

**REGION III REGIONAL RESPONSE TEAM  
GUIDANCE FOR  
USING BIOREMEDIATION TO TREAT OIL POLLUTION**

**Introduction**

The decision to use bioremediation is the responsibility of either the Coast Guard Federal On-Scene Coordinator or depending on the location of where the oil spill has occurred the Environmental Protection Agency (EPA) Federal On-Scene Coordinator (FOSC) and the Unified Command (UC). However, permission to use bioremediation to treat oil pollution must be approved by the incident-specific Regional Response Team (RRT). This guidance document is intended to provide the FOSC, the UC and the RRT guidance and decision-making tools to support the use of bioremediation treatment for oil spills. Area committee members are encouraged to incorporate concepts and other information from this document into their respective Area Contingency Plans (ACP).

Section I of this document defines the purpose, authority, scope, definition of biodegradation and bioremediation, conditions for bioremediation, and natural clean-up methods. Section II describes the decision-making tools, feasibility assessment criteria, RRT notification requirements, bioremediation work plan, monitoring plan, monitoring activities, and documentation and reporting tools associated with bioremediation treatment of oil pollution. Section III contains references used throughout the document. Appendices A through C contain:

- Decision tree diagram for consideration of bioremediation treatment
- Field monitoring parameters
- Bioremediation Use Authorization Form

**SECTION I**

**Purpose**

The purpose of this guidance is solely to support the FOSC's, the UC's and the RRT's decision-making when considering the use of bioremediation for addressing treatment of spilled petroleum products. This document describes the decision-making process, identifies bioremediation treatment issues, monitoring procedures, and provides checklists to aid in the bioremediation decision-making.

## **Authority**

Subpart J of the National Oil and Hazardous Substances Contingency Plan (NCP) [40 CFR 300.900] provides for the use of chemical and biological agents in responding to oil spills. Subpart J specifically restricts the use of chemical and biological agents that may affect United States waters to those listed on the NCP Product Schedule. Subpart J also specifies technical product information that must be submitted to the EPA for an agent to be added to the schedule, and it establishes conditions for obtaining authorization to use chemical or biological agents in a response action.

## **Scope**

This guidance provides the FOSC and the UC with general procedures and processes to proceed with bioremediation treatment to enhance response and removal operations for oil spills within the area of responsibility of Region III.

To obtain step-by-step guidance and more detailed information on procedures and protocols for pursuing bioremediation treatment, one should examine other documents on the topic such as RRT IV's Bioremediation Spill Response Plan (1997) or EPA's Guidance for the Bioremediation of Marine Shorelines and Freshwater Wetlands (2001).

## **Definition of Biodegradation and Bioremediation**

Biodegradation is a natural process of breaking down organic matter into nutrients that can be used by other organisms. Decay is performed by a variety of bacteria, fungi, insects, worms, and other organisms that use organic material as a source of food, and in return, recycle the material into new forms of energy (Arizona State 2002).

Bioremediation is a treatment technology that utilizes biodegradation to reduce the concentration or toxicity of chemical substances such as petroleum products and other hydrocarbons (RRT IV 1997). Microbes that are capable of degrading hydrocarbons are common within nature, and cause the natural remediation of many untreated spills. Bioremediation enhances and accelerates the remediation process by providing these microbes and organisms with nutrients, oxygen, and other conditions that encourage rapid growth.

## **Conditions for Bioremediation**

Bioremediation is an effective technology that can be used to treat certain oil-contaminated environments. Bioremediation typically is used after conventional mechanical clean-up methods have been applied. However, it may be used as a primary response strategy if (1) the spilled oil does not exist as free product, (2) the contaminated area is remote enough not to require immediate cleanup, or (3) the area is not accessible (EPA 2001).

## **Natural Clean-up Methods**

Natural recovery of an oil spill is a “no-action” option in which the oil is removed and degraded by natural means (EPA 2001). This option is most helpful if attempting to clean-up the oil would harm the surrounding environment. Examples of such spills include spills within sensitive areas or spills at remote locations where accessibility would be an issue. Such natural processes that aid the remediation of oil include:

- **Biodegradation:** Biodegradation involves microorganisms that are capable of oxidizing petroleum products and are important in removing nonvolatile components of oil. Biodegradation can be a very slow process and may require up to months or years to degrade significant amounts of oil (EPA 2001).
- **Evaporation:** Evaporation is the most important process during the early stages of an oil spill. Up to 50 percent of the oil may evaporate within the first 12 hours of a spill depending on the composition of the oil (EPA 2001).
- **Photo-oxidation:** Photo-oxidation occurs when sunlight and oxygen react with oil under the right conditions. This leads to the breakdown of complex compounds to compounds that are lighter in weight and more water soluble, allowing them to be removed through mechanical processes such as booming (EPA 2001). However, it is estimated that photo-oxidation only removes approximately 2 to 3% of the oil, which is negligible.

