RECLAMATION OF AN INDUSTRIAL SEWAGE LAGOON[1]

by

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Abstract. The Land Reclamation Division, Alberta Environment, was asked to reclaim an industrial sewage lagoon in the County of Leduc under the Land Reclamation Program. Data showed the lagoon sludges to contain low levels of contaminants considered to be moderately hazardous. Landfarming was selected as the most cost effective method of rendering the sludge non-hazardous. Extra safety precautions were taken to protect workers on site. During the planning phase, the chemical characteristics of the sludge, and the precautions required to protect workers, were considered to be the major obstacles to success. However, the physical soil characteristics created by the sludge caused the greatest reclamation problems.

Additional Keywords: priority pollutants, metals, EC, SAR.

Introduction

The Nisku industrial sewage lagoon, located 10 km south of Edmonton (Figure 1) in the County of Leduc, became operational in 1976/77. The lagoon had sewage trucked to it from holding tanks at each individual property in the Nisku Industrial Park. The lagoon was designed to hold one year's contribution of sewage, with subsequent disposal of supernatant to Black Mud Creek which enters the North Saskatchewan River upstream of the City of Edmonton's Rossdale Water Treatment Plant.

The County did not permit the disposal of industrial by-products or chemical wastes into the lagoon; however, the County did not monitor dumping at the lagoon. As a result, an accumulation of petroleum products began to become a problem by 1980.

In 1981, Alberta Environment requested the County improve the operation of the lagoon. As a result, a caretaker was hired and better monitoring was instituted. In 1984, it was felt that the lagoon was biologically toxic. Chemical treatment with aluminum sulfate was carried out prior to allowing the supernatant to be released to Blackmud Creek.

In June 1985, the County approached the Land Reclamation Division of Alberta Environment with a

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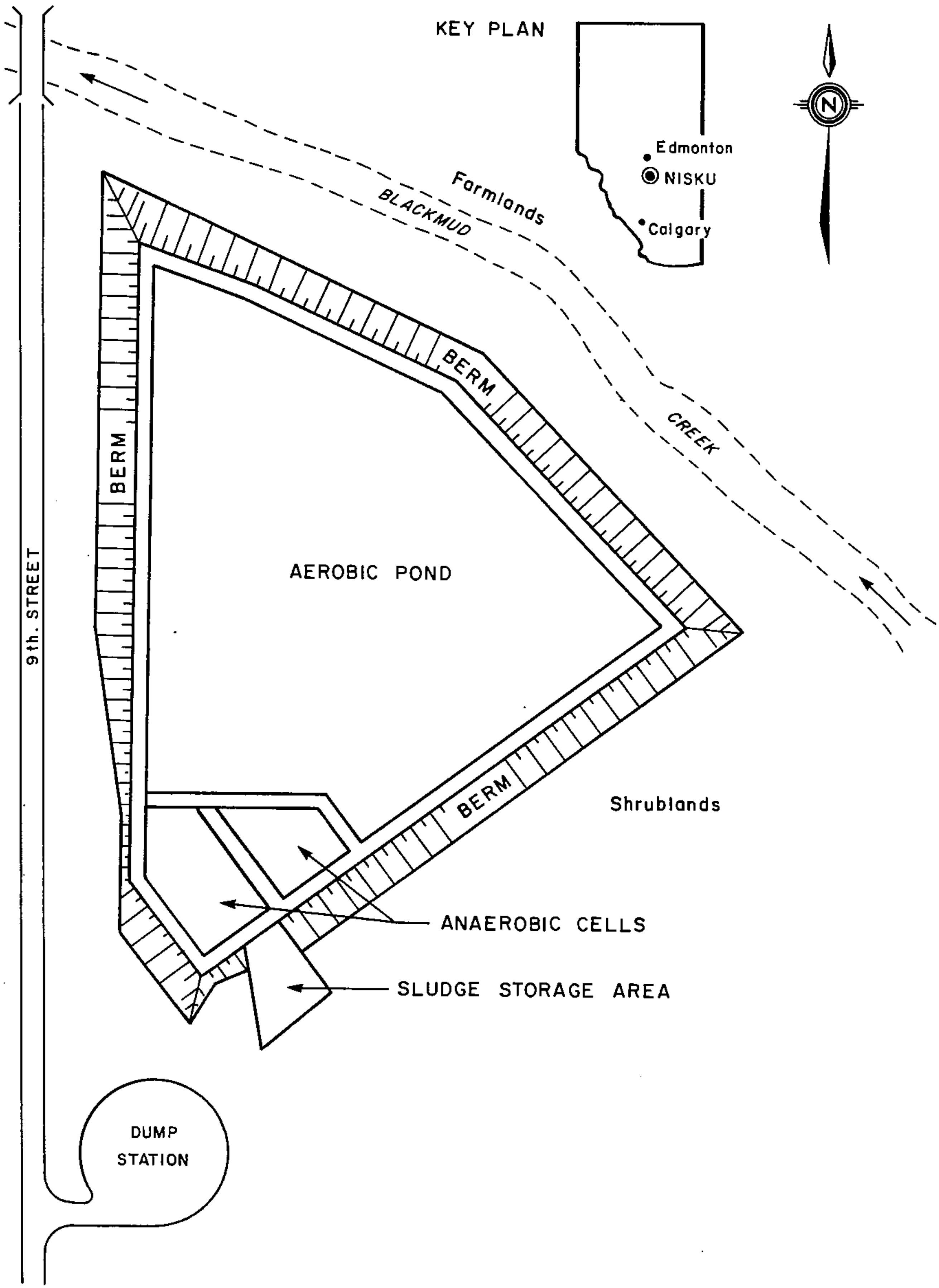

