Tundra Treatment Guidelines

Freshwater Spill Symposium

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Abstract

Spills of oil and other hazardous substances to tundra environments have always been problematic for both the responsible party and the regulatory agencies. Aggressive cleanups have left the tundra badly damaged. Areas where no cleanup was attempted often exhibit problems based upon product type and concentration. In an attempt to better define response tactics and thresholds the Alaska Department of Environmental Conservation (ADEC) and Alaska Clean Seas (ACS) initiated a study of the available literature and historical case files concerning spills of oil and selected hazardous substances to tundra environments. This study culminated in the development of the Tundra Treatment Guidelines (TTG). The overall emphasis of response has shifted from achieving a numerical standard of remaining contamination to a less precise but more practical goal of rehabilitation of the affected environment. The results of this study does not leave behind numerical end points but attempts to redefine those limits at the levels which allow the tundra to recover as quickly as possible without excessive damage from overworking the tundra during cleanup operations.

History of Releases Related to Oil Exploration and Production Activities

Since the mid 1940's when the United States Navy began the first large scale coordinated petroleum exploration activities in the Naval Petroleum Reserve (currently known as the

National Petroleum Reserve of Alaska, NPRA) the North Slope of Alaska has continued to be the site of oil and gas exploration and production. Activities increased dramatically after the discovery of the Prudhoe Bay oil field in the late 1960's. This was followed by the Trans-Alaska Pipeline construction activities in the 1970's and the subsequent oil production.

Numerous other production and exploration projects have taken place in various areas of the North Slope during this period of time. Some of the other major oil reserve discoveries that have lead to production include Milne Point, Kuparuk, Point McIntyre, Lisburne, Endicott, Badami, North Star and Alpine. Smaller "satellite" fields have been discovered near the larger reserves and have been developed using the infrastructure that is in place. A partial listing of these fields include Tarn, Tobasco, Meltwater, and Schrader Bluffs. Additional development of the NPRA is anticipated.

All exploration and production drilling, by it's very nature, requires the transportation, use and handling of large quantities of oil and other liquid hazardous substances to complete the operations. Spills or releases of these substances are a common occurrence. The ADEC Spills Data Base has shown that since 1995, 300 to 500 reported releases, per year, have occurred on the North Slope of Alaska from production and exploration drilling activities. Equipment failure and human error during the transfer of these liquids are the two largest documented causes of these unplanned releases.

In an effort to minimize the number, size and the impacts from oil and hazardous substance releases, governmental agencies have required that the oil producers develop and maintain contingency plans. These plans not only outline storage and handling practices of oil products but also require the producer to maintain enough response personnel and equipment to show that they could recover the worst case scenario release within 72 hours. These contingency plans along with other factors such as cost of cleanup and the value of public good will have provided the impetus for private industry to create a "culture of environmental awareness" among the oil field workers. This awareness along with better-designed equipment and improved handling practices has had a positive effect on the size, number and environmental impact of releases of oil and hazardous substances.

Need for Pre-Approved Response Tactics

During a 1995 meeting, between the environmental staff of the North Slope oil producers and the State on Scene Coordinator (SOSC) for the ADEC Northern Area Response Team (NART), a conceptual idea of developing a set of scripted response tactics for spills on the North Slope, that would be pre-approved by the State of Alaska, was first considered. This consideration by the SOSC was made with the knowledge that less time would be spent on the North Slope by ADEC response personnel to make field judgements on the appropriateness of individual response tactics. All parties recognized that having appropriate, pre-approved tactics would avoid delays in seeking agency approval thus minimizing environmental damage that could be caused by migrating oil or hazardous substances. It was also recognized that a large volume of historical information existed in a variety of locations that could be used to predict that efficacy of the response tactic.

