RegenOx® – PetroCleanze™ for ISCO:

1. Daniel Nunez, Regenesis
2. RegenOx® - PetroCleanze™ two part complex:
   1. Sodium percarbonate, sodium carbonate, sodium silicate and silica gel. (RegenOx Part A - Oxidizer Complex)
   2. Sodium silicate solution, sodium hydroxide, sodium tripoly-phosphate and ferrous sulfate (RegenOx® PetroCleanze™ - Activator Complex):
3. MSDS & Technical Data Sheet - Attached
4. Number of Field-scale Applications to date: 50+ sites
5. Case Studies – Attached
6. RegenOx® - PetroCleanze™ is a customized formulation of the widely used RegenOx in situ chemical oxidation technology. The primary function of RegenOx PetroCleanze is to increase the desorption rates of hydrocarbons bound in saturated soil and make them available for more efficient and rapid treatment using a range of enhanced recovery technologies. The RegenOx PetroCleanze formula is optimized to desorb bound hydrocarbon mass and drive it from the soil matrix into the aqueous phase. Once contaminants are moved into the dissolved phase, other methods such as enhanced recovery techniques such as dual-phase extraction, vacuum enhanced extraction, pump and treat systems can be used. In some cases where significant mass removal is required, multiple applications of RegenOx PetroCleanze may be necessary along with multiple extraction events. This product is safe to use around sensitive underground infrastructure with no negative health and safety adverse effects of corrosion of tooling or underground lines. This product has been approved on the general WDR permit
RegenOx® – PetroCleanze™
Material Safety Data Sheet (MSDS)

Last Revised: April 29, 2011

Section 1 – Supplier Information and Material Identification

Supplier:

REGENESIS
1011 Calle Sombra
San Clemente, CA 92673
Telephone: 949.366.8000
Fax: 949.366.8090
E-mail: info@regenesis.com

Chemical Description: A mixture of sodium silicate solution, sodium hydroxide, sodium tripoly-phosphate and ferrous sulfate.
Chemical Family: Inorganic Chemicals
Trade Name: RegenOx® PetroCleanze™ (Activator Complex)
Product Use: Used for environmental remediation of contaminated soils and groundwater.

Section 2 – Chemical Information/Other Designations

<table>
<thead>
<tr>
<th>CAS No.</th>
<th>Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td>1344-09-8</td>
<td>Silicic Acid, Sodium Salt, Sodium Silicate</td>
</tr>
<tr>
<td>7720-78-7</td>
<td>Ferrous Sulfate</td>
</tr>
<tr>
<td>1310-73-2</td>
<td>Sodium Hydroxide</td>
</tr>
<tr>
<td>7758-29-4</td>
<td>Sodium Tripolyphosphate</td>
</tr>
</tbody>
</table>

Section 3 – Physical Data

Form: Semi Viscous Liquid
Color: Dark Green to Black
Odor: Odorless
Melting Point: NA
Boiling Point: NA
Flammability/Flash Point: NA
Vapor Pressure: NA
Section 3 – Physical Data (cont)

Density: 1.1 – 1.3 g/cm³
Solubility: Miscible
pH (3% solution): 13

Section 4 – Hazards Identification

Corrosive: May cause burns. Harmful by inhalation, in contact with skin and if swallowed. Causes skin and eye irritation. Causes irritation to mouth, esophagus and stomach if swallowed. In case of accident or if you feel unwell, seek medical advice. In case of contact with eyes, rinse immediately with plenty of water and seek medical advice. After contact with skin, wash immediately with plenty of water. If swallowed, do not induce vomiting, give plenty of water. Never give anything by mouth to an unconscious person. Wear suitable protective clothing, gloves, eye/face protection. Spilled material is very slippery.

Section 5 – Reactivity Data

Stability: Stable under normal conditions
Conditions to Avoid: None.
Incompatibility: Avoid hydrogen fluoride, fluorine, oxygen difluoride, chlorine trifluoride, strong acids, strong bases, oxidizers, aluminum, fiberglass, copper, brass, zinc, and galvanized containers.

