




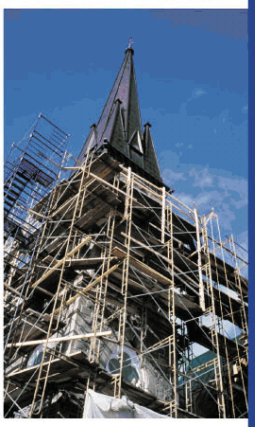

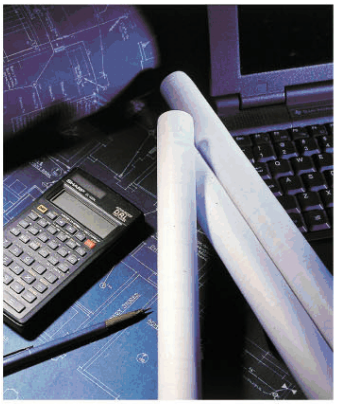

2009 Update - Independent External Review of Crane Mountain Landfill

Crane Mountain Enhancement, Inc.

ADI Limited
Report: (85) 5668-3.1
Date: November 2009

CANADA'S 50 BEST MANAGED COMPANIES

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Project No.: (85) 5668 - 003.1	Date: November 2, 2009
Issue Status: Final	Revision No.: 0
Prepared By: John Sims, M.Sc., P.Geo, P.Eng.	
Reviewed By: Robert Gallagher, M.Eng., P.Eng.	

EXECUTIVE SUMMARY

An update review of the ADI 2005 Independent External Review of the Crane Mountain Landfill was completed. The update review focused on priority aspects relevant to CMEI's objectives and mandate. These priorities relate principally to groundwater resource protection; ensuring that landfill construction, operation and management promote optimal environmental protection; and ensuring that appropriate plans and sufficient funds are in place to support proper post closure management and long term care of the site. A general overview of status/ findings for each of the 2005 recommendations was also developed by ADI as part of the initial update review work.

The Crane Mountain landfill is considered unique among the six provincial regional solid waste landfills in that it is located within the recharge area, and upgradient and in relatively close proximity to approximately 1000 potable water supply wells. In this regard, during the EIA process a commitment was made to address concerns of area residents with respect to landfill operations in general, and in particular potential impacts on aquifer and domestic well water quality. One of the primary objectives of CMEI's mandate is therefore to ensure that the necessary efforts and measures are assessed and implemented to protect the groundwater resource on which the community relies to meet their current and future potable water requirements.

Based on information reviewed over the course of the update review it was concluded that there is significant opportunity to improve on landfill related aspects in the context of FRSWC's commitments and obligations to the host community, and in particular the downgradient domestic well users. The main aspects for improvement and further consideration are broadly categorized as:

- develop an improved understanding of the hydrologic flow system and related aspects of contaminant fate and transport within the flow system with respect to protecting water quality and downgradient groundwater use;

- improve interpretative aspects of the groundwater monitoring program and integrate the domestic well monitoring as a key component of the overall monitoring and reporting program;

- complete further assessment of the landfill liner system;

- develop improved interpretation and reporting protocols related to documenting changes in design and construction and key operational aspects (e.g. leachate buildup in the landfill and related leachate management infrastructure, changes in cell cap, proposed changes in landfill footprint); and

- develop more detailed contingency plans, economic analysis, and verify adequate post closure planning timeline in the context of the unique setting of the Crane Mountain landfill.

A summary of recommendations from the report is provided in Table 8-1, page 38.

1.0 INTRODUCTION

1.1 Background

ADI Limited was retained by Crane Mountain Enhancement Inc. (CMEI) to complete an update of the 2005 Independent External Review of the Crane Mountain Landfill (ADI, 2005). The landfill is operated by the Fundy Region Solid Waste Commission (FRSWC) and began operation in 1997. A site location plan is provided in Figure 1-1, and a recent aerial view is provided in Figure 1-2.

CMEI is a community-based group from within the Host Community near the landfill. CMEI's role is to act as an advisory council and monitor all aspects of the Crane Mountain Landfill. As an independent external reviewer, ADI's role is to act independently of the FRSWC and provide CMEI with an objective review of the design and operation of Crane Mountain Landfill, and technical support regarding consideration of facility aspects in the context of CMEI's environmental protection objectives and concerns.

This update report is presented, where applicable, in accordance to the general organizational topics of the 2005 review with the intent that the update (and subsequent reviews) allow relative ease of cross reference according to facility aspect. Where referenced herein, the twenty six recommendations provided in 2005 retain their original number from the 2005 report. Although all areas covered in ADI's 2005 Review are important, the scope within the main body of this update review focuses on priority aspects relevant to CMEI's objectives and mandate as interpreted by ADI. The concluding section provides a summary of recommendations/ action items developed from the update review. A general overview of status/ findings for each of the 2005 recommendations developed by ADI during the front end of the update review is provided as appended material.

1.2 Scope of Work

The proposed Scope of Work for the update report was provided in an ADI letter proposal dated April 1, 2008. In general, the original scope of work proposed included the following items: a status update of the 26 recommendations from the 2005 Independent External Review, a review of the four Gemtec reports issued since 2005, a review of issues related to chapters 5, 10 and 11 of the 2005 Independent External Review, a review of the anticipated life of the landfill as defined in the February 2006 Gemtec letter report and a review of the NB Department of Environment's December 2004 letter outlining 53 questions related to the proposed increasing of the height of the landfill. Finally, the development of a new set of recommendations. The scope of work was adapted as the work progressed to focus on aspects considered to be most relevant to CMEI's priorities.

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Project Title: 2009 - Update Independent External Review of Crane Mountain Landfill	
Dwg. Title: Site Location Plan	
Drawn By:	Project No.: 5668-003.1
Dwg. Standards Ckd. By:	Dwg. No.: Figure 1-1
Designed By:	Dwg. Design Ckd. By: / Rev. No.

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Proj.
2009 Update - Independent External Review of Crane Mountain Landfill

Dwg.
Aerial View of Site
(October, 2008)

Drawn By:	Proj. No. 5668-003.1
Dwg Standards Chk. By:	Dwg. No. Figure 1-2
Designed By:	Dwg Design Ckd By: / Rev.

Documentation provided during the update review included various reports and letters prepared for the FRSWC, the owner and operator of the landfill, in response to the ADI 2005 Independent Extermal Review. A list of the main documents is provided in Appendix A. The reports and related information (e.g. letter correspondence) were used as the basis for updating ADI's 26 recommendations provided in 2005, and to develop current recommendations focused on priority aspects identified as most relevant to CMEI's mandate and objectives. A copy of Section 12.0 Summary and Recommendations from the 2005 report is provided for reference in Appendix B. The general overview of status/ findings for each of the 2005 recommendations developed by ADI at the front end of the update review is provided in Appendix C. A copy of the facility's current Approval to Operate is provided in Appendix D.

1.3 Project Team and Acknowledgements

This review has been completed by ADI Limited. The personnel who contributed key components to the study included John Sims, M.Sc., P.Eng., P.Geo., and Robert Gallagher, M.Sc.Eng., P. Eng.

ADI wish to acknowledge the assistance of the CMEI Monitoring Committee. The FRSWC were very helpful in compiling and providing relevant background documents.

2.0 CRANE MOUNTAIN LANDFILL AND CMEI PRIORITIES

2.1 2005 Review Summary

Information provided in the 2005 review noted the particular importance of the site's geological/ hydrogeological setting, with related overview and recommendations as follows.

Bedrock Geology

"The EIA report noted bedrock to be fractured, with fracturing described variably as 'highly fractured' to 'numerous fractures'. No major structural discontinuities were reported based on the EIA site characterization work. Additional information and comments on bedrock geology was provided in a review paper (Fracflow Consultants, Inc., 1997) of the EIA. According to this review, bedrock at the site is highly fractured, with observation from outcrops suggesting at least three to four sets of fractures: one set essentially subhorizontal, and three subvertical in orientation." (ADI, 2005, p. 8)

Hydrogeologic Setting

"The landfill site is located in the upper reach (recharge area) of the Mellinger Brook watershed, and is within proximity to the upper reach of the Mill Creek watershed located south of the site. In general, groundwater recharges in upland areas and discharges at the lower reach of a drainage basin. Depending on various factors (e.g. relative size and topographic configuration of a drainage basin) shallow, intermediate, and deeper groundwater flow systems can be present within a given watershed. In general, the deeper groundwater flow system is characterized by recharge in the upper reach, flow to depth, and discharge at the lower reach of the drainage basin, with intermediate and shallow flow systems superimposed on the deeper system depending on topography, geology, etc.

A general comment concerning site specific hydrogeological characterization provided in the detailed characterization report is the generally shallow depth of bedrock penetrated in bedrock boreholes and monitoring wells. Additional boreholes and monitoring wells have been installed as part of the groundwater monitoring system. It is recommended that the collective database be reviewed and documented in the context of an updated hydrogeological characterization report for the site. The review should include consideration of such factors as hydraulic conductivity; fracture distribution and frequency; flow gradients, directions, and velocities; groundwater chemistry; and consideration of site hydrologic setting in the context of shallow, intermediate and deeper flow systems." (ADI 2005, p. 9)

2.2 2009 Update Review

2.2.1 Geological/ Hydrogeological Setting

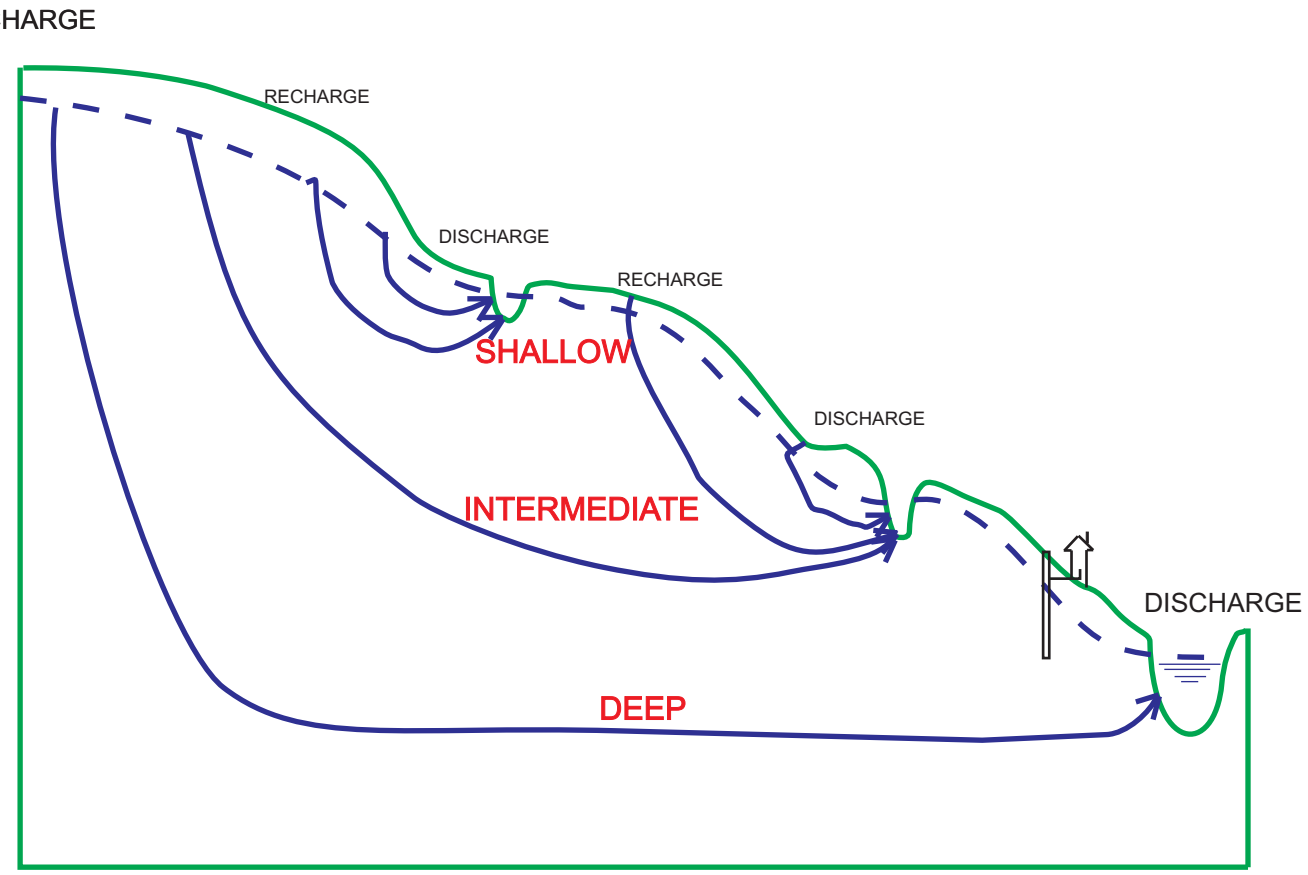
The concept of shallow, intermediate and deep groundwater flow systems is illustrated in Figure 2-1. An important aspect regarding potential landfill impacts on the environment is location of such facilities within the respective regional groundwater flow system. In general, it is desired to locate landfills as far "downstream" as possible in the groundwater flow system (in particular avoid recharge areas as illustrated in Figure 2-2), and in areas that are not upgradient of groundwater supply wells.

Where these objectives have not been met, extra effort is warranted for aspects such as:

- characterization and understanding of site setting and flow system;
- developing and implementing a comprehensive monitoring program for data collection, interpretation and reporting, and that links water quality monitoring results for monitoring points throughout the flow system (e.g. source, pathway, and receptors);
- evaluating and implementing where warranted engineered measures to minimize potential for contaminant impacts on the underlying groundwater resource; and
- ensuring that construction, operation and long term closure plans and perpetual care funding is in place to minimize immediate and future potential impacts on water quality resources.

2.2.2 Identification of CMEI's Priorities

It is the understanding of ADI that the Crane Mountain landfill is unique among the six provincial regional solid waste landfills in that it is located within the recharge area, and upgradient and in relatively close proximity to approximately 1000 potable water supply wells. In this regard, it is understood that during the EIA process, a commitment was made to address concerns of area residents with respect to landfill operations in general, and potential impacts on aquifer and domestic well water quality in particular. In this context, ADI has identified CMEI's overall objective as ensuring that the necessary efforts and measures are assessed and implemented to understand and protect the groundwater resource on which the community relies to meet their current and future potable water requirements. ADI sees the following as CMEI's three priorities:



MELLINGER BROOK	- SHALLOW	i.e. LOCAL
MILL CREEK	- INTERMEDIATE	i.e. SUBREGIONAL
SAINT JOHN RIVER	- DEEP	i.e. REGIONAL

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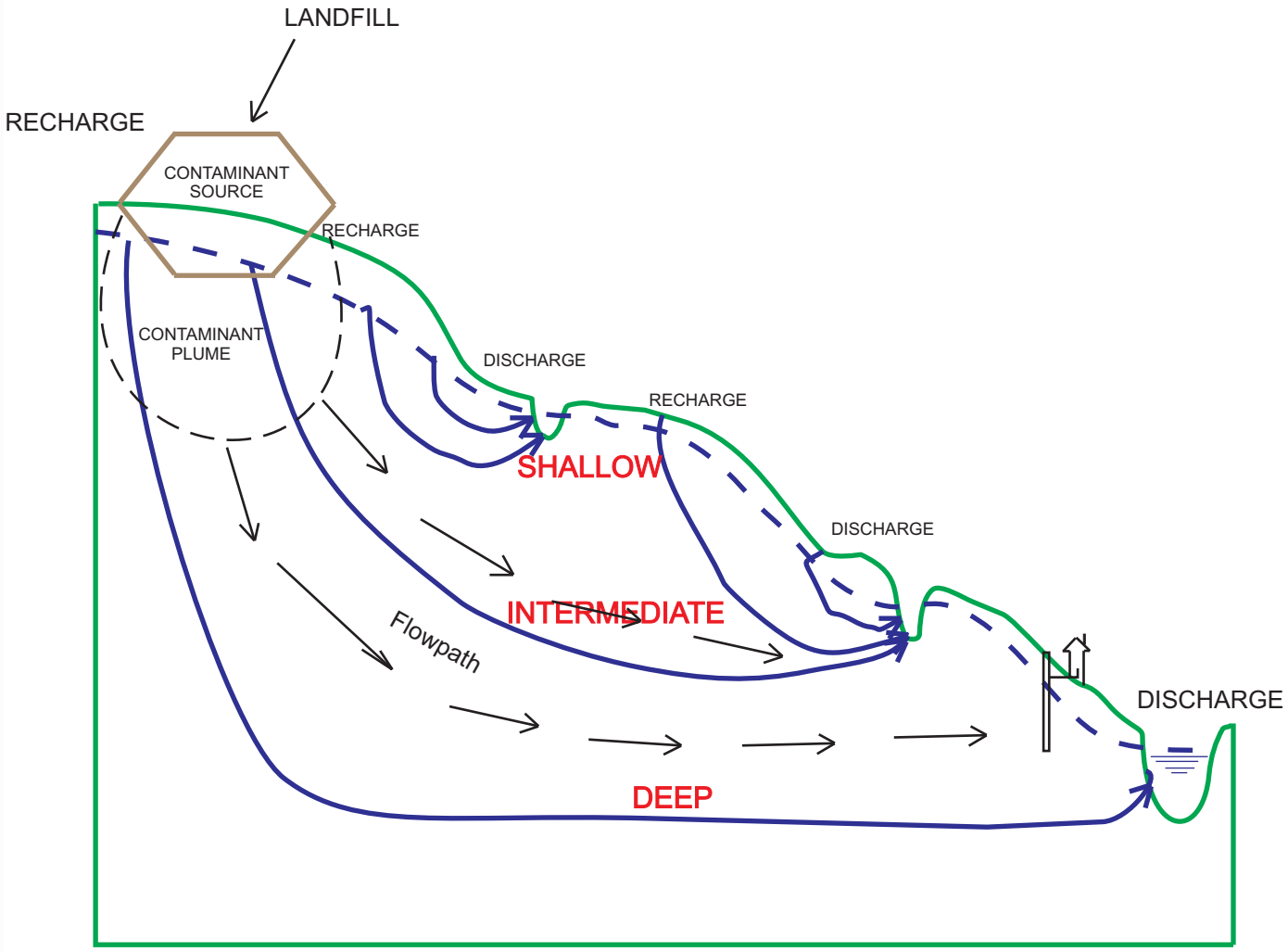
Project Title: 2009 Update - Independent External Review of Crane Mountain Landfill

Dwg. Title: **Groundwater Flow Systems - Conceptual**

Drawn By:	Project No. 5668-003.1	
Dwg. Standards Ckd. By:	Dwg. No. Figure 2-1	
Designed By:	Dwg. Design Ckd. By:	Rev. No.



MELLINGER BROOK	- SHALLOW	i.e. LOCAL
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Project Title: 2009 Update - Independent External Review of Crane Mountain Landfill

Dwg. Title: **Contaminant Migration**

Drawn By:	Project No. 5668-003.1	
Dwg. Standards Ckd. By:	Dwg. No. Figure 2-2	
Designed By:	Dwg. Design Ckd. By:	Rev. No.

- **Priority One - Groundwater Resource Protection**: Understanding and protecting the potable water resource.

- **Priority Two - Landfill Construction, Operation and Management**: Ensuring that the landfill and related facilities are constructed, operated, and managed in a manner that promotes optimal environmental protection.

- **Priority Three - Landfill Life and Perpetual Care**: Ensuring that appropriate plans and sufficient funds are in place to support proper management and long term care of the site.

The remaining sections of this update report focus on these priorities and are organized accordingly.

Priority One: Understanding and Protecting the Potable Groundwater Resource

3.0 REVIEW OF MONITORING WELLS SURROUNDING THE LANDFILL

3.1 2005 Review Summary

The 2005 study noted that the Crane Mountain Landfill groundwater monitoring system consists of over 50 monitoring wells at twenty locations. Samples from the monitoring wells are analyzed to check for any impacts of the landfill on the quality of the surrounding groundwater. The 2005 review included consideration of the following:

- Adequacy of location, design, and number of onsite monitoring wells, given the hydrogeological characteristics of the site.
- Analytical database of monitoring well data.
- Adequacy of background data with respect to scope and variability.
- Identification of analytical anomalies with particular attention to leachate indicator parameters.
- Adequacy of sampling and testing: quality control, frequency, and scope.
- Adequacy of analysis of data from testing.
- Adequacy of emergency response plans relative to findings in onsite monitoring wells.

Key recommendations regarding the monitoring stemming from the 2005 review included the following.

4) Install deeper bedrock monitoring wells and update hydrogeological characterization.

5) Define “trigger” parameters for groundwater monitoring samples.

6) Complete a detailed interpretation of the groundwater monitoring data.

7) Establish a monitoring database that includes analysis for data trends.

The intent of these recommendations was to develop a more complete understanding of the hydrogeological system in the context of understanding contaminant fate and transport in the event of landfill impact on the potable groundwater resource.

3.2 2009 Update Review

3.2.1 Systems established at Landfill since 2005 Review:

- A GIS System has been installed, and the computer system at the landfill has been upgraded so that the system can be accessed at the landfill office building.
- The monitoring well data has been entered into the GIS System.
- A twenty-four-hour automatic underdrain monitoring system has been installed.

3.2.2 Bedrock Monitoring Wells and Hydrogeological Characterization

The updated assessment of the bedrock hydrogeology (Gemtec, 2006[c]) at the landfill site generally involved an examination of existing information and did not include the installation of deeper bedrock monitoring wells. The report neither addresses the geochemical evolution of groundwater in the flow system nor groundwater chemistry issues in general. The report on the updated work (Gemtec, 2006[c]) suggests that the existing potable water wells at the landfill be used to monitor deeper bedrock water quality to allow for the comparison of groundwater chemistry at this location with that observed in the downgradient domestic wells at the bottom of the flow system. Although there may be some benefit to this approach it is considered of marginal value in terms of providing a comprehensive understanding of potential landfill impacts on the flow system and potable groundwater resource.

It is recommended that:

- further work be completed to develop a more complete understanding of the hydrogeological system in the context of understanding contaminant fate and transport in the event of landfill impact on the potable groundwater resources.

- the results of the hydrogeological characterization be used to assess and refine key aspects of landfill construction, operation, closure and long term care with particular focus on approach, data management, and interpretation of the combined monitoring well and domestic well monitoring programs.