Other natural processes that also aid in the remediation of oil include spreading, advection, sedimentation, dissolution, and natural dispersion.

## **SECTION II**

### **Decision-Making Tools**

Based on the characteristics of the spill, the environmental sensitivity of the spill area, and resource use, bioremediation may be used as the primary treatment. The following tools are provided for the FOSC, the UC and the RRT to assist them in evaluating the incident-specific spill conditions relative to bioremediation use: A flow diagram (Appendix A) in the evaluation of spills that are candidates for bioremediation; and the Region III bioremediation form (Appendix B) a Authorization Form for the use bioremediation. Information regarding the characteristics of the spill must be collected and documented by the spill response team on the Authorization Form and presented to the FOSC and RRT before the implementation of bioremediation treatment (RRT IV 1997). In the most likely situations, the FOSC would gather information and input from the State On-Scene Coordinator for which response strategy will most likely be used, and follow the State’s lead in the initiation of the response.

## Feasibility Assessment Criteria

The feasibility criteria for bioremediation treatment are taken from RRT IV's Bioremediation Spill Response Plan, but can be adapted and implemented into Region III.

Assessing the feasibility for bioremediation is a two-step process. The first step determines whether the incident-specific spill conditions are favorable to conduction for bioremediation treatment, and the second step determines whether bioremediation can be implemented effectively.

The possibility and practicality of using bioremediation should be explored before implementation. Bioremediation is useful on moderately to heavy oiled substrates after other traditional removal techniques have been applied, and on lightly oiled shorelines where other techniques are destructive or not effective. Bioremediation can also effective on diesel and other medium-weight oils that do not have highly complex molecular compounds or slowly degrading components. Bioremediation is least effective on thick oil residues and should not be considered for spills involving gasoline, which can be removed by evaporation at a faster rate than by biodegradation. Most oils can be broken down into the general categories listed on the next page (National Oceanic and Atmospheric Administration (NOAA),1992):

- Group I: Very Light Refined Products (for example: gasoline, naphtha, solvents)
  - < Very volatile and highly flammable
  - < Complete removal by evaporation likely
  - < High acute toxicity to biota
  - < Can cause severe impacts to water-column and intertidal resources
  - < Specific gravity less than 0.80
  - < Will penetrate substrate, causing subsurface contamination
  - < **Not considered for bioremediation due to high evaporation rates**
  
- Group II: Diesel-like Products and Light Crude Oils (for example: No. 2 fuel oil, jet fuel, kerosene, marine diesel, West Texas Crude, Alberta Crude)
  - < Moderately volatile
  - < Light fractions will evaporate to no residue
  - < Crude oils leave residue after evaporation
  - < Moderate to high toxicity to biota
  - < Can form emulsions
  - < Tend to penetrate substrate; fresh spills are not adhesive
  - < Specific gravity of 0.80 to 0.85; American Petroleum Institute (API) gravity 35 to 40
  - < **Bioremediation most effective on lower molecular weight oils with faster degrading components; aromatic portions less susceptible to degradation**

- Group III: Medium-grade Crude Oils and Intermediate Products (for example: North Slope crude, South Louisiana crude, No. 4 fuel oil, lube oils)
  - < Moderately volatile
  - < Up to one third will evaporate in the first 24 hours
  - < Moderate to high viscosity
  - < Specific gravity of 0.85 to 0.95; API gravity of 17.5 to 35
  - < Variable acute toxicity, depending on amount of light fraction
  - < Can form stable emulsions
  - < Variable substrate penetration and adhesion
  - < **Bioremediation most effective on lower molecular weight oils with faster degrading components.**
  
- Group IV: Heavy Crude Oils and Residual Products (for example: Venezuela crude, San Joaquin Valley crude, Bunker C, No. 6 fuel oil)
  - < Slightly volatile
  - < Very little product loss by evaporation
  - < Very viscous to semisolid; may become less viscous when warmed
  - < Specific gravity of 0.95 to 1.00; API gravity of 10 to 17.5
  - < Low acute toxicity relative to other oil types
  - < Can form stable emulsions
  - < Little substrate penetration; can be highly adhesive
  - < **Higher molecular weights and fewer number of straight-chained hydrocarbons makes bioremediation a longer treatment processes than on medium oils.**
  
- Group V: Very Heavy Residual Products
  - < Very similar to all properties of Group IV oils, except that the specific gravity of the oil is greater than 1.0, and API gravity is less than 10. Therefore, the oil has a greater tendency to sink when spilled.