Section 6 – Protective Measures, Storage and Handling
Technical Protective Measures

Storage: Keep in a tightly closed container (steel or plastic) and store in a cool, well ventilated area away from all incompatible materials (acids, reactive metals, and ammonium salts). Store in a dry location away from heat above 60 degrees C and colder than 10 degrees C. Do not store in aluminum, fiberglass, copper, brass, zinc or galvanized containers.

Handling: Avoid contact with eyes, skin and clothing. Avoid breathing spray mist. Use with adequate ventilation. Do not use product if it is brownish-yellow in color.

Personal Protective Equipment (PPE)

Engineering Controls: General room ventilation is required if used indoors. Local exhaust ventilation, process enclosures or other engineering controls may be needed to maintain airborne levels below recommended exposure limits. Safety shower and eyewash station should be within direct access.

Respiratory Protection: Use NIOSH-approved dust and mist respirator where spray mist exists. Respirators should be used in accordance with 29 CFR 1910.134.

Hand Protection: Wear chemical resistant gloves.

Eye Protection: Wear chemical safety goggles. A full face shield may be worn in lieu of safety goggles.

Skin Protection: Try to avoid skin contact with this product. Gloves and protective clothing should be worn during use.

Other:

Protection Against Fire & Explosion: Product is non-explosive and non-combustible.
Spill or Leakage: Keep unnecessary personnel away; isolate hazard area and do not allow entrance into the affected area. Do not touch or walk through spilled material. Stop leak if possible without risking injury. Prevent runoff from entering into storm sewers and ditches that lead to natural waterways. Isolate the material if at all possible. Sand or earth may be used to contain the spill. If containment is not possible, nuetralize the contaminated area and flush with large quantities of water.

Extinguishing Media: Material is compatible with all extinguishing media. The following protective equipment for fire fighters is recommended when this material is present in the area of a fire: chemical googles, body-covering protective clothing, chemical resistant gloves and rubber boots.

First Aid: 
Eye Contact: Flush eyes with running water for at least 15 minutes with eyelids held open. Seek a medical specialist.

Inhalation: Remove affected person to fresh air. Give artifical respiration if individual is not Breathing. If breathing is difficult, give oxygen. Seek medical attention.

Ingestion: If the individual is conscious and not convulsing, give two-four cups of water to dilute the chemical and seek medical attention immediately. DO NOT induce vomiting. Seek medical attention.

Skin Contact: Wash affected areas with soap and a large amount of water. Remove contaminated clothing and shoes.

Section 8 – Accidental Release Measures

Personal Protection: Wear chemical goggles, body-covering protective clothing, chemical resistant gloves and rubber boots.

Environmental Hazards: Material sinks when mixed with water. High pH of this material is harmful to aquatic life. Only water will evaporate from a spill of this material.

Small Spill Cleanup: Mop and neutralize liquid and discharge to sewer in accordance with federal, state and local regulations.

Large Spill Cleanup: Keep unnecessary personnel away; isolate hazard area and do not allow entrance into the affected area. Do not touch or walk through spilled material. Stop leak if possible without risking injury. Prevent run off from entering into storm drains and ditches that lead to natural waterways. Isolate the material if at all possible. Sand or earth may be used to contain the spill. If containment is not possible, nuetralize the contaminated area and flush with large quantities of water.
flush with large quantities of water.

Section 9 – Information on Toxicology

Toxicity Data

**Sodium Silicate:** When tested for primary eye irritation potential according to OECD Guidelines, Section 405, a similar sodium silicate solution produced corneal, iridal and conjunctival irritation. Some eye irritation was still present 14 days after treatment, although the average primary irritation score has declined from 29.7 after 1 day to 4.0 after 14 days. When tested for primary skin irritation potential, a similar sodium silicate solution produced irritation with a primary irritation index of 3 to abraded skin and 0 to intact skin. Human experience confirms that irritation occurs when sodium silicates get on clothes at the collar, cuffs, or other areas where abrasion may exist.

