

INDUSTRIAL SITE DECOMMISSIONING
AND RECLAMATION¹

by

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Abstract Monenco Consultants Limited of Calgary has been actively working on industrial site decommissioning projects for the past ten years. During that time Monenco has published a guide to the environmental aspects of industrial site decommissioning which identifies the range of activities involved in the planning and implementation of industrial site decommissioning, cleanup and reclamation. The guide outlines a step by step approach which requires the involvement of expertise from a wide range of disciplines. This paper highlights issues, concerns, and challenges facing individuals practicing soil science within the interdisciplinary framework of industrial site decommissioning projects.

Introduction

The modernization of Canadian industry, consolidation of manufacturing into larger more efficient operations, and the switch to a more service oriented society have resulted in changes in land use patterns around major industrial centres and increased the need for site cleanup and reclamation activities. Although these changes in land use are most obvious in urban centres, a shift from industrial to agricultural land use is not uncommon in rural Alberta.

When a decision is taken to decommission an industrial facility, the determination of the need for and extent of site cleanup will require the completion of a series of assessments and investigations. Waste management practices, byproduct storage methods and spills of chemicals or byproducts during plant operations may have resulted in the contamination of soils, sediments, surface waters or groundwaters on the plant site. In addition, catalysts, sludges and residues within process vessels, gutters and sumps may require special handling and disposal methods.

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Waste handling and disposal can be expensive, especially if the wastes are considered hazardous. Pre-planning, proper site inventory, and development of site specific end land use cleanup guidelines, are important steps in the management and cost control process of any cleanup program.

Regulatory commitment to public health protection through legislation and implementation of supporting regulation is necessary to set industrial standards to which all real property owners can respond. In Canada, policy development is led by the Canadian

Council of Resource and Environmental Ministers (CCREM). CCREM committees are responsible for responding to public environmental concerns by overseeing the development of such things as soil cleanup criteria. Public concern for environmental issues provides a vehicle for the detection of priorities and thereby justification for public financial support for CCREM Committee(s) and provincial environmental regulatory action.

This paper focuses on the technical aspects of plant site assessments, the detection and delineation of contaminants and the development and implementation of site cleanup plans. New trends in procedure for the development of industrial site cleanup guidelines are also presented.

Environmental Concerns at Industrial Facilities

When an industrial site is decommissioned a variety of environmental concerns that may ultimately impact on the reclamation success and the acceptability of the site for future land uses must be addressed. These concerns will be a function of:

1. the product produced and type of chemical and/or manufacturing processes employed;
2. waste management facilities and procedures utilized when the plant was in operation;
3. the geologic and hydrogeologic setting of the site;
4. the age of the facility;
5. site size and location;
6. backgrounds levels of parameters of concern; and.
7. regulatory requirements.

While the precise nature and extent of environmental concerns at any given facility are highly site specific, some generalizations are possible. The following areas, facilities or contaminants are common to many industrial plants and are those most likely to represent or generate concerns at decommissioning;

1. fuel/chemical storage areas;
2. wastewater impoundments;
3. waste/by-product storage areas;
4. landfills;
5. asbestos insulation and fire proofing;
6. sludges and sediments in building gutters and sumps;
7. process equipment and services;
8. underground tanks and services;
9. PCP wood treatment facilities or wood storage yards;
10. PCB's in electrical equipment; and,
11. sewage lagoons.

Guide to Decommissioning Industrial Sites

Addressing site specific environmental concerns requires a flexible approach. In response to this need Monenco prepared a guide to assist industry and government in the decommissioning process. Development of the guide was sponsored by Environment Canada, the Petroleum Association for the Conservation of the Canadian Environment, Canadian Chemical Producer's Association, and the Canadian Petroleum Association.

The Guide to the Environmental Aspects of Decommissioning Industrial Sites (Monenco Consultants Limited 1985) identified a stepwise approach

to decommissioning industrial sites. The main elements of this approach are shown in Figure 1. By following the sequence of activities in a step-by-step manner, the assessment of plant site conditions and the design and implementation of site cleanup will be all-encompassing and cost-effective to permit redevelopment of the site. The approach is flexible and responsive to specific site conditions; the level of effort required for each activity is dictated by site conditions and previous waste management practices.