FIG.1 LAYOUT OF NISKU INDUSTRIAL SEWAGE LAGOON

request to reclaim the sewage lagoon which was to be abandoned in September 1986. The Division determined that the project met the criteria for inclusion in the Heritage Savings Trust Fund Land Reclamation Program.

Site Description

The 4.8 ha Nisku Sewage Lagoon is located in the northeast corner of the Nisku Industrial Park. The site is bordered on the north and east sides by Black Mud Creek, on the west side by 9th Street, and on the south side by an area of shrub and grass. The lagoon consisted of two anaerobic cells (approximately 58 m x 30 m and 46 m x 30 m), one triangular shaped aerobic cell (approximately 238 m x 201 m x 128 m), and one sludge storage pit (approximately 32 m x 27 m). The average depth of the anaerobic cells was 3.4 m, the aerobic cell 3 m and the sludge pit 1.8 m.

In October 1986, prior to commencement of any work, samples of the sludge were taken from one of the anaerobic cells, the aerobic cell, and the sludge storage pit and submitted for analysis of phenols and polycyclic aromatic hydrocarbons (PAHs). The samples were dried at room temperature and soxhlet extracted using dichloromethane (DCM) for 12 hours. The extracts were partitioned and further extracted to generate an acid fraction and a base/neutral (B/N) fraction. The B/N fraction required further clean-up on alumina to generate an aromatic (PAH) fraction. The PAH fraction and the acid fraction were then injected for analysis by gas chromatography/flame ionization (GC-FID) and followed by GC/MS analysis for target EPA phenols and target EPA PAHs. Subsequent generation of mass spectra and NBS library search was completed to characterize the major non-target acids and aromatics. The data obtained indicated the presence of a variety of organic compounds that may be considered to be moderately hazardous (Table 1).

Following review of these data, a further set of sludge samples from one of the anaerobic cells was obtained and analyzed for metals (3 samples) and EPA priority pollutants (1 sample). The metals were extracted with an aqua regia digest and assayed by ICP. The EPA priority pollutant sample was extracted and analyzed according to the EPA method 625S (Haile and Lopez-Avila 1984). This method generates four base/neutral fractions which are a result of a florisil clean-up and one acid fraction which is cleaned up through gel permeation chromatography (GPC). GC/MS total ion chromatograms (TIC) of all the fractions were provided. Table 2 lists the priority pollutants identified in the sludge.

Significant metals (mg/kg dry weight basis) in the sludge included: Al (12,900 - 19,100); Ba (287 - 563); Cd (less than 11.2); Cu (30 - 398); Pb (31 -1620); Mo (2 - 13); and, Zn (106 -1760).

Reclamation Plan and Safety Precautions

The Division's standard practice when reclaiming sewage lagoons is to drain any water from the cells, use a dozer to push in the lagoon berms, displacing the sludge from the bottom of the cells, respread sludge on the levelled berm material, replace topsoil (if available), and seed the site. In the case of the Nisku lagoon, the presence of the organic compounds, coupled with the location of the site next to the Blackmud Creek and an adjacent farm, necessitated some changes.

In consultation with various authorities within Alberta Environment, it was decided that a landfarming operation would be the

Table 1. Compounds identified in sludges at the Nisku sewage lagoon. All values in mg/kg (wet weight basis).