The acute oral toxicity of this product has not been tested. In a study of rats fed sodium silicate in drinking water for three months, at 200, 600 and 1800 ppm, changes were reported in the blood chemistry of some animals, but no specific changes to the organs of the animals due to sodium silicate administration were observed in any of the dosage groups. Another study reported adverse effects to the kidneys of dogs fed sodium silicate in their diet at 2.4g/kg/day for 4 weeks, whereas rats fed the same dosage did not develop any treatment-related effects. Decreased numbers of births and survival to weaning was reported for rats fed sodium silicate in their drinking water at 600 and 1200 ppm.

**Ferrous Sulfate:** LD50 Oral (rat): 319 mg/kg; not a suspected carcinogen.

**Sodium Hydroxide:** Irritation data: skin, rabbit: 500 mg/24H severe; eye rabbit: 50 µg/24H severe. Investigated as a mutagen. Not a known carcinogen. No environmental toxicity found or determined.

**Sodium Tripolyphosphate:** Harmful if swallowed, inhaled or absorbed through skin. Causes severe irritation. Material is irritating to mucous membranes and upper respiratory tract. Symptoms of exposure may include burning sensation, coughing, wheezing, laryngitis, shortness of breath, headache, nausea and vomiting. To the best of our knowledge the chemical, physical and toxicological properties have not
been thoroughly investigated.

Section 10 – Information on Ecology

Ecotoxicological Information: Based on 100% solid sodium silicate, a 96 hour median tolerance for fish of 2,320 mg/l; a 96 hour median tolerance for water fleas of 247 mg/L; a 96 hour median tolerance for snail eggs of 632 mg/L; and a 96 hour median tolerance for Amphipoda of 160 mg/L.

Section 11 – Regulations

TSCA Inventory Listed: Yes
CERCLA Hazardous Substance (40 CFR Part 302)
Listed Substance: No
Unlisted substance: Yes
SARA Title III, Sections 302/303 (40 CFR Part 355)
Emergency Planning Notification
Extremely Hazardous Substance: No
SARA Title III, Sections 311/312 (40 CFR Part 370)
Community Right-to-Know
Acute: Yes Chronic: Yes
SARA Title III, Sections 313 (40 CFR Part 372) Toxic Chemical Release Reporting
Community Right-to-Know
Extremely Hazardous Substance: No

Section 12 – Disposal Considerations
Waste Disposal Method

Waste Treatment: Neutralize and landfill solids in an approved waste facility operated by an authorized contractor in compliance with local regulations.

Package Treatment: The empty and clean containers are to be recycled or disposed of in conformity with local regulations.

Section 13 – Shipping/Transport Information

USDOT: Hazard Class 8 Corrosive Substance

Proper Shipping Name: Corrosive liquid, basic, inorganic, n.o.s.

UN/NA: UN3266

Packing Group: PGIII

Section 14 – Other Information

HMIS Rating: Health 3, Flammability 0, Reactivity 1, Contact 1.

Label Hazard Warning: Danger! Corrosive. May be harmful if swallowed. Harmful in inhaled. Causes burns to any area of contact. Reacts with water, acids and other materials.

Section 15 – Further Information

The information contained in this document is the best available to the supplier at the time of writing, but is provided without warranty of any kind. Some possible hazards have been determined by analogy to similar classes of material. The items in this document are subject to change and clarification as more information become available. This document is intended only as a guide to the appropriate precautionary handling of the material by a properly trained person. Individuals receiving this information must exercise their independent judgment in determining its appropriateness for a particular purpose.
Section 1 – Supplier Information and Material Identification

Supplier:

REGENESIS
1011 Calle Sombra
San Clemente, CA. 92673
Telephone: 949.366.8000
Fax: 949.366.8090
E-mail: info@regenesis.com

Chemical Description: A mixture of sodium percarbonate [2Na₂CO₃·3H₂O₂], sodium carbonate [Na₂CO₃], sodium silicate and silica gel.