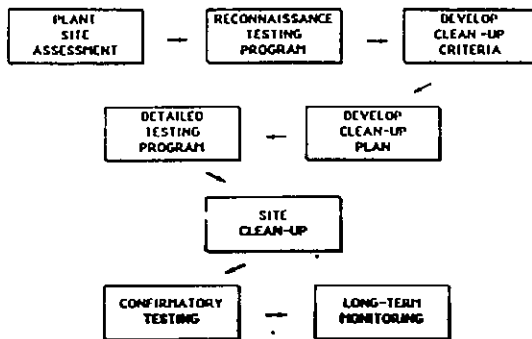


Figure 1 - Main elements of step-wise approach

Plant Site Assessment

The objectives of conducting a plant site assessment are to identify potential environmental concerns associated with plant operations, and accordingly, to provide the basis for the design of sampling and analytical programs. The plant site assessment includes a review of available background, process and waste management information. In addition to the examination of old aerial photographs and construction drawings and files, the site assessment should consider site soils and groundwater information; processing details; composition of solvents, inhibitors, water treatment and other chemicals; available information on solvent degradation products; mercury use; records of spills and leaks; operational details of the plant landfill; disposal practices for sludges and spent catalysts; and operational details of wastewater treatment systems.

Much of the background information can be assembled from discussions with long-term employees of the plant. A thorough assessment should also include detailed site inspections and examinations of key areas.

Reconnaissance Testing Program

Environmental investigations which involve extensive sampling and analysis are more effective if undertaken in phases. The first phase is a reconnaissance program designed to provide indications of contamination and to provide the basis for detailed investigations in certain areas. In some cases, the reconnaissance program may show that subsequent detailed investigations are not required.

The main objectives of a reconnaissance testing program are to:

1. identify the types of contaminants, range of contaminant concentrations and general locations of contaminant concerns; and
2. clarify the geologic and hydrogeologic conditions of the site and surrounding area.

The design of the reconnaissance program would include a consideration of the possible types and locations of contaminant concerns at the site and geologic and hydrogeologic factors. In this way, procedures can be established for the collection of representative samples and for the analysis of chemical parameters of concern.

Field Work. Reconnaissance-level sampling at a typical industrial site may include:

1. a survey of the site using surface geophysics to identify near-surface soil disturbances, shallow groundwater concerns and the location of buried waste pits;
2. sampling of soils from boreholes or test pits located in areas of

- concern. Samples would normally be collected at the surface and at various intervals to a depth below buried services;
3. the establishment of soil sampling sites on a widely spaced grid or at sites located radially outward from a contaminated source to provide an initial estimate of the possible extent of contamination;
 4. sampling sediments in drainage ditches which collect runoff from process areas, landfills and product/waste storage areas;
 5. sampling sediments and sludges from oily water separators, process wastewater ponds and surface water runoff ponds. Grab samples may be sufficient for a reconnaissance characterization of these sediments and sludges; but, if large sludge accumulations exist, coring devices may be required to collect representative samples;
 6. establishing the geologic and hydrogeologic setting of the plant by drilling boreholes at selected locations, collecting samples of soils, overburden and bedrock and installing piezometers to determine rates and direction of groundwater flow;
 7. installation, testing and sampling of piezometers in areas of concern. These may include a series of piezometers installed at various depths in the vicinity of wastewater ponds, process facilities, hydrocarbon storage facilities, chemical handling areas, previous spill locations and landfills;
 8. excavation of test pits or drilling of boreholes in the landfill to determine the nature and extent of buried wastes and to undertake selected sampling;
 9. location of background sampling sites at off-site locations away from the influence of the plant and sampling of soils and groundwater to determine background chemical composition; and,
 10. completion of other miscellaneous sampling to assist in the evaluation of conditions at the site. These may include:
 - in-building residue samples from gutters, sumps and process vessels;
 - samples from the laboratory sump and areas where mercury may have been handled;
 - transformer fluid samples to determine the presence of polychlorinated biphenyls (PCBs); and,
 - process or water treatment chemicals which may not be completely characterized.

Analytical Program. The quality of analytical results is one of the most important aspects of environmental investigations. Analytical quality control is equally important in decommissioning studies, particularly in relation to the detection of trace quantities of various contaminants and in the quantification of waste materials which may have to be handled, treated and disposed of by costly methods. Therefore laboratories selected for the analysis of samples should be experienced in the analysis of environmental samples, possess instrumentation to accurately detect and confirm contaminant concentrations and have internal quality control programs to ensure the precision and reproductibility of analytical determinations (Monenco Consultants Limited 1987).

For a reconnaissance testing program, the analytical parameters should include all potential chemical contaminants. It is effective to analyze some of the samples in phases, for example, one or two samples from a borehole could be analyzed in the

initial phase and further sample analyses would be determined by the initial results. The use of indicator parameters and multi-element scans has proven effective in reconnaissance investigations, followed by more detailed analyses as required.

