. This conversion of land from oil field uses to urban uses has sometimes been painful.

By way of example, the Los Angeles Board of Education recently began building a new high school–The Belmont Learning Center–at the eastern end of what was once the Los Angeles City Field. The Los Angeles City Field is one of several oil fields stretching along the Northern rim of the Los Angeles Basin. To the west, one of those fields–The Salt Lake Field–is associated with the La Brea Tar Pits, a well known, unique urban oil seep where for years scientists have excavated and studied the remains of prehistoric creatures who met their fate trapped in the thick tar.

After construction had begun on the Belmont Learning Center, quantities of methane gas and hydrogen sulfide were discovered at the site. Construction was halted and the debate began. The tenor of that discussion is strident. The media never mentions methane gas at the site without referring to it as "explosive methane gas" and it never mentions hydrogen sulfide without referring to it as "toxic hydrogen sulfide."

The School Board is now testing all of its schools for toxic substances. The future of the Belmont Learning Center remains in limbo. There are those who urge that the school site should be cleaned up and construction resumed. There are those who urge, just as sincerely, the site can never be made safe for school use and therefore should be put to some other use.

Granted this is an extreme example of what can happen when old oil field property is converted to urban use. Nevertheless it clearly defines the issue: Can we make old oil fields safe for commercial and residential development?

This paper will discuss some very basic questions about making old oil fields safe for residential and commercial development. How serious a problem is contamination in old oil fields? How did it come to exist? What can be done about it? Who has to pay for it? It will also demonstrate that oil field cleanup can be accomplished in such a way as to make old oil fields safe for commercial and residential development.

HOW SERIOUS A PROBLEM IS CONTAMINATION IN OLD OIL FIELDS?

In recent years, there has been an increasing rate of oil field areas being involved in conversions to other uses. In Southern California, this has primarily involved oil production and storage areas as oil fields reach the end of their productivity, coupled with major increases in land value.

With the conversion of oil field properties, we may witness environmental concerns that include, but are not limited to:

- Crude Oil
- Methane Gas

- Refined Petroleum Products
- Constituents of crude and refined petroleum products (BTEX)
- Polychlorinated biphenyls (PCB's)
- VOCs
- Drilling Mud
- Condensate
- Hydrogen Sulfide
- Arsenic

In California, these compounds include those that would be considered a hazardous waste or material; according to the California Code of Regulations (CCR), Title 22, a designated waste according to the CCR, Title 23.

Generally, wastes are considered to be hazardous if they are toxic, corrosive, ignitable, or reactive.

Potential Hazardous and Designated Wastes

Crude Oil. Petroleum and crude oil have been observed and used for hundreds of years. In the U.S., lamp oil was distilled from crude oil in the 1800s and used as a light source. Crude oil is a naturally occurring liquid that is a mixture of carbon and hydrogen compounds. There are four chemical series that make up the bulk of crude oil: methene, isoparaffin, cyclo-paraffin (napthalenes), and benzene (aromatics).

Crude oil is not considered to be a hazardous waste in California. However, it is considered a designated waste.

What this waste designation for crude oil has meant in Southern California is that although crude is not considered a hazardous waste, its disposal off-site is subject to regulation. As a result, even though soil containing crude oil is not a hazardous waste, the on-site or off-site handling of this soil is time consuming and expensive. Also, the potential liability associated with soils containing crude oil has had a dramatic effect on developers, lawyers and lenders in transfers.

Methane Gas. Methane gas is a colorless, odorless, tasteless gas that is less dense than air. It is formed as the by-product of organic decomposition and is of concern because of its flammability and explosive potential, particularly in the manmade enclosed spaces that are built in commercial and industrial facilities, as well as Belmont Learning Center.

In California, the sensitivity to methane gas increased dramatically with an explosion and fire in the Fairfax district in 1985. This occurred when methane gas built up in the basement of a department store and exploded. The methane was traced to oil contamination in an abandoned portion of an old oil field–the Salt Lake Field. We now know the problem can b e prevented by venting the methane and installing alarms, as is now required by most local agencies.