Development of the Alaska Clean Seas Technical Manual

Prior to funding authorization of the TTG and independent of its development, ACS, the spill response cooperative owned by the North Slope oil producers, began work on the Alaska Clean Seas Technical Manual. ACS developed this document in cooperation with a variety of agencies from the local, state and federal government, and also private corporations including Alyeska Pipeline Service Company, BP Exploration (Alaska) Inc., and ARCO Alaska Inc. One of the main functions of this document was to describe the resources that would be needed and the tactic that would be used to respond to a variety of spill scenarios. These resource requirements and tactics were individually labeled and then referenced in the contingency plan that the oil producers held with the ADEC.

These described tactics not only serve to fulfill contingency plan requirements but also function during an actual spill event to quickly and effectively communicate to governmental agencies the type of response tactic that is planned. Alaska State Regulation 18 AAC 75.310 requires a responsible party to use approved response methods for all individual spill sites. Using tactics that have gone through a prior review and approval process with ADEC reduces the chance for miscommunication and approval delays between the response organization and ADEC.

Conceptual Development of the Tundra Treatment Guidelines

ADEC was able to provide funding for additional research and project development shortly after the initiation of the ACS Technical Manual. It was decided by ADEC that due to the nature of tundra being damaged from minimal disturbance, that specific information was required to address spill cleanup in the tundra environment. Both ADEC and ACS committed financially resources to address this issue.

It was recognized by private industry, response contractors and governmental agencies that responding to oil and hazardous substance releases on tundra required specific tactics and techniques to minimize damage to tundra from both the contaminate and the response itself. It was noted from prior spill cleanup activities on the North Slope that tundra can not only be damaged from the spilled substance but also from excessive foot traffic of the response personnel, equipment, and excessive response actions. It was the recognition of these problems that the TTG attempted to minimize by directing response personnel to use pre-described methods. These methods developed were based upon knowledge gained from previous response, cleanup and restoration activities.

The first objective of ADEC was to set general goals for response action. The three goals were 1. Minimize damage to the tundra from the spilled material. 2. Minimize damage to the tundra from the response actions. 3. Minimize the recovery period of the tundra. These goals were the main objectives of each tundra cleanup that was attempted. However the response methods had not been subjected to the rigors of in-depth review using historical information from past spill events to judge their effectiveness.

Compilation and Interpretation of Data

Spill files were developed and kept on notable spills from the mid 1970's. In an attempt to improve documentation of the reported releases the ADEC Northern Region Office (NRO) began compiling and storing spill information in a database format in 1981. Many individual spill records from 1973 through 1981 were back entered into the database after its inception. The database format was used by ADEC on a statewide effort following a structural reorganization in 1995. This Spills Database along with a systematic approach to storage of individual spill files has provided an excellent resource for retrieving information from individual spill events across the North Slope.

According to the ADEC Spills Database approximately 2,000-2,500 spills of oil and hazardous substances occur every year in Alaska. For the purpose of defining remediation tactics, ADEC identified five main categories of substances that may be spilled on the North Slope. These categories are crude oil, refined petroleum products, saline waters, drilling fluids and synthetic fluids (i.e. glycol and methanol). These categories were based on the types of activity that is common to the North Slope region. This includes oil and mining activities, delivery of fuel to villages, and the transport of oil and hazardous substances along the highway.

AMEC Earth & Environmental was tasked with evaluating and summarizing available information concerning spills in tundra environments, subsequent response efforts, and the ultimate results of the response. There was an information-gathering phase, construction of a database to catalog and analyze the information, and development of five generalized spill scenarios to support and communicate the lessons learned by this approach. Information was collected from ADEC files, BP Exploration (Alaska) Inc. and Atlantic Richfield Company (ARCO) spill databases, and case study information.

There are different types of tundra that may be found on the North Slope. These include aquatic tundra, wet tundra, moist tundra, and dry tundra. The common characteristics that segregate these types are defined in Table 1.