More detailed information involving oil properties can also be found in American Petroleum Institute's (API) publication 4691, Fate of Spilled Oil in Marine Water.

### **RRT Notification Requirements**

After an Authorization Form has been presented to the RRT by the FOSC, a bioremediation operations plan and monitoring plan must be developed to address necessary issues such as: how to apply treatment, how much to apply, equipment needs, how clean is clean, long-term monitoring endpoints/goals, monitoring equipment, timeframe, and etc., to ensure efficiency and the effectiveness of the bioremediation treatment. After finalizing the bioremediation operational planning for the affected habitat, the completed Authorization Form shall be transmitted to the State(s), EPA Region III, appropriate U.S. Coast Guard (USCG) District, and Federal Trustees for concurrence with the decision for concurrence with the decision. If

applicable, the appropriate Federal Land Manager (for example, U.S. Department of Interior) must be notified, along with the affected State Historic Preservation Office (SHPO), and an informal or formal Endangered Species Act (ESA) consultation will be necessary, if the proposed bioremediation may affect federally listed species or critical habitat.

### **Bioremediation Work Plan**

Work plans are to be used to resolve issues through procedures and guidelines. Issues may include worker and public safety, roles and responsibilities of response personnel, documentation requirements, treatment technique protocols, and application control and oversight considerations (RRT IV1997). Each work plan should include the following:

1. Statement of Objectives describing what must be achieved and can be measured by using bioremediation as a primary treatment method for oil cleanup
2. Organizational outline describing the specific roles and responsibilities of the participants in the bioremediation process and the interaction between one party and another
3. Tactics and Assignments presenting tactics and control operations and what resources will be assigned
4. Supporting Materials such as maps or sketches of the area(s) to be treated, traffic plans, communications, weather data, special precautions, and safety information
5. Risk/Benefits assessment and a probability of success outcome. Applicability of treatment of the product and environment of use.

### **Monitoring Plan**

The biomonitoring plan will be implemented on a site-specific basis and is a two-fold process: (1) to document and monitor the effects the bioremediation process is having on water quality or the surrounding environment, and (2) to provide for evaluation of the effectiveness of the bioremediation treatment (RRT IV 1997).

Biomonitoring should be proportional to the complexity and sensitivity of the affected area(s) chosen for bioremediation. The more complex the affected area, the more complex the biomonitoring plan should be.

A spill may affect several different environments or habitats, and bioremediation treatments may be applied to several different morphological areas (RRT IV 1997). The supporting biomonitoring plan must be designed to accommodate inherent differences that are present in each distinguished habitat. Thus, each habitat may require its own unique monitoring plan.

## **Monitoring Activities**

As part of monitoring activities, observations should be recorded in the approved biomonitoring plan and samples should be collected and analyzed for the following habitat(s):

- Oiled, Untreated Areas
- Oiled, Treated Areas

Monitoring may be needed in multiple habitat types, multiple sensitive areas, and for several media (water, soil, sediment, biota) within these broad areas.

## **Documentation and Reporting Tools**

Cleanup activities and observations should be documented throughout the entire bioremediation treatment process. Several reports shall be prepared and submitted to the FOSC, including the following (RRT IV 1997):

- Activity reports - provide descriptions of the bioremediation activity area, weather, unique observations, activities undertaken, and names and affiliations of persons on site. These reports should be prepared whenever activities on site are undertaken.
- Analytical reports - provide laboratory results of environmental and control samples. Laboratory results should be interpreted and analyzed, then briefly summarized in the report.
- After action report - provide an overall description of the bioremediation activity and monitoring effort, including the field and laboratory results. A draft should be submitted within 30 days after the end of the monitoring activities, and a final report should be submitted within 60 days of the draft.

## **SECTION III**

### **References**

The following references were used throughout the document.

American Petroleum Institute, Publication No. 4691. 1999. "Fate of Spilled Oil in Marine Waters".

Arizona State University, Genetic Engineering and Society. 2002. "Bioremediation".

National Oceanic and Atmospheric Administration, Training Manual Chapter 2. 1997 "Introduction to Coastal Habitats and Biological Resources for Spill Response".

Regional Response Team, U.S. Environmental Protection Agency Region IV. 1997. "Bioremediation Spill Response Plan.

U.S. Environmental Protection Agency. 2001. "Guidelines for the Bioremediation of Marine Shorelines and Freshwater Wetlands."