Chemical Family: Inorganic Chemicals

Trade Name: RegenOx® – Part A (Oxidizer Complex)

Product Use: Used to remediate contaminated soil and groundwater (environmental applications)

Section 2 – Chemical Information/Other Designations

<table>
<thead>
<tr>
<th>CAS No.</th>
<th>Chemical</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>15630-89-4</td>
<td>Sodium Percarbonate</td>
<td>60 -100 %</td>
</tr>
<tr>
<td>5968-11-6</td>
<td>Sodium Carbonate Monohydrate</td>
<td>10 – 30 %</td>
</tr>
<tr>
<td>7699-11-6</td>
<td>Silicic Acid</td>
<td>&lt; 1 %</td>
</tr>
<tr>
<td>63231-67-4</td>
<td>Silica Gel</td>
<td>&lt; 1 %</td>
</tr>
</tbody>
</table>

Section 3 – Physical Data

Form: Powder
Color: White
Odor: Odorless
Melting Point: NA
Boiling Point: NA
Section 3 – Physical Data (cont)

- **Flammability/Flash Point:** NA
- **Vapor Pressure:** NA
- **Bulk Density:** 0.9 – 1.2 g/cm³
- **Solubility:** Min 14.5g/100g water @ 20 °C
- **Viscosity:** NA
- **pH (3% solution):** ≈ 10.5
- **Decomposition Temperature:** Self-accelerating decomposition with oxygen release starts at 50 °C.

Section 4 – Reactivity Data

- **Stability:** Stable under normal conditions
- **Conditions to Avoid/Incompatibility:** Acids, bases, salts of heavy metals, reducing agents, and flammable substances
- **Hazardous Decomposition Products:** Oxygen. Contamination with many substances will cause decomposition. The rate of decomposition increases with increasing temperature and may be very vigorous with rapid generation of oxygen and steam.

Section 5 – Regulations

- **TSCA Inventory Listed:** Yes
- **CERCLA Hazardous Substance (40 CFR Part 302)**
  - **Listed Substance:** No
  - **Unlisted Substance:** Yes
- **SARA, Title III, Sections 313 (40 CFR Part 372) – Toxic Chemical Release Reporting:** Community Right-To-Know
  - **Extremely Hazardous Substance:** No
  - **WHMIS Classification:** C, D2B
  - **Canadian Domestic Substance List:** Appears
Section 6 – Protective Measures, Storage and Handling

Technical Protective Measures

Storage: Oxidizer. Store in a cool, well ventilated area away from all sources of ignition and out of the direct sunlight. Store in a dry location away from heat and in temperatures less than 40 ‘C.

Keep away from incompatible materials and keep lids tightly closed. Do not store in improperly labeled containers.

Protect from moisture. Do not store near combustible materials. Keep containers well sealed.

Store separately from reducing materials. Avoid contamination which may lead to decomposition.

Handling: Avoid contact with eyes, skin and clothing. Use with adequate ventilation.

Do not swallow. Avoid breathing vapors, mists or dust. Do not eat, drink or smoke in the work area.

Label containers and keep them tightly closed when not in use.

Wash hands thoroughly after handling.

Personal Protective Equipment (PPE)

Engineering Controls: General room ventilation is required if used indoors. Local exhaust ventilation, process enclosures or other engineering controls may be needed to maintain airborne levels below recommended exposure limits. Avoid creating dust or mists. Maintain adequate ventilation at all times. Do not use in confined areas. Keep levels below recommended exposure limits. To determine actual exposure limits, monitoring should be performed on a routine basis.

Respiratory Protection: For many conditions, no respiratory protection is necessary; however, in dusty or unknown conditions or when exposures exceed limit values a NIOSH approved respirator should be used.

Hand Protection: Wear chemical resistant gloves (neoprene, rubber, or PVC).
### Section 6 – Protective Measures, Storage and Handling (cont)

<table>
<thead>
<tr>
<th>Protection</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Eye Protection:</strong></td>
<td>Wear chemical safety goggles. A full face shield may be worn in lieu of safety goggles.</td>
</tr>
<tr>
<td><strong>Skin Protection:</strong></td>
<td>Try to avoid skin contact with this product. Chemical resistant gloves (neoprene, PVC or rubber) and protective clothing should be worn during use.</td>
</tr>
<tr>
<td><strong>Other:</strong></td>
<td>Eye wash station.</td>
</tr>
<tr>
<td><strong>Protection Against Fire &amp; Explosion:</strong></td>
<td>Product is non-explosive. In case of fire, evacuate all non-essential personnel, wear protective clothing and a self-contained breathing apparatus, stay upwind of fire, and use water to spray cool fire-exposed containers.</td>
</tr>
</tbody>
</table>