Compound	Anaerobic Cell	Aerobic Cell	Sludge Storage
Naphthalene	5	5	0.11
Methyl Naphthalene	60	45	NP
Dimethyl Naphthalene	100	100	NP
Trimethyl Naphthalene	90	120	16
Methyl Ethyl Naphthalene	15	15	NP
Fluorene	18	13	1.3
Methyl Fluorene	170	160	18
Dimethyl Fluorene	80	40	2
Phenanthrene	105	90	NP
Methyl Phenanthrene	220	250	20
Dimethyl Phenanthrene	60	80	4
Trimethyl Phenanthrene	15	20	2
C_{14} to C_{18} Fatty Acids	6000	1700	770
Aliphatic Compounds	300	600	330
Methyl Dibenzofuran	40	30	NP
Dibenzothiophene	50	45	NP
Methyl Dibenzothiophene	80	80	NP
Dimethyl Napthothiophene	70	60	20
1,1' Biphenyl	15	NP	NP
Methyl Biphenyl	45	NP	NP
Pentachlorophenol	NP	6	1.8
Phenol	NP	NP	0.14
3 Unidentified Aromatic S Compounds	NP	NP	23
Unidentified PAH's	NP	NP	40

NP - chemical not present in the sample

Table 2. EPA priority pollutants identified from one of the anaerobic cells at the Nisku sewage lagoon. All values in mg/kg (wet weight basis).

Compound	Concentration	Compound	Concentration
Naphthalene	86.3	Dibutyl Phthalate	3.8
Phenanthrene	25.1	Bis(2-ethylhexyl) Phthalate	44.3
Fluorene	13.8	Phenol	0.5
Fluoranthene	1.0	2,4 Dimethyl Phenol	0.4
Butyl Benzyl Phthalate	2.6		

most cost effective method of rendering the sludges non-hazardous. A decision was made to fence the entire property to prevent unauthorized access and exposure to the sludge. In addition, signs were posted indicating the site contained potentially hazardous materials.

Lagoon water was tested for contaminants and a decision was made that the low levels found, coupled with the low volume of water present, would permit discharge of the water into the adjacent regional sewer system. The sewage treatment plant operators were notified of the water chemistry and water volumes being added to the system.

Due to the moderately hazardous nature of the sludge, a number of safety precautions were necessary. The precautions required by the Alberta Environment Occupational Health and Safety Officer were: (1) disposable coveralls; (2) rubber boots; (3) rubber gloves; and, (4) respirators complete with dust and organic vapour filters. There was to be no eating, drinking, or smoking on the site.

After consultation, the Alberta Occupational Health and Safety Office recommended the use of full face respirators until the levels of emissions were known. Occupational Health and Safety also required facilities for the crew to change into their protective equipment and be able to wash up prior to breaks and leaving the site. In addition, all construction equipment was to be thoroughly steam cleaned and have air filters changed prior to leaving the site.

As required, operations commenced using the full face respirator. However, problems with condensation on the interior of the glass reduced visibility below acceptable limits. Despite treatments with antifogging solution, applied and dried by various methods, the problem persisted.

Measurements of the levels of emissions on the site (Draeger polytest) indicated the full face respirators were not necessary so permission was granted by the Alberta Environment Occupational Health and Safety Officer to use a half mask with filters for toxic dust and organic vapours, and goggles. This eliminated the visibility problem.

Reclamation and Landfarming Operations

In order to reduce the costs of protective equipment and steam cleaning, it was decided to complete the reclamation with the minimum amount of equipment, as follows: (1) D6C Dozer with wide pads and winch; (2) D8H Dozer with ripper; and, (3) TS14 Motor Scraper.

Reclamation of the lagoon commenced on November 12th, 1987 with the equipment squeezing and then landscaping the aerobic cell. When this was completed, the two anaerobic cells were completed by the same method. The sludge pit was then squeezed and landscaped. After landscaping and spreading of the sludge was completed, containment dikes, interceptor ditches and a sump were constructed to retain surface drainage on-site. Work was completed on December 10th. On December 11th, the machines were steam cleaned and, along with the site trailer, were moved off-site.

At the end of May 1988, following spring thaw and surface subsidence, additional recontouring work was undertaken using D6D and D3 dozers. By July of that year, a considerable volume of water had accumulated in the sump and the interceptor ditches. The water was sampled, analysed and found to be of acceptable quality, and so was pumped into the regional sewer system. The site was then harrowed to help dry out the surface and fertilized to enhance microbial degradation of organics in the sludge. Difficulties were encountered in some of the wetter areas which resulted in the tractor becoming stuck in several spots.

By the end of July, the surface was very dry except in the areas where the tractor had previously gotten stuck. A 350B wide pad dozer was brought in to spread the material in these areas to enhance drying.

The site was chisel-plowed and fertilized again in late August 1988 and accumulated water was again pumped from the sump and ditches into the regional sewer system. The drainage ditches were also harrowed in an attempt to improve drainage and to spread the sludge in the ditches onto the site. The site was given a final disc-harrowing in early October.

