

Meso-Scale Application of a Mixture of Nitrate/Phosphate and Oxygen Release Compound (ORC) to Remediate a Crude Oil Spill

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OUTLINE

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- ❖ **Site Characterization**
- ❖ **Technology Selection**
- ❖ **Description of Technology**
- ❖ **Field Application**
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- ❖ **Results**
- ❖ **Conclusions**



Introduction

- ❖ **Oil Spill, April 2009 – Southern California**
- ❖ **Oil Pipeline**
- ❖ **Approximately 19 barrels of oil spilled**
- ❖ **Steep slope in the hills of Southern California**
- ❖ **Emergency Response**
- ❖ **Agencies involved: EPA, RWQCB, USFW and CDFG involved**
 - ❖ **Initial sampling = 50,000 mg/kg of TPH in top 6-8”**
 - ❖ **Target soil cleanup goal of less than 1000 mg/kg TPH established by EPA**





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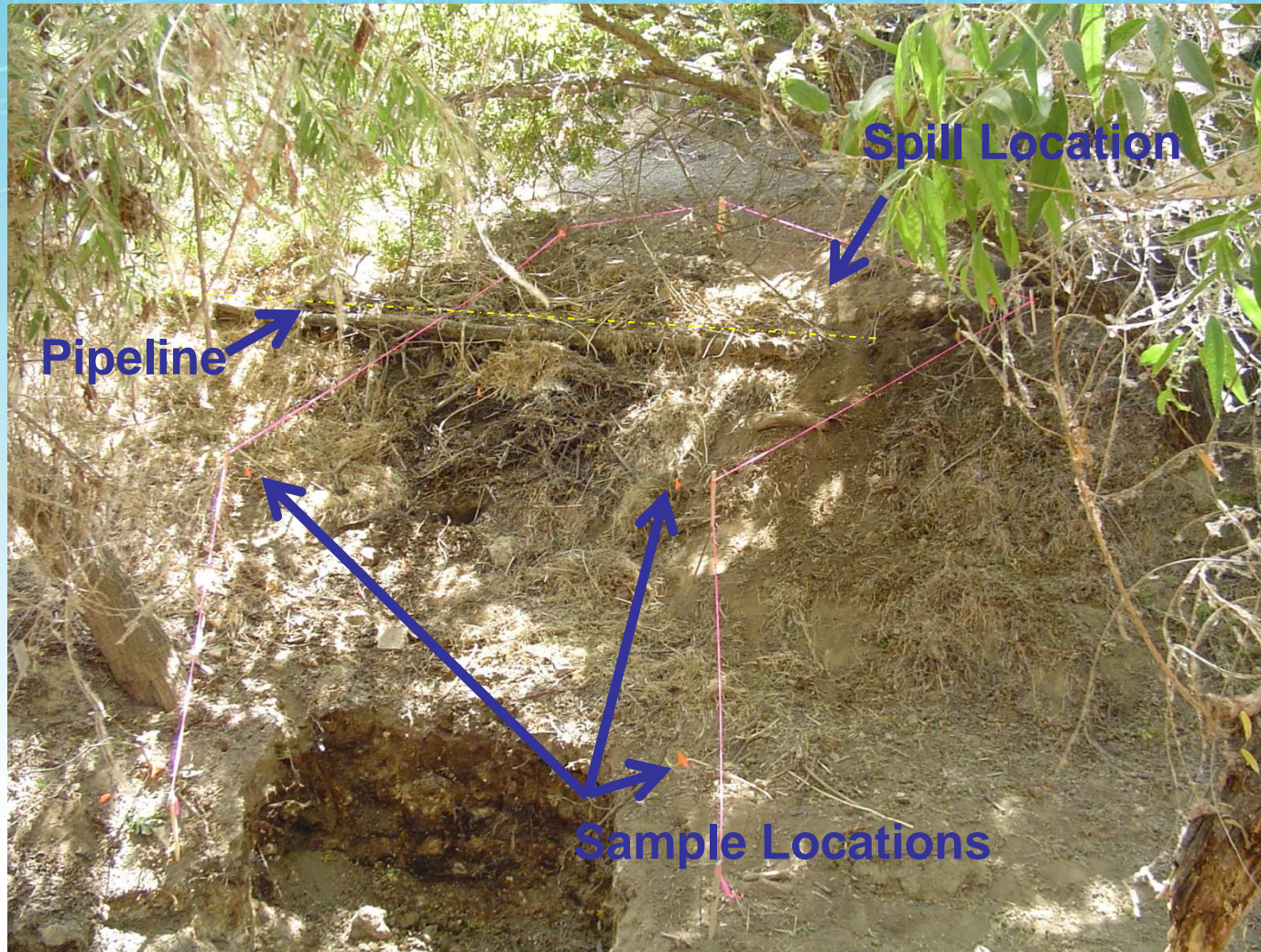
Site Characterization