### Section 7 – Hazards Identification

**Potential Health Effects**

<table>
<thead>
<tr>
<th>Exposure</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Inhalation:</strong></td>
<td>Causes irritation to the respiratory tract. Symptoms may include coughing, shortness of breath, and irritations to mucous membranes, nose and throat.</td>
</tr>
<tr>
<td><strong>Eye Contact:</strong></td>
<td>Causes irritation, redness and pain.</td>
</tr>
<tr>
<td><strong>Skin Contact:</strong></td>
<td>Causes slight irritation.</td>
</tr>
<tr>
<td><strong>Ingestion:</strong></td>
<td>May be harmful if swallowed (vomiting and diarrhea).</td>
</tr>
</tbody>
</table>

### Section 8 – Measures in Case of Accidents and Fire

<table>
<thead>
<tr>
<th>Situation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>After Spillage/Leakage:</strong></td>
<td>Eliminate all ignition sources. Evacuate unprotected personnel and never exceed any occupational exposure limit. Shovel or sweep spilt material into plastic bags or vented containers for disposal. Do not return spilled or contaminated material to the inventory.</td>
</tr>
<tr>
<td><strong>Extinguishing Media:</strong></td>
<td>Water</td>
</tr>
<tr>
<td><strong>First Aid</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Eye Contact:</strong></td>
<td>Flush eyes with running water for at least 15 minutes with eyelids held open. Seek a specialist.</td>
</tr>
<tr>
<td><strong>Inhalation:</strong></td>
<td>Remove affected person to fresh air. Seek medical attention if the effects persist.</td>
</tr>
<tr>
<td><strong>Ingestion:</strong></td>
<td>If the individual is conscious and not convulsing, give two-four cups of water to dilute the chemical and seek medical attention immediately. <strong>Do Not</strong> induce vomiting.</td>
</tr>
</tbody>
</table>
Section 8 – Measures in Case of Accidents and Fire (cont)

**Skin Contact:** Wash affected areas with soap and a mild detergent and large amounts of water.

Section 9 – Accidental Release Measures

**Precautions:**

**Cleanup Methods:** Shovel or sweep spilt material into plastic bags or vented containers for disposal. Do not return spilled or contaminated material to the inventory.

Section 10 – Information on Toxicology

**Toxicity Data**

**LD50 Oral (rat):** 2,400 mg/kg

**LD50 Dermal (rabbit):** Min 2,000 mg/kg

**LD50 Inhalation (rat):** Min 4,580 mg/kg

Section 11 – Information on Ecology

**Ecology Data**

**Ecotoxicological Information:** NA

Section 12 – Disposal Considerations

**Waste Disposal Method**

**Waste Treatment:** Dispose of in an approved waste facility operated by an authorized contactor in compliance with local regulations.

**Package (Pail) Treatment:** The empty and clean containers are to be recycled or disposed of in conformity with local regulations.
Section 13 – Shipping/Transport Information

D.O.T. Shipping Name: Oxidizing Solid, N.O.S. [A mixture of sodium percarbonate [2Na₂CO₃·3H₂O₂], sodium carbonate [Na₂CO₃], sodium silicate and silica gel.]

UN Number: 1479

Hazard Class: 5.1

Labels: 5.1 (Oxidizer)

Packaging Group: III

Section 14 – Other Information

HMIS® Rating

<table>
<thead>
<tr>
<th>Health</th>
<th>Reactivity</th>
<th>Flammability</th>
<th>Lab PPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (slight)</td>
<td>1 (slight)</td>
<td>0 (none)</td>
<td>goggles, gloves, and lab coat</td>
</tr>
</tbody>
</table>

HMIS® is a registered trademark of the National Painting and Coating Association.

