SOIL AND GROUNDWATER REMEDIATION

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 REVISED NOV. 12, 2012

BACKGROUND:

REMOVING CONTAMINANTS FROM SOIL AND GROUNDWATER

SOIL AND GROUNDWATER REMEDIATION DEALS WITH THE REMOVAL OF CONTAMINANTS FROM IMPACTED MEDIA, SUCH AS SOIL AND/OR GROUNDWATER, FOR REGULATORY COMPLIANCE, THE GENERAL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT, SITE RECLAMATION, AND/OR LIABILITY REDUCTION. REMEDIATION IS GENERALLY REQUIRED BY AND SUBJECT TO AN ARRAY OF STATUTORY REGULATORY REQUIREMENTS AND CLEANUP CONCENTRATION STANDARDS. WHERE NO LEGISLATED STANDARDS OF "CLEAN" EXIST, OR STANDARDS ARE ADVISORY ONLY, REMEDIATION IS USUALLY BASED ON ASSESSMENTS OF HUMAN HEALTH AND ECOLOGICAL RISKS.

OUR SERVICES AND APPROACH:

IMPLEMENTING REMEDIATION TECHNOLOGIES

Remediation technologies are many and varied but can be categorized into ex situ and in situ methods. Ex situ methods involve excavation of affected soils and either second-site disposal and/or subsequent treatment at the surface. In situ methods seek to treat the impact without removing it from its in-ground setting. Sage has extensive experience with defining, planning, negotiating, implementation, monitoring, and reporting multimedia remediation, and has used many different technologies, as described below.

EXCAVATION OR DREDGING

Excavation processes can be as simple as hauling the contaminated soil to a regulated landfill, but can also involve removing the soil, treating it at the surface, and then replacing it in the ground. Recent advances in bioaugmentation, biostimulation, ultraviolet exposure, and surfactant co-mixing of the excavated material have also proven to be highly effective onsite treatments.

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If impacted runoff or groundwater affects fresh or marine surface water, then dredging of sediments may be required. Recently, ex situ chemical oxidation has also been used to remediate contaminated soil. This process involves excavating the contaminated area into large bermed areas, where they are treated using chemical oxidation methods. Sage personnel have planned, negotiated, and implemented numerous remediation programs using these technologies.

SURFACTANT ENHANCED AQUIFER REMEDIATION (SEAR)

Also known as Solubilization Recovery, the Surfactant Enhanced Aquifer Remediation (SEAR) process involves the injection of mitigation agents or specialty surfactants into the subsurface to enhance desorption and recovery of bound up otherwise recalcitrant contaminants (most common example: non-aqueous phase liquids or NAPLs).

In hydrogeologic settings that allow delivery and dispersion of mitigation agents or specialty surfactants, this approach provides a cost-effective and permanent solution to sites that may have been previously unsuccessful using other remedial approaches, such as pump and treat. This technology is also successful when used as the initial step in a multi-faceted remedial program involving SEAR followed by in situ oxidation, bioremediation enhancement, or soil vapor extraction (SVE). Sage personnel have planned, negotiated, and implemented numerous remediation programs using the SEAR technology.

PUMP AND TREAT

Pump and treat involves pumping out contaminated groundwater with the use of a submersible vacuum or other type of production pump, and then either disposing of or treating the extracted groundwater. If the groundwater is treated to acceptable levels, it can be discharged, re-injected back into the aquifer (often preferred if plume control is required), or used as industrial make-up water.

Common treatments include chemical reagents, such as flocculants followed by sand filters or, in the case of volatile organics, air stripping. For most biodegradable materials like BTEX, MTBE and most hydrocarbons, bioreactors can be used to clean the contaminated water to non-detectable levels. With fluidized bed bioreactors it is possible to achieve very low discharge concentrations that will meet or exceed discharge standards for most pollutants.

Depending on geology and soil type, pump and treat may be a good method to quickly reduce high concentrations of pollutants. It is more difficult to reach sufficiently low concentrations to satisfy remediation standards with this technology, however, due to the equilibrium of absorption (chemistry)/desorption processes in the soil. Sage has planned, designed, negotiated, and implemented numerous pump and treat remediation programs using direct disposal or water reclamation and re-use.