Refined Petroleum Products. Refined Petroleum Products are not currently considered a hazardous waste, according to California regulations (i.e., Title 22, Division 4, Chapter 30, Articles 9 and 11 of the CCR and the Hazardous Waste Control Act which is found at Cal. Health and Safety Code Section 25100, et seq.) Soils containing refined petroleum products are treated differently from crude oil by the regulatory community in part because of the often relatively high concentration of its constituents: benzene, toluene, total xylenes, and ethylbenzene (BTEX). BTEX, whether in refined petroleum products or crude, are a significant concern in oil field environmental assessments because they can pose a serious threat to human health (benzene is a carcinogen), they have the potential to move through soil and groundwater and their vapor is highly flammable and explosive.

Polychlorinated Biphenyls (PCBS). PCBs are a series of aromatic compounds which contain two bounded benzene nuclei called a bipheny with two or more substituent chlorine atoms. In the oil field environment, the source of PCBs are mainly from transformers and its presence in oil sponged to control dust and vegetation. Typically, PCBs are not mobile in the soil and are, therefore, found primarily in surficial soils when present.

Volatile Organic Compounds (VOCs). Volatile Organic Compounds (VOCs) include BTEXs which are described above and chlorinated solvents. The chlorinated solvents compounds most frequently found include trichloroethylene (TCE), 1,1,1-trichloroethane (TCA), and tetrachloroethylene (PCE). Chlorinated solvents in oil fields are often found in barrels and in sumps.

Drilling Mud. Drilling mud is used in oil field environments to lubricate and cool the drill bit, return cuttings to the surface, maintain the integrity of the hole until casing/ production equipment is installed. Drilling muds are highly variable in consistency and mineral content.

Drilling mud is sometimes of environmental concern, due to heavy metals that can be present that exceed state standards. Current standards include the soluble threshold level concentration (STLC) and total threshold level concentration (TTLC). The former provides a standard for the soluble component of the compound and the latter addresses the total concentration. For example, the State standards for hexavalent chromium are 500 milligrams per liter (mg/l) for the TTLC and 5 mg/l for the STLC. If the total concentration is exceeded the sampled material would be considered a hazardous waste because the

TTLC of 500 ppm was exceeded. It should be noted that the test that is rum to assess the soluble fraction (STLC) is the Waste Extraction Test (WET). The WET is designed to provide an indication of the solubility of metals in a landfill (acidic environment).

Condensate. Condensate is the liquid hydrocarbons recovered at the surface that result from condensation due to reduced pressure or temperature of petroleum hydrocarbons existing initially in a gaseous phase in the reservoir.

It is of environmental concern because it is highly mobile and when released can penetrate deeply into the soil.

Hydrogen Sulfide. Hydrogen sulfide is a highly toxic substance which may be either in free gaseous form or dissolved in liquid water, in liquid hydrocarbon oils, or in specialized chemical solutions utilized for "sweetening" purposes in some facilities under ordinary conditions. At various concentrations, hydrogen sulfide is often present in gas mixtures and dissolved in hydrocarbon oils or in aqueous solutions, any of which may emerge from oil or gas wells.

The nature of the exposure of the public to accidental releases of H2S gas can occur in a variety of ways, usually exhibiting varying concentrations over time. While a time average concentration (values often determined in atmospheric dispersion analyses) might be low, there may still be spikes in the concentration that could kill a person. Care is evidently needed in utilizing data for a fixed concentration level in making health hazard assessments. Recent findings seem to show significant health problems are likely even for chronic low-level exposures to H2S gas. It is important to recognize that almost any single concentration level serving as a measure of the health hazard may not be a credible measure of the true situation unless the actual exposures are reasonably uniform in time.

Arsenic. Arsenic is a highly toxic metallic element. At one time it was commonly used in herbicides and insecticides. It was also extensively used in old oil fields in downhole corrosion inhibitors and biocides.

The types of hazardous waste and petroleum hydrocarbons that can be present at an oil field have been summarized. But for a particular property or abandoned oil field, the questions then arise–which potential sources are present, where are they located, and what compounds, if any, are in the potential source areas? As we shall see hereafter, they all can be remediated and the site made safe for commercial or residential development.

HOW DID CONTAMINATION IN OLD OIL FIELDS COME TO EXIST?