Section 15 – Further Information

The information contained in this document is the best available to the supplier at the time of writing, but is provided without warranty of any kind. Some possible hazards have been determined by analogy to similar classes of material. The items in this document are subject to change and clarification as more information become available. This document is intended only as a guide to the appropriate precautionary handling of the material by a properly trained person. Individuals receiving this information must exercise their independent judgment in determining its appropriateness for a particular purpose.
CASE STUDY: SOIL BOUND BTEX TREATMENT AND ACTIVE REMEDIATION SYSTEM INTEGRATION

Purpose: The purpose of this pilot study was to demonstrate the feasibility of using PetroCleanze™ to desorb petroleum contaminants from the soil into the dissolved phase where they can then be treated by physical extraction or an active remediation system.

Background: A biosparge system was used at the site until groundwater concentrations dropped below cleanup target levels (approximately 2 years), then it was shut down. Rebound occurred during post-active remediation monitoring and groundwater concentrations increased above natural attenuation default concentrations. The observed increase in dissolved contaminant concentrations, combined with high organic vapor analyzer readings in saturated soil samples, and elevated fraction of organic carbon and total organic carbon concentrations in the soil, suggested petroleum contamination was likely absorbed to organics in saturated soils and was slowly desorbing into the groundwater. An approach was needed to liberate bound hydrocarbons for additional treatment using the biosparge system.

Pre-Injection Baseline Analytical: On January 12, 2012, baseline groundwater samples from monitoring wells SW-6R, -17R, and 18 (Figure 1) were collected for BTEX (benzene, toluene, ethylbenzene, xylene) and TRPH (total recoverable petroleum hydrocarbons) analysis (Figure 3, 4). On January 13, 2012, two soil borings (SB-1 and SB-2) were completed and baseline soil samples were collected from 12-14 feet below land surface for BTEX analysis (Figure 2). Figure 2 shows the average soil BTEX concentration for SB-1 and SB-2 before and after PetroCleanze injection.

PetroCleanze Injection: On February 2-3, 2012, a total of 2,220 gallons of 5% solution of PetroCleanze was injected into four injection points surrounding SW-18. Each point received a total of 550 gallons of solution, including 220 lbs of RegenOx Part A, 240 lbs of PetroCleanze, and 500 gallons of water. The biosparge system was reactivated for the duration of the treatment event.

Post-Injection Analytical: On March 12, 2012 and July 10th, 2012, groundwater samples from groundwater monitor wells SW-6R, -17R, and -18 were collected for BTEX and TRPH analysis (Figure 3, 4). Also on March 13th and July 23rd, 2012, two soil borings (SB-1 and SB-2) were completed and soil samples were again collected for BTEX analysis (Figure 2).

www.regenesis.com
Results: Performance parameters were evaluated for SW-6R, -17R, and -18 and a marked increase in ORP values was observed in each of the three wells following the PetroCleanze injection indicating chemical oxidation activity. Additionally, the pH in wells SW-17R and -18 increased significantly, providing evidence that alkaline conditions resulted from the application of PetroCleanze. As anticipated, increases in TRPH and BTEX concentrations in the sampled wells were observed following PetroCleanze injection as compared to baseline (Figure 3, 4). SW-17R was slightly unique in that BTEX concentrations went down. When looking at the average soil BTEX concentration of the two soil samples (Figure 2) in January, March, and July 2012 (7,015, 3,977, and 657 µg/kg, respectively) there was a 43% reduction between January and March and a 91% reduction between January and July 2012 after continued biosparging treatment.

Figure 3. Total BTEX

Figure 4. TRPH

Conclusion and Recommendations: The PetroCleanze application was successful and the material easily applied. Performance exceeded expectations as only one injection was needed to strip 91% of the BTEX contamination from the soil into the dissolved phase. The reactivated biosparge system was able to treat the increased dissolved phase contaminants in the treatment area.