The initial analytical results may dictate further analyses to confirm any contaminant indications. These may include:

1. analysis of certain elements by atomic absorption; and,
2. identification of the organic composition of certain samples by gas chromatography/mass spectrometry (GC/MS).

Development of Cleanup Criteria

The reconnaissance testing program will provide the chemical composition of soils, sediments and groundwaters on the site. These can be compared to the chemical composition of background samples and it may be found that certain chemical concentrations are in excess of background levels. However, the significance of elevated concentrations is directly related to the magnitude of measured levels, the proposed future use of the site and the plant site setting. To determine the maximum contaminant concentrations that may safely remain in soils and groundwaters without causing adverse health and environmental effects, cleanup criteria are required.

Cleanup criteria are benchmarks which identify the significance of contamination on the site and are subsequently the 'numbers' which define the extent of site cleanup. Criteria are directly related to the anticipated future use of the site as well as geologic, hydrogeologic and other site-specific factors. The criteria must be developed on a sound scientific basis to protect future users of the site.

At present, there is limited precedence for the development of cleanup criteria, particularly related to potential health effects of contaminants in soils. Dependent on future land use, considerations may include:

1. soil/crop relationships with respect to crop phytotoxicology and to animal grazing or the production of feed or food crops;
2. potential effects of ingestion, inhalation or dermal exposure of wind blown dusts or vapours;
3. potential effects of inadvertent ingestion of contaminated soils (such as may occur with children at play);
4. biodegradability of organics in soils or groundwaters; and
5. potential effects of contaminants on construction materials.

When the cleanup criteria are finalized, the process of determining cleanup needs can proceed.

Few jurisdictions have established acceptable soil concentrations or cleanup guidelines. To address various pressing issues concerning the decommissioning of industrial sites in Canada, a national Decommissioning Steering Committee was formed that includes representatives from the Provinces of Alberta, Ontario, and Quebec, the Canadian Petroleum Association, the Canadian Chemical Producers Association, and the Petroleum Association for Conservation of the Canadian Environment. The Committee is chaired by Environment Canada.

In late 1986, the Decommissioning Steering Committee decided to act upon one of its highest priorities and initiate the development of a method for setting site-specific cleanup guidelines. Early in 1987, a contract was awarded to a consortium headed by

Monenco Consultants Limited to review the approaches of other agencies to setting guidelines; recommend an approach for Canadian agencies; and develop a method that demonstrates the recommended approach. The total project was funded jointly by the members of the Decommissioning Steering Committee.

The objective of the project was to produce a computer model that can be used to derive cleanup guidelines for industrial sites where redevelopment is being considered or planned. The result is the "demonstration" version of the Aid for Evaluating the Redevelopment of Industrial Sites (AERIS) model. The current form of AERIS is referred to as the "demonstration" version because it contains sufficient information for only seven contaminants (four organic compounds and three metals), four types of future land use, characteristics of two types of receptors, the meteorology of six Canadian cities, the characteristics of nine soil types, and the characteristics of 14 types of geological formations.

When the system becomes fully operational, AERIS will be an attractive aid for a broad spectrum of potential users as follows:

1. AERIS could be used by any regulatory agency asked to comment on the "acceptability" of a contaminated site for a proposed use, determine whether cleanup efforts are necessary, or identify cleanup objectives;
2. AERIS could be used by any current owner of a site interested in knowing whether remediation may be necessary and, if so, to what extent. For contaminants that have not been addressed by regulators, AERIS could be used to give the first approximation of the cleanup guideline that eventually may be established;
3. AERIS could be used by a prospective buyer of a contaminated site to determine if current site conditions are suitable for various potential uses or to determine the level of risk of liability associated with site;
4. AERIS could be used by a consultant assisting any of the above parties;
5. AERIS could be used by educators to demonstrate to students the interrelationships between environment and dose and as a means for incorporating risk assessment into the decision-making process; and,
6. AERIS could be used by any interested party to investigate the sensitivity of the final results to specific parameters and thus help the scientific community to identify those factors and conditions that have the greatest influence in establishing soil guidelines. Where resources are limited, attention should first be paid to improving confidence in the key factors.

Detailed Testing Program

The reconnaissance testing program provides data on the types of contaminants, ranges in concentration and generalized locations of contamination. If contamination concerns are identified on-site, a further investigation is required to provide details for cleanup and reclamation of the site. The detailed investigation will focus on those concerns that are judged to be significant in terms of the cleanup criteria, and will provide additional reclamation-related information required to assist in the evaluation of cleanup and reclamation alternatives.