Site Characterization

- ❖ **Delineation of Impacted Area**
 - ❖ Delineation by visual, olfactory and analytical cues
 - ❖ Samples are taken by stainless steel sleeves by hand
 - ❖ 10 Locations surrounding the impacted area to “confirm” the remediation boundary
 - ❖ Sample locations were plotted along with their respective concentrations
 - ❖ Remediation boundary defined by soil samples with concentration greater than 1000 mg/kg



Delineated Remediation Area and Sample Locations





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Technology Selection

Technology Selection

❖ Two technologies were evaluated:

1. Excavation:

- ❖ EPA and CDFG were concerned about slope stability and potential impacts to root systems of native walnut trees as well as adjacent creek
- ❖ No Waste Discharge Requirement Permit (WDR) needed
- ❖ Fast
- ❖ Outcome predictable



Technology Selection

2. In-Situ Bioremediation

- ❖ Low-impact remediation
- ❖ Application of nutrients and oxygenates requires WDR permit from California Regional Water Quality Control Board ->time&money
- ❖ Uncertainty regarding outcome



Technology Selection

- ❖ **Final Selection: Bioremediation was chosen**
 - ❖ Cleanup and Abatement Order issued by the EPA to override the need for a WDR permit and move the remediation forward
 - ❖ Protective of slope
 - ❖ Protective of native vegetation
 - ❖ Protective of creek (with appropriate precautions taken)
 - ❖ Eco-friendly





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Description of Technology

Description Of Technology

- ❖ **Objective: To utilize both anaerobic and aerobic pathways for maximum metabolization of hydrocarbons**
- ❖ **Conditions Required:**
 - ❖ Sufficient Oxygen supply
 - ❖ Sufficient Nitrate concentrations
 - ❖ A moist environment



Description Of Technology

IN-SITU BIOREMEDIATION

- ❖ Optimizes conditions for naturally occurring bacteria in topsoil to metabolize hydrocarbons
- ❖ A generic Hydrocarbon (C_xH_{2x+2}) can be metabolized by bacteria using Hydrogen ions in solution and Nitrates as a terminal electron acceptor:



DESCRIPTION OF TECHNOLOGY

Creating the Conditions for a Bacterial “Feast”

ORC + Nitrates/Phosphates + H₂O

- ❖ Oxygen Releasing Compound (ORC) can be applied to release Oxygen in-situ and create an oxygen-rich environment
- ❖ Nitrate/Phosphate fertilizer application provides the NO₃⁻ ion for an anaerobic reduction pathway
- ❖ Moist conditions are critical to maintain bacterial growth and metabolism



DESCRIPTION OF TECHNOLOGY

- ❖ **ORC and Nitrate/Phosphate Mixture:**
- ❖ **Bacteria Require 60:1:0.2 ratio of Carbon to Nitrogen to Phosphate**
- ❖ **Conservative estimate: 50000 mg/kg over 260 cu ft of soil = 1180 lbs of non-indigenous carbon in soil**
- ❖ **According to the ratio, 20 lbs Nitrogen, 4 lbs Phosphorous needed**
 - ❖ **50 lbs of 5:1 N:P fertilizer needed**
- ❖ **200 lbs ORC Advanced provides 40 lbs of Oxygen**
- ❖ **Work Plan Prepared in July 2009 and approved by EPA in early August 2009**





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Field Application of Technology

Field Application of Technology

- ❖ **Mobilization: August 2009**
- ❖ **The ORC/Nutrient Admix was mixed in a wheel barrow**



- ❖ **Health and Safety Concerns**
 - ❖ Level C and D



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Field Application of Technology

- ❖ The slurry was spread evenly over the treatment area
- ❖ Using hand mixers, admix was mixed 6-8 inches below ground



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Field Application of Technology

- ❖ A trench lined with Sphagnum Peat Moss was constructed at the base of the remediation area to catch and filter any contaminated runoff and sloughing soil
- A twice per week watering schedule was implemented, applying approximately 120 gallons per visit