Tundra Type	Typical Topography	Soil Conditions	Vegetative Growth
AQUATIC TUNDRA	Ponds, lakes, or streams	Sediment under shallow water, organic accumulations	Aquatic sedges, grasses, and forbes
WET TUNDRA	Coastal or low areas	Soil saturated, standing water often present, thick root and organic layer	Primarily emergent aquatic grasses and sedges
MOIST TUNDRA	Foothills, gentle slopes	Well-drained to saturated soil. Dense root mat with some organics	Includes tussock tundra, grass meadows, low shrubs, and some forbes
DRY TUNDRA	Mountains, steep slopes, bluffs and riverbanks	Well-drained, exposed, rocky, or barren location with little root mat or organics	Sparse, often low-lying plants such as mat-forming heathers, cushions plants, lichens, and mosses

Table 1.

It is quite likely that when a spill occurs, tactics to cleanup, remediate or promote recovery may need to address more than one tundra type.

Current Use of the Tundra Treatment Manual

There are several factors that need to be taken into consideration that will affect spill fate and effects. A logical approach exists to develop treatment goals and strategies. This is clearly defined in Table 2.

STEPS	CONSIDERATIONS
Consult with Government Agencies	• Coordinate with government agencies initially to set site-specific treatment goals and during the treatment and monitoring process. • All site characterization/assessment plans, sampling plans, and monitoring plans must be approved by the Alaska Department of Environmental Conservation (ADEC).
Characterize Site	• What spilled? • What is the tundra type? • What are the effects of the spill residuals on the soils, hydrology, vegetation? • Do wildlife or humans use the site?
Set Treatment Goals	**General Tundra Treatment Goals** • Reduce the toxicity, mobility and volume of spill residuals to (a) allow revegetation, (b) control risks to wildlife, aquatic and human receptors, and (c) return affected tundra to original state with similar plant species composition and abundance and to restore original value to wildlife and humans. • Protect sensitive tundra soils from physical damage and induced thermal effects
Select Treatment Tactics	**To The Extent Practicable, Select Tactics To:** • Avoid or minimize treatment impact. • Achieve a balance between (a) the impact of abandoning the spill residuals on site and (b) physical impacts of treatment and (c) length of recovery time.
Assemble Tactics into a Strategy	• A variety of tactics may be needed throughout the treatment process, or different tactics many be needed at different locations. • The same tactics may have to be applied more than once.
Monitor Treatment and Recovery	• Coordinate with government agencies to select or create acceptable monitoring methods and to determine when treatment goals have been reached.

Table 2.

In addition to looking at the receiving environment, properties of the substance spilled must be considered. There are a number of factors affecting spill fate and response in tundra environments. Such properties include solubility, viscosity, specific gravity, volatility, freezing point, biodegradability, toxicity, and the temperature of the spilled substance. Time of year also plays a role in the determination of tactics used to respond to spills.

As described above, time of year also will affect the fate and effects of spills in tundra environments. Table 3 summarizes the factors that most influence spill fate and effects during frozen conditions (winter and freezeup) and melted or melting conditions (summer and spring thaw).

Season	Climatic Variable	Properties of the Spilled Substance	Characteristics of the Tundra Type
Winter/ Freezeup	Snow depth Wind Air temperature	Temperature when spilled Freezing point Viscosity	Slope
Summer/ Spring Thaw	Active layer depth Air temperature Soil Temperature Growing Season	Water solubility Specific gravity Volatility Biodegradability	Slope Drainage patterns Surface and standing water Soil type and saturation Vegetative cover

Table 3.

The five stereotypical spill descriptions include a wide range of approaches identified during the initial, short term and long term response actions. Decisions on what approach is the most effective for cleaning up a spill to tundra may be found by following the decision trees found below (Diagrams 1, 2, 3).