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SOLIDIFICATION AND STABILIZATION (S/S)

Solidification/stabilization (S/S) requires exacting application to a specific and well-defined impact. There are serious deficiencies related to durability of solutions and potential long-term effects. In addition, CO2 emissions due to the use of cement in solidification are becoming a major obstacle to its widespread use in S/S projects.

S/S is a remediation/treatment technology that relies on the reaction between a binder and soil to stop/prevent or reduce the mobility of contaminants.

- Solidification involves the addition of reagents to an impacted material to impart physical/dimensional stability to contain contaminants and render them non-leachable in a solid product, thus reducing access by external agents (e.g. air, rainfall).
- Stabilization involves the addition of reagents to an impacted material (e.g., soil or sludge) to produce more chemically stable constituents.

Conventional S/S is an established remediation technology for impacted soils and a treatment technology for hazardous wastes in many countries in the world. However, the uptake of S/S technologies has been relatively modest, as there are a number of barriers, including the following:

- Relatively low cost and widespread use of disposal to landfill
- Uncertainty over the durability and rate of contaminant release from S/S-treated material
- Experiences of past poor practice in the application of cement stabilization processes used in waste disposal in the 1980s and 1990s
- Residual liability associated with immobilized contaminants remaining onsite, rather than their removal or destruction

IN SITU OXIDATION

In situ oxidation technologies are used for remediation of a wide range of soil and groundwater contaminants that can be mitigated in an aerobic environment. Remediation by chemical oxidation involves the injection of strong oxidants, such as hydrogen peroxide, ozone gas, potassium permanganate or persulfates, oxygen gas or, in some rare cases, ambient air. The introduction of an oxygen-rich environment provides abundant nutrients for naturally occurring aerobic bacteria, which accelerate the attenuation of organic contaminants.

One disadvantage of this approach is if the soil or aquifer matrix material is predominantly reducing and the natural microbial community is dominated by anaerobic transformation, the introduction of an oxygen-rich environment will rapidly decrease all anaerobic attenuation. Before use, it is important to have an understanding of the ongoing attenuation processes. Aerobic attenuation is much faster and the decline rate is much faster than anaerobic attenuation.

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The injection of gases into the groundwater may also cause contamination to spread faster than normal depending on the site's hydrogeology. An understanding of the plume area hydrogeology is essential to promote effective injection dispersion without promoting plume growth. The pattern of the injection points can be used to mitigate these negative effects while effectively providing adequate microbial nutrients prior to exposure at area receptors.
Migration of metal contaminants must also be considered whenever modifying subsurface oxidation-reduction potential. Certain metals are more soluble in oxidizing environments, while others are more mobile in reducing environments.

Sage designs, negotiates, and implements in situ oxidation programs to effectively enhance the natural bioattenuation of aquifers.

SOIL VAPOR EXTRACTION (SVE)/MULTI-PHASE EXTRACTION (MPE)

Soil vapor extraction (SVE) is an effective remediation technology for soil.
Multi-phase extraction (MPE) is also an effective remediation technology when soil and groundwater are remediated coincidentally. SVE and MPE use different technologies to treat the off-gas volatile organic compounds (VOCs) generated after vacuum removal of air and vapors (and VOCs) from the subsurface and include granular activated carbon (most commonly used historically), thermal and/or catalytic oxidation, and vapor condensation. Generally, carbon is used for low (<500ppmV) VOC concentration vapor streams, oxidation is used for moderate (up to 4,000 ppmV) VOC concentration streams, and vapor condensation is used for high (>4,000 ppmV) VOC concentration vapor streams.

GRANULAR ACTIVATED CARBON (GAC)

Granular activated carbon (GAC) is used as a filter for air or water. This is commonly used to filter tap water in household sinks. GAC is a highly porous adsorbent material, produced by heating organic matter (e.g., coal, wood and coconut shell) in the absence of air, which is then crushed into granules. Activated carbon is positively charged and, therefore, able to remove negative ions (e.g., ions, ozone, chlorine, fluorides and dissolved organic solutes) from the water by adsorption onto the activated carbon.
The activated carbon must be replaced periodically, as it may become saturated and unable to adsorb (i.e., reduced absorption efficiency with loading). Activated carbon is not effective in removing heavy metals. Sage has designed and implement several GAC-based SVE projects throughout the U.S. and internationally.

