

FINAL REPORT



NUMERICAL SIMULATION, RISK ASSESSMENT, SITE REMEDIATION, AND MONITORING DESIGN

— A Study of Soil and Groundwater Contamination at
the Cantuar Field Scrubber Site



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PART TWO – Methodology for Subsurface Modeling

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PART THREE – Result of Subsurface Modeling

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PART FOUR – Risk Assessment

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PART FIVE – Design of Remediation Systems

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EXECUTIVE SUMMARY

The Cantuar Field Scrubber Site has been contaminated by petroleum hydrocarbons, benzene, toluene, ethyl-benzene, and xylenes (BTEX). Previously, a number of investigation projects and dual phase vacuum extraction (DPVE) remediation actions have been undertaken. However, insight of the site contamination, pollutant migration, biodegradation kinetics, interactions among different hydrocarbon phases, and DPVE system performance is still unavailable. Many questions remain to be answered, such as:

- (1) What happened underground?
- (2) Are there specific impacts on the community?
- (3) What will be the influence of DPVE remediation on site cleanup?
- (4) What will happen in the future if we do not take any further remediation action?
- (5) Which further remediation technologies are suitable for the site?
- (6) What clean-up efficiency is needed?
- (7) When should we take actions?
- (8) Where should be the focus for the actions?
- (9) Where should we monitor?
- (10) What should be the suggested future sampling frequency?
- (11) What should be the contaminants of concern to be monitored at the site?

Answers to the above questions will help decision makers to get insight into the current site situation. They will then know what they have to spend for, what they do not have to; how much they really have to spend, and how much is still uncertain. These will also be very helpful when they are discussing the problems (and the relevant decisions) with the local authorities.

A good decision will help to reduce a big amount of costs, while a not-so-good one may mean a number of consequences to the present and the future. For a complicated system, such as the site-contamination problem under consideration, this good decision should be based on good and thorough research efforts.

This project is to conduct a thorough study of the site to answer the above questions, according to the letter of July 20, 2001 from the Environmental Affairs, TransGas (see Appendix One). In detail, it consists of the following tasks:

- Modeling for the fate of petroleum contaminants in subsurface under various remediation scenarios;
- Modeling for the DPVE remediation process to examine the system performance;
- Environmental risk assessments under various remediation scenarios;
- Recommended decisions for problem solving;
- Decision analysis for remediation actions;
- Operations analyses for monitoring networks.

The results indicate that the above tasks have been successfully fulfilled.

The element of modeling for the fate of petroleum contaminants transport in subsurface and modeling for the DPVE remediation process is one of the most challenging tasks in this study. A large-scale 3-D numerical simulation model is developed for the site to predict the contaminants transport fate in the subsurface, and a large 2-D numerical simulation model is also developed to simulate the DPVE remediation process (Our program is the only organization in western Canada being also to conduct this type of simulation). The results are useful for:

- quantitatively answering questions related to site contamination situations under various remediation scenarios;
- predicting spatial distribution of contaminant concentrations in different time periods under each given remediation scenario;
- providing necessary inputs for further environmental impact and risk assessments.

The results of environmental impact and risk assessments are useful for:

- answering questions related to impacts and risks of the subsurface contamination under a variety of remediation scenarios;
- quantifying risks of different land use options under each given remediation scenario;
- identifying spatial distribution of risky zones and hot spots, required clean-up efficiency, and timing for remediation actions;
- providing necessary bases for decisions of remediation actions.

The task of remediation system design is undertaken based on analysis of site conditions, research of technology suitability, experimental studies for a number of remediation alternatives, as well as support of the earlier simulation and risk assessment tasks. The research outputs contain:

- recommendation for several remediation technologies that are feasible and applicable to the site;
- provision of detailed designs for the recommended remediation techniques.

The monitoring network design for future sampling program is carried out using the existing site infrastructure, statistical trend analysis, as well as support of the earlier simulation, assessment, and remediation tasks. The design is useful for:

- tracking the changes in shape, size, or position of the contaminant plume;
- tracking contaminants exceeding the standards;
- assessing the performance of the remedial studies;
- satisfying the regulatory requirements for the site closure.

This report consists of seven parts. Part 1 is an introduction of the project and the study site. Part 2 details the methodology of petroleum contaminants transport and remediation modeling. Part 3 illustrates formulation of the developed numerical models for the Cantuar Field Scrubber Site, as well as modeling results for predicting free product thickness, concentrations of benzene, toluene, ethyl-benzene, and xylenes in different temporal and spatial units under various remediation scenarios. Part 4 is to assess environmental risks of the subsurface contamination at the site, given different land use options, remediation scenarios, and evaluation criteria. Part 5 presents the results of remediation system design, where technologies that are feasible and applicable to the site are

recommended, with the detailed designs provided. Part 6 is devoted to monitoring system design, where comprehensive network design schemes are proposed for future sampling at the site. Part 7 lists the summary of this project, which is followed by appendices.

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- Appendix Two: Progress Report (Submitted on December 30, 2001)
- Appendix Three: Design of a Monitoring Network for Detecting Underground
Contamination — A Study for the Cantuar Field Site (SW 30-16-
16 W3M)
- Appendix Four: Design of the Phase III Monitoring Program for the Cantuar
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- Appendix Five: Design for the Phase IV monitoring wells at the Cantuar Field
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