A detailed testing program may include:

1. establishment of the boundaries of areas contaminated with chemicals or compounds at levels greater than cleanup criteria;
2. clarification of hydrogeologic conditions and examination of temporal groundwater quality concerns;
3. determination of the form and mobility of chemical contaminants through detailed chemical analyses and leaching tests; and,
4. compilation of site-specific factors such as moisture/density relationships, buffering capacity, ion exchange capacity, etc., which will be necessary to develop cleanup and reclamation measures.

Preparation of Cleanup Plan

The completion of a detailed testing program at the site and finalization of cleanup criteria will permit the development of a cleanup plan. This plan will thoroughly define cleanup actions, measures for worker health and safety and treatment and disposal of wastes. The evaluation of cleanup options may necessitate a change in the desired future use of the site if cleanup to established criteria cannot be achieved due to technical or economic reasons.

The cleanup plan, when completed, would normally be integrated with other decommissioning activities (i.e. removal of buildings, equipment, etc.) and would contain detailed descriptions of all cleanup, reclamation, containment and monitoring plans.

Site Cleanup

When the cleanup plan is finalized, cleanup of the site can commence. Depending on site conditions, it may be undertaken over several years, or may be a relatively simple and straightforward program involving the removal of byproducts

and processing components and disposal of sludges. While cleanup activities vary from site-to-site, important factors which must be considered in the implementation of a cleanup plan are the collection and treatment of wastewaters during the cleanup program, provisions for worker safety and health and the sequence of cleanup activities.

A typical sequence of cleanup actions is summarized as follows:

1. removal of byproducts, chemicals and catalysts;
2. removal of in-building sludges and residues;
3. removal of process equipment;
4. cleaning of building interiors;
5. dismantling of buildings;
6. removal or sealing of buried services;
7. installation of containment facilities;
8. excavation of contaminated soils and sediments;
9. implementation of in-place reclamation measures; and
10. installation of long-term monitoring facilities.

Confirmatory Testing

When site cleanup is completed, or when phases of a multi-phase cleanup program are completed, confirmatory testing is required to ensure that the task of removing contaminants from the plant site or reclaiming contaminated soils has been effective.

With respect to areas of excavation, the confirmatory testing program would involve sampling of soils within and nearby excavated areas and analysis of samples with respect to cleanup

criteria. Usually an independent contractor (i.e. one who has not previously been involved in site investigations) would conduct the confirmatory testing program.

Other confirmatory testing would likely be carried out in conjunction with long-term monitoring of the site.

Long-Term Monitoring

Requirements for long-term monitoring of site conditions will vary from site-to-site, and will provide assurances that cleanup and reclamation programs have been effective. Monitoring may include groundwater, surface water runoff, biodegradation rates and metal uptake in crops. The monitoring program may continue for several years and may be gradually phased out when sufficient monitoring data demonstrate the integrity of the site.

Cost Implications

The costs of mitigating environmental concerns at a decommissioned industrial facility will depend heavily on the nature of materials and wastes produced and the extent to which they have been properly managed during the facility's lifetime. Costs can easily range into the millions of dollars for facilities operated using the less than rigorous waste management practices commonly applied in the past. In some instances, current practices still do not provide for adequate management of environmental risks and may eventually result in high decommissioning costs.

Overview

Ideally, site decommissioning, cleanup and reclamation planning begins at site selection phase of project development. It is at this time that critical site characteristics such as soils, groundwater, geology and the interaction between site factors should be evaluated as to their sensitivity to the types of

contaminants likely to be found on site after development is complete. Data from this early site evaluation procedure can then be integrated into the development program and thereby minimize the need for expensive site decommissioning and cleanup activities later on.

At older plant sites the damage has often already been done. Decommissioning and reclamation specialists must implement a number of studies to find out what contaminants have been released, what risk to human, animal and environmental health these contaminants pose on site and what potential hazards off-site soil contaminant migration might be.

Research is required into the development of site-specific cleanup criteria, biodegradation properties of organic compounds, uptake of heavy metals by plants, rate of contaminant migration through soils, soil solidification and disposal methods, and leachate treatment systems. Based on knowledge of these factors environmentally appropriate cleanup procedures will ultimately be more cost-effective and ultimately pose less risk to future land use.

Summary

Environmental concerns which may require cleanup or reclamation actions at retired industrial sites are directly related to site geologic and hydrogeologic conditions and previous waste management practices. By completing the sequence of assessments, investigations and cleanup evaluations identified herein, the cleanup of an industrial site will be cost-effective and successful. The site can then be safely re-developed for other uses.

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