Most of the contamination that exists in old oil field sites is there for the same reason that contamination exists in old industrial areas. It accumulated long before anyone paid attention to the environment. At a time when the average homeowner, having painted his house, pitched his leftover paint and paint thinner on the ground in the vacant lot next door to his house and discarded his empty paint cans in the trash to be carried away and disposed of in a landfill, oil operators impounded drilling fluids, waste oil and condensate in open pits. When those pits were closed, they weren't dug out–they were covered over. Who cared? Land was plentiful and cheap.

Oil spilled on the ground was thought to be cleaned up when it had been covered over with fresh earth. Condensate spilled on the ground was thought to evaporate. No one considered that it might soak into the ground and reach the water table.

Just as farmers used arsenic to kill weeds, oil operators used it to kill weeds as well as using it as a biocide in their tanks, pipeline systems and oil wells to inhibit corrosion. Thus if produced water happened to spill on the ground, it often left behind an arsenic residue.

In the early days operators sometimes found that condensate had gathered in their natural gas pipelines. This would sometimes build up in low lying areas and put back pressure on their producing wells. Absent a better system, condensate was sometimes released from those pipelines into open pits until it could be recovered and routed to crude oil tanks. Much of this condensate evaporated and much of it soaked into the ground. It is not unusual to find that condensate which soaked into the ground many years ago, still exists many feet below the surface.

With early primitive technology, oil wells often blew out, sometimes leaving large craters in the ground. The authors are aware of one well that blew out in 1925 in Southern California, leaving a hole over 60 feet deep. It became an informal dump site in which the public freely disposed of its trash for the next 20 years or so.

The Los Angeles City Field, in which the Belmont Learning Center is a located, was discovered in 1892 when Edward L. Doheny and Charles A. Canfield drilled a well near the present intersection of West 2nd Street and Glendale Boulevard just west of downtown Los Angeles. They hit oil at a depth of 155 feet using a crude cable tool rig and a sixty foot eucalyptus tree which they sharpened into a make shift drill bit. See Franks and Lambert, Early California Oil (Texas A & M University Press, 1945) p. 73. At p. 74, Franks and Lambert describe the then prevailing level of environmental concern in the Los Angeles City Field:

> "Much crude was wasted during the early development in the Los Angeles Basin. One long-time oil man recalled that when he purchased a half-filled oil-storage tank, located near the intersection of Glendale and Beverly avenues, he told the former owner that the tank had to be emptied before he could move it to another site. The former owner replied, "I'll empty it right now," and opened the valves. The oil flowed down the street.
>
> West Second Street 'became a greasy, vibrant, oil-soaked little canyon.' In some areas, the oil on the ground was so thick that oil-field

> horses were forced to stand in the crude all the time. Eventually it softened their hoofs so they could not walk. At Echo Park Lake, where it joined what is today Glendale Boulevard, the water and ground became so soaked with oil that in 1907 local oil men set it afire to get rid of the crude. The fire blazed for several days."

Not only was environmental concern virtually nonexistent in the early days but there were and are many oil seeps in the area. We have already mentioned the La Brea tar pits. There are others. Indeed, today, drivers proceeding south on the Pasadena Freeway making the transition to the eastbound Santa Ana Freeway at the downtown interchange just northwest of the Belmont school site briefly encounter the strong scent of rotten eggs. Most of them probably think they have detected a leaking sewer line. They have not. It is probably a seep.

For better or worse we are a nation in which we, the voting public, have caused our cities to dump our sewage into our rivers, lakes and oceans. As individuals we have drained our waste crank case oil into sewers or into storm drains. We shouldn't have to ask why old oil field sites are often contaminated and have to be cleaned up. On the other hand, there is no reason to fear old oil fields. They can be cleaned up very effectively. This is the topic of our next section.

WHAT CAN BE DONE ABOUT CONTAMINATION IN OLD OIL FIELDS?

Once the oil and gas wells have been plugged and abandoned and a site investigation has been completed, those areas that contain soil and/or water that would be classified as a hazardous waste need to be remediated. It can generally be done efficiently and in a cost effective manner.

Normally, the factors that are considered when selecting a remedial alternative include:

- Cost
- Time to complete
- Technical Feasibility
- Regulatory acceptance
- Space requirements
- Potential Site disturbance

A list of remedial alternatives that are generally available for oil-field mitigation is presented on Table 1. A summary of selected remedial alternatives and associated cost are presented in Table 2.