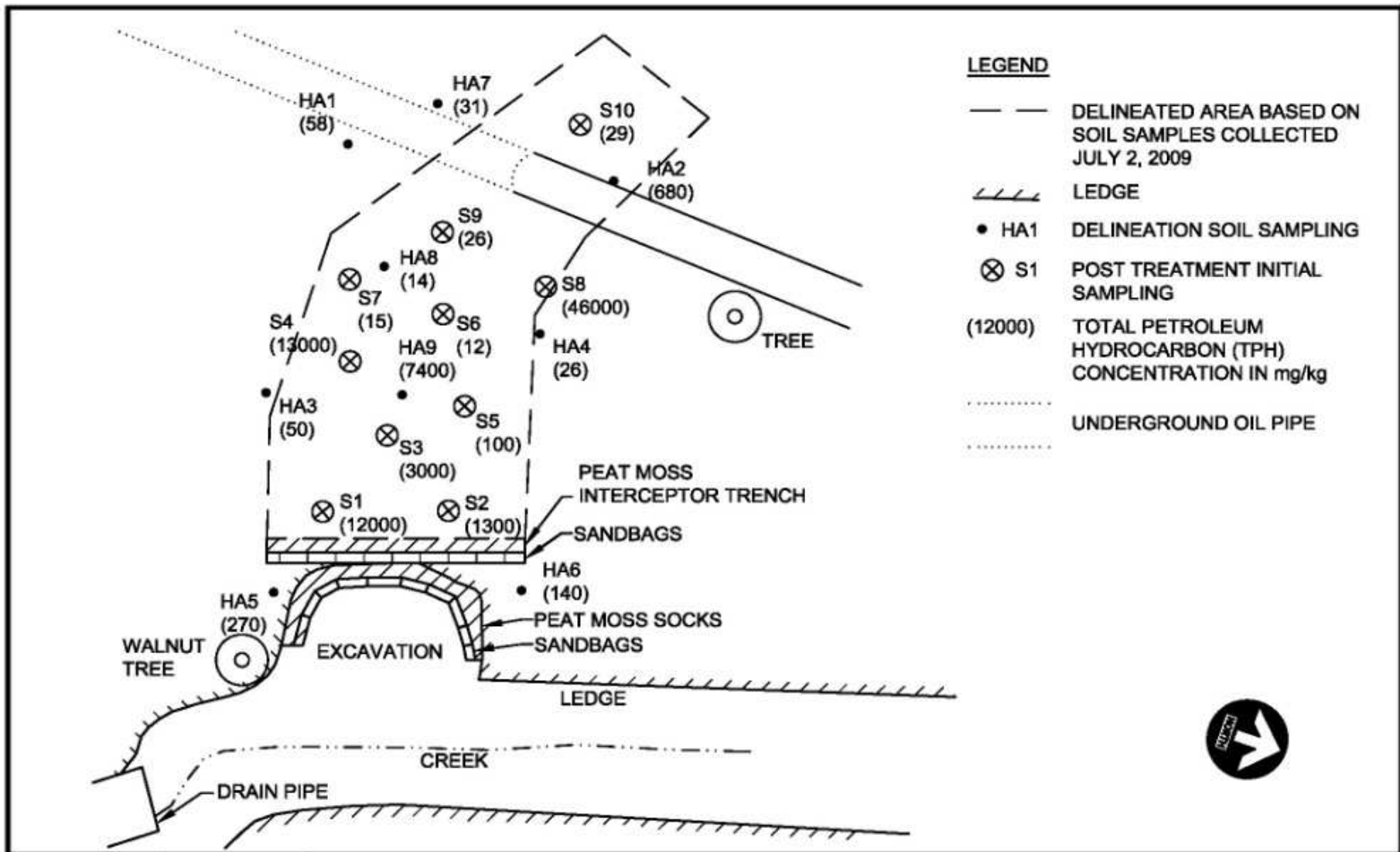
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Post-Application Sampling

Post Application Sampling

- ❖ Initial post-remediation sampling event consisted of using 2 inch steel sleeves to sample the top 6-8 inches of soil
- ❖ 10 evenly distributed points within the remediation area
- ❖ The 3 “hottest” points were chosen to track remediation progress
 - ❖ S1 12,000 mg/kg
 - ❖ S4 13,000 mg/kg
 - ❖ S8 46,000 mg/kg
- ❖ Cleanup goal is 1,000 mg/kg