Key aspects in successfully implementing these recommendations include referring to earlier work to refine objectives and approach; installation of additional wells as warranted to characterize the flow system; and consideration of geochemical evolution within the flow system. This work should include development of a numerical model(s) of groundwater flow and contaminant transport to promote a better understanding of the regional flow system; groundwater and surface water interaction; monitoring approach (including analytical suites, target parameters and concentrations; statistical and trend analysis methods for data interpretation); site construction (e.g. liner system) aspects; and site operational aspects (e.g.

leachate levels on liner, implications of landfill extent and life) in the context of protecting the potable water supply of the downgradient domestic well users.

Regarding implementation of the above recommendation, it must be recognized that characterization of fractured rock systems and related modelling of contaminant fate and transport is a relatively specialized field and should be completed by individuals with demonstrated expertise in these fields.

3.2.3 "Trigger" Parameters and Trigger Concentrations/ Levels

"Trigger" parameters[1] were established for the underdrain, groundwater monitoring well and domestic well monitoring data in the Gemtec report on the Management of Monitoring Data prepared for FRSWC (Gemtec, 2006[b]). These parameters are essentially leachate indicator parameters[2].

"Trigger" concentrations[3] were also established for the underdrain, groundwater monitoring well and domestic well monitoring data in the Gemtec report on the Management of Monitoring Data prepared for FRSWC (Gemtec, 2006[b]), as required by the EMI. Baseline groundwater and surface water quality data for the Crane Mountain area that was collected in the Fall of 1997, prior to the commissioning of the Landfill, was used to determine the "trigger" concentrations. Gemtec's 2007 and 2008 Annual Reports, however, did not use the "trigger" concentrations established in 2006. Instead, the results for the monitoring wells and the underdrains were compared to the Canadian Water Quality Guidelines for Drinking Water (CDWQ) and the results from the surface water stations were compared to the Canadian Water Quality Guidelines for Freshwater Aquatic Life (FWAL) (Gemtec, 2008).

Notes:

1) Trigger Parameters - chemical parameters in water quality monitoring data which are of interest since their presence at elevated concentrations relative to background concentrations may signify the onset of water quality impacts.

2) Leachate indicator parameters - chemical parameters in landfill water quality monitoring data which are of interest since their presence at elevated concentrations may signify the presence of leachate impacts to water quality.

3) Trigger concentration or level - the statistically defined threshold quantity or concentration of a trigger parameter in water above which some interaction between the water and the contaminant of concern may be occurring.

In Gemtec's 2006 report on monitoring, trigger concentrations were calculated as follows:

1. mean concentration+4 standard deviations for normally distributed data
2. threshold values for parameters not normally found in groundwater (e.g. ammonia)
3. 97.5th percentile x 1.3 for variable data.

It is agreed that Method 2 approach is required for selected parameters. Regarding the two remaining methods, it is noted that although these approaches are statistically based, the calculation of the trigger parameter values appears to be somewhat arbitrary. We agree with the opinion of Craig HydroGeoLogic Inc. (2007; copy provided in Appendix E) that Method 1 tends to yield trigger concentrations which are too high and that Method 3 should be substituted for Method 1. As noted by Craig (2007), the validity of the selected triggers should be reviewed after some time and adjusted as required. In the context that there are approximately 1000 domestic wells located downgradient of the site, it is ADI's opinion that data interpretation and related statistical approach warrants supporting documentation. Documentation should include industry recognized standard adopted (e.g. USEPA), advantages/ disadvantages of the selected approach, and other relevant information.

It is recommended that:

- Major ion chemistry plots be prepared to isolate water of similar chemical "type" in an effort to remove some of the background variation in the water quality data.
- Trigger concentrations/levels should then be developed for each chemical type of water to potentially allow for more meaningful comparisons with future results.
- These concentrations/levels should be compared with previously derived trigger levels to assess what effect this approach has on the trigger levels.
- The most stringent trigger levels should be adopted for use.
- Recognized industry standards developed for interpretation of environmental groundwater and surface water monitoring data should be reviewed, and the most appropriate standard adopted to interpret the landfill monitoring well, surface water and domestic well monitoring data.

3.2.4 Underdrain Monitoring

The Gemtec (2006) report suggests that an automatic monitoring system be installed on the current underdrain monitoring location which is understood to be a manhole located along the lower trunk line common to all of the underdrains. It is understood that a twenty-four hour automatic monitoring system has since been installed at this location. The report also notes that historically, the underdrain water was sampled at four different locations. Presently, three underdrains are sampled and analysed (Gemtec, 2008).

It is reasonable to concentrate monitoring efforts on potential early detection points (i.e. underdrains) and, in the spirit of this safeguard philosophy, we suggest that it would be prudent to monitor the underdrain water quality at multiple locations in the flow system to avoid potential downstream dilution effects (e.g. inflow of groundwater) and maximize the sensitivity of the early detection system. It is acknowledged that it would probably be cost prohibitive to install automated monitoring systems at multiple locations. However,

regardless of whether or not automated systems are installed, it is recommended that underdrain samples be collected from more than one location such as what was done in the past. The approach of monitoring underdrain water quality at multiple locations should also be adopted for future waste cells. As a minimum, the underdrain water quality should be periodically monitored at each cell location.

3.3 Action Items

- Deeper groundwater monitoring wells should be installed at intermediate locations in the flow system.
- The geochemical evolution of groundwater in the flow system should be examined.
- A numerical model(s) of groundwater flow and contaminant transport should be developed.
- "Trigger" concentrations should be established for the different groundwater "types" and taking into consideration the baseline data collected in 1997. These values should be compared with the previously derived trigger parameters to assess what effect this approach has on the trigger concentrations. The most stringent trigger parameters, which would be expected to be the revised ones, should be adopted for use.
- Data interpretation method and related statistical approach should be further developed and supported with documentation. Documentation should include industry recognized standard adopted (e.g. USEPA), advantages/ disadvantages of the selected approach, and other relevant information.
- Domestic monitoring well data should be included in the GIS database.
- The underdrain water quality should be periodically monitored at each cell location.

4.0 REVIEW OF ISSUES RELATED TO DOMESTIC WELLS

4.1 2005 Review Summary

The scope of the investigation in the 2005 study included an assessment of the following issues:

- Number and location of the wells currently monitored;
- Monitoring frequency;
- Suite of analytical parameters included in the monitoring program; and,
- Adequacy of the emergency response plans relative to domestic well contamination.

In addition to the above, ADI was requested to comment on database management system(s) whereby the results of the domestic well monitoring program can be traced in a more meaningful manner.

The 2005 review recommendations were as follows.

17) Update the well location plan based on current participants, and re-evaluate the number and location of wells.

18) Encourage homeowners to participate in the domestic well monitoring program.

19) Increase frequency of domestic well monitoring to document seasonal conditions.

20) Define "trigger" parameters for domestic well monitoring samples.

21) Complete a detailed interpretation of the domestic well data.

22) Establish a domestic well monitoring database that includes analysis for data trends.

Related discussion within the 2005 review noted that a more precise emergency response plan regarding impact to the potable groundwater resource should be developed.

4.2 2009 Update Review

As a general comment concerning monitoring of domestic wells, it is understood that the landfill facility was approved on the understanding that there would be a comprehensive domestic well water quality monitoring program in place to sample, interpret and in the event impacts were identified, implement appropriate remedial actions.

Related documentation relevant to the commitment to monitor domestic wells in a comprehensive manner, including a copy of a recent CMEI submission to the FRSWC concerning this matter is provided in Appendix F. It is ADI's opinion on review of this information and related documents (e.g. EMP) that the domestic well monitoring program is marginalized as a key component in the monitoring program and as a means to document that environmental protection objectives are addressed. For example, the wells being tested do not appear to have been selected on a technical basis (i.e. in consideration of location and well intake interval within the flow system), but more from the perspective of who was willing to volunteer to have their wells tested. Additionally, the wells were originally tested to reflect, in part, seasonal conditions but are now sampled only once per year. It is understood that the full analytical suite of General Chemistry parameters, as defined in the current Approval to Operate #94, has been reduced for domestic well testing. Overall, the results of the well testing are considered poorly integrated into the overall facility monitoring system; e.g. they are only provided to the individual and the Department of Health (DOH). Review and interpretation by DOH is understood to be limited to comparing results to drinking water quality guidelines with no year to year trend analysis, or consideration of statistical aspects and site specific aspect of hydrogeochemical signature.

The following summarizes update review results for the 2005 recommendations concerning domestic well monitoring, and related recommendations referenced above.

4.2.1 Well Location and Number of Wells

The domestic monitoring well data has not been included in the GIS database, which is a significant limitation. Including this information in the GIS database would further the use of the domestic well monitoring data as an integral aspect of facility monitoring, and facilitate data interpretation and overall potable water supply monitoring and protection objectives. It is understood that the domestic well data has not been included in the GIS database due to perceived privacy issues related to the domestic well monitoring program. It has been suggested that the participants in the monitoring program sign a waiver outlining items such as how the data is stored; the accessibility of the data; and how the data may be used in the event that a trigger concentration is exceeded. This is considered to be an unnecessarily onerous and ineffective approach since individuals may understandably be

reluctant to sign a "legal document" without wholly understanding or being able to predict the potential implications of such action.

Since it is understood that the FRSWC is the "owner" of the domestic well data, it is suggested that as a minimum the data be anonymously identified by number and scrutinized as the fourth tier in the monitoring program. This and other possible solutions should be examined. It is agreed with Craig (2007) and recommended that the entire program be revamped such that, among other things, the locations of the wells in the program be selected on the basis of a technical rationale (e.g. location of individual wells in the regional flow system). It is agreed that the Environmental Management Plan (EMP) should be updated to reflect any revised domestic well monitoring program and to include a protocol to be followed in the event of a trigger exceedance. The protocol must be equitable to the well owners as well as the FRSWC.

It is recommended that:

- the domestic well monitoring program be revamped such that, among other things, the locations of the wells in the program be selected on the basis of a technical rationale (e.g. location of individual wells in the regional flow system)

- revamping of the program include development of a protocol that allows the sampling data to be used without limitation imposed by current access conditions(e.g. privacy issues)**.**

4.2.2 Homeowner Participation

Current participants in the domestic well monitoring program are issued a letter prior to the annual sampling event directing them to contact FRSWC's consultant for this work to arrange a sampling appointment. As noted above, the list of participants should be revised to reflect technical based selection criteria, and a protocol should be established such that excess paperwork is eliminated (e.g. put in place a long term agreement so that the consultant does not have to await approval to sample) and thereby minimize the possibility of "no sample" events due to access permission.

4.2.3 Frequency of Monitoring

The current Approval to Operate (I-5524 - expires December, 2011) continues to only require that the domestic wells be monitored once per year in September/October. The ADI 2005 review recommended monitoring be completed to adequately document seasonal conditions.

It is recommended that:

- the domestic wells be sampled to adequately document seasonal conditions. Seasonal variations, if any, should be accounted for in the monitoring interpretation aspects.

4.2.4 Domestic Well "Trigger" Parameters and Concentrations, and Data Interpretation

Trigger parameters and concentrations for domestic wells were developed in the Gemtec report on the Management of Monitoring Data prepared for FRSWC (Gemtec, 2006[b]). However, these trigger parameters were not used in their 2007 and 2008 Annual Reports. The 2007 Craig HydroGeoLogic report has suggested that trigger concentrations may be too high.

Regarding domestic well analytical suite and potential trigger parameters, it is understood that certain parameters (e.g. sulfide, TSS) listed in the Approval to Operate as part of the monitoring program analytical suite are not currently being analysed.

Concerning data interpretation, it is understood that to date, major ion plots have not been prepared for the domestic well data to isolate geochemically similar well types. It is ADI's opinion that additional work is required to better understand the geochemical types and evolution of groundwater in the groundwater flow system (shallow, intermediate and deep) in the regional watershed which encompasses the landfill site and surrounding area in order to adequately assess potential for impact to potable water supply wells.

A related comment concerning data interpretation and reporting pertains to presentation and discussion of results for anomolous or elevated parameters. For example, elevated chloride has been encountered in certain sample results and the interpretive explanation is that, where detected, the elevated concentrations are likely due to road salt. It is acknowledged that this can be a common occurrence but further rationale and evidence supporting this conclusion should be provided (e.g. other leachate indicator parameters are within historical trends/ statistical confidence intervals). In the event other anomalies are noted concise rationale regarding the cause of the anomaly should be provided.

It is recommended that:

- trigger parameters and concentrations be established and used to assess and document probability, if any, of impact to the subsurface, and domestic well water quality. Development of parameters and concentrations should be revisited to ensure that they are not too high in the context of work to refine understanding of the flow system contaminant fate and transport work recommended above (section 3).

- Sulfide, chemical oxygen demand, colour, phenols, total suspended solids, and total kjeldahl nitrogen be tested for during future monitoring rounds in accordance to the current Approval to Operate.

4.2.5 Monitoring Database

The domestic well data has not been included in the GIS environmental monitoring database for the landfill recently developed by Gemtec as noted in the report on the management of monitoring data (Gemtec, 2006[b]).

It is recommended that:

- the domestic well monitoring data be integrated into the GIS environmental monitoring database.

- Domestic well monitoring results should be incorporated as an integral part of the overall overall monitoring data and intepretation program including development and implementation of statistical interpretation and trend analysis aspects.

4.2.6 Emergency Response Plan (EMP)

The current EMP plans pertaining to response and mitigation to potential impact on the potable groundwater resource and domestic wells are extremely general in nature. As noted earlier in this report, the Crane Mountain landfill is relatively unique amongst the provinces regional engineered landfill facilities as it is located upgradient and in the recharge area of a significant number of potable groundwater supply wells. It is acknowledged that engineered landfills have a number of systems to mitigate potential impact on subsurface water quality. However, it is recommended that the current EMP aspects pertaining to domestic wells be more fully developed to ensure that adequate measures and funds are in place to respond rapidly and decisively (e.g. establish a centralized water supply system or extend the existing municipal system) in the event the potable water resource is impacted.

4.3 Action Items

- the domestic well monitoring program be revamped such that, among other things, the locations of the wells in the program be selected on the basis of a technical rationale (e.g. location of individual wells in the regional flow system)**.**

- the domestic wells be sampled to adequately document seasonal conditions. Seasonal variations, if any, should be accounted for in the monitoring interpretation aspects.

- trigger parameters and concentrations be established and used to assess and document probability, if any, of impact to domestic well water quality. Development of parameters and concentrations should be revisited to ensure that they are not too high in the context of work to refine understanding of the flow system contaminant fate and transport work recommended above (section 3).

- Sulfide, chemical oxygen demand, colour, phenols, total suspended solids, and total kjeldahl nitrogen be tested for during future monitoring rounds in accordance to the current Approval to Operate.

- the domestic well monitoring data be integrated into the GIS environmental monitoring database.

- Domestic well monitoring results should be incorporated as an integral part of the overall monitoring data and interpretation program including development and implementation of statistical interpretation and trend analysis aspects.

- mitigative measures, decisive action plans, and funding requirements to address impacts to potable water supply wells be more thoroughly defined and developed.

Priority 2 - Leachate Management and Landfill Liner; Handling and Control of Onsite Surface Water

5.0 REVIEW OF HANDLING AND CONTROL OF LEACHATE

5.1 2005 Review Summary

The leachate management system at the Crane Mountain Landfill includes a number of systems and facilities designed to contain, collect and manage leachate. The basic concept is to contain the leachate in each landfill cell with an engineered liner, collect the leachate in a network of collector pipes that drain to a sump, and pump out the leachate for treatment. Leachate treatment has included treatment on-site at the Zenon plant, and trucking to Saint John's Lancaster treatment plant. The 2005 study included review of the following.

- *Effect of uncapped cells on leachate quantity and quality.*
- *Effect of raising height of cells on integrity of clay and synthetic liners.*
- *Adequacy of material used for cell-capping.*
- *Permeability/breakthrough time of clay liner, under field conditions, relative to recorded heights of leachate in cells (based on studies of three sources of materials tested).*
- *Effect on clay and synthetic liners of using cells as holding ponds.*
- *Pre-treatment of leachate before disposal.*
- *Assessment of interaction between groundwater and surface water.*
- *Surge pond: Integrity of clay liner and synthetic liner, using projected depth of stored leachate.*
- *Identification of chemical composition of leachate.*
- *Adequacy of sampling and analysis of sampling of under-drain layer.*
- *Adequacy of emergency response plans relative to leachate control.*

The key recommendations stemming from the 2005 review were as follows.

8) Implement a strategy of progressive landfill closure.

9) Reduce the leachate level in the cells or consider double liner in future cells.

10) Consider automatically pumping leachate to the Surge Pond, upgrade the liner to a double liner and possibly pre-treat the leachate before discharge.

11) Complete a detailed analysis of the underdrain monitoring data.

5.2 2009 Update Review

5.2.1 Landfill Closure and Leachate Management

A strategy for progressive landfill closure and leachate management was outlined in the 2006 Gemtec report entitled "Design and Operations Plan - Fundy Region Solid Waste Commission, Saint John, NB" (Gemtec, 2006[a]). A hypothetical schedule and associated estimated costs for the progressive construction of the landfill cell liner and cap is outlined based upon several assumptions. On the basis of this assessment, a total of sixteen landfill cells will be constructed with the final cell projected to be capped in 2047. The report also references a recent decision to establish the final operating elevation of the landfill at 90 m. The option of filling to elevation 105 m was considered for some time but it is noted that this was rejected, in part, on the disposal potential of other areas of the commission's property.

The report also addresses leachate management. To minimize leachate production, landfill cells are generally capped as soon as possible subsequent to filling. This process did not initially take place at the FRSWC site. However, it is understood that in recent years, the cell capping operations have been "catching up" with new cell development (e.g. cells 1, 2 and 3 were capped in 2006) with a resulting significant reduction in on-site leachate generation. The proposed liner and capping construction sequence noted above is intended to minimize the future rate of increase in leachate production. Future annual leachate volumes for the site were subsequently calculated based upon the hypothetical future construction timeline; an average annual precipitation rate of 1100 mm; and the assumption of leachate production levels of 70% and 3% of precipitation for active and capped portions of the landfill. Leachate from the landfill collects in sumps installed in the cells along the lower lying east side of the landfill where it is pumped to the surge pond lift station and then into tanker trucks for transport to the Lancaster Treatment Plant.

The surge pond is designed to provide leachate storage during large storm events. In addition, the thickness of clay within the sumps was increased from 900 mm in Cell 1 to 1300 mm in Cell 3 to accommodate the periodic accumulation of leachate over the liner. The frequency of leachate storage within the landfill cells is expected to decrease with time assuming that cell capping progresses in step with new cell construction as planned. However, the report notes that "...there will be times when the volume of leachate generated within the cells will exceed the capacity of the sump pumps..." Therefore, the report recommends that the additional clay thickness provided in Cell 3 be extended to all future cells on the east side of the landfill. The report also stresses the importance of monitoring leachate levels in the sumps and surge pond.

Regarding the long term treatment of landfill leachate for the life of the site, the report notes that the decision to establish the final elevation of the landfill at 90 m will result in 20%

reduction in leachate production compared with earlier estimates based on a final elevation of 105 m as detailed in a report on the assessment of leachate management options. The report notes that, in consideration of the reduced leachate volumes, the projected cost of trucking the leachate is essentially the same as the cost of constructing a pipeline. It was therefore recommended that the trucking option continue. The rationale for this recommendation was that there is greater uncertainty associated with the cost of the pipeline option.

In general, the outlined approach for long term site development and leachate management is reasonable. The report acknowledges that the plan may be modified pending future conditions and is to be used only as a general guide and planning tool.

However, if it is planned to use additional FRSWC property for future waste disposal, it is important that the proposed disposal area(s) be thoroughly assessed (e.g. soils investigations, etc.) for the suitability of landfill construction. This would include assessing the thickness of the native till and completing other work as required in a reasonably timely manner so as to accommodate future waste disposal planning.

5.2.2 Leachate Level Reduction

Use of landfill cells for storage of leachate is not known to be standard operating procedure at New Brunswick engineered landfill facilities. If leachate levels are to be regularly in excess of typical design criteria provided in the literature (e.g. 0.3 m head on liner), it is recommended that a comprehensive strategy for monitoring, interpretation and reporting of leachate levels be developed and implemented. This should include consideration of implication of leachate buildup regarding liner leakage. Results of this work should be provided in regular update reports.

5.2.3 Landfill Liner

A one page summary of PROS/ CONS of double liner versus single liner system was developed by GEMTEC, which essentially dismissed consideration of upgrading to a double liner system. It is ADI's understanding that selection of materials, layered systems, and attention to proper construction can result in significantly lower rates of leachate leakage through composite liners. For example, a common design for engineered landfills in New Brunswick is double geomembrane liners separated by a geonet drainage layer. This type of system provides the advantage of reducing the hydraulic head on the lower components of the liner system; hydraulic head (height of liquid buildup on the liner) is a significant variable in determining advective breakthrough and flux (leakage) through the liner. A second potential advantage is for the geonet between the liners to serve as a secondary leachate collection system in event of leakage through the primary liner.

As noted above, one of the main factors controlling leakage rate through a liner is the hydraulic head (height of leachate) on the liner. For a simplified comparison of a double geomembrane liner with geonet leak detection/ secondary collection layer versus the single liner system, assume the two representative liner systems indicated in Figure 5-1. For the comparison it is assumed that:

- the primary HDPE liner is discounted as an effective barrier (a conservative design assumption used in New Brunswick for calculating landfill liner advective breakthrough times);

- the underlying soil liner hydraulic conductivity is $1x10^{-10}$ m/s (meters/second) and porosity (0.44) for both liners (based on representative numbers assumed for the Crane Mountain landfill recompacted clay liner), and the hydraulic conductivity of the secondary HDPE is $1x10^{-11}$ m/s ;

- the hydraulic head on the primary HDPE liner is 0.3 m, and for the double liner system the hydraulic head on the secondary HDPE is equal to 0.006 m (the thickness of a representative geonet drainage layer);

- leachate flux through the secondary liner of the double liner system is calculated assuming representative design assumptions in the literature (e.g. 2.5, 1 cm^2 holes per hectare of liner, and 0.05 m^3/ha/day for the liner with no holes); then

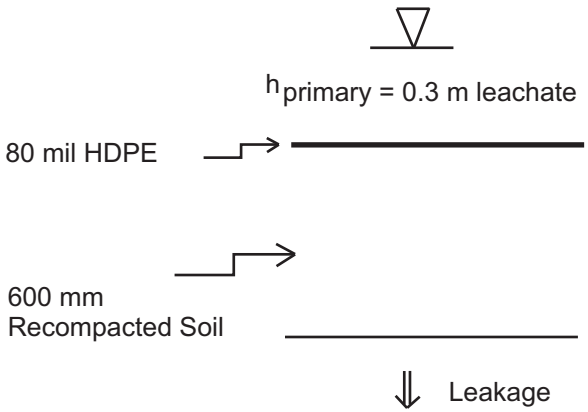
the liner advective leakage rate is approximately 0.233 m^3/ha/day for the single HDPE and 0.050 m^3/ha/day for the double liner. Assuming this flux is distributed uniformly over the liner area, the advective breakthrough for the single liner is 31 years and 145 years for the double liner. For this assessment therefore, the double liner system reduces by over four times the leachate volume through the liner and increases by a factor of 4 the breakthrough time (i.e. the time it takes for the leachate to first breakthrough the bottom of the liner assuming advective transport only). In addition to reducing the flux and increasing the breakthrough time, there is the added advantage for the geonet to serve as a secondary leachate drainage feature in the event of a breach in the primary liner.