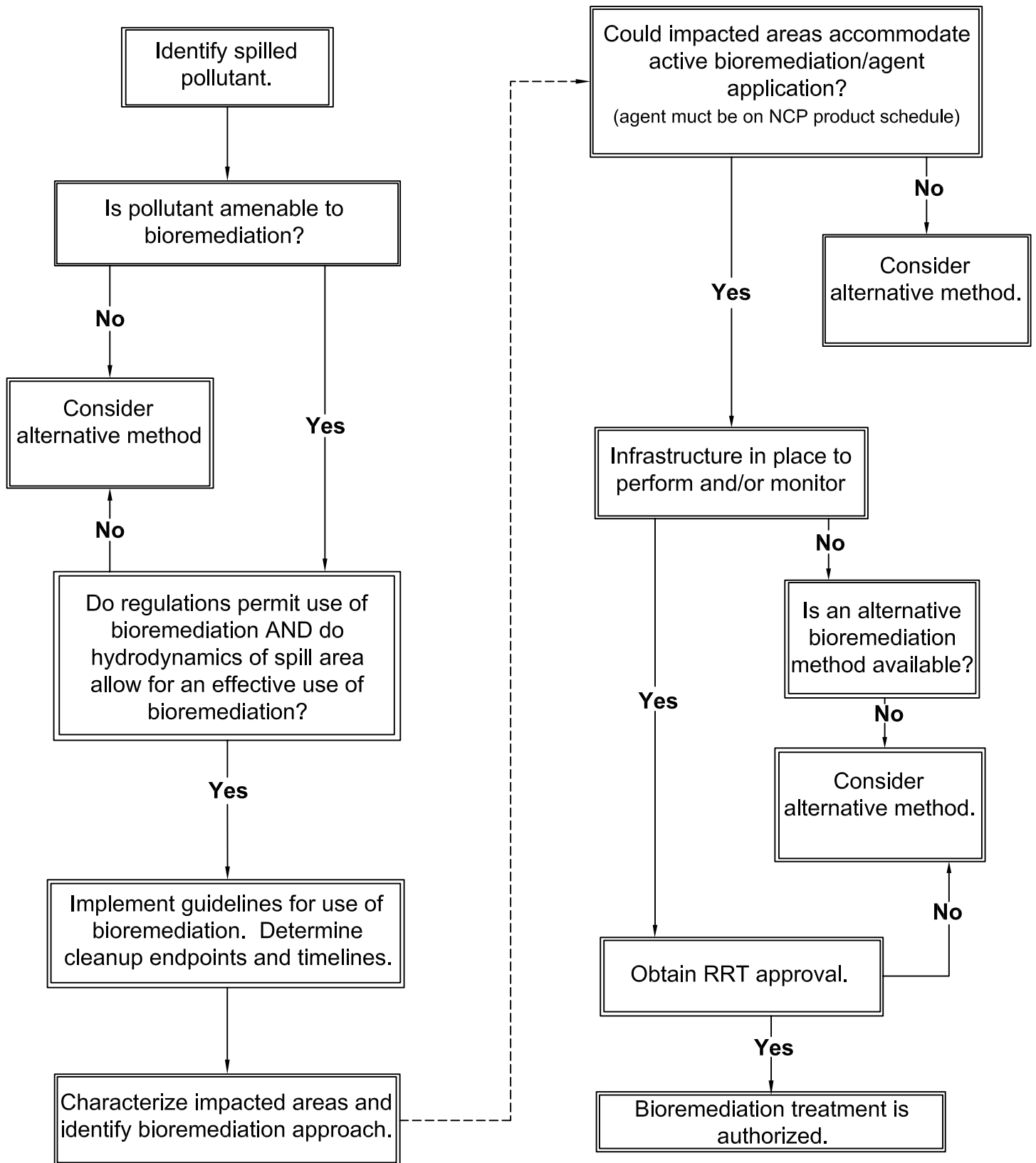


**APPENDIX A**

**DECISION TREE DIAGRAM FOR CONSIDERATION  
OF BIOREMEDIATION TREATMENT**

(One Page)

# DECISION TREE DIAGRAM FOR CONSIDERATION OF BIOREMEDIATION TREATMENT



**APPENDIX B**

**FIELD MONITORING PARAMETERS**

(One Page)