There are increasingly more publications available which describe remedial alternatives. Some of those publications include the proceedings for the National Water Well Association (NWWA) – American Petroleum Institute (API) Conference held annually in Houston, Texas, i.e., NWWA/API (1988), publications available from NWWA in Dublin, Ohio; Koestecki and Calabrese (1989); DOHS (1986) and Environmental Protection Agency (EPA), 1987.

No Action. In areas where the soil is not visually stained, doesn't have petroleum hydrocarbon odors, and has TPH concentrations of less than 100 ppm, remediation typically does not need to be implemented.

TABLE 1. MITIGATION METHODS

		SOIL	WATER
1.	No Action	X	X
2.	Reworking or Land Treatment	X	X
3.	Vapor Extraction System (VES)	X	(1)
4.	Air Sparging	X	
5.	In-place Encapsulation	X	
6.	In-Situ Chemical Treatment	X	
7.	In-Situ Bioremediation	X	
8.	Excavate and On-site Chemical Fixation	X	
9.	Excavate and Off-site Incineration	X	
10.	Excavate and Dispose Off-site	X	
11.	Excavate and On-site Land farming	X	
12.	Excavate and On-site Bioremediation	X	
13.	Excavate and Use as Road Base	X	
14.	Excavate and Use as Road Base	X	
15.	Remove And Treat Air Strip/Scrubber (Activated Carbon)/Separator(2)	X	
16.	In-Situ Vitrification	X	

Notes:

(1) The VES can assist in the removal of VOCs from the shallow water table if the wells are installed at depths where vapor phase migration can occur from the shallow groundwater.

(2) Air stripping "scrubbing" are designed to remove the dissolved chemical constituents from the discharge water. The separator is designed to separate free-product from the recovered water.

TABLE 2. SUMMARY OF SELECTED REMEDIAL ALTERNATIVES

Alternative	Unit Cost(3)	Time(4)	Technical Feasibility(1)	Regulatory Acceptance(2)	Comments
IN-SITU VAPOR EXTRACTION	$20/cubic yard(3)	18 to 24 months	High	High	
IN-SITU BIODEGRADATION	$75/cubic yard	12 to 36 months	Moderate	Moderate	Treatment process may mobilize hydrocarbons and impact shallow groundwater.
IN-SITU TREATMENT	$200/cubic yard	24 to 30 months	Low to Moderate	Moderate	Treatment process may mobilize hydrocarbons and impact groundwater.
NO ACTION	$5/cubic yard(3)	6 to 12 months	High	Low	Surface will be paved to minimize infiltration of storm water.
EXCAVATE + DISPOSE IN CLASS I LANDFILL	$100 to $150/ cubic yard(3)	13 to 30 months	High	Moderate	Excavation involved import of fill and backfill and compaction.
EXCAVATE + ON SITE BIODEGRADATION	Excavate $8/cubic yard Treat $75/cubic yard	12 to 18 months	High	Moderate	Excavation involves import of fill and backfill and fill compaction.
EXCAVATE + INCINERATE	Excavate $8/cubic yard Treat $40-$50/ cubic yard	12 to 18 months	High	High	Excavation involves import of fill and backfill and compaction.
EXCAVATE + PEROXIDE OXIDATION TO MODERATE	Excavate $8/cubic yard Treat $100/cubic yard	12 to 18 months	Low	Moderate	Excavation involves import of fill and backfill and compaction.

Notes:

(1) Technical feasibility - Assessment of whether the technology exists and has been demonstrated in the past for generally similar materials and conditions.

High - The technology is commercially available but may be limited to a single vendor, and has been employed successfully at least one site;

Low - The technology is not readily available through commercial sources, is considered experimental or in a developmental stage, and has had only very limited or trial application.

(2) Regulatory acceptance - Assessment of whether the regulatory agencies approved of the alternative in the past for generally similar materials and conditions.

High - A greater than 90 percent likelihood of agency approval;

Moderate - A less than 90 percent and greater than 10 percent likelihood of agency approval;

Low - A less than 10 percent likelihood of agency approval.

(3) These estimates require detailed review and analysis and appropriate modification before they can be used for budget preparation. These estimates are intended for comparative purposes only and have an inherent uncertainty factor of at least 100 percent.

