1. DETERMINE THE LEVEL OF CONTAMINATION

For contaminant plumes of ½ acre or less, five (5) borings should be completed and groundwater and soil samples (below the water table – upper 1 foot of the saturated zone) collected. One boring should be located at the upgradient (based on groundwater flow direction) edge of the contaminant plume, one from the down gradient edge, and three across the center of the plume (perpendicular to the direction of groundwater flow).

These five groundwater and soil samples should be tested for Total Petroleum Hydrocarbons (TPH), as well as Chemical Oxygen Demand (COD). But if the plume is greater than ½ acre, then one additional boring (for a soil and groundwater sample) should be collected for each additional ½ acre. Additional samples can be located based on the plume shape, dimensions and location of previous borings which will characterize the contaminate levels in the plume.

LIMITING FACTORS

Free Product – Must not be present on the groundwater at amounts greater than a sheen. Chemical oxidation will not be an effective method to remediate the site.

pH – The upper foot of the groundwater surface should be tested. In most cases the pH should be between 6 and 8. If not, then the designer must address what impact the pH will have on the oxidation process.

Soil Porosity – A soil sample from the contaminated zone must be collected and tested for soil porosity. Porosity is a measure of the void space between soil particles, and is used to estimate the volume of dissolved contaminants in the saturated zone.

2. MASS OF CONTAMINANTS

Using the information obtained from the borings, find an average concentration of contaminants in the soil and groundwater. The higher level of either TPH or COD should be used to find this average.

The amount of oxygen required to remediate the site must satisfy the oxygen demand of all oxygen users (COD) found in the borings not just the petroleum constituents (TPH). In most cases the TPH will be about the same as the COD values at a leaking UST site.

Once you have the average concentration in the soil and groundwater, you can calculate the mass of contaminants to be treated. Although a portion of the contaminants adsorbed to the soil will not dissolve into the groundwater, we use the average amount in the soil to be conservative (factor of safety).

You should find the mass of contaminants in the soil samples are greater than those found in the groundwater samples. You then calculate the mass of contaminants requiring remediation. The following example demonstrates how to calculate this amount:

\[
\text{Highest average concentration (TPH or COD)} = 10 \text{ ppm} \\
\text{Volume of contaminated mass (plume)} = 1,000 \text{ cy} \\
\text{(Assume a saturated clay weighs } 118\text{#/cf (3,186#/cy) and sand weighs } 124\text{#/cf (3,348#/cy))} \\
\text{The total mass of contaminates is conservatively estimated to be:} \\
10/1E6 [3200#/cy X 1000 cy] = 32\#'s
\]
3. WHAT AMOUNTS OF OXYGEN ARE REQUIRED TO REMEDIATE THE COC?

Once you know the total mass of contaminants, you can calculate the amount of oxygen required. As a rule of thumb, 3 pounds of oxygen are required per pound of hydrocarbon.

You could calculate the stoichiometric amount of oxygen required for the exact amount of each contaminant and add them together to get the amount of oxygen required. As an example, how much oxygen is needed to degrade benzene?

\[ C_6H_6 + 7.5 \ O_2 = 6CO_2 + 3 \ H_2O \]

[Molecular weights: C = 12, H = 1 and O = 16]

\[ C_6H_6 \ [12\times6 + 1\times6] = 78 \]
\[ 7.5 \ O_2 \ [7.5 \times (16\times2)] = 240 \]

Therefore, it would take 240 pounds of oxygen to degrade 78 pounds of benzene, or 3.08 (240/78) pounds of oxygen per pound of benzene.

Let’s assume 3 pounds of O₂ required per pound of contaminant (TPH or COD). So, if 32# of contaminants required remediation, this would need 96# (32# X 3 #O₂/#) of oxygen.

4. HOW MUCH PRODUCT IS REQUIRED?

The percent (%) oxygen by weight in the product and an estimate of how much will actually be released for chemical oxidation must be provided.

Manufacturers provide the amount of oxygen contained in their product. Normally this information is provided in a ### ratio. For example, if a manufacturer claims the product contains 10% oxygen by weight, the product will have 1 pound of oxygen available for every 10 pounds of product.

The difficult part is estimating how much of the actual oxygen content will be released during the process. If we use the calculated oxygen requirement of 96# from above, the amount of this product that will be required is 960#s (96#/10%), assuming all available oxygen is released.

A reasonable discussion of the amount of oxygen available in the product versus the amount released under field conditions is required of the designer. Since it is unlikely the total amount of oxygen available will be released, the Agency has allowed a 20% factor of safety in addition to the amount of product required. So if 960#s of a product is required this amount should be increased to 1152#s (960 #s X 1.2 (20%)).

Always ensure the products injected will not cause violations of the groundwater quality standards for constituents in the product. A thorough knowledge of the impurities and additives in a product and their potential impact on the groundwater is required of the designer.

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