SOIL REMEDIATION OF A FORMER TANK FARM SITE IN WESTERN ARCTIC CANADA

Yvan Pouliot[1], Calvin Pokiak[2], Nicolas Moreau[1], Eric Thomassin-Lacroix[1] and Christian Faucher[1]
[1]Biogenie Inc., Quebec City, QC, G1P 4P3
[2]Inuvialuit Land Administration, Tuktoyaktuk, NT, X0E 1C0

ABSTRACT

In Spring 1999, Defence Construction Canada issued a public tender for the soil remediation of a former tank farm site located near Tuktoyaktuk in Western Arctic Canada. This tank farm, built in the 1950's, supplied diesel fuel to radar stations of the Distant Early Warning (DEW) line in Northwest Canada. The environmental characterization of the site, performed in 1996, indicated that hydrocarbon contamination had migrated down to the permafrost, which reached a depth of two metres at the end of summer.

Based on treatability study results, on conditions specific to the site and to the project, and in view of minimizing costs, a remediation strategy was designed, which comprised the following elements:

- minimization of soil handling;
- utilization of a wind-powered soil aeration system;
- adapted design of the biological treatment to site characteristics;
- maximum use of local resources.

The project commenced in Spring 2000. A volume of 17,000 m^3 of hydrocarbon-contaminated soil was excavated and placed directly onto a treatment area where over 100 ventilation chimneys equipped with wind turbines were installed. At the end of the first season of treatment, approximately 45% of the soil undergoing treatment had reached the remedial criterion. This proportion rose to 85% after the second season (2001) and reached 100 % during the third season (2002). The success of the project relied on a good understanding of the site characteristics and of the contamination profile. It also involved the active participation of Tuktoyaktuk's Inuvialuit community. To this respect, local benefits were significant, through manpower hiring, rental of heavy equipment as well as all available services.

INTRODUCTION

Location and History

Saviktok Point lies on the eastern edge of the Mackenzie River Delta region where the river enters the Beaufort Sea (69° 26' N, 133° 00' W). The closest community is the Hamlet of Tuktoyaktuk, located across the harbour just 1 km west of the site, with a population of nearly 1,000 people. Saviktok Point hosted a tank farm which formerly served as bulk fuel storage for the western DEW Line sites during their construction and operation. The tank farm was formerly composed of seven (7) fuel tanks with associated piping interconnected by a pipe manifold. The tank farm had an overall capacity of approximately 9 M litres. A site characterization performed in 1996 revealed that diesel was the contaminant of concern for the site. Total petroleum hydrocarbons (TPH) were then identified as the control parameter for the remediation of the site. The remedial criterion used for this project was the Government of Northwest Territories (GNWT) Industrial Limit set at 2,500 mg/kg. According to the site characterization, the contaminated area was estimated at 11,000 m^2, and the volume of contaminated soil exceeding the remedial criterion was estimated at approximately 25,000 m^3 (ESG, 1997). Groundwater was not a concern for the site

since no water was detected in the piezometers, except for one, where only 150 ml was collected after five days. The site's proximity to the sea made it necessary to take special precautions regarding shore erosion, a particular concern on the West Arctic Coast. In 1999, the site was cleared of all tanks and associated structures during a demolition phase that was completed prior to remediation activities. Fauna in the general area includes caribou, polar bears, Arctic fox, Arctic ground squirrels and lemmings. Bowhead and Beluga whales and various species of seals also frequent the area. Birds found in the area include a variety of gulls, plovers, robins, ravens, sparrows and pipits, as well as waterfowl including loons and tundra swans. The vegetation is typical for the Beaufort Sea and the Mackenzie River Delta region including willows, grasses, sedges and mosses.