(4) Includes permitting, implementation and regulatory sign-off.

Reworking. In the upper 5 feet of the subsurface where the soil is visually stained, has petroleum hydrocarbon odors, or the TPH concentration is between 100 and 1,000 ppm, it is often prudent to rework the soil to bring the concentrations of TPH down to levels close to 100 ppm. This reworking typically occurs during the conduct of grading operations at the site. It needs to be done carefully to minimize the likelihood that areas of "oily soil" are not simply moved intact from one location to another without desegregation and reworking. Where the reworking takes place and the soil is reused at the site, there should be careful documentation that the reworked soil has TPH concentrations less than 100 ppm after placement.

Reworking the soil in this manner is considered by the State to be "land treatment" (CCR, 1988b). Where land treatment takes place, the local California Regional Water Quality Control Board (CRWQCB) is to be notified. In response to this notification, the CRWQCB has required that groundwater monitoring wells be installed at the site along with other reporting and monitoring requirements. The implication of these requirements should be reviewed carefully before implementing this alternative. Although the methodology has a relatively low cost, it may involve long-term monitoring of groundwater when implemented in Southern California.

Vapor Extraction System (VES). This alternative involves the removal of the volatile compounds from the subsurface via "dry" wells that are connected to a pump and in turn connected to a scrubber or thermal destruction unit. While potentially a relatively low cost approach to remediation, this alternative may not be technically feasible where there are fine-grained soils and/or the petroleum hydrocarbons have low volatility.

This alternative involves the injection of air into the soil through one or more injection wells. The intent is to drive air through one or more injection wells. The intent is to drive air through the soil stripping VOCs in the process. The VOC-laden air is then recovered in vapor recovery wells and the VOCs are removed by incineration (in the air stream of a boiler for example), activated carbon “scrubbing” or similar process. This alternative works somewhat in the reverse of the VES described above.

This alternative has been used in a limited number of cases to remove lighter fraction petroleum hydrocarbons (such as gasoline and related aromatic constituents); it is not applicable to remediation of the heavier fraction petroleum hydrocarbons and may not be appropriate where the soils are fine-grained. Where used, the costs are similar to those for a VES and the length of time to conduct the remediation is also similar.

In-Place Encapsulation. This alternative involves the excavation and on-site burial in a lined excavation that is subsequently covered with a liner and fill. It is technically feasible for many sites. However, in effect it makes the site a “landfill” with the resultant regulatory requirements, including overview by the State, soil and groundwater monitoring requirements and related responsibilities and liabilities. In addition, the value of the property may be adversely affected. The cost of this alternative is relatively moderate. It involves an open-ended time commitment to maintaining and operating the containment area. This is not an alternative routinely presented to the regulatory agencies and is likely to involve extensive review and monitoring.

In-Situ Chemical Treatment. This alternative involves the use of a large drill rig to inject steam, oxidizing chemicals, and a fixant into the subsurface. It has been used on one site that the authors are aware of with mixed results. Extensive review by the regulatory community should be expected. The fixation part of the process has not always been successful in the past resulting in the later excavation of the treated soil to achieve desired compaction characteristics, and it is still considered an R&D alternative. It is not applicable for use in areas where utilities are present or are close together.

The costs can be relatively low (<$100/cubic yard) and the equipment is available in Southern California. The process takes several months to conduct and is, therefore, relatively rapid.

In-Situ Bioremediation. This alternative involves the injection of microbes, oxygen and nutrients to enhance the activity of microorganisms in the biological degradation of the petroleum hydrocarbons. This alternative may not be feasible in areas that have fine-grained soils in which crude oil is primarily present. This alternative also introduces the potential for driving the crude oil into the shallow groundwater table before the biodegradation takes place, and the potential need to monitor (and/or remediate) groundwater to ascertain whether or not groundwater has been impacted. The process has moderate costs and is of moderately long duration.

Excavation and On-Site Chemical Fixation. Some sites have been reported to have been remediated by treating excavating soil with materials such as lime with the intent to "cook" off the volatile compounds and then fix the remaining soil that can be used as foundation grade material. To date the authors have not seen data to document that the process has been used, has been effective in the treatment of petroleum hydrocarbons, and has been "signed off" by the applicable regulatory agencies.