DATE AUGUST 2009	PROJECT NUMBER 051378
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PROJECT
LOCATION



FIGURE
1



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Results

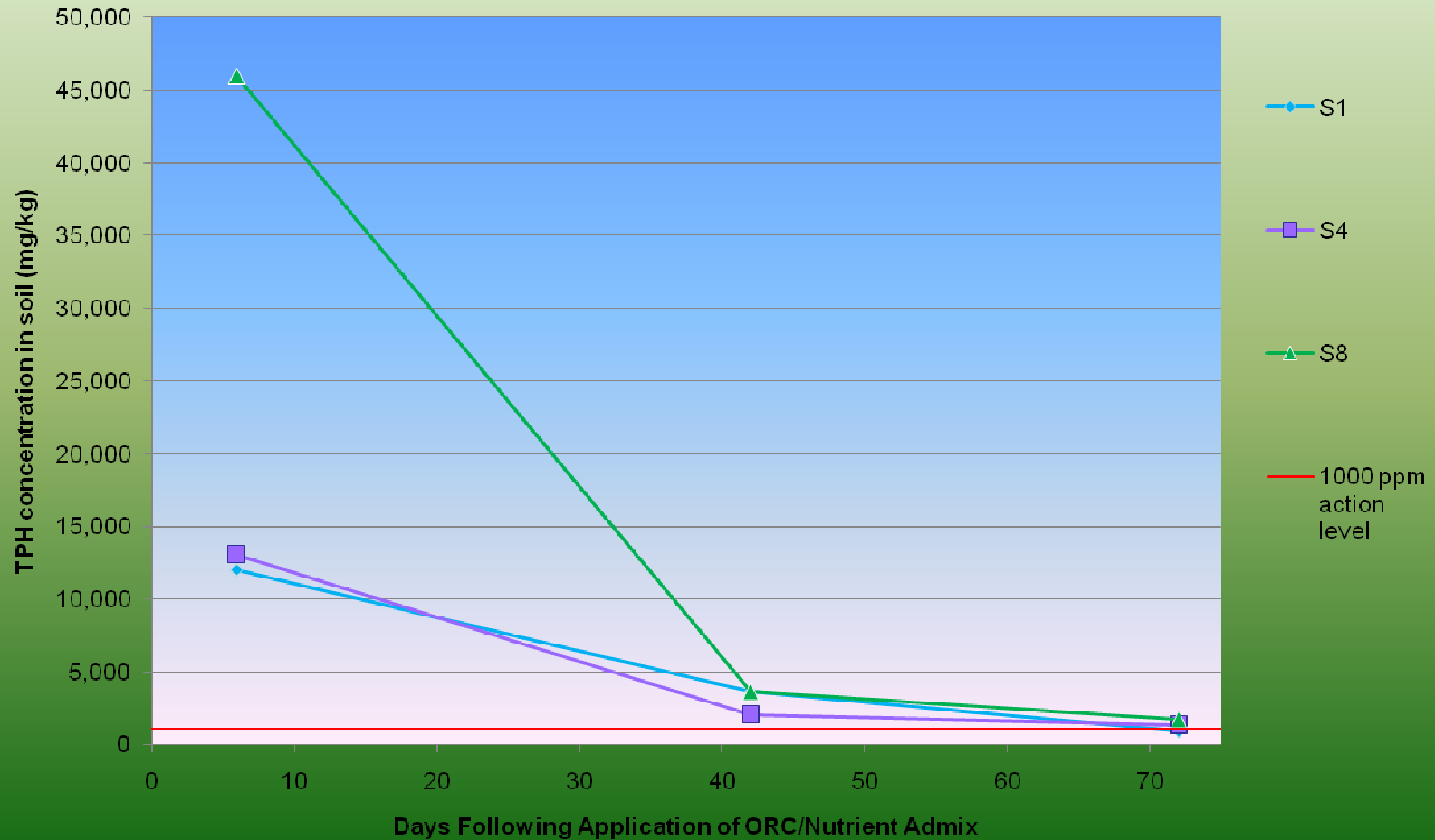
Results

- ❖ After the first month, soil samples collected from the 3 stations had decreased in TPH concentration by an average of 82%!!!
- ❖ The October results (second month) show an average decrease of 52% from September.
- ❖ One of the three sample locations already exhibits concentrations below cleanup goal.



Results

In-situ Remediation Progress



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Conclusions



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Conclusions

- ❖ **260 cubic feet of impacted soil will have taken 3 months using:**
 - ❖ 50 lbs Nitrate/Phosphate Fertilizer
 - ❖ 200 lbs Oxygen Release Compound
 - ❖ A consistently moist environment (100-150 gallons of water twice a week)
- ❖ **Bioremediation of high concentrations crude oil is possible with admix of ORC/nutrients**
- ❖ **Total Cost: \$ 33,000**
- ❖ **Cost per cubic yard: \$3,300**





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THANKS!

Ian Ziraldo, Gannett Fleming - Irvine

Arul Ayyaswami, Gannett Fleming - New Jersey

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