Geological and Climatic Conditions at Saviktok Point

The site was constructed on the southwest side on the highest elevation of a 2 km-wide peninsula, 10 m above sea level. The tanks were constructed on a pad of dense granular fill containing a mixture of sand, silt, some clay, stones, cobbles and small boulders. The thickness of the pad varied from 0.8 m at the north end to approximately 1.5 m at the south end. A dyke and liner system was constructed around the tanks subsequent to the original construction. The gravel pad was well drained and the surroundings showed positive drainage (slopes between 5% and 10% all around). The active layer over the permafrost was approximately 2 m deep in the gravel pad and less than 1 m deep in the surrounding tundra. Good drainage conditions combined, with very low precipitation in this region, render the permafrost little water-saturated. The Tuktoyaktuk area is a very dry location within Canada with an annual average precipitation of ~140 mm, compared to ~1,500 mm for Vancouver, ~1,200 mm for Quebec City and ~880 mm for Ottawa. Rainwater or groundwater was therefore not a concern for this project. The average temperature for the summer months (July and August) is around 10°C (see Table I).

Table I: Monthly Climatic Data for Different Canadian Locations

	TEMPERATURE (° C)				PRECIPITATION (mm)			
Month	**Tuktoyaktuk**	**Vancouver**	**Quebec**	**Ottawa**	**Tuktoyaktuk**	**Vancouver**	**Quebec**	**Ottawa**
January	-28.4	2.8	-12.4	-11.3	5	214	90	62
February	-29.1	4.2	-11.0	-9.7	5	161	74	58
March	-26.5	6.4	-4.6	3.6	4	151	85	67
April	-17.2	9.5	3.3	5.5	7	90	76	69
May	-4.7	12.8	10.8	12.7	6	69	100	70
June	5.1	15.6	16.3	17.9	13	65	110	77
July	10.6	17.8	19.1	20.8	20	39	119	88
August	9.0	17.2	17.6	19.2	28	44	120	92
September	2.6	14.5	12.5	14.3	15	83	124	83
October	-7.7	10.3	6.5	8.4	18	172	96	67
November	-19.7	6.4	-0.5	1.4	9	198	106	69
December	-25.2	4.2	-9.1	-7.6	7	243	109	78
TOTAL	--	--	--	--	137	1,529	1,209	880

Source: Environment Canada (average for the last decades)

Another important factor in the Tuktoyaktuk area is the high wind velocity. This characteristic represented an interesting source of available energy since no power was accessible at the site.

Comparative monthly averages for different Canadian locations can be found in Table II

Table II: Comparison of the Mean Wind Velocity at Different Canadian Locations (Km/h)

Months	Locations in Canada			
	Tuktoyaktuk	**Quebec City**	**Cap-aux-Meules***	**Ottawa**
June through September	19	12	27	12

* Cap-aux-Meules, one of the windiest places in Canada, is located in the Magdalena Islands.

REMEDIATION APPROACH

Since the bidding process for this project included a treatability study prior to the full-scale remediation proposal, representative samples were collected during a site visit and brought back to Biogenie's laboratory in Quebec City. In order to determine the best remediation strategy at the lowest possible cost, the treatability study focused on assessing different treatment alternatives. Two technologies, biopile and landfarming, were considered and two amendments, mineral and organic, were tested in order to determine which one induced the highest stimulation with regard to the indigenous microflora. An experimental protocol was developed considering the environmental conditions prevailing in the Tuktoyaktuk area so that the results obtained would reflect what would be expected during the full-scale project. The use of a landfarming technology was not feasible due to the available space. A surface of approximately 100,000 m^2 or the successive treatment of 5 to 6 layers of soil would be required for such a technology. Furthermore, a traditional *insitu* treatment system (vertical well installed in the undisturbed soil) would also not have been applicable in this project for the following reasons:

- the shallowness of the soil significantly limits the radius of influence of the vertical wells;
- a traditional *in-situ* system cannot emit enough heat to maintain an adequate biodegradation temperature;
- the geology is too heterogeneous (gravely on the surface and silty below the surface);
- the subsurface soil is not permeable enough (compact silt) to allow the creation of an aeration effect;
- the low level of nutrients in the soil would not have sustained the metabolic activities of the indigenous microorganisms.