Potentially, this alternative is of utility because the cost appears to be moderate, the application of lime to soils for soil stabilization is a proven technology, and it is a relatively quick alternative that could be conducted at many sites in a couple of months.

Excavation and Incineration/Low Temperature Thermal Disorption (LTTD). This alternative involves the excavation of the oily soil and incineration either on-site or off-site. There are many incinerators and/or Low Temperature Thermal Disorption (LTTD) facilities permitted in Southern California and the transportation costs for off-site Thermal treatment are very cost-effective. For sites across the United States that are within a reasonable distance from licensed Thermal treatment units such as those in California, this alternative can be a cost-effective, quick remedial alternative.

Excavation and Off-Site Disposal. This is the quickest remedial alternative and is routinely accepted by the regulatory community. It is also the most expensive. Even with disposal at a Class II facility licensed in California to accept soil with petroleum hydrocarbons, the costs can be prohibitively expensive. Our experience has been that the total cost of this alternative typically is \$300 to \$350 per cubic yard.

Excavate and On-Site Land farming. This alternative involves the excavation and spreading of the oily soil in lifts of 1 to 2 foot thickness, the addition of nutrients to enhance microbial activity (to degrade the petroleum hydrocarbons into carbon dioxide, water and residual low levels of petroleum hydrocarbons), and the periodic disking or turning of the soil. It is a proven technology and is accepted within the regulatory community. The costs are low to moderate and the treatment program is likely to take 1 to 2 years to complete and obtain regulatory acceptance of completion.

Excavation and On-Site Bioremediation. This alternative involves the excavation of the oily soil and placement in a lined excavation (either completely or partially below ground). At the base of the excavation, a fabric or soil liner would be placed above which a french drain or other collection system would be placed. The oily soil is placed above the drain system and a sprinkler system is installed at the top of the soil to be treated (or within it) and nutrients are added to the soil via the sprinkler system. The nutrients are added to enhance the biodegradation process as discussed previously. Depending on the volume of oily soil present and the available area, several acres can be required to implement this alternative and at least two years to conduct the bioremediation process. The cost is typically moderate ($40 to $70/cubic yard) and the technology is established to treat many tens of thousands of cubic yards of oily soil.

Remove and Treat by Air Stripping, Activated Carbon, Separator. Most of the remedial alternatives discussed elsewhere in this section are related to the remediation of petroleum hydrocarbons in soil. This subsection briefly summarizes what is a complete topic in its own right–groundwater remediation. In oil fields groundwater remediation typically involves the:

- Removal of free product on the ground-water zone; and
- Extraction of groundwater with dissolved petroleum hydrocarbons and constituents (BTXE) and in some cases other VOCs such as TCE, PCE, etc.

Free Product Removal. The remediation of free product from the water zone is straightforward in concept but is often difficult in practice. Free-product recovery can be done simply by use of a bailer to remove product on a periodic basis. This is a labor intensive method (unless a mechanical bailer system is used) that is often used where there is a small amount of free product, the thickness of free product is small, recharge of petroleum products into the well is slow and/or there is concern about capital expenditures. The method is not often used in oil-fields; however, where it is used, the method removes relatively small amount volumes of petroleum products over relatively long periods of time.

Where an increased rate of free-product recovery is desired (or required) one of two types of pumping schemes typically are used. One type does not draw down the groundwater zone during product recovery (or draws it down to a very limited degree); the other type draws down the groundwater zone creating a cone of depression with the intent to increase the rate of petroleum product migration into the recovery well.

Dissolved Petroleum Hydrocarbons and Constituent Removal. Removal of petroleum hydrocarbons and related constituents (BTXE) as well as other VOCs (TCE, PCE, etc.) is typically accomplished in one or more wells by means of a submersible pump. These pumps are normally compressed air- or electric-driven. In addition to the factors cited above, this groundwater remediation technique involves consideration of methodologies designed to remove the dissolved constituents. These methodologies typically include activated carbon, air stripping, ultraviolet light with hydrogen peroxide and bioremediation.