The current groundwater concentrations at the site are very low in key monitoring wells; therefore, the project does not require additional treatment at this time. However, should a change in contaminant concentration be observed at the site once active remediation has been ceased then additional treatment will be considered.
Enhanced Desorption of Bound Hydrocarbon Mass for Increased Recovery Rates via Physical Removal Systems

Ryan Ferguson, MS; Bryan Vigue, MS

Land Science Technologies | 1011 Calle Sombra, San Clemente, CA 92673 | Ph: (949) 481-8188 / bmark@regenesys.com, rferguson@regenesys.com

INTRODUCTION

Physical System Limitations

Production well systems such as gas liquids extraction (GEL) pumps & heat exchangers, and routine extraction systems are widely used for remediation of hydrocarbon non-solvent phases (NSPs) at operational sites. These systems, while effective in rapidly reducing the mass of NSPs, are sometimes unattainable due to limited access to equipment and infrastructure at the location of operation. Additionally, these systems are typically limited in the area of hydrocarbon desorption through lack of airflow. These limitations are generally caused by the presence of study facilities, structural obstructions, or construction of both of these systems.

When DEP systems become inaccessible or ineffective conditions may arise, chemical stimulation (CES) is a method of removing the remaining 10-90% of NSPs that may not be economically solvable by other means. These techniques normally involve the use of a series of chemicals that are injected into the system which cause the hydrocarbon molecules to be released into the surrounding environment. The efficiency of this method is highly dependent on the level of contamination, but is usually effective in reducing the level of NSPs by 90-95%. However, these methods are often cost-prohibitive and are not recommended for use in situations where the contaminant concentrations are low or when the cost of remediation is high.

PetroCleanze Technology

PetroCleanze is a physical removal technology designed to address the limitations of current physical extraction technologies. PetroCleanze is a technology that uses a combination of physical removal processes to effectively and efficiently remove hydrocarbon mass from contaminated sites.

PetroCleanze Benefits

- Continuous extraction technology for physical removal
- Additional removal of NSPs through desorption
- Increased efficiency and effectiveness of physical extraction

MATERIAL FORMULATION

- Regenera-Plus
- Ethanol
- Dissolvent
- Propylene Glycol

MECHANISMS

The mechanism of action for PetroCleanze is through the use of physical extraction technology. This technology involves the use of a series of physical processes such as heating, cooling, and vacuuming, which enables the removal of NSPs from the soil matrix. The efficiency of this method is highly dependent on the level of contamination, but is usually effective in reducing the level of NSPs by 90-95%.

PETROCLEANZE FIELD OBSERVATIONS

Location: Hawaii, HI
- PetroCleanze Service Station

Site Description:
- Geological: Sand and Gravel
- Medium Dissolution and Reactive Soil
- Contaminant: Petro-Residues

Remediation Approach:
- Treatment Area: 24,000 ft²
- Treatment Time: 6-12 months

Field Observation Results:
- Oil Range (mg/L): 200-500

CONCLUSIONS

PetroCleanze is a proven technology that has been successfully used to address the limitations of chemical stimulation. This technology offers a new approach to the remediation of hydrocarbon mass at contaminated sites. PetroCleanze is a cost-effective and efficient method of removing NSPs from contaminated sites. It is a technology that can be used in situations where chemical stimulation is not feasible or cost-prohibitive. The efficiency of this method is highly dependent on the level of contamination, but is usually effective in reducing the level of NSPs by 90-95%.
PetroCleanze™ Treats Petroleum Hydrocarbons at Active Manufacturing Site

Highlights:
- An active manufacturing site in Hastings, Michigan previously housed a leaking underground storage tank (UST)
- Previous remediation activities included excavation and off-site disposal of the accessible soils
- Contaminants of concern identified as toluene, 1,2,4-trimethylbenzene, ethylbenzene and xylene
- Total VOC concentrations measured as high as 770,820 µg/kg in soil and 12,387 µg/L in groundwater
- REGENESIS Remediation Services (RRS) proposed in-situ treatment using direct injection of PetroCleanze
- VOC levels in certain targeted areas showed a 99% decrease in soil and 66% decrease in groundwater contamination (Figure 1)

Summary:

Following excavation activities, VOC contamination testing reported concentrations of 770,820 µg/kg in soil and 12,387 µg/L in groundwater. In-situ remediation using PetroCleanze™, an enhanced desorption/extraction technology was planned to treat the remaining high levels of VOCs in soil and groundwater. The PetroCleanze formula is optimized to desorb bound hydrocarbon mass and drive it from the soil matrix into the aqueous phase. Once pollutants are moved into the dissolved phase, its ability to chemically oxidize portions of the contamination coupled with enhanced recovery (physical extraction) effectively reduces contaminant concentrations. The PetroCleanze technology works well with a range of enhanced recovery techniques including: dual-phase extraction, vacuum-enhanced extraction as well as traditional pump and treat systems. In early 2013, a total of four PetroCleanze injection/extraction events took place in two treatment areas close to where the UST was once located. Each injection used a total of 1,320 lbs. of PetroCleanze and 925 lbs. of RegenOx Part A; the material was applied as a 5% solution through eight direct-push injection points. The vertical treatment interval ranged between 5 feet to 15 feet below ground surface. Following each injection, an extraction event was performed approximately two weeks later to remove the newly desorbed aqueous phase hydrocarbon mass (Figure 2). Correlating soil samples in key treatment areas indicated that concentrations were reduced up to 99% with the exception of one area which is currently under review. Six months after treatment, groundwater VOC levels in EW-2 were reduced from 12,000 µg/L to 4000 µg/L marking a 66% reduction in the treatment zone (Figure 1). Within the same well, following each injection/extraction event, TPH data reported concentrations consistently decreasing from 20,000 µg/L to 10,000 µg/L to 5,900 µg/L. Overall, PetroCleanze effectively treated hydrocarbon levels in soil by up to 99% with the exception of one area and in groundwater by up to 66%.
CASE STUDY: SITE BACKGROUND

- Site: International Sea Port
- Remedial Driver: Redevelopment
- Source: Line leaks between USTs and offloading points
- Aquifer Type: Sand
- Contaminant: Diesel Range HC’s (weathered)
- GW Depth: Approx. 20 feet bgs
- GW TPH Concentration: Range 10-100 mg/L
- Soil TPH Concentration: >5,000 mg/kg
CASE: METHODS

- Injection – Extraction
  - “Push-Pull”

- Injection “Push” Phase
  - Injection via 17 dedicated injection–extraction wells
  - App. Rate Approx. 20 lbs/yd³
  - 5% Solution
CASE: METHODS

• Reaction
  • Allowed 14-21 days between “Push” and “Pull”
  • Maximize desorption & ISCO rxn

• Extraction “Pull” Phase
  • Vacuum Truck
  • Extracted from Injection Wells
  • Removed 5,000 gals/event
CASE: CONTAMINANT CONCENTRATION CHANGES

MW201

<table>
<thead>
<tr>
<th></th>
<th>TPH C29-C36</th>
<th>TPH C15-C28</th>
<th>TPH C10-C14</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hist</td>
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<tr>
<td>BL</td>
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<td>Mon. 1</td>
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<td>Mon. 2</td>
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<tr>
<td>Mon. 3</td>
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</tr>
</tbody>
</table>

Concentration (µg/L)

- Hist: 0
- BL: 0
- Mon. 1: 120,000
- Mon. 2: 100,000
- Mon. 3: 80,000

Map showing locations of MW201, MW205, MW204, MW202, MW201, MW210, MW213, SB03, SB09, MW207, MW211.
CASE: POST APPLICATION WATER QUALITY (VISUAL)

Event 1  Event 2  Event 3
CASE: CONTAMINANT CONCENTRATION CHANGES

MW204

- TPH C29-C56
- TPH C15-C28
- TPH C10-C14

Concentration (µg/L)

Hist.
BL
Mon. 1
Mon. 2
Mon. 3

MW218
MW214
MW205
MW207
MW204
MW202
MW219
MW213
MW210
MW211
SB09
SB03
CASE: RESULTS

• **Average Site Reduction 71%**
  
• **Representative Reductions**
  
  • High Concentration Wells: 
    105 to 21 mg/L
  
  • Medium Concentration Wells: 
    36 to 3 mg/L
  
  • Low Concentration Well: 
    7 to 2 mg/L
• Remedial Results
  • 3-6 month period
  • removed about 1,000 lbs. of HC mass

• Site Implications
  • Minimal Rebound
  • GW remains below cleanup criteria 24 months later