The volume of leachate leakage and time of entry of leachate through the base of the landfill are considered the primary variables regarding protection of the potable groundwater resource. Therefore, it is ADI's opinion that further consideration of a double liner system is warranted. Work should include comparison of leachate leakage rates for various liner

FILE
DATE: *DATE*
TIME
PLOTTED BY: *USER*
PLOT CHARGES: *CHARGES*

Case A

Single HDPE Liner

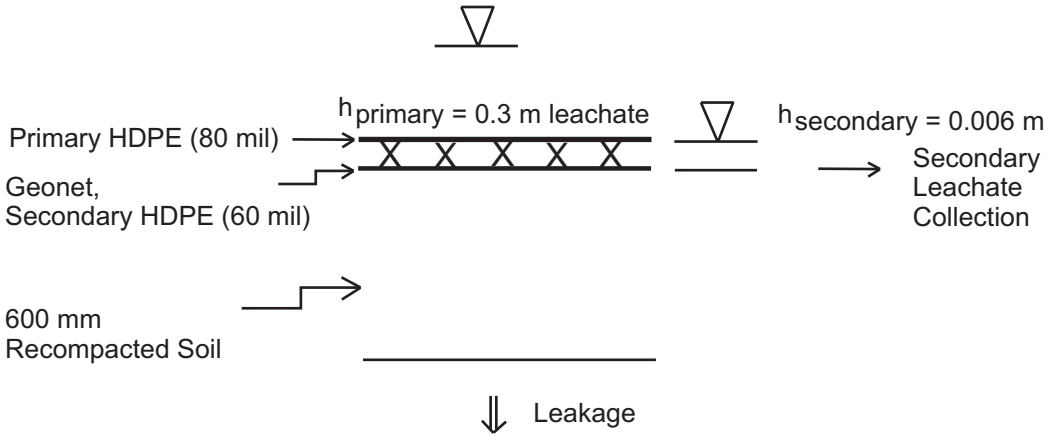


Advective Breakthrough time = 31 years

Advective flux = 0.233 m^3/ha/day

Case B

Double HDPE Liner w/ Geonet



Advective Breakthrough time = 145 years

Advective flux = 0.050 m^3/ha/day

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ADI Limited
Moncton, NB, Canada
Engineering, Consulting, Procurement and Project Management

Proj.
2009 Update - Independent External Review of Crane Mountain Landfill

Dwg.
Representative Single & Double Geomembrane Liner Systems

Drawn By:	Proj. No. 5668-003.1	
Dwg Standards Chk. By:	Dwg. No. Figure 5-1	
Designed By:	Dwg Design Ckd By:	Rev.

scenarios and incorporation and comparison of these various liner systems into site specific modelling in terms of optimal liner system for minimizing contaminant flux to the subsurface and thereby mitigating to the extent practical potential impact on groundwater quality and downgradient domestic water supply wells. Estimates of flux through the liner should include consideration of the two dominant transport mechanisms, i.e. advection and diffusion.

5.2.4 Underdrain Monitoring Data

"Trigger" parameter concentrations were developed for the underdrain, groundwater monitoring well and domestic well monitoring data in the Gemtec report on the Management of Monitoring Data prepared for FRSWC (Gemtec, 2006[b]). Some trending analysis in the form of graphical plotting of historical water quality data was also completed for the 2007 and 2008 annual report on the environmental monitoring program at the landfill (Gemtec, 2007 and 2008). These data plots included trend plots for selected leachate indicator parameters for the landfill cell underdrain and the leachate surge pond underdrain monitoring locations.

In our opinion, there is some opportunity for improvement in the establishment of the trigger parameters. Trend analysis should continue to be used in conjunction with the statistical analysis in the assessment of underdrain water quality data.

See related discussion in section 3.2.4.

5.2.5 Reporting

Various aspects of landfill operations (e.g. leachate management, cell capping) have evolved with time, and it is possible that these and other items may change in response to future conditions. To the outside reviewer (and CMEI) changes can be difficult to track. It is recommended that:

- a record and change management system be established in order that changes in landfill construction, operation, and management can be more easily followed, are clearly documented, and can be tracked more effectively by CMEI and FRSWC.

One option suggested to be explored to facilitate record keeping and access by CMEI to documents of public record could be use of a virtual environmental electronic database in which records were clearly organized and changes documented according to facility aspect.

5.3 Action Items

- A comprehensive strategy for monitoring, interpretation and reporting of leachate levels be developed and implemented. This should include consideration of implication of leachate buildup regarding liner leakage. Results of this work should be provided in regular update reports.

- A more detailed assessment of the landfill liner system should be completed. This work should include consideration of leachate leakage rates for various liner scenarios, and incorporation and comparison of these various liner systems into site specific modelling in terms of optimal liner system for minimizing contaminant flux to the subsurface and thereby mitigating to the extent practical potential impact on groundwater quality and downgradient domestic water supply wells.

- a record and change management system be established in order that changes in landfill construction, operation, and management can be more easily followed, are clearly documented, and can be tracked more effectively by CMEI and FRSWC.

6.0 REVIEW OF HANDLING AND CONTROL OF ONSITE SURFACE WATER

6.1 2005 Review Summary

Review of Handling and Control of Onsite Surface Water in the 2005 study included the following.

- *Effectiveness of sedimentation ponds in treating and containing surface runoff during normal conditions.*
- *Effectiveness of sedimentation ponds in treating and containing surface water during conditions of heavy or extended precipitation.*
- *Effectiveness of monitoring of surface water runoff.*

The key recommendations stemming from the 2005 review were as follows.

12) Develop specific stormwater management plans for each phase of construction.

13) Complete a detailed analysis of the stormwater monitoring data.

6.2 2009 Update Review

Findings for each of the recommendations above were as follows.

6.2.1 Stormwater Management Plans

A general review of the stormwater management system at the landfill was completed (Gemtec, 2006[d]). The report indicates that during the construction of new cells, "the 2 - 3 ha of disturbed area is ditched so that storm water run-off is directed to the treatment system".

However, to our knowledge, specific stormwater management plans have not been prepared for new construction projects.

6.2.2 Stormwater Monitoring Data Analysis

The total suspended solids (TSS) results for the sedimentation pond discharge data from 2000 to 2007 are included and discussed in the report on the review of the stormwater management system (Gemtec, 2006[d]). The report indicates that the TSS value exceeded the 25 mg/L limit on one occasion in 2004 when the commission reportedly ran out of the chemical flocculating agent which promotes the settling out of suspended sediments in the treatment pond. The report indicates that steps have been taken to ensure that the commission does not run out of flocculating agent in the future.

It is understood that TSS exceedances continue to be experienced during adverse runoff conditions. The system should continue to be monitored and mitigative measures implemented if exceedances continue to be observed under adverse conditions.

6.3 Action Items

- Develop specific stormwater management plans for each phase of construction.
- Mitigative measures should be implemented if TSS exceedances continue to be observed.

Priority 3 - Landfill Life and Perpetual Care Fund

7.0 PERPETUAL CARE FOR LANDFILL

7.1 Review of Existing Conditions

The documents made available to ADI for review regarding the perpetual care fund include the Design and Operations Plan (Gemtec, 2006), a two page study on the life of the landfill (Gemtec, 2006), the Fundy Region Solid Waste Commission's (FRSWC) financial statements for 2007, a letter from the Department of Environment in response to the application to raise the height of cells (December, 2004) and email conversations about where to place the funds from the perpetual care fund in the budget (March, 2007). The following is a summary of the aforementioned documents as they pertain to the current situation.

Based on the total space available from the start of landfill operations and tonnage landfilled to date, it was calculated that the site would be filled in 2046 or 2048, depending on the final garbage density (Gemtec, 2006). The 2007 FRSWC financial statements also recognize that the Crane Mountain facility will receive waste until 2048. The government of New Brunswick dictates that the time period for which the FRSWC will be responsible for site maintenance after closure is 30 years. Closure and post-closure expenses, which include the restoration of landfill sites, the maintenance of equipment and environmental monitoring, must be calculated according to section 6.5(2) of Regulation 96-11 of the Clean Environment Act.

According to the schedule of capital expenditure included in the Design and Operations Plan (Gemtec, 2006), the total amount of the liner and capping costs from 2008 to site closure is $36,149,600 and the cost of leachate management is estimated at $18,572,700. These cost estimates suggest that the total operational cost to site closure is $54,722,300. All cost estimates in the Design and Operations Plan are in 2006 dollars. The FRSWC 2007 financial records state that a General Capital Reserve Fund was established to provide for the future replacement of equipment and construction of cells for the facility. As of 2007, $521,737 was accumulated for equipment replacement and $1,564,008 was accumulated for cell construction by means of the tipping fee . On March 15, 2007, all net assets were transferred to the General Operating Fund as requested by the Department of Local Government (FRSWC, 2007). As explained in a March 15, 2007 email from Sandra Jessop-Roach to Andrew Logan, creating more than one capital reserve or to specify for what purpose the funds can be used is not permitted. The logic is that this will afford councils flexibility when faced with changing priorities. Consequently, the total capital accumulated for the General Operating Fund as of 2007 is $2,085,745.

The FRSWC 2007 financial records state that the total cost of site maintenance for the required 30 year post-closure period is $24,701,000. A portion of the tipping fee is to be set

aside for this purpose. The assets accumulated by the Commission for future closure and post-closure liability as of December 2007 is $794,652.

7.2 2009 Update Review

There are approximately one thousand domestic water supply wells located downgradient of the landfill. Moreover, the landfill site is located in the recharge area of the Mellinger Brook watershed, and is within proximity to the upper reach of the Mill Creek watershed. For these reasons, further development and clarification of the perpetual fund plan is warranted.

First, it is unclear how the total cost of site maintenance for the required 30 year period was calculated by the FRSWC. Furthermore, it is not known if the value calculated is in 2007 dollars or in 2048 dollars. As the residents in the area depend on subsurface water for their water source, a contingency plan should include the replacement or treatment of the water source should the water supply become contaminated. This plan should identify options and adequate funds should be put aside in the event the plan requires implementation. Items other than remediation and contingency costs that should be considered for the development of the perpetual care fund include: monitoring expenses, facility maintenance, staff, insurance, property taxes, decommissioning, property value, environmental cost, social cost, post operation cost, legal cost, retirement benefits and extended future (should the operator(s) of the facility separate themselves from the operation of the facility). In addition to specifying what items were used in their calculation of the perpetual care costs, the FRSWC should indicate what methods/equations were used and indicate if the costs were calculated in 2007 or 2048 dollars.

Second, it is unclear how the FRSWC intends to accumulate its current perpetual fund estimate of $24,701,000 by 2048. According to data supplied in the Design and Operations Plan and the 2007 FRSWC financial statements it was calculated (Total amount of perpetual care fund divided by total space available in the landfill in tonnes) that $7.02 per tonne should be put aside for the perpetual care fund. It should be verified that the present tipping fees reflect this figure. More detail should also be given as to the steps that will be taken to ensure that the required capital will be available by the time the facility closes.

Third, it should be noted that the landfill, which opened in 1997, was initially intended to operate for 25 years. In 2004, the FRSWC applied to increase the cell elevations at the landfill with the intent of increasing its operational life. It was at that time that the closure date was changed from 2022 to 2048. On December 10, 2004, a letter from the technical review committee of the Environment and Local Government was sent to the FRSWC commenting on their registration package regarding the increase in cell elevations. In the letter, the review committee commented on the inconsistency of the closure date within the

FRSWC document and also noted that several of the claims made regarding the closure date were not quantified. Also, there was no evidence submitted in support of the claim that extending the life of the landfill would "benefit the Fundy Region environmentally and economically."

Another important point brought up in the letter was that the FRSWC did not indicate how precipitation and snowmelt data was used when calculating the maximum leachate volumes, or if snowpack available for melting was maximized. Notably, it was brought up that precipitation events would very likely be increasing within the landfill's lifespan and post-closure period due to the effects of climate change. The increased rainfall would require an adjustment in the design criteria for the surge pond and it was suggested that it might be prudent to make these adjustments now. The issue of measuring the strength of the leachate was also addressed. Until then, leachate had only been described in terms of BOD. It was recommended that a complete chemical characterization of the leachate be provided including BOD, COD, pH, TDS, TSS, alkalinity, Total P, TKN, Ammonia-N, heavy metals and sulphate. The issues brought up in the 2004 letter have the potential of greatly affecting the calculation of capital needed for the General Operating Fund. Additionally, as landfills have the potential to act as long term contaminant sources, it should be adequately determined that the regulatory specified 30 year post-closure perpetual care timeline is adequate given the unique setting of the Crane Mountain site relative to other engineered regional landfills in the Province.

7.3 Action Items

- Develop more detailed contingency plans regarding potential impact to domestic wells and long term monitoring and post closure of the site.

- Complete a detailed economic analysis which addresses all aspects relevant to the closure plans and long term perpetual care to ensure that sufficient funds are accumulated.

- Assess whether the 30 year post-closure planning timeline for the perpetual care fund is adequate for the Crane Mountain landfill.

8.0 SUMMARY AND RECOMMENDATIONS

8.1 Summary of Review

An update review of the ADI 2005 Independent External Review of the Crane Mountain Landfill was completed. The main focus of the update review was on priority aspects relevant to CMEI's objectives and mandate as interpreted by ADI. A general overview of status/ findings for each of the 2005 recommendations was developed by ADI as part of the initial update review work.

The Crane Mountain landfill is considered unique among the six provincial regional solid waste landfills in that it is located within the recharge area, and upgradient and in relatively close proximity to approximately 1000 potable water supply wells. In this regard, during the EIA process a commitment was made to address concerns of area residents with respect to landfill operations in general, and in particular potential impacts on aquifer and domestic well water quality. One of the primary objectives of CMEI's mandate is therefore to ensure that the necessary efforts and measures are assessed and implemented to protect the groundwater resource on which the community relies to meet their current and future potable water requirements.

Key CMEI priorities as identified by ADI are:

> **Priority One - Groundwater Resource Protection**: Understanding and protecting the potable water resource;
>
> **Priority Two - Landfill Construction, Operation and Management**: Ensuring that the landfill and related facilities and constructed, operated, and managed in a manner that promotes optimal environmental protection.
>
> **Priority Three - Landfill Life and Perpetual Care**: Ensuring that appropriate plans and sufficient funds are in place to support proper management and long term care of the site.

Based on information reviewed over the course of the update review it is concluded that there is significant opportunity to improve on landfill related aspects in the context of FRSWC's commitments and obligations to the host community, and in particular the downgradient domestic well users. The main aspects for improvement and further consideration are broadly categorized as:

- develop an improved understanding of the hydrologic flow system and related aspects of contaminant fate and transport within the flow system with respect to protecting water quality and downgradient groundwater use;

- improve interpretative aspects of the groundwater monitoring program and integrate the domestic well monitoring as a key component of the overall monitoring and reporting program;

- complete further assessment of the landfill liner system;

- develop improved interpretation and reporting protocols related to documenting changes in design and construction and key operational aspects (e.g. leachate buildup in the landfill and related leachate management infrastructure, changes in cell cap, proposed changes in landfill footprint); and

- develop more detailed contingency plans, economic analysis, and verify adequate post closure planning timeline in the context of the unique setting of the Crane Mountain landfill.

Specific recommendations are summarized below.

8.2 Recommendations

Recommendations from the 2009 update review by facility aspect are summarized in the following table.

Table 8-1: Summary of 2009 Update Review Recommendations

Aspect	Action Items
Groundwater Monitoring	• Deeper groundwater monitoring wells should be installed at intermediate locations in the flow system. • The geochemical evolution of groundwater in the flow system should be examined. • A numerical model(s) of groundwater flow and contaminant transport should be developed. This model should be used as a tool to refine various facility aspects such as monitoring program, liner design, long term care. • "Trigger" concentrations should be established for the different groundwater "types" and taking into consideration the baseline data collected in 1997. These values should be compared with the previously derived trigger parameters to assess what effect this approach has on the trigger concentrations. The most stringent trigger parameters, which would be expected to be the revised ones, should be adopted for use. • Data interpretation and related statistical approach should be supported with documentation. Documentation should include industry recognized standard adopted (e.g. USEPA), advantages/ disadvantages of the selected approach, and other relevant information. • The underdrain water quality should be periodically monitored at each cell location.
Issues Related to Domestic Wells	• Include domestic well water sample results in the GIS information system. • Revamp the domestic well monitoring program such that, among other things, the locations of the wells in the program be selected on the basis of a technical rationale (e.g. location of individual wells in the regional flow system). • Revise list of participants to reflect technical criteria (e.g. hydrogeological aspects). • Establish a sampling, data management and data interpretation protocol to facilitate use and integration of the domestic well sampling results into the overall facility monitoring program. • Include full suite of General Chemistry parameters as defined in current Approval to Operate #94 in future testing. • Develop specific and detailed plans within the EMP regarding domestic wells in the event of impact to the potable groundwater resource (e.g. identify options, put funding in place).

Aspect	**Action Items**
Leachate Management, Landfill Liner, and Reporting	• Develop and implement a comprehensive strategy for monitoring, interpretation and reporting of leachate levels. This should include consideration of implication of leachate buildup, if any, regarding liner leakage. Results of this work should be provided in regular update reports. • Comparison of leachate leakage rates should be completed for various liner options. The various options should be compared using site specific modelling to determine optimal liner system for minimizing contaminant flux to the subsurface. The objective is to minimize to the extent practical leachate contaminant loadings to the subsurface and thereby mitigate potential impact on groundwater quality and downgradient domestic water supply wells. • establish a record and change management system to record and manage changes in landfill construction, operation, monitoring and reporting so that landfill aspects can be tracked more easily by CMEI and FRSWC.
Handling and Control of On Site Surface Water	• Develop specific stormwater management plans for each phase of construction. • Mitigative measures should be implemented if TSS exceedances continue to be observed.
Perpetual Care	• Develop more detailed contingency plans regarding potential impact to domestic wells and long term monitoring and post closure of the site. • Complete a detailed economic analysis which addresses all aspects relevant to the closure plans and long term perpetual care to ensure that sufficient funds are accumulated. • Assess whether the 30 year post-closure planing timeline for the perpetual care fund is adequate for the Crane Mountain landfill.

9.0 REFERENCES

Main reference documents are indicated below.

ADI Limited, 2005. Independent External Review of Crane Mountain Landfill, ADI File No. (85) 5668-003.1, November, 2005.

Craig HydroGeoLogic, 2007. Review of Gemtec Reports to Fundy Region Solid Waste Commission. Letter report to Crane Mountain Enhancement Inc. dated May 28, 2007.

Gemtec, 2009. Environmental Monitoring Program - Crane Mountain Landfill. Annual Report for 2008 (Final). Report to the Fundy Region Solid Waste Commission dated March 2009. Gemtec File No. 4662.04 - R01.

Gemtec, 2008. Environmental Monitoring Program - Crane Mountain Landfill. Annual Report for 2007 (Final). Report to the Fundy Region Solid Waste Commission dated May 2008. Gemtec File No. 658.98 - R01.

Gemtec, 2006a. Design and Operations Plan - Fundy Region Solid Waste Commission, Saint John, NB. Report to the Fundy Region Solid Waste Commission dated July 2006. Gemtec File No. 658.86 - R02.

Gemtec, 2006b. Crane Mountain Landfill - Management of Monitoring Data. Report to the Fundy Region Solid Waste Commission dated December 2006. Gemtec File No. 658.85 - R01.

Gemtec, 2006c. Update of Bedrock Hydrogeology - Crane Mountain Landfill, Saint John, New Brunswick. Report to the Fundy Region Solid Waste Commission dated November 2006. Gemtec File No. 658.87 - R01.

Gemtec, 2006d. Stormwater Management System. Report to the Fundy Region Solid Waste Commission dated November 2006. Gemtec File No. 658.90 - R01.

APPENDIX A

LIST OF DOCUMENTS

Documents Delivered to ADI, for 2008/2009 Review of Crane Mountain Landfill

1. Leachate sampling, 2007

2. Agreement, City of Saint John and Waste Commission re disposal of leachate into Lancaster Wastewater Treatment Facility, adopted June 20, 2005

3. Financial Statements December 31, 2007

4. Post Closure Fund: e-mail from Andrew Logan (Teed, Sunders, Doyle) to Commission

5. Cell Construction Sequence, GEMTEC Design and Operations Plan

6. Operations Manual, FRSWC

7. Environment Management Plan, FRSWC

8. NB Department of the Environment, Approval to Operate, FRSWC for the Crane Mountain Landfill, I-5524, January 1, 2007-December 31, 2011

9. Objectives of Independent External Review of the Crane Mountain Landfill, 2005

10. FRSWC Environmental Monitoring Program Annual Report, 2007

11. FRSWC Environmental Monitoring Program Annual Report, 2008

12. FRSWC Environmental Monitoring Program January-June report 2008

13. Leachate Data (cell level): 2005, 2006, 2008

14. Leachate Composition: 2006, 2007

15. Domestic Well Scope of Work (for Sampling by Gemtec)

16. NB Department of Health, Aubrey Gaudet, Public Health Inspector: Role of DOE in Domestic Well Monitoring, Crane Mountain Landfill.