THERMAL OXIDATION

Thermal oxidation (or incineration) can also be an effective remediation technology.
This approach is somewhat controversial because of the risks of dioxins released in the atmosphere through the exhaust gases or effluent off-gas. Controlled, high-temperature incineration with filtering of exhaust gases, however, should not pose any risks.

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Two different technologies can be employed to oxidize the contaminants of an extracted vapor stream. The selection of either thermal or catalytic depends on the type and concentration in parts per million by volume of constituent in the vapor stream. Thermal oxidation is more useful for higher concentration (~4,000 ppmV) influent vapor streams (which require less natural gas usage) than catalytic oxidation at ~2,000 ppmV. Thermal oxidation uses a system that acts as a furnace and maintains temperatures ranging from 1,350 to 1,500 °F (732 to 816 °C). Catalytic oxidation uses a catalyst on a support to facilitate a lower temperature oxidation. This system usually maintains temperatures ranging from 600 to 800 °F (316 to 427 °C). Sage has designed, implemented, and managed numerous thermal oxidation remediations throughout the U.S.

VAPOR CONDENSATION

Vapor condensation is the most effective off-gas treatment technology for high (>4,000 ppmV) VOC concentration vapor streams. The process involves cryogenically cooling the vapor stream to below 40 °C, such that the VOCs condensate out of the vapor stream and into liquid form where it is collected in steel containers. The liquid form of the VOCs is referred to as dense non-aqueous phase liquids (DNAPL) when the source of the liquid consists predominantly of solvents or light non-aqueous phase liquids (LNAPL) when the source of the liquid consists predominantly of petroleum or fuel products. This recovered chemical can be reused or recycled in a more environmentally sustainable or green manner than the alternatives described above. This technology is also known as cryogenic cooling and compression (C3-Technology).

BIOREMEDIATION

Treating environmental problems through biological means is known as bioremediation. The specific use of plants is known as phytoremediation. Bioremediation is sometimes used in conjunction with a pump-and-treat system. In bioremediation, either naturally occurring or specially bred bacteria are used to consume contaminants from either in situ or extracted groundwater. Extracted groundwater treatment is sometimes referred to as a bio-gac system. In most extracted water systems, the groundwater is recycled to allow for continuously flowing water and enhanced bacteria population growth. Like a wastewater biotreater, continuous monitoring must be performed to ensure that any radical change in the groundwater chemistry (such as sudden pH or contaminant concentration) does not kill the bacteria. Sage has designed and implemented numerous in situ bioremediation programs throughout the U.S. Although not specific to extracted ground, Sage also has experience with wastewater biotreaters utilized as part of extracted groundwater treatment.

DUAL-PHASE EXTRACTION

Dual-phase extraction uses an SVE system that produces a high vacuum, resulting in the extraction of both contaminated vapors as well as a limited amount of contaminated

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groundwater. These systems are most efficient when remediating light-end hydrocarbons such as gasoline and other fuels. At depths below 25-feet, this method is somewhat inefficient due to the large amount of energy required from pulling water by vacuum compared to pushing water with a submersible pump.

MYCOREMEDIATION/MYCOFILTRATION

Mycoremediation is a form of bioremediation, but the process uses fungi instead of microbes for contaminant reduction in an environment setting. This type of bioremediation has had very favorable results in treating surface soils but less success at treating impacted water. The key to mycoremediation is determining the right fungal species to target a specific pollutant. Certain strains have also been reported to successfully degrade the nerve gasses VX and sarin. Mycofiltration is a very similar process, using mycelial mats to filter toxic waste and microorganisms from polluted water.

SUMMARY:

REMEDIATION TECHNOLOGIES

The soil and groundwater remediation system chosen for a particular application depends on various factors, such as chemical contaminant and concentrations, geology type, depth to groundwater, volume of contamination, and various other factors that must be considered. Sage performs all stages of remediation programs, from planning to final “no further action” determination. Our experience includes many different types of remediation technologies that have successfully remediated different contaminants from oil and gas and industrial processes.