In-Situ Vitrification (ISV). This alternative is still in the development phase and is not in widespread use in California but is considered to be potentially significant in its application to degraded soils. In-situ vitrification (ISV) is a thermal treatment process that converts degraded soil into a chemically inert and stable glass and crystalline product. Through an electrical potential applied using electrodes in the soil, an expanding area of soil is heated to as high as 3600° F which is above the melting point of soil and produces molten soil. The molten soil is electrically-conductive which causes an expansion of the heated zone. As this area grows, nonvolatile elements are encased or vitrified and the organic components are destroyed by pyrolysis. The pyrolysis products migrate to the surface of the vitrified area and are combusted in the presence of oxygen. The combustion off-gases are collected by a hood placed over the processing area and drawn into an off-gas treatment system.

WHO HAS TO PAY FOR CLEANING UP CONTAMINATION IN OLD OIL FIELDS?

This section is based on the law of California. For those interested in other jurisdictions an excellent state by state survey covering the law of oil field restoration in most of the oil producing states in the United States is "*Restoration of Oil Field Sites*," Berry St. John and Craig Wyman, Editors (American Bar Association Section of national Resources Energy and Environmental Law, 1999).

Cleanup work at the time of abandoning oil operations on any particular property normally will be paid for, in the first instance, by the then current oil and gas operator. Cleanup work, if any, required at some later time normally will be paid for, in the first instance, by the then current owner. This will usually, but not always, occur when the property is being developed for some more intensive use. A variation on this general theme occurs in California when the State agency charged with regulating oil and gas operations, the State Division of Oil, Gas and Geothermal Resources (commonly referred to as the "DOGGR"), exercises its authority under Public Resources Code Section 3208.1 to order the re-abandonment of a previously abandoned well if it finds that the future construction of any structure over or in the proximity of the well could result in a hazard. If the well was not properly abandoned in the first place, the statute places the responsibility for re-abandonment on the last operator of that well. If the well was properly abandoned in the first place (in accordance with then existing regulations), the statute places the responsibility for re-abandonment upon the current property owner.

Having undertaken cleanup, abandonment or re-abandoned work, the party doing so can be expected to investigate the possibility of passing some or all of those costs onto someone else. The abandoning operator or the landowner, has several options in this regard. If an operator has had to remedy environmental problems caused by a previous operator, his cost recovery claim will probably be based on negligence, breach of warranty of good oil field practice and/or fraudulent concealment.

His negligence theory would be based on the previous operator's failure to follow good oil field practice. For instance, failure to conform to industry standards as they existed at the time the previous operator acted or failed to act might constitute negligence and a failure to comply with applicable environmental regulations could be negligence *per se*. The statute of limitations for negligent injury to real property in California is three years, and the claim usually accrues upon the injured party's discovery of the injury to the property and its cause. His breach of warranty theory would also be based upon the previous operator's failure to follow good oil field practice assuming that the current operator obtained from the former operator a warranty that the former followed good oil field practice.

His fraud theory would be based on the argument that the selling operator knew of problems in the field and that he failed to disclose them to the purchasing operator. The law in California, as well as various other states, does not require an active misrepresentation. Simply failing to disclose that which is known to be material with intent to deceive is a fraud. *Lingsch v. Savage* (1963) 213 Cal.App.2d 729.

Another cost recovery possibility exists for the operator, if the oil property in question was operated under a joint operating agreement or a unit agreement. Typically those agreements require all of the interested parties to share in operating expenses in proportion to their interests in production unless the particular operating expense in question was caused by the operator's gross negligence.

Similarly the landowner who is required to cleanup after someone else's oil operation will have several possible avenues of recovery. Like the operator who pursues a previous operator, he will probably assert negligence and negligence *per se* theories. He will also probably use a continuing nuisance and trespass theory.

A lessee's use of the leased property in excess of the rights granted by the oil and gas lease (for example, leaving unauthorized contamination on the property) can be a nuisance and a trespass if the lessee's excess use of the leased land was intentional, reckless, or ultrahazardous. In a number of recent California appellate court decisions, owners of contaminated property have successfully stated claims for continuing nuisance or continuing trespass and have therefore avoided the three years statute of limitations. Those cases include *Capogeannis v. Superior Court*, 12 Cal.App.4th 688 (1993); *Wilshire Westwood Associates v. Atlantic Richfield Co.*, 20 Cal.App.4th 722 (1993); and *Newhall land & Fanning Co. v. Superior Court*, 19 Cal.App.4th 334 (1993). The theory underlying each of these decisions is that soil contamination may create a continuing tort (either trespass or nuisance) if it can be reasonably abated (that is, cleaned up), and if its impact could theoretically vary over time (that is, migrate or spread deeper into the soil or groundwater).