17. City of Saint John agreements re Lancaster Lagoon

18. Latest scale map (October 2007)

19. Sedimentation Ponds discharge data: 2006, 2008

20. Detailed Emergency Reports, overflow of Sedimentation Pond, 2009: February 21, March 13, September 9, October 29

21. Detailed Emergency Report, Spill of Leachate: March 5, 2009

22. QA/QC Report Cell #4 Containment

23. Specs: Cells 1-3 Final cover and Gas

24. Drawings: Cells 1-3 Final Cover and Gas

25. Specs: Cell #5 Subdrains and Berms

26. Drawings: Cell # 5 Subdrains and Berms

27. 2006 Asbestos Location

28. Leachate BOD5 analysis, 2008; Leachate analysis, 2008; Analysis of pond samples, 2008

APPENDIX B

SECTION 12.0 - 2005 REPORT

12.0 SUMMARY AND RECOMMENDATIONS

12.1 Introduction

This chapter provides a summary of the Independent External Review,a and presents recommendations for improving the Crane Mountain Landfill.

12.2 Summary of Review

The findings of the Independent External Review of Crane Mountain Landfill are summarized in the following table. Summary comments are provided for each specification of the review. The Request For Proposals called for highlighting real or potential areas of concern, if any, and proposals for remedial measures. These are included in the summary. Some comments indicate that a particular item "appears adequate". Such an assessment is based on the information available for the study, which may not have been complete.

Summary of Review

Specifications		Comments
Review of Approvals to Operate	*Assessment of the Fundy Region Solid Waste Commission's compliance with Approvals to Operate*	In general the FRSWC operates the landfill in compliance with the Approval, including design, monitoring and reporting. Amendments should be considered relative to leachate treatment and disposal. An air quality sampling station should be considered during construction activities. Improved analysis of monitoring data is recommended.
	Assessment of adequacy of the Approvals to Operate in providing protection for domestic wells and streams in "host community" down gradient of landfill.	The design of the landfill meets current Approval requirements. Improvements that lower the operating level of the leachate level within the landfill cells should be implemented to better protect the groundwater. A double liner system should be considered for future cells.
Review of Monitoring Wells Surrounding the Landfill	*Adequacy of location, design, and number of onsite monitoring wells, given the hydrogeological characteristics of the site.*	Adequate. Consideration to installing deeper bedrock wells should be given to assist in further addressing characterization of the flow system and fracture network. Improve management of the monitoring program in the context of down gradient domestic well users.

Specifications		Comments
	Analytical database of monitoring well data.	Adequate.
	Adequacy of background data with respect to scope and variability.	Adequate.
	Identification of analytical anomalies with particular attention to leachate indicator parameters.	Further work required. Trigger parameters and levels referenced in EMP should be defined. Site warrants more detailed level of interpretation and reporting in the context of location in upstream end of drainage basin with large number of domestic supply wells located downgradient of site.
	Adequacy of sampling and testing: quality control, frequency, and scope.	Adequate.
	Adequacy of analysis of data from testing.	Further work required. Trigger parameters and levels referenced in EMP should be defined. Site warrants more detailed level of interpretation and reporting in the context of location in upstream end of drainage basin with large number of domestic supply wells located downgradient of site.
	Adequacy of emergency response plans relative to findings in onsite monitoring wells.	General framework is adequate. More work should be completed in terms of practical implementation (e.g. trigger parameters and levels referenced in EMP require definition).
Review of Handling and Control of Leachate	*Effect of uncapped cells on leachate quantity and quality.*	The uncapped cells mean increased leachate generation rates. It is suggested that additional portions of Cells #1 and #2, and portions of Cell #3 receive final closure. A strategy of progressive closure should be implemented.
	Effect of raising height of cells on integrity of clay and synthetic liners.	Raising the height of the landfill does not appear to adversely affect the liner systems beyond their design capacity, particularly since there are no pipe penetrations through the liner.
	Adequacy of material used for cell-capping.	The landfill cover system used to cap the sideslopes of Cells #1 and #2 appears to adhere to the Approval.

Specifications		Comments
	Permeability/ advective breakthrough time of clay liner, under field conditions, relative to recorded heights of leachate in cells (based on studies of three sources of materials tested).	Appears adequate if typical municipal design head of 0.3 m is maintained. *Relative to recorded heights of leachate in cells, further clarification of documentation provided on breakthrough time is warranted.* Breakthrough time should be revisited in context of proposed ponding of leachate in cell, and the fact that existing data suggests during operation there have been prolonged periods wherein leachate head is higher than the 0.3 m typically used in landfill design.
	Effect on clay and synthetic liners of using cells as holding ponds.	It is recommended that the leachate levels be maintained at a lower level. It is suggested that leachate be automatically pumped to the Surge Pond and that a double liner system be used.
	Pre-treatment of leachate before disposal.	Since the Zenon treatment plant closed there is not pre-treatment of leachate prior to trucking it to the Lancaster treatment facility. The FRSWC is in negotiations with the City of Saint John to establish an agreement for the long-term discharge of leachate to the Lancaster Facility. An option that could be considered in conjunction with using the Surge Pond to lower leachate levels in the cells, would be to add aeration to the Surge Pond for pre-treatment.
	Assessment of interaction between groundwater and surface water.	The removal of water as leachate, out of the groundwater system is expected to have a nominal impact on the hydrology of the landfill watershed.
	Surge pond: Integrity of clay liner and synthetic liner, using projected depth of stored leachate.	The present operation of the Surge Pond involves only temporary use of the facility. Therefore the increased depth of leachate on the liner is not expected to cause a problem.
	Identification of chemical composition of leachate.	The leachate composition is regularly monitored and documented. Over time, the BOD concentration has dropped to very low levels for a landfill. In 2004 the average was 140 mg/L. This is partly due to the diversion of organics waste to the composting facility.

Specifications		Comments
	Adequacy of sampling and analysis of sampling of under-drain layer.	The underdrain sampling frequency seems adequate, but the analysis of the data is inadequate.
	Adequacy of emergency response plans relative to leachate control.	The leachate control emergency response plans appear adequate.
Review of Handling and Control of Onsite Surface Water	*Effectiveness of sedimentation ponds in treating and containing surface runoff during normal conditions.*	The available monitoring data indicates that under normal rainfall and operating conditions, the sedimentation ponds can effectively treat the surface runoff.
	Effectiveness of sedimentation ponds in treating and containing surface water during conditions of heavy or extended precipitation.	Under adverse conditions, the system may not be able to adequately treat the surface water. This occurred in Nov. 2004 during heavy rains, lack of flocculent and during construction projects. Improvements have been made to reduce the risk. It is recommended that a specific stormwater management plan be established for construction projects.
	Effectiveness of monitoring of surface water runoff.	The available data indicated a data gap in 2002. Monitoring should be completed in accordance with the schedule in the Approval, and the monitoring data should be analysed for trends in key leachate indicator parameters.
Review of Handling/Disposal of Hazardous Wastes	*Methods of identification and control of industrial and household hazardous wastes.*	Adequate monitoring of waste materials appears to be conducted on-site at the landfill active face and at the C&D site. It is recommended that a HHW drop-off facility be provided at the landfill to assist the public in separating hazardous wastes from municipal waste. It should be located beside the residential drop-off bin/ transfer station.
Review of Waste Diversion	*Methods used.*	Waste is diverted out of the engineered landfill cells through composting, recycling and the separate C&D debris disposal site. Additional waste is diverted privately through commercial paper recycling.

Specifications		Comments
	Rate of diversion.	The rate of diversion can be calculated several different ways. Using only the 2004 data from the landfill scale, the diversion including ICI material was about 25% and the residential diversion rate was about 36%. An on-site blue bin recycling depot is recommended.
Review of Daily Operations	*Daily cover.*	Appears adequate.
	Quality control of acceptable and unacceptable waste.	Monitoring of waste at the C&D site appears to be very good. It is more difficult at the landfill active face, so better opportunities for the public to sort their HHW would help to reduce unacceptable waste going to the landfill.
	Pest and bird control.	Appears adequate.
General Review of Monitoring/Control of Landfill Gas	*Effect of uncapped cells on landfill gas production.*	The uncapped cells allow more water into the landfill and therefore more gas production.
	Monitoring/control of concentration and migration of methane, carbon dioxide, non-methane organic compounds (NMOCs).	There is no landfill gas monitoring station. Without a cap the gases cannot be controlled.
	Monitoring/control of lateral migration of landfill gas.	Lateral gas migration is not a serious issue given the HDPE lined cells and that the cells are largely above grade.
	Monitoring/control of airborne particulate and odour.	Capping, gas collection and flaring or gas utilization is recommended to control odours and reduce greenhouse gas emissions.
Review of Issues Related to Domestic Wells	*Location of wells tested.*	Appears adequate, based on a 1997 plan. Should update and reevaluate.
	Number of wells tested.	Marginal. Well owners should be encouraged to continue to participate in monitoring program to provide as large a sample population as practical.
	Frequency of testing.	Increase to document seasonal conditions.
	Parameters tested.	Considered generally adequate, but should be reviewed in context of developing detailed EMP trigger parameters.

Specifications		Comments
	Adequacy of emergency response plans relative to domestic well contamination.	General framework is adequate. More work required in terms of practical implementation (e.g. trigger parameters and levels referenced in EMP require definition).
	Devise a system whereby results of domestic well tests can be managed.	Further work required.

Discussion of Landfill Issues

The design and operation of the landfill requires a coordinated approach consistent with the original design concept, such that the liner design is compatible with the operation of the leachate controls and the landfill closure philosophy.

The leachate system operation needs to consider the landfill liner design concept relative to the depth of leachate over the liner and the collection sump. The original objective was to keep the leachate levels as low as possible and therefore this approach should be maintained, which means the landfill cells should not be used for leachate storage.

The landfill should be capped according to the design assumptions of each cell. For example Cell #1 and #2 designs assumed that these cells would be capped shortly after reaching capacity. This has only been done on the sideslopes. Capping these two cells would reduce leachate production.

If the landfill cells are not going to be progressively closed as each cell is completed, then the design of the liner system for those cells should reflect that design approach. If the cells are going to left open for an extended period of time, resulting in higher leachate production levels and higher leachate levels over the liner, then consideration should be given to a double liner system.

The Cell #1 clay liner under the sump is 900 mm compared to 1300 mm under the Cell #3 sump. The rest of Cell #1 and Cell #2, which flows through Cell #1, have a 600 mm clay layer under the whole liner. The design of the cell's composite clay/geomembrane liner takes advantage of the high quality marine clay locally available. This is a key factor in the selection of the liner design.

The design of Cell #3 includes a thicker 1300 mm clay layer under the leachate collector sump, and a thickening of the liner's clay layer from 600 mm to 1000 mm at the lower east end of the landfill. This design improvement provides a higher quality barrier system. This would seem to reflect the operational concept of some leachate storage in the sump and lower portion of the landfill.

Given the difference in clay thicknesses, the leachate level within Cell #1 should be maintained as low as possible at all times. Given that the system is manually operated to pump into tanker trucks as they are available, there are potentially times when the leachate level periodically gets elevated and ponds in the lower portion of Cells #1 and #3. As a initial improvement, consideration could be given to automating the system so that the excess leachate is pumped directly to the Surge Pond for storage. In this case leachate levels will be at a higher level and therefore a double liner system for the pond should be considered. Also, an aeration system could be utilized to pre-treat the leachate if the BOD levels increase.

The long term solution, which the FRSWC is evaluating, is to construct a pump station and forcemain that would discharge at the Lancaster treatment plant. This would allow direct pumping of leachate without having to wait for tanker trucks, and therefore minimize leachate ponding over the liners.

The FRSWC plans to increase the finished landfill height from 90 m to 105 m. This concept should be coordinated and integrated with the design concepts and assumptions of each cell. It is noted that the final closure concept needs to be updated to reflect the Surge Pond being maintained as a permanent component of the landfill. The Surge Pond creates a significant cutout in the landfill footprint, which tends to isolate Cells #1 and #2 as well as Cell #3. Therefore those areas cannot be effectively raised to the 105 m level. Hence, these areas should be brought to final grade of 90 m for closure.

Overall, a clearly defined Design and Operations Plan should be developed that would provide clear direction for the design on each new cell, when to close completed cells, and how the leachate system would be operated for each cell.

12.3 Recommendations

Based on the findings of this review, recommendations have been developed. These relate to RFP Item 4.2, proposals for remedial measures, and Item 4.3, proposals for regular, ongoing monitoring/ review of the landfill. The recommendations are as follows:

Approval to Operate

1. That the FRSWC comply with all aspects of the Approval to Operate.

2. Apply for an amendment to the Approval to reflect the current leachate treatment and disposal strategy.

3. Establish an air quality sampling station during construction activities.

Groundwater Monitoring Wells

4. Install deeper bedrock monitoring wells and update hydrogeological characterization.

5. Define “trigger” parameters for groundwater monitoring samples.

6. Complete a detailed interpretation of the groundwater monitoring data.

7. Establish a monitoring database that includes analysis for data trends.

Leachate Management

8. Implement a strategy of progressive landfill closure.

9. Reduce the leachate level in the cells or consider double liner in future cells.

10. Consider automatically pumping leachate to the Surge Pond, upgrade the liner to a double liner and possibly pre-treat the leachate before discharge.

11. Complete a detailed analysis of the underdrain monitoring data.

Stormwater

12. Develop specific stormwater management plans for each phase of construction.

13. Complete a detailed analysis of the stormwater monitoring data.

Hazardous Waste

14. Establish a Household Hazardous Waste drop-off facility at the landfill.

Waste Diversion

15. Establish an on-site recycling facility at the landfill.

Landfill Gas

16. Install a landfill gas collection and flaring or utilization system to reduce odours and greenhouse gases.

Domestic Wells

17. Update the well location plan based on current participants, and reevaluate the number and location of wells.

18. Encourage homeowners to participate in the domestic well monitoring program.

19. Increase frequency of domestic well monitoring to document seasonal conditions.

20. Define “trigger” parameters for domestic well monitoring samples.

21. Complete a detailed interpretation of the domestic well data.

22. Establish a domestic well monitoring database that includes analysis for data trends.

Operations

23. Install an on-site rainfall monitoring gauge.

24. Prepare a Design and Operations Plan that defines the landfill development, closure and leachate management strategies.

Crane Mountain Enhancement, Inc.

25. The Crane Mountain Enhancement, Inc. continue to provide ongoing review of the landfill's monitoring programs to help ensure that adequate analysis is conducted of the monitoring data.
26. That Crane Mountain Enhancement, Inc. continue to work with the Fundy Region Solid Waste Commission to help improve the operation of the Crane Mountain Landfill.

These recommendations provide measures to improve the operation of the Crane Mountain Landfill, improve analysis of the monitoring data, and to suggest improvements to the planning and implementation of landfill development. The implementation of these recommendations should help to improve the protection of groundwater and surface water quality.

APPENDIX C

OVERVIEW OF STATUS/FINDINGS

Status of 2005 Recommendations from Previous ADI Report - January 22, 2009

Approval to Operate

1. *That the FRSWC comply with all aspects of the Approval to Operate.*

The current Approval to Operate (I-5524 - expires December, 2011) was reviewed as part of the current work. ADI's interpretation is that the FRSWC operates the landfill in compliance with the approval. Our assessment was a general compliance review based upon the background information provided for the completion of the landfill review project. It was therefore not possible to confirm strict compliance with many of the more detailed requirements of the approval.

2. *Apply for an amendment to the Approval to reflect the current leachate treatment and disposal strategy.*

The new approval generally reflects the current leachate treatment and disposal strategy.

3. *Establish an air quality sampling station during construction activities.*

Item 48 in the approval suggests that a high volume air quality sampling station has been installed at the landfill site. This item states that the unit is to be maintained such that total suspended particulate (TSP) matter can be monitored in the future if required by subsequent Approvals to Construct.

However, it is not definitively stated that TSP will be required to be measured during future construction activities.

Groundwater Monitoring Wells

4. *Install deeper bedrock monitoring wells and update hydrogeological characterization.*

The updated assessment of the bedrock hydrogeology (Gemtec, 2006[c]) at the landfill site generally involved an examination of existing information and did not include the installation of deeper bedrock monitoring wells. The report on the updated work (Gemtec, 2006[c]) suggests that the existing potable water wells at the landfill be used to monitor deeper bedrock water quality to allow for the comparison of groundwater chemistry at this location with that observed in the downgradient domestic wells at the bottom of the flow system.

Although there may be some benefit to this approach, additional deeper groundwater monitoring wells should be installed at intermediate locations in the flow system to allow for an assessment of the geochemical evolution of the deeper groundwater as it moves through the flow system. The report neither addresses the geochemical evolution of groundwater in the flow system nor groundwater chemistry issues in general. The geochemical evolution of

groundwater in the flow system should be examined to allow for better discernment and detection of potential landfill sourced impacts on groundwater quality.

It is ADI's opinion that this issue be revisited, and given more effort. Key aspects should include referring to the report by Fracflow (1997) to refine objectives and approach; installation of additional wells as warranted to characterize flow system; and consideration of geochemical evolution within the flow system. The data from this additional work could be used to develop a numerical model(s) of groundwater flow and contaminant transport to promote a better understanding of the regional flow system and related aspects of monitoring approach.

5. *Define "trigger" parameters for groundwater monitoring samples.*

"Trigger" parameters[1] were established for the underdrain, groundwater monitoring well and domestic well monitoring data in the Gemtec report on the Management of Monitoring Data prepared for FRSWC (Gemtec, 2006[b]). These parameters are leachate indicator parameters[2] and we are in agreement with the individual parameters chosen.

Notes: 1) Trigger Parameters - chemical parameters in water quality monitoring data which are of interest since their presence at elevated concentrations relative to background concentrations may signify the onset of water quality impacts.
2) Leachate indicator parameters - chemical parameters in landfill water quality monitoring data which are of interest since their presence at elevated concentrations may signify the presence of leachate impacts to water quality.

6. *Complete a detailed interpretation of the groundwater monitoring data.*

This was partially addressed in the aforementioned Gemtec report on the Management of Monitoring data prepared for FRSWC (Gemtec, 2006[b]). Although it is acknowledged that the analysis and recommended approach outlined in this report is an improvement over the previous situation, it is our opinion that there are opportunities to improve upon this work. Based upon our review of the report, we have the following comments and/or concerns.

6a) It is important to recognize that the hydrogeological setting of the FRSWC landfill is unique among the six provincial regional solid waste management facilities in that there are approximately 800 domestic wells located in Martinon Beach and surrounding communities which are downgradient of the site. Therefore in this context, concerning the overall report, it is ADI's opinion that given the hydrogeologic setting of the landfill, data interpretation and related statistical approach warrants supporting documentation. Documentation should include industry recognized standard adopted (e.g. USEPA), advantages/ disadvantages of the selected approach, and other relevant information.

6b) It is noted that ADI had recommended that major ion chemistry plots be prepared to isolate water of similar chemical "types" in an effort to remove some of the background variation in the water quality data. Trigger levels[1] could then be developed for each chemical type of water to potentially allow for more meaningful comparisons with future results. However, this approach was evidently not adopted. It is recommended that trigger parameters be developed for the different groundwater "types" and that these values be compared with the previously derived trigger parameters to assess what effect this approach has on the trigger parameters. The most stringent trigger parameters, which would be expected to be the revised ones, should be adopted for site usage.

6c) Trigger concentrations were calculated as follows: 1) mean concentration + 4 standard deviations for normally distributed data; 2) threshold values for parameters not normally found in groundwater (e.g. ammonia); and 3) 97.5th percentile x 1.3 for variable data. It is agreed that the Method 2 approach is required for selected parameters. Regarding the two remaining methods, it is noted that although these approaches are statistically based, the calculation of the trigger parameter values appears to be somewhat arbitrary. We agree with the opinion of Craig Hydrogeologic that Method 1 tends to yield trigger concentrations which are too high and that Method 3 should be substituted for Method 1. As noted by Craig, the validity of the selected triggers could be reviewed after some time and adjusted as required.

6d) It is noted in the report that the domestic monitoring well data has not been included in the GIS database which is a significant limitation. The confidentiality of the domestic well data has been cited as the reason for this considerable limitation of the current monitoring program. It has been suggested that the participants in the monitoring program sign a waiver outlining items such as how the data is stored; the accessibility of the data; and how the data may be used in the event that a trigger concentration is exceeded. This is considered to be an unnecessarily onerous and ineffective approach since individuals may understandably be reluctant to sign a "legal document" without wholly understanding or being able to predict the potential implications of such action. Since it is understood that the FRSWC is the "owner" of the domestic well data, it is suggested that as a minimum the data be anonymously identified by number and scrutinized as the fourth tier in the monitoring program. This and other possible solutions should be examined. It is agreed with Craig that the entire program be revamped such that, among other things, the locations of the wells in the program be selected on the basis of a technical rationale (e.g. location of individual wells in the regional flow system). It is agreed that the Environmental Management Plan (EMP) should be updated to reflect any revised domestic well monitoring program and to include a protocol to be followed in the event of a trigger exceedance. The protocol must be equitable to the well owners as well as the FRSWC.

6e) Finally, it is noted that the report suggests that an automatic monitoring system be installed on the current underdrain monitoring location which is understood to be a manhole located along the lower trunk line common to all of the underdrains (it is understood that an automatic monitoring system has since been installed at this location). The report also notes that historically, the underdrain water was sampled at four different locations (it is unclear if this continues to be the case).

It is reasonable to concentrate monitoring efforts on potential early detection points (i.e. underdrains) and, in the spirit of this safeguard philosophy, we suggest that it would be prudent to monitor the underdrain water quality at multiple locations in the flow system to avoid potential downstream dilution effects (e.g. inflow of groundwater) and maximize the sensitivity of the early detection system. It is acknowledged that it would probably be cost prohibitive to install automated monitoring systems at multiple locations. However, regardless of whether or not automated systems are installed, it is recommended that underdrain samples be collected from more than one location such as what was done in the past. The approach of monitoring underdrain water quality at multiple locations should also be adopted for future waste cells. As a minimum, the underdrain water quality should be periodically monitored at each cell location.

Even with these improvements, it must be kept in mind that no monitoring system is infallible as noted by Craig. For example, if it is hypothetically assumed that there is there is an initially undetected breach in the liner system and leachate enters the underlying groundwater flow system (e.g. through a coincidental localized hole/pathway in the HDPE membrane and soil liners), the movement of the contaminated leachate in the groundwater will be dictated by a complex set of variables including bedrock fracture size and spacing; hydraulic groundwater flow gradients; the timing and magnitude of groundwater recharge to the regional flow system; and other factors. These factors will determine when and where the leachate impacts are initially detected in the groundwater flow system. However, it is possible that these impacts could initially be undetected in the groundwater monitoring well network since it is neither feasible nor practical to install monitoring wells at all points in a three dimensional groundwater flow system.