The treatability results showed that two (2) factors had a significant effect on the TPH biodegradation: temperature and aeration. Hence, the design of the process to be applied at Saviktok Point had to take both factors into account. Moreover, to comply with project specifications and in order to ensure successful results, the selected technology had to meet several requirements, which are described below:

- on-site technology (DCC's preference);
- proven in comparable geographic conditions;
- efficient enough to achieve the clean-up goal (2,500 mg/kg TPH);
- safe for the environment: no risk for the surrounding areas and people;
- social friendliness: involves extensive participation of the community;
- allows for the segregation of clean soil from the contaminated soil;
- cost-effective compared to other approaches;
- flexible enough to adjust to the northern vicissitudes;
- may be operated during cold fall and spring temperatures;
- project to be completed before October 15, 2002.

A bioremediation process had been designed in order to meet all the above-mentioned requirements. Similar approaches were used extensively in several previous projects carried out in northern environments and proved successful results (Pouliot and Sansregret, 1999). Moreover, project cost ultimately constituted the main selection criterion, the challenge was to design an optimal remediation strategy taking into account the particularities of the site and of the project. Since there was no electrical facilities at Saviktok Point and given that a powerful generator (50 to 100 kw) was technically and environmentally risky to operate on the site, a wind-powered venting system was designed. Biogenie had successfully used this same kind of system in remote locations for the past 5 years. This process allows for the efficient treatment of the soil while ensuring that the appropriate biodegradation conditions prevail over the entire zone to be remediated. The stockpiling of the soil reduce the loss of heat by increasing the volume/surface ratio. When specific amendments are added and the system is properly operated, the biological hydrocarbon degradation generates a fair amount of heat. This exothermic reaction has been advantageous in many northern and winter projects. It has allowed the treated soils to maintain temperatures ranging from 20 º C to 30 º C even during the cold winter months where the outdoor temperature varies between –10 º C and –30 º C (Pouliot *et al.*, 2001). Based on treatability study results, on conditions specific to the site and to the project, and in view of minimizing costs, the remediation strategy which was designed comprised the following characteristics: minimization of soil handling, utilization of a wind-powered soil aeration system, customization of the biological treatment to the site characteristics (topography, geology, type of contamination, soil matrix and climate), extensive use of local resources and of time allowed for project completion.

FIELD WORK

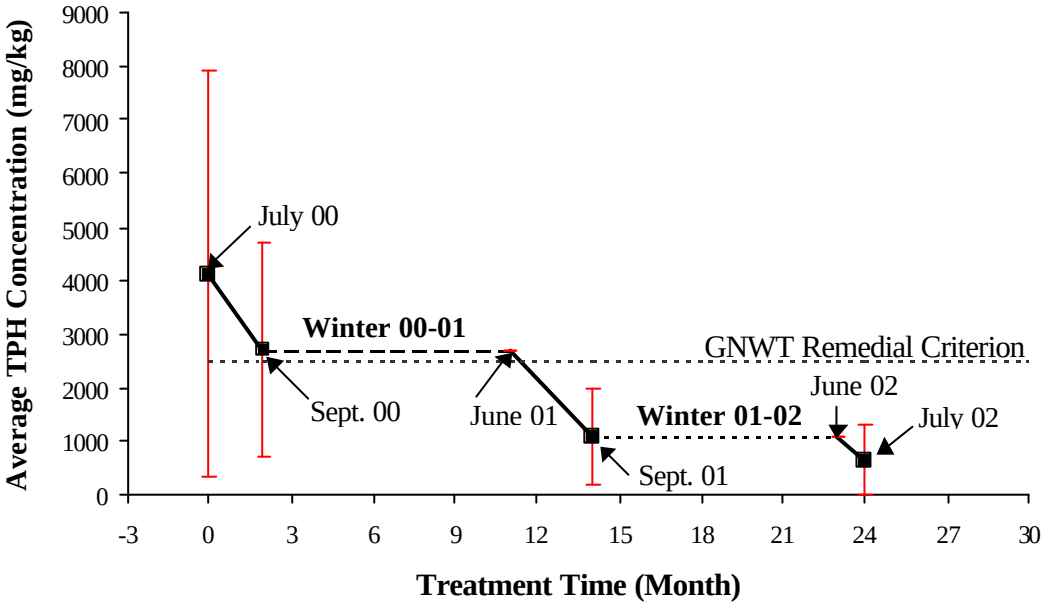
The land treatment area (LTA) was divided into 15 m x 15 m parcels. Each parcel was managed individually with regards to the remedial criterion. At regular intervals during the project, all parcel on the LTA were sampled in order to follow the remediation process. Parcels still showing TPH concentrations above the remedial criterion (2,500 mg/kg) were conditioned to promote and enhance biodegradation. Throughout the project, parcels showing TPH concentrations below the GNWT criterion were classified as "remediated" and no other activities were undertaken.