DIESEL SPILL RESPONSE DECISION TREE

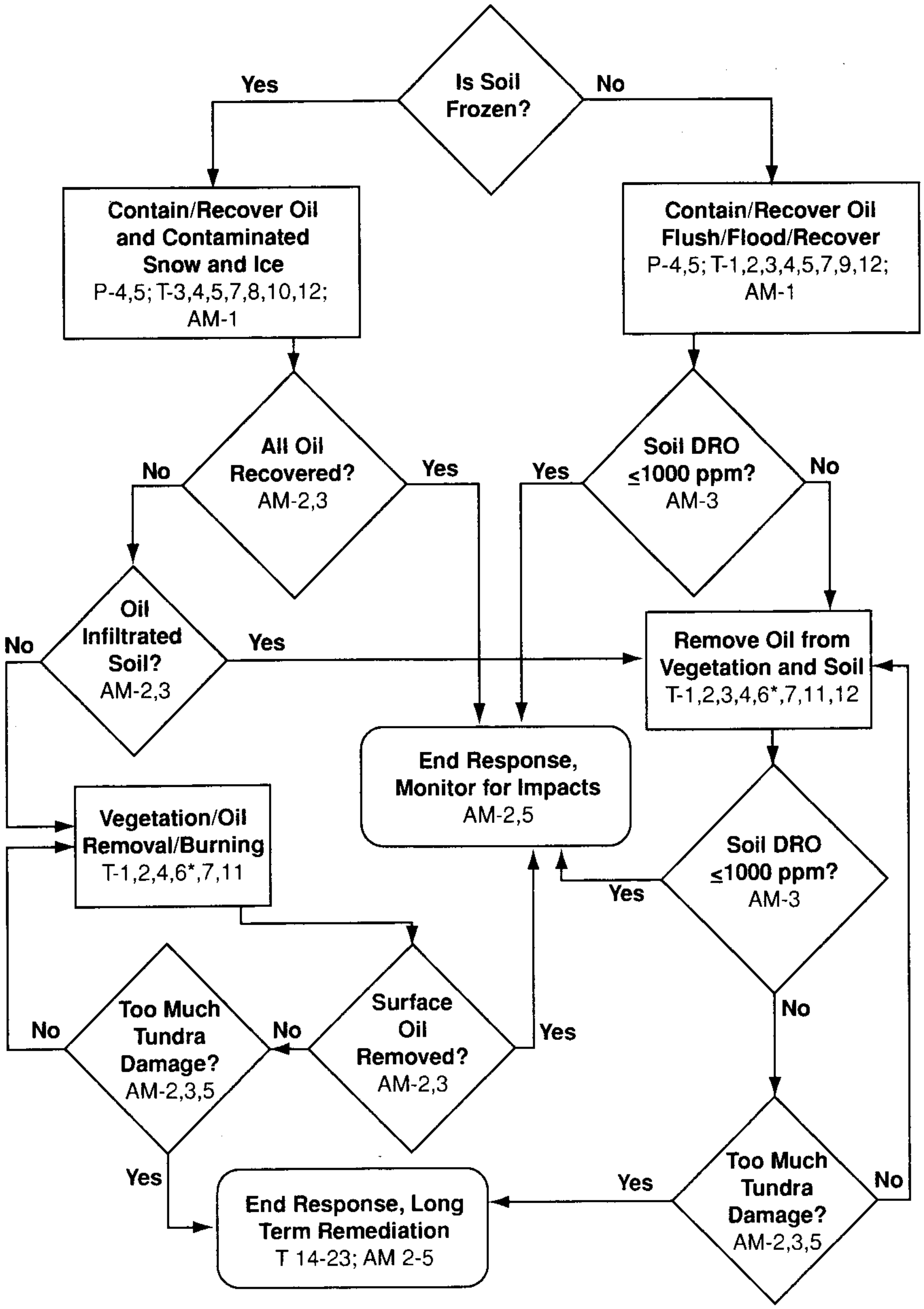

Diagram 1.