Each time the site was worked, all equipment was steam cleaned prior to leaving the site. All overalls, mask filters and air filters were left on-site for later disposal.

Results and Discussion

In mid-October, 1988, surface soils (0 to 15 cm) were again sampled for metals and EPA priority pollutants. As these analyses are extremely expensive, only one sample would be processed; it was therefore decided to collect four subsamples from areas of obvious contamination, (i.e., pure sludge and obvious salt crusts) in order that the worst-case scenario would be determined. EM-38 readings taken on-site, coupled with evident salt crusts, led to analysis for EC and SAR as well.

Only two of the EPA priority pollutants were found in the sample (expressed on a wet weight basis): Bis (2-ethylhexyl) phthalate (2.3 mg/kg) and dioctyl phthalate (2.4 mg/kg). Neither of these is considered hazardous, even at much higher concentrations (Naylor and Loehr 1982a,b).

Care should be taken when evaluating the results of both EPA priority pollutant analyses as there was only one sample taken in each case. In particular, the results of the second sampling do not necessarily mean that the landfarming operation has successfully degraded the pollutants shown in Table 1. Many more samples would be required to prove this hypothesis; however, the costs to do these analyses precludes a massive sampling program.

Significant metals (total levels as mg/kg dry weight) included: Al(15,300); Ba(483); Cu(36.3); Pb(58); and, Zn(133). Diethylenetriamine pentacetic acid (DTPA) extracts of the same samples (McKeague 1978), which test for plant available metals, showed much lower levels (i.e. in mg/kg on a dry weight basis, Zn - 10.9 and 12.1 vs 133; Pb - 13.7 and 16.1 vs 58; Cu - 4.3 vs 36.3) than those found in the total extractable analysis. However, even the total values are lower than those specified in Alberta's sludge application guidelines (McCoy et al. 1982). The sludge/soil mixture is therefore acceptable from the standpoint of metal content.

Of greater concern for future reclamation are the results of the particle size and salinity analyses. The samples were classed as clay loam to clay with a saturation percentage of 83%. The materials had EC values of 4.1 to 6.4 dS/m and SAR values of 7.2 to 8.4, which render them Fair to Poor as subsoils (ASAC 1987). Soluble sodium was present at 26.0 meq/L to 41.0 meq/L.

Conclusions and Future Work

In assessing the best methods for reclaiming this site, Alberta Environment decided to err on the side of safety. Extra precautions were taken on-site to protect workers and to reduce the likelihood of unauthorized personnel being exposed to the sludge. Results of the soils analysis one year after reclamation commenced appear to indicate a reduction in the potential hazard posed by the sludge. This apparent reduction may be due to biodegradation of organic compounds as a result of the landfarming operation or to a dilution of the sludge contents through mixing with soil, or a combination of both. It is important to note, however, that the limited sampling does not allow firm conclusions as to the extent of degradation. For this reason, the fence will remain in place for several more years to ensure unauthorized access is restricted.

During the planning phase of this project a great deal of attention was given to the organic constituents in the sludge and their potentially hazardous properties. However, once landfarming operations commenced, the addition of the sludge to the soil produced other problems which may, in the longer term, be more difficult to address than the organics.

The high clay content of the sludge/soil mixture leads to the formation of surface crusts when dry and sealing when saturated, resulting in ponding of water. The surface crust (approximately 10 cm deep) slows the drying process below the surface, leaving visually dry areas soft enough underneath to trap the equipment used in the landfarming operation. This necessitated bringing in construction equipment a number of times to expose the subsurface material for drying, and thus greater expense.

The salinity and sodicity of the surface materials, coupled with low organic matter levels and a minimal amount of topsoil available to cover the reclaimed area poses future problems. Amendments such as manure, straw or peat are being considered to increase organic matter content, and hopefully, to further enhance the biodegradation of the remaining organic compounds. Gypsum or other calcium sources may be required to improve the chemistry of the soil to ensure adequate plant growth.

Work in 1989 will include recontouring the site to enhance drainage, organic matter additions to enhance degradation of the remaining organics and to improve soil drainage, continued landfarming (tillage plus fertilization), respreading of available topsoil, and reseeding.

Work in 1990 and later will depend on the results of chemical analyses and growth of the crop planted in 1989.

In summary, landfarming appears to have resulted in an acceptable reduction of the hazard posed by the sludge. However, the Division will continue the landfarming operation for one more year and will maintain restricted site access.

The physical properties and inorganic chemistry of the sludge/soil mixture have posed more operational reclamation difficulties than the organics have.

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