RESULTS

Figure 1 shows TPH removal throughout the project, based on average concentrations taken at different dates, with regard to the GNWT remedial criterion.

The average TPH concentration at Saviktok Point was at 4,136 mg/kg in July 2000 when the project commenced. The first season showed a TPH decrease of 34% (2,712 mg/kg TPH). After the second season, the TPH decrease was in the order of 74% (1,082 mg/kg TPH), and reached 85% (649 mg/kg TPH) during the third treatment season. The average TPH concentration remaining in the LTA was 649 mg/kg at the end of the treatment period. The total project duration was 24 months, which included an actual treatment time of 6 months (no biodegradation occurred between October and May due to freezing temperatures).

Figure 1: TPH Removal at Saviktok Point During Treatment



ABORIGINAL PERSPECTIVES

Background

The Inuvialuit Regional Corporation (IRC) and the Department of National Defense (DND) signed a Cooperation Agreement for the cleanup of six Distant Early Warning (DEW) Line sites in the Inuvialuit Settlement Region. During the cleanup process of the six DEW Line sites, discussions lead to the tank farm at Saviktok Point. The United States Air Force (USAF) had built and used the Saviktok tank farm storage facility in the late 1950's as a re-supply for their DEW Line operations. IRC requested that DND/DCC include the Saviktok Point tank farm as part of the cleanup. DND submitted a project description ("the application") to ILA for the cleanup of the tank farm facilities. The ILA Commission gave DND the approval in the spring of 2000 to proceed with the cleanup of the site. Biogenie was the successful contractor for the reclamation of the Saviktok Point tank farm. ILA and DND consulted with other environmental

specialists to discuss the project and agree to the method for remediation. In regard to the criteria for clean-up of contaminated sites, there were no established criteria by Government of Canada, therefore, agreed to the GNWT criteria set at 2,500 ppm for industrial and commercial land use.

Prior to the approval, DND and ILA had to successfully negotiate a site specific Participation and Access Agreement (P/A). In the P/A Agreement,

DND, and its contractors were required to follow a number of terms and conditions. One of these specific conditions was that Inuvialuit would have first preference for the supply of any equipment, training and employment opportunities. Futhermore, ILA would employ an Environmental Monitor for the duration of the project at DND's expense to ensure the terms and conditions were adhered too. The Inuvialuit Final Agreement (IFA) signed between the Inuvialuit of the Western Arctic and Government of Canada has given the Inuvialuit the opportunity to negotiate Cooperation Agreements, Participation and Access Agreements, and annexed terms and conditions for any activity anticipated by a developer(s) on private and crown land. The requirements of the IFA allowed Inuvialuit businesses and personnel to provide Biogenie with the equipment, manpower and transportation in the prompt cleanup of the Saviktok Point tank farm.