SALINE WATER SPILL RESPONSE DECISION TREE

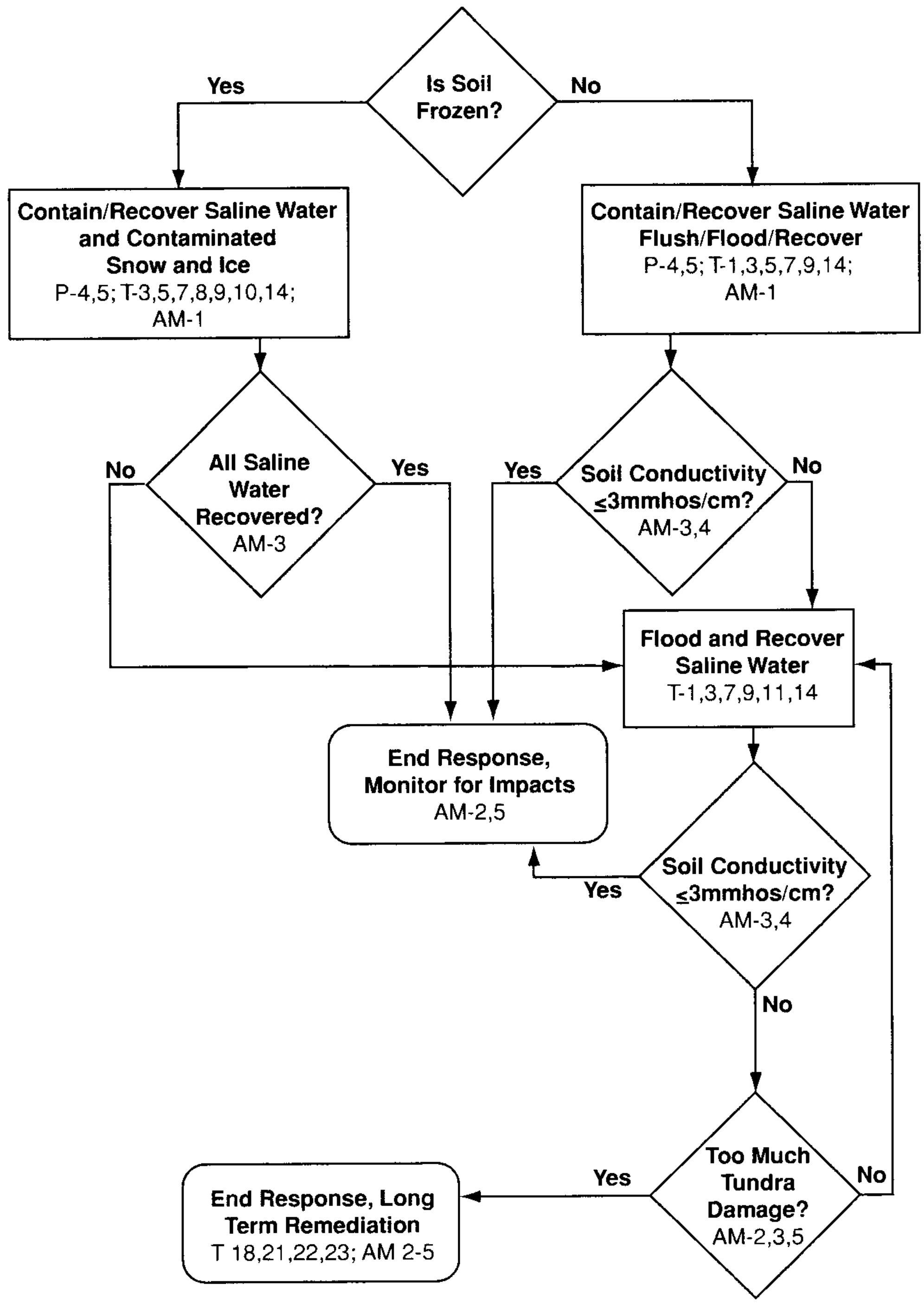

Diagram 2.