## FIELD MONITORING PARAMETERS

Parameter	Sample Size	Assessment/Collection Location	Assessment/Collection Frequency <sup>1</sup>
Visual observations (mortality, behavioral, effects, appearance changes, oil distribution).	N/A	All test sites	Daily to the extent possible; at least each day that water, sediment, and/or shoreline material sampling is performed
Temperature (air and water).	N/A	All test sites	Daily assessment and recording.
Salinity	N/A	All test sites	Daily assessment and recording
Dissolved Oxygen	N/A	All test sites	Daily assessment and recording
Sea State	N/A	Activity Area	Daily assessment and recording.
Tidal cycling	N/A	Activity Area	Days 1, 7, 10 and 20.
Wind velocity	N/A	Activity Area	Daily assessment and recording
Efficacy (water, sediment, and/or shoreline material).	1 liter water; 20 grams sediment or shoreline material	All test sites and, as appropriate, all water depths	Days 1, 7, 14 and every week thereafter.
Toxicity <sup>2</sup> : water sediment and/or shoreline material.	8 liters water 2 gallons sediment or sufficient quantity of shoreline material	All test sites and, as appropriate, all water depths	Days 1, 7 for Daphnia bioassay or other suitable organism for water and amphipod bioassay (Hyalloella or other suitable organism) for sediment or shoreline material.

Notes:

<sup>1</sup> Frequency is relative to the time of agent application

<sup>2</sup> Toxicity testing is case-specific and somewhat dependent upon the amount of laboratory toxicity data available on the bioremediation agent, and previous use history and biomonitoring results. Toxicity testing will follow American Society for Testing and Material (ASTM) standards.

N/A - not applicable

This table was taken from U.S. EPA Region IV RRT Bioremediation Response Plan

**APPENDIX C**

**BIOREMEDIATION USE AUTHORIZATION FORM**

(Four Pages)

## **BIOREMEDIATION USE AUTHORIZATION FORM**

The following questions should be answered, if possible, and presented to the FOSC who will review them and present them to the RRT for consideration. A question left unanswered will not automatically result in a “no-go” decision, but every effort should be made to present accurate and up-to-date information. The RRT will use the information provided below to assist in making the decision for use for bioremediation.

The form consists of two parts, incident characteristics and feasibility assessment criteria. Additionally, a Bioremediation Work Plan and Biomonitoring Plan must be prepared and submitted to the FOSC or his/her designee for review. (Note: Many of the items requested in the feasibility assessment criteria section can and should be included in the Bioremediation Work Plan.)

Note: This Authorization Form and all its contents were adapted from Region IV RRT’s Bioremediation Spill Response Plan.

### **Incident Characteristics**

Time and date of release:
Product spilled:
Quantity spilled:
Status of spill:
Location of incident:
Description of incident:
Specific or API gravity:
Viscosity, cp:
Pour point, at temp, F:
Sulfur content, %w:

### **Responsible Party Information**

<b>Company and Address</b>	<b>Telephone and Fax Numbers</b>	<b>Contact Person and Telephone</b>

## Feasibility Assessment Criteria

Specific location proposed for treatment:

What are the characteristics of the spill environment?:

- Type of environment, habitat:
- Marine, brackish, freshwater:
- Past spill history:

Amount of weathering spilled product has undergone:

Description of impact(s):

Has ownership of land been determined?:

Has written permission from landowner been obtained?:

Bioremediation agent proposed for use:

- Name of product:
- Type of agent (microbial, nutrient, microbial + nutrient, etc.):
- Is the agent listed on the National Contingency Plan (NCP)?:
- To what step in the bioremediation process has the agent been formally evaluated?:
- Does the responsible party have any previous first-hand experience with the use of the proposed remediation agent, or is there additional data available to indicate that it is efficacious (i.e. that it actually enhances biodegradation)?
- Are basic laboratory toxicity data for the proposed agent available for standard aquatic species and land species?
- Are degradation results (based on oil chemistry and microbial tests) available for review?:

## Supply:

- Source of supply:
- Amount available:
- ETA to site:

## Application:

- Estimate total area to be treated and amount of agent(s) needed:
- Who will supply the agent (vendor personnel, response contractor personnel, or other contractor):
- Method to be used in applying agent:
- Impacts of proposed application method:
- Time to prepare agent for application.
- Has application equipment been calibrated for this particular application?:
- Rate of application:
- How long will application take for the specified application area?:
- Will product have to be reapplied?:  
How frequently?:

### Bioremediation Work Plan

Has Bioremediation work plan been prepared?:

Has the plan been reviewed?:

### Biomonitoring Plan

Has a monitoring plan been prepared?:

Has the plan been reviewed? And approved by States, Trustees and Land Owner Manager?:

### Project Management

Bioremediation application project manager:

Contact Number:

Address:



This bioremediation application has been approved by:

\_\_\_\_\_  
Federal OSC

\_\_\_\_\_  
State OSC

\_\_\_\_\_  
EPA

\_\_\_\_\_  
U.S. Department of Commerce

\_\_\_\_\_  
U.S. Department of Interior