During the Remediation Project

The Saviktok Point project began with a partnering workshop where all stakeholders were present: Defence Construction Canada (DCC) as the contract manager for the Department of National Defence (DND), the Inuvialuit Land Administration (ILA) as the land holding organization, Biogenie as the prime contractor, E. Gruben's Transport Ltd. as the main sub-contractor, the Environmental Sciences Group (ESG) and UMA Engineering Ltd. as the scientific and technical advisors for DCC. During the workshop and throughout the project, ILA represented the interests of the local community and the aboriginal point of view. From the beginning of the project, a spirit of trust, cooperation and mutual respect was initiated. The following commitments were agreed to by all parties: to communicate openly and frequently, to maximize work opportunities for shared benefits, to remediate the soil in the interest of the environment and the people who inhabit the land, to respect the project budget, to implement effective health and safety procedures, to promote a team spirit and to determine and agree upon each other's expectations. The qualities that were requested by all parties to maintain good work relationships were transparency and openness. Honesty, integrity and goodwill are prerequisites to a satisfactory partnering and this is why great efforts were invested in strengthening these relationships throughout the project. A total of five public meetings were also held with the local community and additional daily meetings with the ILA field representative. In each of these meetings, the community was welcomed and encouraged to address their concerns and questions regarding the project. No special issues were raised during the project with the exception of a minor hydraulic spill that occurred at the site and the disposal of the contaminated material following the incident. Another question that was raised concerned the fate and re-use of the material following remediation. The community was disappointed that the material could not be used as fill material for residential purposes. Tuktoyaktuk is located in a low-level area where erosion has become a major problem for the community in recent years. The reasons why the material could not be used were related to the established remedial criterion (2,500 mg/kg TPH) which was too high for use in residential development and an inappropriate grain size distribution. In fact, considering the final average TPH concentration of 649 mg/kg, a large proportion of the remediated soil met the GNWT residential criterion of 500 mg/kg TPH. Finally, considering the need for cover material at the old hamlet dump, the community decided to use it for this purpose.

CONCLUSION

The entire volume of contaminated soil found on the Saviktok former tank farm pad (17,000 m^3) was excavated and placed in the land treatment area (LTA) for remediation. The technology used, an *In* situ Biopile with a wind turbine-based aeration system, produced a TPH removal efficiency of 85% over three treatment seasons. By July 2002, all soil in the LTA had reached the remedial criterion of 2,500 mg/kg TPH. The average TPH concentration of the remediated soil was 649 mg/kg at the end of the project.

The treatability study performed prior to conducting the field work had a key role in this project and revealed the potential for biological degradation at Saviktok Point. It also allowed to estimate the duration of treatment, the potential degradation rate as well as the optimal biodegradation conditions specific for this site. Based on these conclusions, the full-scale technology was successfully implemented at Saviktok Point and showed similar results to the ones obtained with the treatability study. The approach and the technology used for the this project were customized and site-specific, thus they could not be applied directly for project in another location. Overall, the success of the project relied on the thorough knowledge and understanding of the site characteristics and on the active participation of the Inuvialuit community of Tuktoyaktuk. To this respect, local benefits were significant, through manpower hiring, rental of heavy equipment as well as the use of all available services.

REFERENCES

Pouliot, Y. and J.L. Sansregret, 1999. Bioremediation of hydrocarbon-contaminated sites in northern regions: A synthesis of full-scale projects. Proc. Conf. Assessment and Remediation of Contaminated Sites in Arctic and Cold Climates (ARCSACC), Edmonton, AB, May 3-5 1999, p. 148-154.

Pouliot Y., N. Moreau and C. Faucher, 2001. Bioremediation of Arctic soils contaminated by petroleum hydrocarbons. Proc. Conf. Assessment and Remediation of Contaminated Sites in Arctic and Cold Climates (ARCSACC), Edmonton, AB, May 7-9 2001, p. 195-203.

Environmental Sciences Group, Royal Military College, 1997. Environmental Assessment of the Saviktok Point Tank Farm, Tuktoyaktuk, NWT. Presented to the Director General of the Environment (DGE), pp. II-1-IV-1.