CRUDE OIL SPILL RESPONSE DECISION TREE

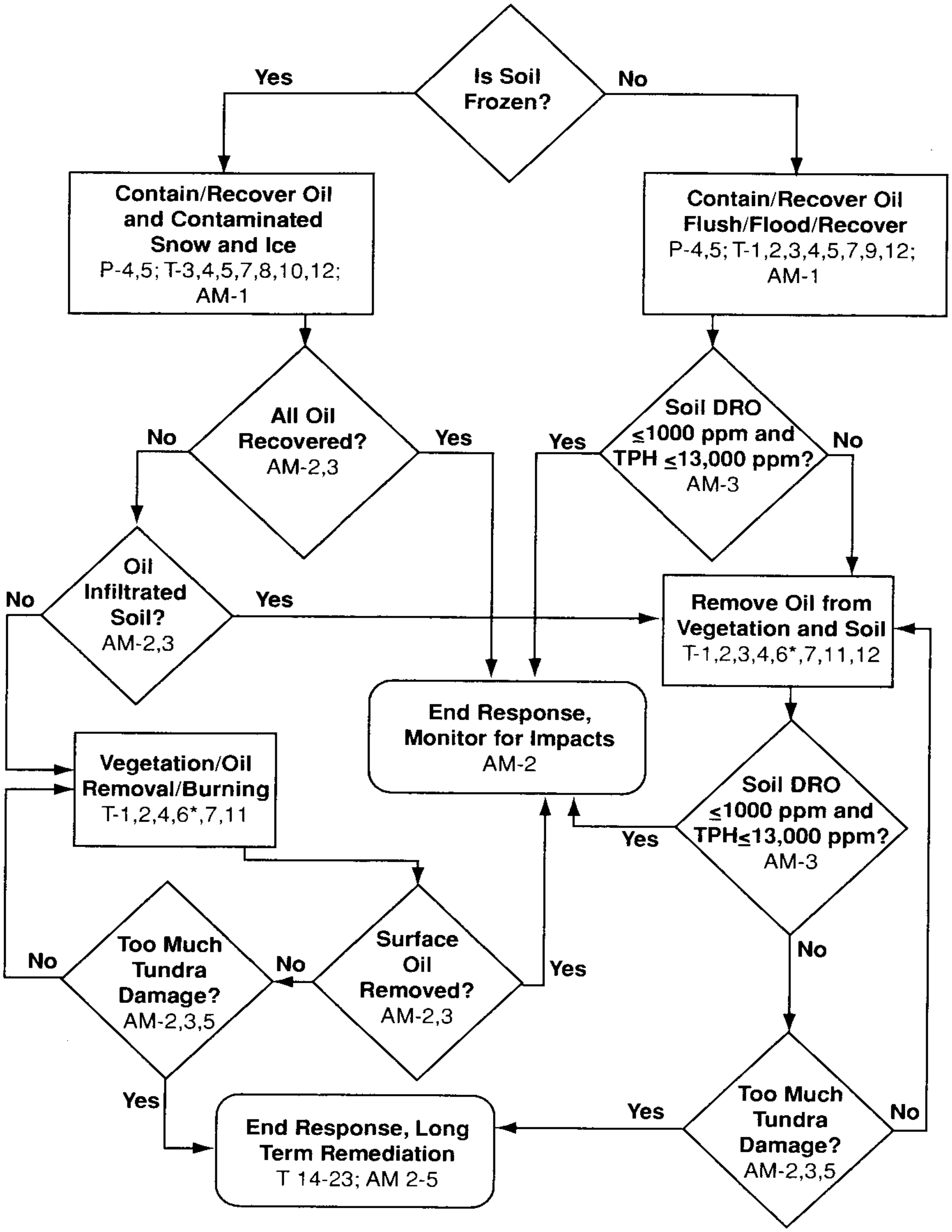

Diagram 3.

There are a number of tactics associated with each part of the decision tree. There are three types of tactics that the above decision tree lists: Planning Tactics (P), Treatment Tactics (T) and the Assessment and Monitoring Tactics (AM). For example, P-4,5 refers you to the planning tactics section that describes "minimizing physical damage to tundra" and "tundra travel". Other such tactics include flooding, flushing with surfactants, land barriers, sorbents, drainage protection, recovery with skimmers and pumps, and many more. Under each tactic there is a description of the proposed tactic, the applicability of the tactic (spilled substance, tundra type, and season), considerations and limitations of the tactic, and the equipment, materials and personnel to deploy the tactic.

Use of Documented Restoration Levels in Cleanup Actions.