Note: 1) Trigger concentration or level - the statistically defined threshold quantity or concentration of a trigger parameter in water above which some interaction between the water and the contaminant of concern may be occurring.

7. *Establish a monitoring database that includes analysis for data trends.*

Trending graphs are included in the most recent annual Environmental Compliance Monitoring Report for the landfill (Gemtec, 2008). *It is recommended that trend graphs be used in conjunction with the overall data interpretation approach including the statistical approach undertaken (see #6b, above). The trend assessment and water quality monitoring data review in general should be completed by a qualified individual. In our opinion, a qualified individual would be a hydrogeologist or an engineer or geoscientist with hydrogeological training.*

Leachate Management

8. *Implement a strategy of progressive landfill closure.*

A strategy for progressive landfill closure and leachate management was outlined in the 2006 Gemtec report entitled "Design and Operations Plan - Fundy Region Solid Waste Commission, Saint John, NB" (Gemtec, 2006[a]). A hypothetical schedule and associated estimated costs for the progressive construction of the landfill cell liner and cap is outlined based upon several assumptions. On the basis of this assessment, a total of sixteen landfill cells will be constructed with the final cell projected to be capped in 2047. The hypothetical timeline is based upon the assumption that liner and capping construction projects will be completed on an alternating three year cycle in consideration of cashflow optimization, such that in any three year period there is a construction project (liner or cap) in two of the three years. The cells are sized to accommodate the anticipated required quantity of waste disposal and vary due to the several factors including the geometry of the final landfill footprint and the internal side slopes of the refuse. The closure strategy calls for the landfill gas management system at the landfill to be expanded with the progression of the landfill. It is noted that cell capping costs include the costs associated with landfill gas management. The report also references a recent decision to establish the final operating elevation of the landfill at 90 m. The option of filling to elevation 105 m was considered for some time but it is noted that this was rejected, in part, on the disposal potential of other areas of the commission's property.

The report also addresses leachate management. To minimize leachate production, landfill cells are generally capped as soon as possible subsequent to filling. However, this process did not initially take place at the FRSWC site. According to the report, there was a delay in final capping activity due to the time taken to consider raising the final elevation of the landfill. Also, a landfill gas collection and management system was not installed at the site until 2006. Since the collection pipes for these systems are generally installed prior to the construction of the final cap, the on-site capping operations were further delayed. However, it is understood that in recent years, the cell capping operations have been "catching up" with new cell development (e.g. cells 1, 2 and 3 were capped in 2006) with a resulting significant reduction in on-site leachate generation. The proposed liner and capping construction sequence noted above is intended to minimize the future rate of increase in leachate production. Future annual leachate volumes for the site were subsequently calculated based upon the hypothetical future construction timeline; an average annual precipitation rate of 1100 mm; and the assumption of leachate production levels of 70% and 3% of precipitation for active and capped portions of the landfill. Leachate from the landfill collects in sumps installed in the cells along the lower lying east side of the landfill where it is pumped to the surge pond lift station and then into tanker trucks for transport to the Lancaster Treatment Plant.

The surge pond is designed to provide leachate storage during large storm events. In addition, the thickness of clay within the sumps was increased from 900 mm in Cell 1 to 1300 mm in Cell 3 to accommodate the periodic accumulation of leachate over the liner. The frequency of leachate storage within the landfill cells is expected to decrease with time assuming that cell capping progresses in step with new cell construction as planned. However, the report notes that "...there will be times when the volume of leachate generated within the cells will exceed the capacity of the sump pumps..." Therefore, the report recommends that the additional clay thickness provided in Cell 3 be extended to all future cells on the east side of the landfill. The report also stresses the importance of monitoring leachate levels in the sumps and surge pond.

Regarding the long term treatment of landfill leachate for the life of the site, the report notes that the decision to establish the final elevation of the landfill at 90 m will result in 20% reduction in leachate production compared with earlier estimates based on a final elevation of 105 m as detailed in a report on the assessment of leachate management options. The report notes that, in consideration of the reduced leachate volumes, the projected cost of trucking the leachate is essentially the same as the cost of constructing a pipeline. It was therefore recommended that the trucking option continue. The rationale for this recommendation was that there is greater uncertainty associated with the cost of the pipeline option.

In general, the outlined approach for long term site development and leachate management is reasonable. The report acknowledges that the plan may be modified pending future conditions and is to be used only as a general guide and planning tool.

However, if it is planned to use additional FRSWC property for future waste disposal, it is important that the proposed disposal area(s) be thoroughly assessed (e.g. soils investigations, etc.) for the suitability of landfill construction. This would include assessing the thickness of the native till and completing other work as required in a reasonably timely manner so as to accommodate future waste disposal planning.

9. ***Reduce the leachate level in the cells or consider double liner in future cells.***

(Examine and comment on leachate levels - digital data should be provided).

10. ***Consider automatically pumping leachate to the Surge Pond, upgrade the liner to a double liner and possibly pre-treat the leachate before discharge.***

ADI to respond to one page PROS/ CONS of double liner versus single liner system.

11. ***Complete a detailed analysis of the underdrain monitoring data.***

"Trigger" parameter concentrations were developed for the underdrain, groundwater monitoring well and domestic well monitoring data in the Gemtec report on the Management of Monitoring Data prepared for FRSWC (Gemtec, 2006[b]). Some trending analysis in the form of graphical plotting of historical water quality data was also completed for the 2008 annual report on the environmental monitoring program at the landfill (Gemtec, 2008). These data plots included trend plots for selected leachate indicator parameters for the landfill cell underdrain and the leachate surge pond underdrain monitoring locations.

In our opinion, there is some opportunity for improvement in the establishment of the trigger parameters (Refer to the update related to ADI Recommendation #6c). Trend analysis should continue to be used in conjunction with the statistical analysis in the assessment of underdrain water quality data.

Stormwater

12. ***Develop specific stormwater management plans for each phase of construction.***

A general review of the stormwater management system at the landfill was completed (Gemtec, 2006[d]). The report indicates that during the construction of new cells, "the 2 - 3 ha of disturbed area is ditched so that storm water run-off is directed to the treatment system".

However, to our knowledge, specific stormwater management plans have not been prepared for new construction projects.

13. ***Complete a detailed analysis of the stormwater monitoring data***.

The total suspended solids (TSS) results for the sedimentation pond discharge data from 2000 to 2007 are included and discussed in the report on the review of the stormwater management system (Gemtec, 2006[d]). The report indicates that the TSS value exceeded the 25 mg/L limit on one occasion in 2004 when the commission reportedly ran out of the chemical flocculating agent which promotes the settling out of suspended sediments in the treatment pond. The report indicates that steps have been taken to ensure that the commission does not run out of flocculating agent in the future.

Hazardous Waste

14. ***Establish a Household Hazardous Waste drop-off facility at the landfill.***

According to the FRSWC website, there is currently a drop-off location at the landfill for household hazardous waste. It is understood that this location operates on Saturday mornings from 8 am to 12 pm.

Consideration should be given to extending the hours of operation of the on-site drop of location to make it more readily accessible to the public in general and, in particular, to Fundy region residents who live in more remote locations relative to the landfill site.

Waste Diversion

15. ***Establish an on-site recycling facility at the landfill.***

It is understood that there is currently no on-site recycling drop-off facility at the landfill. However, there are many recycling drop-off areas located throughout the landfill service area and the current distribution of these facilities appears to be adequate.

Landfill Gas

16. ***Install a landfill gas collection and flaring or utilization system to reduce odours and greenhouse gases.***

A landfill gas collection and flaring system has been installed.

Domestic Wells

17. ***Update the well location plan based on current participants, and reevaluate the number and location of wells.***

It is assumed that this has not been completed due to perceived privacy issues related to the domestic well monitoring program. The entire program should be revamped such that, among other things, the number and location of the wells in the program be selected on the basis of a technical rationale (e.g. consider the location of individual wells in the regional flow system). Refer to the update related to ADI Recommendation #6d for additional discussion of this matter.

18. ***Encourage homeowners to participate in the domestic well monitoring program.***

Current participants in the domestic well monitoring program are issued a letter prior to the annual sampling event directing them to contact FRSWC's consultant for this work to arrange a sampling appointment. Recently, this letter has reportedly been worded such that the participants are to contact the consultant for an appointment "if they so desire". The latter comment could be construed as discouraging participation in the program and, therefore, it would be helpful if this comment was omitted in future "request for appointment" letters.

19. ***Increase frequency of domestic well monitoring to document seasonal conditions***.

The current Approval to Operate (I-5524 - expires December, 2011) continues to only require that the domestic wells be monitored once per year in September/October.

20. ***Define "trigger" parameters for domestic well monitoring samples*****.**

Trigger parameters for domestic wells were developed in the Gemtec report on the Management of Monitoring Data prepared for FRSWC (Gemtec, 2006[b]). However, it is understood that the domestic well data was not included in the GIS environmental monitoring database for the landfill developed by Gemtec. Refer to the update related to ADI Recommendation #6d for additional discussion of this matter.

21. ***Complete a detailed interpretation of the domestic well data*****.**

Trigger parameters for domestic wells were developed in the Gemtec report on the Management of Monitoring Data prepared for FRSWC (Gemtec, 2006[b]).

However, major ion plots were not prepared for the domestic well data to isolate geochemically similar well type. Furthermore, it is our opinion that additional work is required to better understand the geochemical evolution of groundwater in the deeper groundwater flow system in the regional watershed which encompasses the landfill site and surrounding area. Refer to the updates related to ADI Recommendation #4 and ADI Recommendation #6b for additional discussion of this matter.

22. ***Establish a domestic well monitoring database that includes analysis for data trends***.

The domestic well data has not been included in the GIS environmental monitoring database for the landfill recently developed by Gemtec as noted in the report on the management of monitoring data (Gemtec, 2006[b]). Refer to the update related to ADI Recommendation #6d for additional discussion of this matter. It is assumed that trending analysis of this data is not being completed.

Operations

23. ***Install an on-site rainfall monitoring gauge*****.**

It is understood that an on-site rainfall gauge has been installed.

However, the meteorological data appended to the most recent annual environmental compliance monitoring report is the Environment Canada data for the Saint John airport (Gemtec, 2008). The on-site rainfall data should also be included with future monitoring reports.

24. ***Prepare a Design and Operations Plan that defines the landfill development, closure and leachate management strategies.***

A design and operations plan which outlines the key features of these issues has been prepared (Gemtec, 2006[a]). Refer to the update related to ADI Recommendation #8 for additional discussion of this matter.

Crane Mountain Enhancement, Inc.

25. ***The Crane Mountain Enhancement, Inc. continue to provide ongoing review of the landfill's monitoring programs to help ensure that adequate analysis is conducted of the monitoring data.***

This work has been on-going and is partially addressed by the current work by ADI related to the update of the independent review of landfill prepared by ADI Limited in 2005. Recommendations for future potential projects which may assist CMEI in carrying out this function have been provided in the cover letter accompanying this update/review of the principal recommendations provided in our 2005 report on the landfill.

26. ***That Crane Mountain Enhancement, Inc. continue to work with the Fundy Region Solid Waste Commission to help improve the operation of the Crane Mountain Landfill.***

CMEI has continued to work diligently with the FRSWC to improve the overall operation and environmental sustainability of Crane Mountain landfill.

REFERENCES

Craig Hydrogelogic, 2007. Review of Gemtec Reports to Fundy Region Solid Waste Commission. Letter report to Crane Mountain Enhancement Inc. dated May 28, 2007.

Fracflow Consultants Inc. 1997. Review of Environment Impact Statement, Regional Landfill at Crane Mountain. Report to Dr. Phillip J. Lee, Saint John, NB dated September, 1997.

Gemtec, 2008. Environmental Monitoring Program - Crane Mountain Landfill. Annual Report for 2007 (Final). Report to the Fundy Region Solid Waste Commission dated May 2008. Gemtec File No. 658.98 - R01.

Gemtec, 2006[a]. Design and Operations Plan - Fundy Region Solid Waste Commission, Saint John, NB. Report to the Fundy Region Solid Waste Commission dated July 2006. Gemtec File No. 658.86 - R02.

Gemtec, 2006[b]. Crane Mountain Landfill - Management of Monitoring Data. Report to the Fundy Region Solid Waste Commission dated December 2006. Gemtec File No. 658.85 - R01.

Gemtec, 2006[c]. Update of Bedrock Hydrogeology - Crane Mountain Landfill, Saint John, New Brunswick. Report to the Fundy Region Solid Waste Commission dated November 2006. Gemtec File No. 658.87 - R01.

Gemtec, 2006[d]. Stormwater Management System. Report to the Fundy Region Solid Waste Commission dated November 2006. Gemtec File No. 658.90 - R01.

APPENDIX D

APPROVAL TO OPERATE

Environment Environnement

5668-3.1/22

New Nouveau Brunswick
CANADA

December 22, 2006
File: 26915-F2

Ron Nelson
Fundy Region Solid Waste Commission
P.O. Box 3032
Grand Bay-Westfield, NB
E5K 4V3

Dear Mr. Nelson:

Re: Approval to Operate

On behalf of the Honourable Roland Haché, Minister of Environment, I am writing to inform you that an Approval to Operate has been issued to your Facility and a copy of the Approval, **I-5524**, is enclosed.

Please note that this Approval includes terms and conditions that must be adhered to. Several of these terms and conditions include dates by which reports must be submitted or other work must be conducted. Care should be taken to ensure that all such terms and conditions are complied with, in the specified time frame.

If you have questions about your Approval or any other environmental concern with your Facility, please feel free to contact me at (506) 453-4334.

Sincerely,

Jeff Porter, P.Eng.
Solid Waste Engineer
Stewardship Branch
Environmental Management Division

Encl.

P.O. Box 6000
Fredericton
New Brunswick
Canada E3B 5H1

Case postale 6000
Fredericton
Nouveau-Brunswick
Canada E3B 5H1

New Nouveau Brunswick

APPROVAL TO OPERATE

I-5524

Pursuant to paragraph 8(1) of the *Water Quality Regulation - Clean Environment Act*, and paragraph 5 (3) (a) of the *Air Quality Regulation - Clean Air Act*, this Approval to Operate is hereby issued to:

Fundy Region Solid Waste Commission
for the operation of the
Crane Mountain Landfill

Description of Source:	A regional sanitary landfill with leachate collection and disposal.
Source Classification:	Fees for Industrial Approvals Regulation - Clean Water Act Class 4 Air Quality Regulation Class 4
Parcel Identifier:	55087001, 55087027, 55086987, 55087019, 55043301, 55043293, 55160352
Mailing Address:	P.O. Box 3032 Grand Bay-Westfield , NB E5K 4V3
Conditions of Approval:	See attached Schedule (s)"A" and "B" of this Approval
Supersedes Approval:	SL6-HHW1
Valid From:	January 01, 2007
Valid To:	December 31, 2011

Recommended by: _____
Environmental Management Division

Issued by: _____
for Minister of Environment

DEC 22 2006
Date

SCHEDULE "A"

A. DESCRIPTION AND LOCATION OF SOURCE

The Fundy Region Solid Waste Commission operates a regional solid waste management and disposal facility that is commonly referred to as the Crane Mountain Landfill. The Landfill is located in Saint John near Grand Bay-Westfield and serves the residents of Saint John county and the western portions of Kings and Queens county. The Commission operates a construction and demolition debris disposal site and a household hazardous waste depot at the Landfill. A designated area on site is also utilized for the temporary storage of metal, tires, wood, white goods and other such salvageable/recyclable materials.

As a result of the operation of the regional solid waste management and disposal facility, there exist *potential* environmental impacts from: 1) the generation of leachate in the landfill containment cells and the construction and demolition debris disposal site; 2) spillage, mishandling or release of leachate, a petroleum product or other material; 3) the operation of the household hazardous waste depot; 4) failure or accidental discharge from the leachate treatment pond or collection system; 5) site run-off or suspended solids discharge from the sedimentation pond(s); 6) fugitive dust emissions from truck traffic and other on-site activities; and 7) elevated odour and/or noise emissions.

The operation of the regional solid waste management and disposal facility by the Fundy Region Solid Waste Commission, located in the City of Saint John, County of Saint John, and the Province of New Brunswick and identified by Parcel Identifier (PID) numbers 55087001, 55087027, 55087019, 55043301, 55086987, 55160352 & 55043293 is hereby approved **subject to the following:**

B. DEFINITIONS

1. "**Approval Holder**" means Fundy Region Solid Waste Commission.

2. "**Department**" means the New Brunswick Department of Environment.

3. "**Minister**" means the Minister of the Department and includes any person designated to act on the Minister's behalf.

4. "**Director**" means the Director of the Stewardship Branch of the Department and includes any person designated to act on the Director's behalf.

5. "**Facility**" means the property, leachate collection and treatment systems, buildings, equipment and any other activities involved with the operation of the regional solid waste management and disposal facility by the Fundy Region Solid Waste Commission at PID numbers 55087001, 55087027, 55086987, 55087019, 55043301, 55160352 & 55043293.

6. **"containment cell"** means the area at the Facility approved in writing by the Department for the disposal of solid waste.

7. **"watercourse"** means the full width and length, including the beds, banks, sides and shoreline, or any part of a river, creek, stream, spring, brook, lake, pond, reservoir, canal, ditch or other natural or artificial channel open to the atmosphere, the primary function of which is the conveyance or containment of water whether the flow be continuous or not.

8. **"friable asbestos"** means waste material containing asbestos fibre or asbestos dust in a concentration greater than 1% by weight that is **not** tightly bound within a solid matrix such that it is easily crumbled by the hands.

9. **"petroleum product"** means a mixture of hydrocarbons, or their by-products, of any kind and in any form, including airplane fuel, asphalt, bunker "C" oil, crude oil, diesel fuel, engine oil, fuel oil, gasoline, kerosene, lubricants, mineral spirits, naphtha, petroleum based solvents regardless of specific gravity, transformer oil and waste petroleum products and excluding propane and paint.

10. **"biomedical waste"** means,
    a) any part of the human body, including tissues and bodily fluids, but excluding fluids, extracted teeth, hair, nail clippings and the like, that are not infectious,
    b) any part of the carcass of an animal infected with a communicable disease or suspected by a licensed veterinary practitioner to be infected with a communicable disease,
    c) non-anatomical waste infected with communicable disease,
    d) a mixture of a waste referred to in clause (a), (b) or (c) and any other waste or material; or
    e) a waste derived from a waste referred to in clause (a), (b) or (c), unless the waste that is derived from the waste referred to in clause (a), (b) or (c) is produced in accordance with a certificate of approval that states that, in the opinion of the Director, the waste that is produced in accordance with the certificate of approval does not have characteristics similar to the characteristics of waste referred to in clause (a), (b) or (c

11. **"hazardous waste"** means any waste material intended for disposal or recycling, that is identified as a hazardous waste or hazardous recyclable material by the federal *Export and Import of Hazardous Waste and Hazardous Recyclable Material Regulations*, and/or is included in Class 1 and/or Class 7 of the federal *Transportation of Dangerous Goods Regulations*. This definition excludes any waste(s) for which the Director of the Approvals Branch has issued a written exemption.

12. **"sludge"** means a solid, semi-solid or liquid residue having less then 15% solids generated during the treatment of municipal and/or industrial wastewater, or generated as a result of other processes.

13. **"liquid waste"** means bulk liquids in a volume greater then 20 litres.

14. **"liquid oily waste"** means any waste containing free flowing petroleum products.

15. **"petroleum contaminated soil"** means soil that contains petroleum products at quantities determined, to the satisfaction of the Department, to be above the level indicated in the most recent version of the RBCA Tier I Risk-Based Screening Level (RBSL) Guidelines for Soil: Commercial, Non-potable, Coarse-grained for Modified TPH (Gas + Diesel#2 + #6 Oil). The current level is 450 mg/kg (ppm).

16. **"C&D debris"** means

a) concrete, brick and untreated wood,
b) siding, ceiling tile, gyproc, insulation,
c) asbestos that is not friable asbestos,
d) solid roofing materials such as asphalt shingles,
e) glass from doors and windows,
f) metal, wood, fibreglass and durable plastic structural materials from the demolition of a building,
g) wiring and incandescent light fixtures that do not contain fluorescent tubing/lighting,
h) toilets, bathtubs, wash basins, and plumbing fixtures,
i) floor coverings attached to a building during demolition,
j) broken and aged asphalt, or
k) any mixture of (a) thru (j)

that has been obtained during the construction, renovation or demolition of a building or structure. Debris or other materials obtained from commercial, industrial and manufacturing sources is not acceptable. Debris: i) from a building that has or may have manufactured, contained, transferred or distributed contaminated or hazardous (such as a pesticide storage warehouse) products; or ii) that contains PCB's (polychlorinated biphenyls), or iii) that contains lead paint of a known concentration greater then 1000ppm (parts per million) or that has been deemed leachable toxic (exceeds 5 mg/L) or contains lead paint that is flaking/chipping/peeling is not considered C&D debris for the purpose of this Approval.

17. **"C&D Site"** means the portion of the Facility approved by the Department for the disposal of C&D debris.

18. **"disposal cell"** means the area at the C&D Site approved by the Department for the disposal of C&D debris.

19. **"sorting area"** means a location at the C&D Site, if approved in writing by the Director, where loads of C&D debris may be dumped and sorted. Unapproved materials may temporarily be stored here.

20. **"household hazardous waste"** means, for the purposes of this approval, hazardous waste that is generated in New Brunswick households.

21. **"hazardous waste collection and transportation network"** means a company that is approved by or acceptable to the Department to collect and transport hazardous waste.

C. EMERGENCY REPORTING

22. The Approval Holder, operator or any person in charge of the Facility **shall immediately** notify the Department where:

a) there has been, or is likely to be, a release of a contaminant or contaminants, such as leachate, wastewater, petroleum products, hazardous materials, or gaseous material, from the Facility which is of such magnitude or duration that there is a concern for the health or safety of the public, or there could be an impact to the environment.

Notification Procedure

Verbal notification should immediately be made to the **Region 4 (Saint John) Office by calling (506) 658-2558**. If contact cannot be made for any reason the problem should immediately be reported to the **Canadian Coast Guard at 1-800-565-1633**. At this time the problem that occurred, its resulting impact and what was done to minimize the impact should be clearly expressed.