In April of 1996, however, the California Supreme Court issued its opinion in *Manginiv. Aerojet General Corp.*, 12 Cal.4th 1087 (1966).[1] Although the Supreme Court did not overturn the lower courts' opinions in the *Capogeannis, Wilshire Westwood*, and *Newhall land* cases, the Supreme Court did make it clear that a plaintiff seeking to prove continuing nuisance or trespass, and thereby avoid the three-year statute of limitations, must "present substantial evidence that the contaminated condition is one that is both

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[1] The Supreme Court's opinion in *Mangini* was the third published appellate court opinion in the case. *See also Mangini v. Aerojet General*, 230 Cal.App.3d 1125 (1991); and *Mangini v. Aerojet General Corp.*, 31 Cal.App.4th 688 (1994).

subject to remediation (or cleanup) and that the cost of cleanup is 'reasonable.'"[2] If the plaintiff cannot prove both of these elements, the nuisance or trespass is "permanent" rather than "continuing," and the three-year limitations period accrues when the plaintiff knew or should have known of the contamination.

Although the California Supreme Court in *Mangini* did not fully define the term "reasonable" in this context, it did indicate that the plaintiff must prove at least a reasonable estimate of the cleanup costs.[3] The court also indicated that "practicality," "fairness," and "cost" were relevant factors and concluded that "'abatable' means that the nuisance can be remediated at a reasonable cost by reasonable means."[4] In *Santa Fe Partnership v. ARCO Products Co*., 46 Cal.App.4th 967 (1966), the court of appeal held that so-called "stigma" damages are unavailable in an action for continuing nuisance. Such damages are available in an action for permanent nuisance.

It should be noted that a plaintiff seeking to prove nuisance or trespass in California must also prove that the defendant's conduct was either ultrahazardous, reckless, or negligent.[5]

The current landowner will also usually have the advantage of whatever cleanup obligations are spelled out in the original oil and gas lease under which the operator was producing oil and gas. There are two particularly significant issues raised by an action for breach of the cleanup provisions in an oil and gas lease. First, many of the leases covering oil fields currently being converted to other uses were drafted many years ago and the

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[2] 12 Cal.4th at 1090.

[3] 12 Cal.4th at 1099.

[4] 12 Cal.4th at 1100-03.

[5] *Wilson v. Interlake Steel Co*., 32 Cal.3d 229, 233 (1982) (trespass); *Tint v. Sanborn*, 211 Cal.App.3d 1225, 1228 (1989) (nuisance).

cleanup requirements contained in those leases do not reflect current regulations, industry practice, and prevailing concerns about soil contamination. Does the lease incorporate the recent regulatory standards, thus increasing the lessee's obligations, or is the lessor responsible for any required cleanup not covered by the specific provisions in the lease? We know of no reported cases deciding this issue although two unreported cases have suggested the language of the lease controls.

Second, California law on the accrual of a breach of lease claim may be changing. The older rule is that the breach of lease claim accrues upon breach (i.e., upon quitclaim), regardless of whether the lessor is aware of the breach. However, the trend in California appears to be toward a "discovery accrual" rule, and there is at least one reported decision in which such a rule has been applied when a commercial contract was breached secretly and the breach was not reasonably discoverable by the plaintiff.[6] This issue is potentially significant in the oil and gas lease context because contamination left on a property at the time of the quitclaim is often below the surface and difficult or impossible to detect upon visual inspection.

Perhaps more important than all his possible legal theories, the landowner will have one very powerful weapon: the great majority of judges and jurors were told over and over again by their mothers as they grew up, "If you made the mess, you clean it up!" Very few judges or juries fail to reach results that they truly feel are just!

CONCLUSION

It is the authors' view that the danger from contamination in old oil fields is greatly overstated. Oil field contamination can be, and has been, remediated and it can be, and

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6 *April Enterprises, Inc. v. KTTV*, 147 Cal.App.3d (1983).

has been, done in a cost effective manner. There is no reason why old oil field sites cannot be made safe for commercial and residential development.

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