The production of the TTG resulted in a major shift for spill site closure actions from the ADEC. Closure is now based on restoration rather than achieving a numerical value. The TTG defines conditions under which restoration and re-growth are most likely to occur following a spill event. Although the decision tree for cleanup actions still lists numerical standards, they are not used for site closure. They are intended to be used as action levels during the response phase following a spill. Based upon the compilation of information made for the TTG it was established that if contaminate levels exceed these values it can be expected that moderate to sever tundra damage will occur.

This effort has lead ADEC through an evolutionary process to develop standards for acceptable levels of remaining site contaminate. This process continues today. The TTG has become a resource in that process. A matrix was developed in the early 1990's for petroleum cleanup levels based upon the type of product and the receiving environment. This matrix was used as a guidance document in site closure until 1997 when ADEC promulgated regulations that included this matrix, now known as method one, and a set of cleanup levels based upon risk to human health into regulation. The method one matrix continues to be used for site closure following spills of petroleum based products to North Slope gravel pads but does not address tundra.

Application of only the regulatory human health cleanup standards for petroleum contaminates would leave contaminate levels high enough to kill much of the tundra vegetation. With the method one matrix not addressing tundra, and human health standards too high for environmental protection, it left cleanup levels to be set on a site by site bases. This becomes an expensive and time-consuming exercise. The TTG brings information together from past research and spill events so that cleanup levels can be established and used on the entire North Slope tundra environment.

The TTG was first applied to an incident that occurred in April 2001, at the Kuparuk Oil Field Central Processing Facility, North Slope, Alaska. An estimated 92,400 gallons of produced water containing 554 gallons of crude oil spilled all to tundra. The release was due to external line corrosion. The technique used to remove the oil and salt water (produced water) consisted of more than one tactic as outlined in the TTG. A regime of hot water flushing, thermoremediation (burning) and detergent washing was implemented. As expected, it took multiple flushing events to loosen and remove the crude oil from the tundra vegetation. The areas of the spill site that did not contain floating crude took less effort to remove the produced water but the removal techniques remained the same. Conductivity (salt levels) and hydrocarbon testing was conducted in all areas of the spill site. Target levels for conductivity were <3 mmhos/cm, TPH <13,000 mg/kg and diesel range organics (DRO) <1,000 mg/kg. It was with the aid of the TTG that the spill site was cleaned up to a standard that allowed for optimal re-growth/regeneration of the tundra.

Future Development

During November 2001, in the western operating area of the Prudhoe Bay reserve, a 1,764 gallon mix of hydrochloric acid, xylenes, freshwater, and corrosion inhibitor spilled all to tundra. The cause of the release was a tanker truck that rolled off the road and spilled all of the contents of the first compartment and some from the second compartment. This mixture of chemicals is typically used down hole in an oil well to remove all materials that, over time, has built up on the pipeline casing that may be impeding flow and production. It became apparent that a spill of this type to tundra, has not been documented in the past, and that no set cleanup tactics ever developed. This is an obvious informational gap in the TTG. Eventually tactics were developed and implemented, and the spill cleaned up. Damage to the tundra may be extreme in this case, so the better development of initial, short term and long term response tactics are warranted.

It has become apparent that this document is an excellent tool in developing site-specific response strategies to oil and hazardous substance spills to tundra. It was designed to be a dynamic and living document in that additional information from research and future spill events can easily be incorporated. It is intended that the TTG will be maintained on the ADEC website so that the latest version can be downloaded for free.

References

Athey, P., J. Conn, J. Lukin, J. McKendrick, D. Reeder, *Tundra Treatment Guidelines, A Manual for Treating Oil and Hazardous Substance Spills to Tundra,* State of Alaska Department of Environmental Conservation, Oasis Environmental, Inc., Lazy Mountain Research, and Lukin Publications Management, 2001.

Behr-Andres, C., J. Conn, S. Forester, and J. Wiegers, *Tundra Spill Cleanup and Remediation Tactics: A Study of Historic Spills and Literature,* AMEC Earth & Environmental and State of Alaska Department of Environmental Conservation, 2001.