Within 24 hours of the original notification, a copy of an "Incident Report" shall be faxed to the Region 4 (Saint John) Office at (506) 658-3046. The "Incident Report" shall clearly detail as much information about the incident that is available. As a minimum the faxed report should include: details of the problem, its resulting impact and what was done to minimize the impact.

Within five (5) working days from the original notification, a faxed "Detailed Emergency Report" shall be sent to the Region 4 (Saint John) Office and also to Central Office in Fredericton at (506) 453-2390. The "Detailed Emergency Report" shall describe in detail the problem that occurred, why the problem occurred, what the environmental impact was, what was done to minimize the impact, and what measures have been taken to prevent a re-occurrence of the problem.

D. GENERAL INFORMATION

23. The issuance of this Approval does not relieve the Approval Holder from the responsibility of complying with other applicable federal, provincial or municipal legislation and/or bylaws.

24. A copy of this Approval to Operate should be maintained on-site or in the office of the Approval Holder.

25. The Approval Holder shall immediately notify the Department in writing of any change in the legal name or address of the Facility.

26. Any operating problems or other matters that could cause the Facility to be in non-compliance with this Approval should be reported to the Department immediately.

27. Be advised that the design and operation of any borrow pit by the Approval Holder must comply with the Department's guidelines for Pits and Quarries.

E. TERMS AND CONDITIONS

GENERAL CONDITIONS

28. **Prior to September 30, 2011,** the Approval Holder shall submit a written application to the Department for a renewal of this Approval on a form provided by the Minister. The application shall include documentation supporting any proposed changes to the terms and conditions of this Approval.

29. In the event of Facility closure, the Approval Holder shall, in addition to any requirements under the *Environmental Impact Assessment Regulation 87-83* filed under the *Clean Environment Act*, prepare plans and an engineering closure proposal with ongoing monitoring, landfill gas and leachate management and complete site rehabilitation if appropriate. The plan shall also include other information as requested in writing by the Minister. The plans shall be submitted to the Director for review and approval **at least six (6) months** before the planned closure date. The plans must be prepared or approved by a person who is a member of the Association of Professional Engineers and Geoscientists of the Province of New Brunswick.

30. In the event of closure of the C&D Site at the Facility, the Approval Holder shall ensure that a Closure Plan is prepared and submitted to the Director for review and approval **at least three (3) months** before the planned closure date. The plans must be prepared or approved by a person who is a member of the Association of Professional Engineers and Geoscientists of the Province of New Brunswick and include, but not necessarily be limited to, updated site plans and an engineering proposal for the site rehabilitation, monitoring, leachate treatment if appropriate and closure.

31. The Approval Holder shall ensure that any item received at the Facility containing ozone-depleting substances, including but not limited to those utilized for refrigeration and/or air conditioning, are decommissioned according to the *Ozone Depleting Substances Regulation 97-132* filed under the *Clean Air Act*.

32. The Approval Holder shall ensure that waste, including C&D debris and friable asbestos, that originates from outside of New Brunswick is not accepted at the Facility unless specifically approved by the Minister following an evaluation under the *Environmental Impact Assessment Regulation*.

33. The Approval Holder shall ensure that an Environmental Management Plan (EMP) is in place at the Facility. The EMP should include detailed emergency, contingency response and clean-up procedures for potential spillage, release or mishandling of leachate, a petroleum product, or other dangerous materials at the Facility. The EMP should also include details on how the Facility will respond to emergency situations that may arise such as forest fires, restricted access to the Facility (traffic accidents or other blockade for example), failure of the leachate treatment and sedimentation ponds or leachate collection systems or other events that would interrupt normal operation of the Facility.

Facility personnel should be appropriately trained to perform emergency and contingency response procedures as described in the EMP.

OPERATING CONDITIONS

34. The Approval Holder shall ensure that the Facility is not used for the disposal of:

- petroleum contaminated soil,
- liquid wastes (with the exception of septage from the Facility sewage system),
- sludge (with the exception of sludge from the Facility leachate treatment system),
- liquid oily wastes,
- hazardous wastes,
- biomedical waste or
- any mixture of the above.

35. The Approval Holder shall ensure that any solid waste disposed of at the Facility is done so in the containment cells at the Facility unless otherwise approved in writing by the Director. It is recommended that the waste be regularly and uniformly compacted.

36. The Approval Holder shall ensure that the minimum 25-year breakthrough requirement for the containment cells at the Facility is maintained.

37. The Approval Holder shall ensure that all exposed waste in the containment cells of the Facility is covered with a minimum of 150 mm of clean soil (or an alternate daily cover that has been pre-approved in writing by the Director), as a minimum, at the end of each operating day.

38. The Approval Holder shall provide supervision when any material is being disposed of at the Facility, including the C&D Site. No disposal at the Facility, including the C&D Site, is permitted otherwise.

39. The Approval Holder shall ensure that the incoming waste at the Facility is routinely scrutinized to ensure that unacceptable waste is not received at the Facility.

40. The Approval Holder shall ensure that the household hazardous waste depot at the Facility is operated in accordance with an operating manual approved by the Department.

41. The Approval Holder shall ensure that a buffer strip of native softwood trees is maintained around the Facility in accordance with the Environmental Impact Assessment Study.

42. The Approval Holder shall ensure that a Pest Management Program is in place at the Facility that is in compliance with "Pest Control at NB Landfill Sites and Transfer Stations", attached as Schedule "B".

CONSTRUCTION

43. The Approval Holder shall ensure that the necessary engineering documentation is submitted to the Director, and approved in writing by the Department, prior to the construction, modification or expansion of 1) additional solid waste disposal cells, 2) landfill gas management systems; 3) sludge handling facilities, 4) leachate collection and treatment systems, 5) facilities for processing recyclables or managing organics, 6) storage of waste including household hazardous waste, 7) special waste disposal cells/locations or any other pertinent construction activity at the Facility.

44. The Approval Holder shall ensure that final cover applied to the containment cells at the Facility shall be a minimum of 300 mm granular layer, 600 mm low permeability clayey till @ 1 x 10^{-7} cm/sec hydraulic conductivity, 150 mm granular protection layer, 150 mm growing medium and vegetative cover and shall be sloped a minimum of 2% to promote precipitation runoff from the disposal cell. All holes, cave-ins and faults shall be filled in or repaired, as required, until the final cover has been properly stabilized. All side slopes shall be designed to ensure proper slope stability and full containment of leachate. As a minimum, a side slope of less than 4 horizontal to 1 vertical should be utilized.

If approved in writing by the Director, an alternative final cover plan may be used.

45. The Approval Holder shall ensure that a Quality Assurance and Quality Control (QA/QC) report is submitted to the Department upon completion of the installation of final cover on a containment cell or cells at the Facility. The report must be prepared or approved by a person who is a member of the Association of Professional Engineers and Geoscientists of the Province of New Brunswick or is licensed to practise as a professional engineer pursuant to the *Engineering Profession Act* and include as a minimum:
- commentary that confirms that all construction activities and testing associated with the installation of final cover were supervised by a qualified independent third party and that the final cover meets the Department's requirements as detailed in the previous condition;
- all test parameters, the number of tests and locations;
- copies of any inspection and testing reports;
- a summary of any problems or deficiencies encountered and how they were corrected; and
- other information as requested by the Department.

The QA/QC report should be forwarded to the Department no later then 3 months upon completion of the final cover.

46. The Approval Holder shall ensure that all future containment cells (cell #5 and on) at the Facility are designed such that the installed leachate piping can be inspected in the future by video or an alternate method approved in writting by the Director, to ensure that the leachate piping is in proper working condition.

47. The Approval Holder shall ensure that, prior to decommissioning any monitoring wells at the Facility, a decommissioning plan and schedule is submitted to the Director and approved in writing by the Department.

48. The Approval Holder shall ensure that the high volume air quality sampling station at the Facility is maintained in proper working condition for measuring total suspended particulate (TSP) matter for use if required in subsequent Approvals to Construct.

LEACHATE AND SURFACE WATER

49. The Approval Holder shall ensure that no leachate (including treated leachate) or water that has come in contact with solid waste, is released from the Facility to the environment or to the Facility's surface water drainage system including the sedimentation ponds.

50. The Approval Holder shall ensure that all leachate and all water at the Facility that has come in contact with solid waste is directed to the Facility's leachate collection system.

51. The Approval Holder shall ensure that the leachate levels in the disposal cells at the Facility are monitored and recorded Monday thru Friday. If precipitation is scheduled on Saturday and/or Sunday, or if the leachate levels in the disposal cells are high, then monitoring on Saturday and Sunday is also required.

52. The Approval Holder shall ensure that any leachate taken from the Facility to the Lancaster Wastewater Treatment Facility is treated to a level that is acceptable to the City of Saint John.

53. The Approval Holder shall ensure that surface water at the Facility that has not been in contact with leachate or solid waste is directed to the sedimentation pond(s). Clean surface water that has a total suspended solids (TSS) value of 25mg/l or less may be diverted from the sedimentation pond(s) if approved in writing by the Department. Water from empty disposal cells that has not been in contact with leachate or solid waste should bypass the leachate collection system and be directed to the surface water drainage system at the Facility.

54. The Approval Holder shall ensure that the drainage ditches at the Facility are maintained to ensure they remain free flowing at all times.

55. The Approval Holder shall ensure that there is a continuous, permeable layer of gravel surrounding the waste at the Facility from the top of the upper side slopes through the top of the berm area to the leachate collection system. Particular care must be exercised at the top of berm area so that the final cover will properly intersect the top of berm.

56. The Approval Holder shall ensure that the leachate collection piping at the Facility is properly maintained to ensure they remain free flowing.

57. **Prior to October 13, 2007**, and at least once every two years thereafter, the Approval Holder shall ensure that the leachate collection piping at the Facility is inspected by video or other method pre-approved in writing by the Director, to ensure the leachate collection system is in proper working condition.

WASTE DISPOSAL

58. The Approval Holder shall ensure that hot loads arriving at the Facility containing ashes or other materials that could potentially cause a fire in the containment cells are temporarily stored in a separate secure location until the risk of fire has been eliminated. The material shall then be disposed of in the containment cells (or a designated area that has been approved in writing by the Director) at the Facility.

59. The Approval Holder shall ensure that any friable asbestos accepted at the Facility for disposal has been wetted, placed in securely tied, double bagged 6 mil polyethylene bags or securely tied single 6 mil polyethylene bag that has been placed in a drum or cardboard box with all seams securely taped and each bag, cardboard box and/or drum is clearly labelled "WASTE ASBESTOS UN2590" or "DECHETS D'AMIANTE UN2590" and there are no punctures in the containers (if they are punctured, the contents must be wetted and repackaged prior to land filling) and they are placed at a dedicated location within the containment cells and are immediately covered with a minimum of 300 mm of clean cover material, or 1000 mm of municipal solid waste. Asbestos should be accepted at the Facility by appointment only, and not disposed during windy conditions.

60. The Approval Holder shall ensure that there is a sufficient quantity of wetting agent on-site when asbestos is being handled and disposed at the Facility.

61. The Approval Holder shall ensure that any unloading of friable asbestos at the Facility is done by the driver (or assistant) and that they or any personnel at the Facility who handle the asbestos are wearing the proper respirators and clothing during the unloading and disposal of the asbestos waste. Appropriate facility staff must supervise the unloading and covering of the asbestos waste.

62. The Approval Holder shall ensure that an "Asbestos Disposal Record" is maintained. The Record shall include, but not necessarily be limited to, the disposal date, volume of asbestos waste, origin of the shipment, contractor delivering the asbestos waste and a detailed plan of the disposal location at the Facility.

HOUSEHOLD HAZARDOUS WASTE

63. The Approval Holder shall ensure that the household hazardous waste depot at the Facility is operated in accordance with the most recent edition of the household hazardous waste Operations Manual that has been approved in writing by the Department.

64. The Approval Holder shall ensure that only household hazardous waste that is generated in New Brunswick is received and stored in the household hazardous waste depot at the Facility. All household hazardous waste received by the Facility is to be stored in the household hazardous waste depot.

65. The Approval Holder shall ensure that all household hazardous waste being stored in the household hazardous waste depot at the Facility is collected by a hazardous waste collection and transportation network. No household hazardous waste is to be stored at the Facility for more than one year.

66. The Approval Holder shall ensure that household hazardous waste at the Facility shall only be received, sorted, stored, and transferred from the Facility.

67. The Approval Holder shall ensure that all household hazardous waste stored in the household hazardous waste depot is:

a) secured in sealed and chemically resistant containers;
b) away from high traffic areas and protected from vehicle impacts;
c) away from electrical panels;
d) in a containment area that has secondary containment adequate to contain 110 % of the total volume contained with in the containment area;
e) in a containment area that is designed to prevent contact between incompatible chemicals; and
f) in a containment area designed to prevent the release or discharge of chemicals to the environment as a result of a spill or other upset condition.

68. **Within 15 days of the end of each month,** the Approval Holder shall submit a monthly report to the Director of the Approvals Branch that includes:

a) a summary report of all household hazardous waste stored in the household hazardous waste depot for the previous month using a form acceptable to the Department, and
b) a summary report of all spills that have occurred in association with the operation of the household hazardous waste program. This summary shall identify the material spilled, the approximate volume spilled, the date of the spill, the containment methods employed, and the steps taken to prevent a future recurrence of the spill. This does not relieve the Approval Holder of compliance with the Emergency Reporting section of this Approval.

CONSTRUCTION AND DEMOLITION DEBRIS

69. The Approval Holder shall ensure that only C&D debris is disposed of in the C&D Site's disposal cell. Any material at the C&D Site that is not located in a designated sorting area is considered disposed.

70. The Approval Holder shall ensure that all loads of C&D debris that are brought to the C&D Site have been properly scrutinized before they are disposed. If previously approved in writing by the Director, a designated sorting area may be used to scrutinize loads of C&D debris brought to the C&D Site.

71. The Approval Holder shall ensure that any unapproved materials brought to the C&D Site, including those in a designated sorting area, are either immediately placed in a temporary storage area and removed daily from the C&D Site and properly disposed. If the unapproved material is hazardous or may cause immediate impacts to the environment then it shall be immediately removed from the C&D Site and properly disposed of.

72. The Approval Holder shall provide on-site supervision when C&D debris is being disposed of at the C&D Site. No disposal at the C&D Site is permitted otherwise.

73. The Approval Holder shall ensure that clean/uncontaminated granular cover material at least 150 mm deep is applied to all exposed C&D debris at the C&D Site at least once per week.

74. The Approval Holder shall ensure that any final cover applied at the C&D Site is sloped in such a manner to ensure positive drainage and prevent standing or pooling of water on the surface.

75. The Approval Holder shall ensure that the area between the property line of the Facility and the C&D Site disposal cell is maintained with a treed or bermed buffer zone.

76. The Approval Holder shall ensure that the C&D Site is designed and operated such that surface water is prevented from entering the C&D debris disposal cell. No C&D debris shall be disposed of in free standing water.

77. The Approval Holder shall ensure that a minimum of 1.5 metres of overburden is maintained between the C&D debris and the bedrock and seasonal high groundwater.

78. The Approval Holder shall ensure that the C&D debris disposed of at the C&D Site is regularly compacted to minimize voids. Compaction with a dozer or equivalent is recommended.

79. The Approval Holder shall ensure that the side slopes of the disposal area of the C&D Site are properly stabilized (using riprap or a vegetative layer as part of the cover system for example) and maintained to limit erosion.

80. The Approval Holder shall ensure that a 50 metre treed or bermed buffer zone is maintained on the southern, northern and western boundaries of the C&D Site. It is understood at this time that the entire approved area for the C&D Site may be clearcut as part of a scientific evaluation of woodlot procedures. Ensure that the clearcut area is not grubbed if the scientific evaluation proceeds.

SITE MANAGEMENT

81. The Approval Holder shall ensure that areas of the containment cells at the Facility that will be inactive for at least three months are covered with a 300 mm intermediate cover layer, graded to promote drainage and minimize erosion and infiltration. Any leachate or any water that has, or could, come in contact with waste in the containment cells must be directed to the leachate collection system.

82. The Approval Holder shall ensure that white goods, scrap metals, electronics, propane tanks/canisters, wood, tires and any other materials being salvaged at the Facility are stored in a secured area separate from the main waste disposal area.

83. The Approval Holder shall ensure that debris and litter at the Facility is controlled. Adequate barriers and/or fencing shall be utilized to confine debris and litter to the immediate disposal area. Any debris or litter found along the access roads or otherwise not contained in the disposal cells shall be routinely collected and disposed in an appropriate location.

84. The Approval Holder shall ensure that unauthorized access to and scavenging at the Facility is controlled.

85. The Approval Holder shall ensure that the visibility buffer that has been established on the south and west borders of the Facility is maintained at a height of at least 6 meters.

86. The Approval Holder shall ensure that a buffer strip of native softwood trees is maintained around the Facility to help reduce visibility of the landfill in accordance with the Environmental Impact Assessment.

EMISSIONS AND DISCHARGES

87. The Approval Holder shall ensure that no leachate is discharged from the Facility to the environment, unless approved in writing by the Director.

To approve the discharge, the Director will require documentation that shows that the leachate can be discharged to meet the Canadian Environmental Quality Guidelines for the Protection of Drinking Water on a monthly (as a minimum) grab sample basis for Mercury, GENERAL CHEMISTRY & TRACE METALS (except for dissolved oxygen), and the Canadian Environmental Quality Guidelines for the Protection of Freshwater Aquatic Life on a yearly weighted average of the contaminate loading for Mercury, GENERAL CHEMISTRY & TRACE METALS (except for dissolved oxygen).

Also, the discharge must have a pH value between 6.5 and 9.0 and a dissolved oxygen value between 5.5mg/l and 9.5mg/l.

88. The Approval Holder shall ensure that any discharge from the Facility, including the sedimentation pond, to a watercourse has a total suspended solids (TSS) value of 25 mg/l or less.

89. The Approval Holder shall ensure that there is no open burning conducted at the Facility, including the C&D Site.

90. The Approval Holder shall ensure that both odour and noise emissions released from the Facility are controlled to prevent impacts to off-site receptors. In the event that odour or noise emission impacts do occur, the Department may require the Approval Holder to develop, submit and implement a Control Plan that mitigates the impacts such that they no longer cause a nuisance to off-site receptors. The Control Plan shall be submitted to the Director for review and approval prior to implementation.

91. The Approval Holder shall ensure that fugitive dust emissions generated from truck traffic or other activities at the Facility are controlled by the use of water. Written permission from the Department must first be obtained if calcium chloride or other chemical compounds are to be used for dust control. The use of a petroleum product for dust control is **prohibited.**

TESTING AND MONITORING

92. The Approval Holder shall ensure that the groundwater monitoring wells at the Facility are sampled at seasonal intervals that provide an accurate representation of groundwater quality at the Facility. The existing network of groundwater monitoring wells at the Facility is as follows:

Well Nest	Shallow Till	Deep Till	Shallow Bedrock	Mid Bedrock	Deep Bedrock
MW17	-	-	MW17-S	-	MW17-D
MW18	-	MW18	-	-	-
MW22	-	-	MW22-S	-	MW22-D
MW31	-	-	MW31-S	MW31-U	MW31-L
MW32	-	-	MW32-U	MW32-L	-
MW33	MW33-S	-	MW33-U	-	-
MW34	MW34-S	-	MW34-U	-	-

MW35	MW35-S1	MW35-S2	MW35-L	-	-
MW36	MW36-S	-	MW36-U	-	MW36-L
MW37	MW37-S	-	-	-	-
MW38	MW38-S	-	MW38-U	MW38-L	-
MW39	MW39-S	-	-	-	-
MW40	MW40-S	-	MW40-U	-	-
MW41	MW41-S	-	MW41-U	MW41-L	-
MW42	MW42-S	-	MW42-U	-	MW42-L
MW43	MW43-S	-	MW43-U	-	-
MW44	MW44-S	-	MW44-U	-	-
MW45	-	-	MW45-U	-	MW45-L
MW46	-	-	MW46-U	-	MW46-L
MW47	MW47-S	-	MW47-U	-	MW47-L
MW48	MW48-S	-	MW48-U	-	MW48-L
MW49	MW49-S	-	MW49-U	MW49-L	-
MW50	MW50-S	-	MW50-U	-	MW50-L
MW51	MW51-S1	MW51-S2	-	-	MW51-D
MW52	MW52-S	-	-	MW52-D	-
MW53	-	-	-	MW53-D	-
MW54	MW54-S	-	MW54-U	-	-

93. The Approval Holder shall ensure that any new groundwater monitoring wells, underdrains, leak detection systems or other sampling points at the Facility are sampled and analyzed as directed by the Department in writing.

94. The Approval Holder shall ensure that all ground and surface water samples required to be obtained for the Facility are obtained by a qualified technician and, unless otherwise approved in writing by the Director, analyzed by a laboratory that is, as a minimum, a member in good standing of the Canadian Association of Environmental Analytical Laboratories (CAEAL) Proficiency Testing Program for Environmental Laboratories.

For the purpose of this Approval, "GENERAL CHEMISTRY" shall include the following analyses:

Ammonia	Alkalinity (as $CaCO_3$)	Calcium
Chemical Oxygen Demand	Chloride	Colour
Copper	Hardness (as $CaCO_3$)	Iron
Nitrate-Nitrite (as N)	Magnesium	Manganese
o-Phosphate (as P)	Phenols	Potassium
r-Silica (as SiO_2)	Sodium	Sulphur (Sulphate & Sulphide)
Total Suspended Solids	Total Organic Carbon	Turbidity
Total Kjeldahl Nitrogen (TKN)	Zinc	

with the associated calculated parameters: Bicarbonate, Carbonate, Hydroxide, Cation Sum, Anion Sum, % difference, Theoretical conductanoe, Saturation pH (5°C) and Langelier Index (5°C).

and "TRACE METALS" shall include the following analyses:

Aluminum	Antimony	Arsenic	Barium
Beryllium	Bismuth	Boron	Cadmium
Calcium	Chromium	Cobalt	Copper
Iron	Lead	Magnesium	Manganese
Mercury (CVAAS)		Molybdenum	Nickel Potassium
Selenium	Silver	Sodium	Strontium
Thallium	Tin	Uranium	Vanadium
Zinc			

and "BTEX/TPH" shall be analysed in accordance with the Atlantic RBCA Tier 1 Guidelines for Laboratories and shall include the following parameters:

Benzene	C6-C10 Hydrocarbons
Toluene	>C10-C21 Hydrocarbons
Ethylbenzene	>C21-<C32 Hydrocarbons
Xylene	Modified TPH (Tier 1)

% Rec. iso-butylbenzene-Volatile
% Rec. iso-butylbenzene-Extractable
% Rec. n-dotriacontane-Extractable

95. The Approval Holder shall ensure that the following field parameters are obtained during each sampling event at the Facility:

Conductivity	Dissolved Oxygen	pH
Temperature	ground water elevations (referenced to geodetic datum)	

96. The Approval Holder shall ensure that prior to obtaining a ground water sample from a monitoring well at the Facility, a minimum of one well volume and a maximum of three well volumes be purged from that monitoring well.

97. The Approval Holder shall ensure that all field testing equipment is calibrated before and after each sampling event conducted at the Facility.

98. The Approval Holder shall ensure that groundwater samples to be submitted for analysis of TRACE METALS are field filtered using 0.45 μm in-line waterra filter or equivalent. All other samples should be unfiltered.

99. The Approval Holder shall ensure that the leachate surge pond, leachate holding pond and disposal cell underdrains (UD2, UD3 and UD4) at the Facility are sampled on at least 5 different occasions each calendar year and analyzed for GENERAL CHEMISTRY, TRACE METALS and BTEX/TPH.

100. The Approval Holder shall ensure that the leachate discharged from the containment cells at the Facility (MH#1) is sampled monthly and analyzed for the following parameters:

Alkalinity	Ammonia	Barium	Boron
BOD_5	Cadmium	COD	Chromium
Calcium	Chloride	Copper	Cyanide
Iron	Magnesium	Manganese	Lead
Mercury	Nitrite-Nitrate	Nickel	Phenols
Sodium	Sulphate	TSS/TDS	Total Organic Carbon (TOC)
TKN	Total Phosphate	Zinc	

and BTEX/TPH

101. The Approval Holder shall ensure that the groundwater monitoring well nests MW17 thru MW50 are sampled during the Spring and Fall seasons of each calendar year for GENERAL CHEMISTRY, TRACE METALS and BTEX/TPH.

102. The Approval Holder shall ensure that the groundwater monitoring well nests MW51 thru MW54 are sampled in the Spring, Summer and Fall months and analyzed for GENERAL CHEMISTRY, TRACE METALS & BTEX/TPH.

103. The Approval Holder shall ensure that the groundwater monitoring wells MW33U, MW34S, MW34U, MW35S2, MW35L, MW38U, MW41S and MW41U are sampled on at least five different occasions between February and November of each year and analyzed for GENERAL CHEMISTRY.

104. The Approval Holder shall ensure that the surface water sampling stations SW1, SW2, SW3, SW4, SW5, SW6 and the sedimentation pond discharge shall be sampled in the Spring and Fall seasons of each year and analyzed for GENERAL CHEMISTRY, TRACE METALS, BTEX/TPH, TKN, BOD_5 and TSS/TDS.

The sedimentation pond discharge shall be sampled near the mid-point of a discharge event.

105. The Approval Holder shall ensure that the results of all sampling and analysis conducted at the Facility are kept on file in both a hardcopy and electronic version.

106. The Approval Holder shall ensure that in September or October of each year the domestic wells chosen for the Domestic Well Monitoring Program are sampled and analyzed for GENERAL CHEMISTRY (except dissolved oxygen).

107. The Approval Holder shall ensure that for each discharge of water from the sedimentation pond at the Facility a sample is obtained at the mid-point of the discharge event and analyzed for Total Suspended Solids (TSS).

REPORTING

108. On or before **May 31, August 31 & November 30 of each calendar year**, the Approval Holder shall ensure that an environmental monitoring report is submitted to the Director. It is understood that the May report will include monitoring from January to March, the August report will include monitoring from April to June and the November report will include monitoring from July to September. The 4th quarter report for monitoring of October to December will be included with the Annual Environmental Report. The reports must be prepared or approved by a person who is a member of the Association of Professional Engineers and Geoscientists of the Province of New Brunswick or is licensed to practise as a professional engineer pursuant to the *Engineering Profession Act* and include, as a minimum, a copy of the analysis, a comparison of the analysis with previous analytical results from the Facility, and commentary indicating whether their is an indication of any immediate, or potential threat or impact to the environment, ground or any surface waters. If an impact has occurred or is suspected the report must include a proposal for further investigation and/or remediation.

109. On or before **February 28 of each year**, the Approval Holder shall ensure that an Annual Environmental Report for the previous calendar year is submitted to the Director. The report must include as a minimum:
- a copy of the Asbestos Disposal Record;
- recommendations for any future monitoring, groundwater well installation or other work at the Facility;
- confirmation that all field testing equipment has been calibrated before and after each sampling event conducted at the Facility;
- confirmation that each groundwater monitoring well has been appropriately purged prior to obtaining a sample;
- dates of all sampling conducted at the Facility;
- dates of each discharge from the sedimentation pond;
- a copy of the analytical results of the sampling and monitoring data obtained from the Facility for the previous calendar year and a review of those analytical results that is completed by a professional engineer or geoscientist licensed with the Association of Professional Engineers and Geoscientists of New Brunswick that includes as a minimum:
  - comparisons with historical results from the Facility;
  - identification of possible analytical anomalies;
  - an evaluation and discussion of the results for the surface water sampling points, groundwater monitoring wells, any cell or leachate pond underdrains/subdrain collection manholes and commentary on whether or not there is evidence of an immediate or potential impact to the environment, ground or surface waters and if so, recommendations for additional investigation, monitoring and remediation to mitigate the impacts;
  - confirmation that the containment cells and leachate pond(s) have been operated such that the minimum breakthrough requirements have been maintained; and
  - trending graphs for each monitoring well at the Facility and the leachate pond leak detection and cell underdrain manholes for the following indicator parameters showing results vs. time:

Alkalinity, Ammonia, Barium, Boron, Calcium, Chloride, Conductivity, Iron, Magnesium, pH, Sodium, Sulphate, and Dissolved Organic Carbon.

Note: Trending graphs should be completed on an annual basis but an alternate schedule may be accepted if approved in writing by the Director.

110. **Prior to May 05, 2007**, the Approval Holder shall ensure that a copy of the Environmental Management Plan, as detailed in condition 33, is submitted to the Department.

111. **Prior to May 05, 2007**, the Approval Holder shall ensure that a Surface Water Management Plan is submitted to the Department. The Plan should detail how all surface water at the Facility (including water from all access roads, capped portions of the cells, and any other areas that are not directed to the sedimentation pond) is managed to ensure that their is no discharge of total suspended solids from the Facility to a watercourse in excess of 25 mg/l. An updated scaled site map that illustrates the surface water management system for the Facility must also be included.

112. In the event the Approval Holder violates any Term or Condition of this Approval the Approval Holder is to immediately report this violation to the Department by calling (506) 453-7945. In the event the violation may cause the health or safety of the general public to be at risk and/or harm to the environment could or has resulted, the Approval Holder shall follow the Emergency Reporting procedures contained in this Approval.

113. In the event the Approval Holder receives a complaint from the public regarding unfavourable environmental impacts associated with the Facility, the Approval Holder is to report this complaint to the Department within one business day of receiving the complaint.

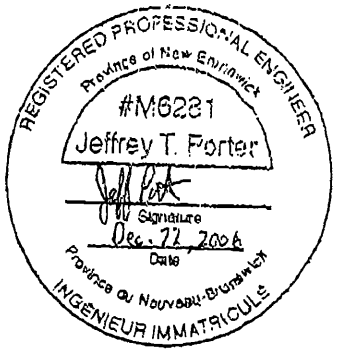
114. **Prior to November 30 of each year,** the Approval Holder shall ensure that each homeowner that has their well sampled as part of the Domestic Well Monitoring Program receives a signed copy of the analysis from the laboratory that did the analysis and a summary sheet that highlights any concerns or potential problems found in the analysis.

115. **Prior to November 30 of each year,** the Approval Holder shall ensure that a Domestic Well Monitoring Program report is submitted to the Department of Health. The report, as a minimum, shall include a signed copy of the analytical results and a summary of each well that has been completed by a qualified person that highlights any concerns or potential problems found.

A letter shall also be sent to the Department prior to November 30 of each year indicating that the sampling and analysis has been completed and that 1) a report has been forwarded to the Department of Health and 2) a signed copy of the analysis and summary of the results by a qualified person has been sent to each homeowner participating in the program.

Prepared by: _____
Jeffrey Porter, P.Eng.
Solid Waste Engineer, Stewardship Branch

Reviewed by: _____
Mark Boldon, Manager
Bioscience and Resource Management Section, Stewardship Branch



SCHEDULE "B"

PEST CONTROL AT NB LANDFILL SITES AND TRANSFER STATIONS

1. **Terms and Conditions for Rodent Control at NB Landfill Sites and Transfer Stations**

1. All personnel directly involved in the mixing, loading and application of the pesticides for the control of rodents at waste disposal facilities must hold a valid Class F or Class L Pesticide Applicator's Certificate, which must be in their immediate possession.

2. Professional companies hired to conduct this work must hold a valid Provincial Operator's License and Pesticide Use Permit.

3. The treatment area must be posted with an approved sign prior to the treatment.

4 The signs are to be conspicuously posted at all ordinary points of access.

5 The applicator shall ensure that the signs are removed after either the completion of treatment or the expiration of their permit.

6 The sign shall be rectangular in shape with a minimum size of 14 cm x 21 cm, rain resistant with type or letters of sufficient size and clarity to be easily read together with a symbol of a cautionary raised hand inside a symbol of a stop sign. The information on the sign must be bilingual and must contain the words "Attention, Pesticide Application", the name of the pesticide, the Pest Control Product registration number, date of application, name of applicator, operator name or logo and telephone number.

7 Industry approved tamper resistant bait stations must be attempted before using other methods of baiting.

8 The Director of Pesticides Control or any member of the Pesticides Management Unit must approve areas that require alternative baiting methods. They can be contacted at (506) 453-7945.

November 8, 2005

APPENDIX E

CRAIG HYDROGEOLOGIC OPINION (2007)

CRAIG HYDROGEOLOGIC INC.

Groundwater and Soil Contamination
Groundwater Protection
Environmental Assessment
Groundwater Modelling
Resource Development

May 28, 2007.

Crane Mountain Enhancement Inc.

Review of Gemtec Reports to Fundy Region Solid Waste Commission

Crane Mountain Enhancement Inc. retained ADI to review the operation of the Crane Mountain landfill and prepare a report with recommendations (ADI, 2005). As a result of this the Fundy Region Solid Waste Commission retained Gemtec Ltd. to review the ADI report and provide recommendations in response. Gemtec Ltd. has provided the following reports:

1. Design and Operations Plan Fundy Region Solid Waste Commission Saint John, New Brunswick, October 2006
2. Storm Water Management System Report, November 2006;
3. Update of Bedrock Hydrogeology Crane Mountain Landfill Saint John, New Brunswick, November 2006
4. Crane Mountain Landfill Management of Monitoring Data, December 2006

Crane Mountain Enhancement Inc. retained Craig Hydrogeologic Inc. to review the above listed reports and to provide a report with recommendations. This letter report represents the results of that review. In the following sections each of the reports is reviewed individually. Where the results of the Gemtec reports are summarized or paraphrased these portions appear in italics. My comments appear in standard font.

Craig HydroGeoLogic Inc.
140 Meadow Cove Road. Dipper Harbour, NB E5J 2S9
Telephone 506-**659-3064** Fax 506-**659-9002** Email **craig@nbnet.nb.ca**

Design and Operations Plan Fundy Region Solid Waste Commission Saint John, New Brunswick, October 2006

No comment.

Storm Water Management System Report, November 2006

This report outlines the site controls which are in place in order to prevent excess turbidity in surface water runoff. The limit specified in the Approval to Operate is 25 mg/L total suspended solids. Based on the data provided in Table 1 in the report the Commission has been able to consistently achieve this level with only one exception. The single exception was due to a shortage of treatment materials and the recommendation included with this report is intended to prevent this from occurring again.

In summary the Storm Water Management System appears to be functioning adequately and the recommended monitoring should provide sufficient information on future operations.

Update of Bedrock Hydrogeology Crane Mountain Landfill Saint John, New Brunswick, November 2006

The ADI report made the following specific recommendations relating to the hydrogeological characterization of the Crane Mountain Landfill.

1. "Additional boreholes and monitoring wells have been installed as part of the groundwater monitoring system. It is recommended that the collective database be reviewed and documented in the context of an updated hydrogeological characterization report for the site. Reviews should include considerations of such factors as hydraulic conductivity; fracture distribution and frequency; flow gradients; directions and velocities; ground water chemistry; and consideration of site hydrologic setting in the context of shallow intermediate and deeper flow systems".
2. "Further characterization of the hydrogeological system be made as it relates to flow pathways within the bedrock and geochemical evolution of groundwater in the context of water supply usage by downgradient domestic wells."
3. "Install deeper bedrock monitoring wells and update hydrogeologic characterization."

In terms of these three recommendations relating to hydrogeological characterization of the site, the following comments are provided.

The site bedrock hydrogeology was discussed and a map produced showing the distribution of the bedrock. The hydraulic conductivities measured at the site were reviewed and an updated map

was produced showing groundwater gradients and flow direction. Based on this information groundwater velocities were estimated.

The fracture distribution and frequency was discussed, based on monitoring well log records; however, based on the monitoring well logs a high degree of sub-vertical fracturing is predicted. This would appear to conflict somewhat with the general observation of relatively low to medium well yields in these bedrock units.

Vertical flow directions were assessed. The presence of shallow, intermediate and deeper flow systems was mentioned very briefly on page 9 where it was observed that the shallow and deeper well water table elevations produced similar flow direction and gradients.

The private well logs available for this area were reviewed and summarized.

The groundwater chemistry was not reviewed and, as a result, no evaluation of geochemical evolution of groundwater in the context of the downgradient, private water well users was possible. The review of the groundwater chemistry and evaluation of geochemical evolution of groundwater relating to downgradient private well water users was recommended by ADI and I agree with this recommendation. Such a review would provide insight into both natural and anthropogenic changes in groundwater chemistry in terms of the downgradient water users.

Deeper bedrock monitoring wells were not installed; the report recommended using the existing drilled onsite water supply wells.

Report Conclusions and Recommendations

In general terms the report concluded that the updated information does not significantly alter the understanding of the site hydrogeology from that portrayed in the original site assessment report. I agree with this conclusion; however, the review provides a more detailed understanding of site hydrogeological conditions. In any event periodic reviews are necessary to check for potential changes over time of operation.

The report recommended that more detailed bedrock mapping be conducted in the area down gradient from the landfill. The purpose of this mapping would be determining fracture orientation, trace length, aperture and spacing. It is hoped that this would aid in better assessing groundwater flow direction and velocity.

The report further recommended that the deep water supply wells at the landfill be used to monitor the deep bedrock groundwater flow system. The deep water supply wells appear to be located such that monitoring of the deep groundwater with these wells may be possible given the current layout of the waste cells. The chemistry data from these wells should be reviewed to determine if this is acceptable or feasible. The locations of these supply wells are shown in Figure 4 in the report

The report also recommended that groundwater levels should be obtained from all monitoring wells over a short discrete time period. Water levels in the deep monitoring wells (i.e. supply wells) *should be recorded continuously using electronic data loggers.* The water levels in all the monitoring wells should be measured over as short a period as possible in order to collect data that is representative of site conditions during a given time interval. I would assume that the recommendation that the water levels in the deep supply wells be monitored with continuous data loggers is due to the fact that the water levels in these wells will fluctuate rapidly with use. Such fluctuation may impact the water levels in adjacent monitoring wells. Therefore such monitoring is necessary, at least until the impact of the water level fluctuations can be evaluated.

Crane Mountain Landfill Management of Monitoring Data, December 2006

The ADI report recommended that the monitoring program could be enhanced by greater review and interpretation of the groundwater monitoring data. It was further recommended that a group of trigger parameters could be developed with trigger or action levels for each parameter.

In response to the first point GEMTEC customized a web based Geographic Information System (GIS) to manage the monitoring data. The use of GIS systems to manage monitoring data represents a state-of-the-art application. While I have not seen or used this specific GIS database the use of these normally makes monitoring data more accessible and understandable to both professionals and laypeople. The report does not mention who would have access to the GIS system.

In response to the second point the report outlines the development of trigger parameters for the three monitoring systems (monitoring wells, underdrains, and the domestic wells). The criteria used to identify suitable leachate indicator parameters where as follows

1. *Parameters that are typically found at high concentrations in leachate.*
2. *Mobile ions in groundwater (allowing for early detection).*
3. *Parameters which have been measured in the landfill leachate and the monitoring systems since program initiation in 1997.*

Based on the above the following parameters were selected:

pH – subject to geochemical evolution

Alkalinity - subject to geochemical evolution

Ammonia – reactant in geochemical reactions, form related to oxygen concentration. For locations removed from source may have to measure other forms such as nitrate-nitrite.

Chloride – usually conservative and mobile, a very good indicator parameter.

Iron – reactant in geochemical reactions, form related to oxygen concentration. Mobility related to oxygen concentrations

Manganese – reactant in geochemical reactions, form related to oxygen concentration. Mobility related to oxygen concentrations

Sulfate – reactant in geochemical reactions, form related to oxygen concentration

Total Organic Carbon – may decompose or adsorb, may not be strongly mobile

Conductivity - usually conservative and mobile, a good indicator parameter.

Irrespective of the limitations of the above parameters they represent a reasonable list as no parameter is perfect in terms of mobility and persistence in groundwater.

Trigger Concentrations

The approach used in the report to estimate trigger concentrations was to derive descriptive statistics for each of the three monitoring systems. Based on the descriptive statistics three methods of determining trigger concentrations are proposed. These are as follows:

1. *For normally distributed data the trigger concentration is calculated as the mean plus four times the standard deviation (mean + (4xSD).*
2. *In cases where most of the data for a parameter was below the laboratory reporting limit a single threshold value was calculated which was equal to two times the laboratory reporting limit.*
3. *For highly variable data, the trigger concentration was calculated using the 97. 5th percentile value (1.3x97.5th percentile value).*

Underdrain Monitoring System

The proposed trigger concentrations for the underdrains monitoring system are provided in Table 2. Using the above described system most of the trigger concentrations appear reasonable. The proposed trigger concentration for sulphate; however, which is calculated using the mean + (4xSD), is 56 mg/L, which appears to be too high when compared to the mean concentration of sulphate in the leachate (52.8 mg/L).

Groundwater Monitoring Wells Monitoring System

The proposed trigger concentrations for the groundwater monitoring wells monitoring system are provided in Table 3 in the report. Due to the relatively high Coefficient of Variation observed in

this data set method #1 listed above cannot be used. Where a trigger concentration is determined method #2 and #3 are used. Based on a comparison with the observed concentrations in the leachate, the trigger concentrations proposed in Table 3 appear reasonable.

Domestic Wells Monitoring System

The proposed methods of calculating the proposed trigger concentrations for the domestic wells monitoring system are provided in Section 4.4 and the data is provided in Table 4 in the report. The report outlines the proposed method of using method #1 for determining trigger criteria for each individual well. The example of a calculated trigger concentration for chloride is provided which produces a trigger concentration of 539 mg/L, which greatly exceeds the Canadian Drinking Water Quality Guideline of 250 mg/L. If the trigger concentration for conductivity is calculated using method #1 then the result is 1,835 umhos, which again, is quite a high number.

Discussion of Trigger Concentrations

For method #1, which is the mean + (4xSD), it is stated in the report that this method will place the trigger outside the normal population and will avoid a lot of unnecessary triggers. I agree that it will avoid a lot of triggers; however, it appears that the numbers derived using this method are too high, particularly given the limited number of samples available for the Domestic Well Monitoring System and the nature of typical well chemistry data, that is, that the Coefficient of Variation can be relatively high in a small sample population. It is concluded, based on the information provided, that Method #3 should be substituted for Method #1 for all samples in each of the three monitoring system.

As is mentioned in the report, trend analysis will provide valuable information relating to potential breaches in the containment system prior to any trigger concentrations being exceeded. Due to the potential expense of any remedial work in the event of a breach or failure, particularly in the underdrain system, trend analysis should be performed on the indicator parameters as part of the yearly reporting.

Implementation

The report recommends that the environmental management plan for the landfill be revised to include a defined approach to evaluating and dealing with a trigger to sample results from a domestic well. The report recommends that the Landfill Commission's first response to a trigger should be a thorough review of the on-site monitoring data in order to determine any environmental issues at the landfill. If no problems are evident at the landfill then it would become the responsibility of the homeowner to further investigate the cause of the trigger.

I understand the recommended approach for the Landfill Commission; however, most homeowners will find it very difficult to investigate the cause of the statistical hydrogeologic

trigger. If possible, some method of adjudication might help the situation. In addition, the contention that if no environmental issues or problems are evident at the landfill then any impacts or triggers are not the responsibility of the Landfill Commission is not necessarily true 100% of the time. No monitoring program is infallible. In each case, a through review of all factors, not just the landfill monitoring data, should be conducted.

The report recommends that the confidentiality of the domestic well data needs to be addressed. An option that is brought forward is to have the homeowners signed a waiver outlining how the current information is stored, how it is used, and who has access to the information. I wholeheartedly agree with this recommendation. Further to this it would be prudent to review which private wells are currently being tested and for what parameters. This can be done in light of the updated hydrogeological information provided in these reports. The goal of such a review would be to focus the private well monitoring on locations chosen for technical reasons.

Conclusions and Recommendations

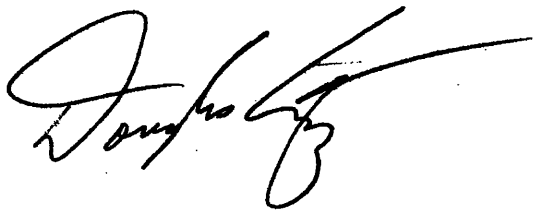
In the report the following conclusions and recommendations were presented:

1. *Trigger parameters where selected based on: 1) elements that are typically found at high concentrations in leachate; 2) mobility; and, 3) historical baseline information. Selected trigger parameters include: pH, alkalinity, ammonia, chloride, conductivity, iron, manganese, sulfate and total organic carbon.* The selection of trigger parameters is based on a sound approach and has provided an appropriate list.
2. *Total organic carbon is a recommended trigger parameter but it is currently not measured at all monitoring locations and should be added to the standard analytical package.* Yes.
3. *A statistical approach was used to develop trigger concentrations. Trigger concentrations were calculated for the underdrain system, the monitoring wells, and domestic wells as follows: 1). Mean conc. + (4xStandard Deviation), for normally distributed data; 2). Threshold values for parameters not normally found in ground water, such as ammonia; and, 3). 97.5th percentile x 1.3, for variable data.* Based on the information presented it appears that the use of Method 1 yields trigger concentrations that are too high and too far outside distribution of the data. I would recommend eliminating the use of Method 1 and substituting the use of Method 3. The validity of such derived trigger concentrations should be reviewed for appropriateness after a period of use and the methods of determination adjusted if necessary.
4. *Given the importance of the underdrain system as a first line of defense in detecting potential impacts from the landfill, GEMTEC recommends that an automatic monitoring system should be installed on the underdrain sampling point.* The use of an automatic monitoring system for selected parameters can provide real-time data. It should not: however, replace the collection of water samples. It would be my interpretation that for the Commission to comply with the terms of the Approval to Operate that the required monitoring samples would have to be analyzed in a Canadian Association of Environmental Laboratories (CAEL) certified laboratory.

5. *Trigger levels should be used to supplement existing data analysis practices, such as trend analysis.* I strongly support this conclusion and would like to emphasize the importance of ongoing trend analysis of the data in providing an understanding of the functioning of the environmental protection systems at the landfill.
6. *The Environmental Management Plan should be revised to outline how the Commission will determine the specific steps and responsibilities whether or not a domestic well has been impacted by the landfill in the event that a sample result exceeds the established trigger values.* To produce a standard protocol for response to events that we know will occur is a common sense and prudent approach.
7. *The Commission should review its responsibilities with respect to maintaining confidential homeowner's information in the event that further investigation into a domestic well issue is triggered.* The confidentiality of the domestic well analytical results appears to be an ongoing problem. Currently the Commissions options are very limited due to the way the program was initially set up. Recognition of the confidentiality problem and the limitations that this poses both on the Commission and Crane Mountain Enhancement Committee may provide an opportunity to revise this portion of the monitoring system. I would recommend that the entire private well monitoring program be revised at this time, based on technical requirements, and the need to provide coherent publicly available and understandable data.

Should you have any question or if we can be of further service please do not hesitate to contact me.

Yours truly,



Douglas Craig, M.Sc., P.Geo.
Consulting Hydrogeologist

APPENDIX F

DOMESTIC WELL MONITORING PROGRAM
RELATED CORRESPONDENCE

EMP Monitoring Plan, November 1997

6.0 THE ENVIRONMENTAL MONITORING PLAN

The Commission is committed to carrying out environmental monitoring as part of the overall environmental management plan. That is, monitoring will be conducted by measuring quantitatively and qualitatively components in both the ecosphere and socio-economic sphere before and during construction and operation of the landfill. Environmental monitoring will be conducted as part of the Commission's overall commitment to environmental protection and as committed to in the EIA.

Monitoring will permit impact predictions in the EIA to be verified, it will also allow mitigative measures to be implemented, if necessary, in a timely fashion and will facilitate the minimization of environmental impacts. The monitoring program is designed to:

- provide for the collection of meaningful data that will allow mitigative measures to be implemented as required,
- fulfill all monitoring commitments made in the EIA,
- fulfill all monitoring required by the COA to Operate, and
- be flexible in scope and content such that the program can be easily adjusted to reflect real world conditions and ongoing monitoring.

The monitoring program described herein is to be carried out in conjunction with the routine inspection activities mandated in the Operations Manual.

As part of the program, air quality, groundwater, surface water, leachate, noise, waste, visual buffers, assessment and land values, collection vehicles, and traffic will be monitored during site operations. Groundwater and surface water monitoring will begin before construction and operational activities in order that meaningful baseline data is compiled. During the construction phase, groundwater and surface water, as well as dust, noise and traffic will be monitored.

The Environmental Coordinator, with assistance from the General Manager, as required, will have overall responsibility for ensuring the environmental monitoring

plan is implemented, the required sampling stations established and an Environmental Monitoring Log is maintained.

The Environmental Monitoring Log will be divided into various sections as outlined below, in which the various components of the monitoring program will be recorded. A log will be kept for each calendar year and will be summarized at year end by the Environmental Coordinator. A summary of the Monitoring Log will be included in the Annual Report and environmental incidents described within will be reported to the Commission by the General Manger as required.

Monitoring Log Components:

- Air Quality
- Leachate
- Groundwater - On-site
- Groundwater - Off-site
- Surface Water
- Indiscriminate Dumping
- Waste Inspection
- Aesthetics
- Noise
- Property Assessments
- Collection Vehicles
- Traffic

6.1 Air Quality

6.1.1 Monitoring Requirement

Non Methanagenic Compounds

Air quality monitoring will be conducted to confirm calculated emission rates from the landfill and off property concentrations for total suspended particulate (TSP). Specifically, air quality at the gas vent in the cell and at a receptor 100 metres outside the peripheral road near the landfill is to be monitored for the parameters, frequency and duration identified in Table 6-1. If air quality does

not meet the levels shown in Table 6-1, then mitigative measures and continued sampling will be undertaken.

Landfill Gases

Monitoring of methane concentrations in soil above the water table will be conducted annually. In addition, combustible gas concentration measurements will be taken at leachate sumps, and associated storage infrastructure. If concentrations are above 25% of the lower explosive limit, a more detailed monitoring will be undertaken and mitigative measures implemented. Monitoring will begin once the site has been in operation for five years.

6.1.2 Monitoring Responsibility

The Environmental Coordinator is responsible for engaging qualified air quality monitoring personnel, maintaining monitoring data, compiling data for the annual report and reporting monitoring results to the Commission.

TABLE 6-1: AIR QUALITY MONITORING REQUIREMENTS NON-METHANAGENIC COMPOUNDS

Location	Gas Vent in Cell	Station AQ - 1*
Parameter	carbon tetrachloride, chloroform, 1,2-dichloroethene, ethylene dibromide, ethylene dichloride, methylene chloride, perchloroethene, trichloroethene, vinyl chloride, 1,1,1,-trichloroethane, viylidene chloride, total non methane organic compounds	total suspended particulate
Initiation	after first gas vent is installed	November 1997
Frequency	quarterly	quarterly
Duration	two years minimum	two years minimum
Requirement	trace amounts observed	annual average < 70 ug/m^3, 24 h max < 120 ug/m^3

*Station AQ -1 is located 100 metres away from the peripheral road near the landfill in the direction of the prevailing wind.

6.1.3 Remedial Measures

If TSP levels are higher than the regulated maximums the following remedial measures will be implemented during prolonged dry and windy periods:

- treating the unpaved roads with water, calcium chloride and/or chemical stabilizers
- flushing and/or sweeping of paved roadways,
- treating areas where heavy equipment is operating with water or other chemical stabilizers,
- spraying or wetting cover material prior to loading or unloading operations.

If methane concentrations are above acceptable limits, vents will be inspected and gas dissipated as required.

6.2 Leachate

6.2.1 Monitoring Requirements

Leachate collected from the waste disposal cell(s) shall be sampled *weekly* and analyzed for BOD, referred to as Package A on the monitoring schedule. In addition, leachate collected from the waste disposal cell(s) shall be sampled *monthly*, and analyzed for the parameters listed in Table 6-2 below, also referred to as Package B.

TABLE 6-2: LEACHATE ANALYSIS PARAMETERS - PACKAGE B

Ammonia	Iron	Nickel
Chloride	Chromium	Nitrite - Nitrate
COD	Copper	TKN
Conductivity (Field Parameter)	TOC	Total Phosphate
pH	Manganese	Zinc

6.2.2 Monitoring Responsibility

The Environmental Coordinator or his designate is responsible for engaging qualified sampling personnel, maintaining monitoring data, reporting monitoring results to the Commission on a monthly basis, and compiling data for the annual report. He is also responsible for forwarding monitoring data to NBDOE quarterly as outlined in the COA - Operate. The General Manager is also responsible for ensuring mitigative measures are undertaken as required.

6.2.3 Remedial Measures

Remedial measures will be determined when the leachate treatment system design is finalized.

6.3 Groundwater - Monitoring Wells

6.3.1 Monitoring Requirements

The locations of the groundwater monitoring sites are shown on Figure 6-1. Groundwater monitoring nests MW31, MW32, MW33, MW34, MW35, MW36, MW37, MW38, MW39, MW40, MW41, MW42, MW43, MW44, MW45, MW46, MW47, MW48, MW49 and MW50 will be sampled and analyzed for the parameters identified in Table 6-3, and identified on the monitoring schedule as Package C.

TABLE 6-3: GROUNDWATER MONITORING - PACKAGE C

Alkalinity	Conductivity (Field Parameter)	Selenium
Aluminum	Copper	Silver
Ammonia	Dissolved Oxygen (Field Parameter)	Sodium
Antimony	Hardness	Strontium
Arsenic	Iron	Sulfate
Barium	Lead	TDS
Beryllium	Lignin & Tannin	Temperature (Field Parameter)
Boron	Manganese	Thallium
BOD_5	Magnesium	Tin
Cadmium	Mercury	TKN
Calcium	Molybdenum	Total Organic Carbon
Chloride	Nickel	TPH/BTEX
Chromium	Nitrate - Nitrite	TSS
Cobalt	pH	Uranium
COD	Potassium	Vanadium
Coliform (Total and Faecal)	Phosphate	Zinc

Sampling will take place prior to acceptance of waste, then in the spring and summer of the following year, as per the monitoring schedule.

In addition to the parameters listed in Table 6-3, samples from monitoring nest MW31, MW32, MW34, MW38 and MW43 will be analyzed for EPA 624 Volatile Organic Compounds. Package C in addition to EPA 624 volatile organics is referred to as Package D on the monitoring schedule.

Groundwater samples from monitoring well nests MW33, MW34 MW35, MW38 and MW41 from the underdrains of both the cell and the sedimentation pond shall be sampled once per month as presented on the monitoring schedule and analyzed for the parameters identified in Table 6-4.

TABLE 6-4: GROUNDWATER MONITORING - PACKAGE E

Ammonia Chloride Dissolved Oxygen Conductivity	pH Nitrate - Nitrite Manganese	Iron TKN Total Organic Carbon

Every six months an additional set of samples will be obtained from these wells (MW33 - MW41) following prolonged pumping and analyzed for the parameters identified in Table 6-4.

Groundwater elevations shall be recorded for each sampling event and rainfall events shall be reported for the seven days prior to the sampling event.

6.3.2 Monitoring Responsibility

The Environmental Coordinator or his designate is responsible for engaging qualified groundwater sampling personnel, maintaining monitoring data, compiling data for the annual report and reporting monitoring results to the Commission on a monthly basis. He is also responsible for reporting the results to NBDOE quarterly. The General Manager is also responsible for ensuring mitigative measures are undertaken as required.

6.3.3 Remedial Measures

From an analysis of the background water chemistry data, "trigger" concentrations will be established for key parameters. If these trigger concentrations are exceeded, those wells will be sampled and tested on a more frequent basis in accordance with the intent of ASTM PS 64-96. Should it become clear that these exceedances reflect a true change in water quality attributed to landfill presence, not statistical or seasonal variability, remedial measures will be implemented.

One of more of the following remedial measures will be considered:

- plume delineation and source identification by the construction and sampling of additional more closely spaced monitoring wells
- containment and remediation of affected groundwater by pump and treat
- containment of affected groundwater by slurry cut-off or reaction walls in-situ groundwater remediation by biological and/or chemical means

6.4 Groundwater - Domestic Wells

6.4.1 Monitoring Requirements

Two comprehensive rounds of domestic well groundwater sampling have been completed prior to placing waste at the site. Future samples will be collected on a semi-annual basis, as specified in the monitoring schedule, and analyzed for the parameters in Table 6-5. The third round of sampling will take place in April, 1998.

Selected locations may be targeted for more comprehensive chemical analysis.

TABLE 6-5: DOMESTIC WELL SAMPLING - PACKAGE F

Ammonia Chloride Conductivity (Field Parameter) Iron	Manganese Nitrate - Nitrite pH (Field)	TKN Total Organic Carbon Coliform (Total and Faecal)

6.4.2 Monitoring Responsibility

The Environmental Coordinator or his designate is responsible for engaging qualified groundwater sampling personnel, maintaining monitoring data, reporting monitoring results to the Commission on a semi-annual basis and compiling data for the annual report. He is also responsible for reporting the monitoring results to NBDOE. The General Manager is also responsible for ensuring mitigative measures are undertaken as required.

6.4.3 Remedial Measures

From an analysis of the background water chemistry data, "trigger" concentrations will be established for key parameters. If these trigger concentrations are exceeded, those wells will be sampled and tested on a more frequent basis in accordance with the intent of ASTM PS 64-96. Should it become clear that these exceedances reflect a true change in water quality attributed to landfill presence, not statistical or seasonal variability, remedial measures will be implemented. The Department of Environment and Health will be advised. Supplementary measures by the property owner and/or the Commission may be required to address the situation.

Should water quality deteriorate and become non potable as a direct result of the landfill operation, then one or more of the following remedial measures will be implemented so as to ensure that property owners have an acceptable water supply:

- replacement of the domestic supply or supplies with an alternative supply
- provision of in-line treatment using filtering processes

6.5 Surface Water

6.5.1 Monitoring Requirement

Surface water monitoring will be conducted at three locations in the unnamed drainage basin, at one location in Henderson Brook and at two locations in Mill Creek, refer to Figure 6-1. Surface water samples will be collected quarterly as outlined on the monitoring schedule and analyzed for the parameters identified in Table 6-7.

TABLE 6-7: SURFACE WATER MONITORING - (PACKAGE G).

Ammonia Chloride Conductivity (Field Parameter Iron	Manganese Nitrite - Nitrate pH	TKN Total Organic Carbon TSS

In addition, surface water that discharges from the sedimentation pond shall be sampled monthly and analyzed for the parameters in Table 6-7.

6.5.2 Monitoring Responsibility

The Environmental Coordinator or his designate is responsible for engaging qualified surface water sampling personnel, maintaining monitoring data, reporting monitoring results to the Commission on a quarterly basis and compiling data for the annual report and reporting monitoring results to the Commission on a quarterly basis. He is also responsible for reporting results to NBDOE. The General Manager is also responsible for ensuring mitigative measures are undertaken as required.

6.5.3 Remedial Measures

The discharge from the sedimentation pond shall have total suspended solids of less than 25 mg/L. If surface water contamination originating from the landfill is detected, one or more of the following remedial measures will be implemented:

- contamination source identification and restoration

CMEI Jan 2008 Domestic Well Monitoring Proposal to FRSWC

Monitoring Program, Crane Mountain Landfill

The Domestic Well Monitoring Program was established prior to the opening of the Crane Mountain Landfill in 1997 and was clearly intended to be a part of the overall monitoring program of the landfill site. Extensive communication took place prior to the opening of the landfill, primarily in the form of reports issued between the NB Department of the Environment and GEMTEC, which acted on behalf of the Waste Commission. The reason for establishing the Domestic Well Monitoring Program was stated in numerous documents: "The site is located in a groundwater recharge area which is up-gradient of private wells;" "Groundwater flow is eastward, leading to the requirement to monitor down-gradient domestic wells." Because protection of groundwater and domestic wells is the purpose of the monitoring program as a whole, domestic well monitoring is not peripheral but central to determining whether or not safeguards at the landfill are functioning properly. As evidenced in the Environmental Monitoring Plan (section 6.4, pp 6-9, 6-10), the Groundwater Monitoring Program for the Crane Mountain Landfill site consists of both Monitoring Wells and Domestic Wells. The May, 1998 letter from the Waste Commission to those whose wells were part of the program reads as follows: "One of the **conditions that was set for the operation of the Crane Mountain Landfill site** by the Minister of the Environment is that the Fundy Commission would conduct groundwater monitoring programs. Under this condition, the more than 50 monitoring wells at the landfill and approximately 60 domestic wells in the River Road area must be tested periodically."

1. The *Independent External Review of the Crane Mountain Landfill* (2005 ADI) recommends that **Crane Mountain Enhancement, Inc. continue to provide ongoing review of the landfill's monitoring programs to help ensure that adequate analysis is conducted of the monitoring data."** (80) See 12.2, Summary of Review, pp. 71-77 for frequent use of the phrase "in the context of large numbers of domestic supply wells located down-gradient of site."

2. The ADI Review makes the following **recommendations about Domestic Well Testing** at the landfill (#4, pp18-23; #11, pp. 64-70; #12, pp. 71, 72, 74, 75, 76, 79):

a. **Update and reevaluate the location** of the wells currently being tested(65,79)
b. **Reevaluate the number** of wells being tested. "Consideration should be given to increasing the number of wells in the monitoring program to provide a more representative indication of the quality of the domestic groundwater supplies (65)."
c. **Increase frequency of testing** to document seasonal conditions: conduct "bi-annual sampling events as a minimum to assess the effect of the groundwater recharge cycle on water quality." (66,79)
d. **Define "trigger" parameters** for domestic well monitoring samples (22).
e. **Establish a database** for domestic well data that includes analysis for data trends. Ensure quality of data put into database (69).

f. **Complete** a **detailed interpretation of the domestic well data**. Monitoring data should be reviewed "by a qualified individual (e.g. hydrogeologist or environmental engineer with hydrogeological training)."(68,69)
g. **Develop a clearer protocol** for the implementation of an emergency response. "Suggested remedial approaches are vague and lacking in detail." (22)
h. **Conduct a review of groundwater chemistry:** "further characterization of the hydrogeological system…as it relates to flow pathways within the bedrock and geochemical evolution of groundwater in the context of water supply usage by down-gradient domestic wells (19)."

3. GEMTEC was engaged by the Commission to respond to the ADI Review, and did so in four reports (Oct., Nov., Dec. 2006). CMEI engaged Douglas Craig, of Craig HydroGeoLogic to review three of GEMTEC's reports, in particular *Management of Monitoring Data* (Dec.2006). Craig's Review was the focus of several meetings during the summer and fall of 2007 between the Monitoring Committee and General Manager Marc MacLeod.

4. Meeting July 31, 2007 at the Landfill: General Manager Marc MacLeod and Monitoring Committee, CMEI, with its consultants Sid Lodhi and Douglas Craig.

a. Developing "trigger" parameters:
    i. Craig explained how Method #1 in GEMTEC's report yields concentrations that are too high and recommended using Method #3. (See p. 9, GEMTEC, *Management of Monitoring Data*; See pp. 5,6, Craig, *Review of GEMTEC Reports to Fundy Region Solid Waste Commission*)
    ii. Craig stated that from the perspective of **management**, it is important to **identify problems before they get out of control** because remediation is expensive. If trigger parameters are too high, true problem events are blocked out, and therefore cannot be appropriately addressed.
b. Protocol if problem found in domestic well:
    i. GEMTEC recommended changing the Environmental Management Plan to read that if no problems are seen in monitoring wells or underdrains at the landfill, it is up to the well owner to investigate the problem.
    ii. Craig pointed out that the average well owner has no way to approach problem situations. He recommended that the Commission resample, verify, evaluate, and further investigate the problem. (He cited similar protocol used by insurance companies)
    iii. Craig maintained that it is important to have a **clear protocol** for responding to triggers in domestic wells. (See also ADI, "g" above).
c. A database has been developed by GEMTEC, and General Manager Marc MacLeod plans to recommend that the Commission purchase it. (Note: Commission has subsequently voted to purchase the database.)
    i. Question: Who will be responsible for analyzing the data?
    ii. Question: Who will have access to the database?

d. Problem of access to data from Domestic Wells.
   i. Commission claims to have no access to data, maintaining that it is protected by privacy legislation.
   ii. At present, data from well tests is sent to the individual well owner and to Dept. of Health and Wellness. Craig reported that the Dept. of Health and Wellness has no hydrogeologists on staff. Thus, the data is only looked at relative to Canadian Drinking Water Guidelines. It would be desirable to have the data screened by an independent qualified person to ensure that any effluent from the landfill is not having a detrimental effect on the local groundwater and on the domestic wells which draw their water from it..

5. Douglas Craig's *Review of GEMTEC Reports to Fundy Region Solid Waste Commission* (May, 2007) includes the following recommendations:

a. **Ongoing trend analysis** of all the monitoring systems at the landfill; cites potential expense of remedial work in the event of a breach or failure.
b. **Review** of **groundwater chemistry** (as recommended by ADI)
c. Use of **Method 3** instead of **Method 1** for determining trigger parameters (See 5a above)
d. **Establishment of detailed protocol** for response to problem situations (See 5b above)
e. **Review of the domestic well monitoring program at this time, based on technical requirements (location and number of wells tested, frequency of testing, parameters tested, trigger parameters which indicate when action is required) and the need to provide coherent publicly available and understandable data.**

The CMEI Monitoring Committee supports the recommendations made by ADI in their *Independent External Review of the Crane Mountain Landfill* (November 2005) and **Douglas Craig of Craig HydroGeoLogic in his** *Review of GEMTEC Reports to Fundy Region Solid Waste* Commission (May, 2007), and including **his remarks at the July 31st meeting.**

The CMEI Monitoring Committee recommends that the Domestic Well Testing Program be revised and enhanced in the ways recommended by ADI and Douglas Craig.

Roberta W. Lee

Roger McKenzie

Department of Health E-mail Inquiry

Role of the Department of Health in the Domestic Well Monitoring Program
Crane Mountain Landfill

You have inquired as to the role of the Department of Health in relation to the well monitoring program that is carried out for wells that could be impacted by the Crane Mountain Landfill.

Gemtec Consulting Engineers sends our department a copy of the results for the samples that are collected each year. These results are reviewed and compared to the Guidelines for Canadian Drinking Water Quality. If a sample shows an exceedence for a parameter that could adversely affect the health of users of that particular supply, the home owner is notified and the health implications of the sample result and possible treatment options are discussed.

The Dept. of Health has not been comparing results from one year to previous years results to determine if a trend is developing.

I am not aware if the landfill operator receives these results but it would be helpful if the could develop some method of entering the results into a data base that would facilitate the spotting of trends in water quality.

If you have any further questions regarding this matter, please do not hesitate to call me.

Aubrey Gaudet
Public Health inspector
658-2252