Belle Park Landfill

Assessment of Long-Term Management Alternatives

Final Draft Report

Prepared for:

CITY OF KINGSTON

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CH2MHILL

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Executive Summary

Cataraqui Park (better known as Belle Park Landfill Site) is a landfilled marshland that extends into the Kingston Inner Harbour from the west bank of the Great Cataraqui River to Belle Island. The site is approximately 44 hectares (108 acres) in size.

Citizens, businesses and institutions in the City of Kingston (City) used this site as a municipal landfill from 1952 to 1974. After the landfill was closed in accordance with Ministry of the Environment (MOE) requirements, the City developed the site into a multiple-use recreational facility that includes a nine-hole golf course, tennis courts, and walking paths.

In 1997, the City took measures to assess the risks at the site and to address leachate seepage into the Cataraqui River. Seep management measures have been implemented and expanded since 1997. The current leachate collection system is operating effectively to address leachate seepage into the river; however, this system requires extensive operation and maintenance effort. The City commissioned this study to assess alternative long term leachate seepage management strategies. This study identifies and evaluates alternative long-term management strategies in terms of technical, regulatory, economic, social, and natural environment considerations.

The long-term management objective for the site is to successfully manage leachate-contaminated groundwater and mitigate unacceptable impacts to human health and the environment. A process was developed to generate comprehensive remediation alternatives for the area that can satisfy this long term management objective. The first step in the process was to identify individual remediation methods that could achieve, in full or in part, the long-term management strategy. These remediation methods were assembled into a long list of comprehensive management alternatives that consisted of primary components, as well as enhancing secondary features that could augment the level of protection offered by any given management alternative.

Following the generation of a long-list of comprehensive remediation alternatives, each alternative was evaluated against two screening criteria, technical effectiveness and public support. These screening criteria reflect the fundamental requirements of the long-term management strategy for the site. The screening of the long list resulted in a short-list of comprehensive management alternatives. The short listed comprehensive management alternatives include:

- Maintain Existing Containment System
- Constructed Treatment Wetland
- Perimeter Leachate Containment, Collection, and Treatment
- Hybrid Alternative(s): Various Remediation Methods Used at Individual Site Management Areas
- Engineered Low Permeability Clay Cap

A scoring system was developed using a set of detailed evaluation criteria that was selected in consultation with various stakeholder groups. Input from the public, steering committee, and agencies was sought regarding the detailed evaluation criteria list and the weighting of the criteria before carrying out the ranking. The alternatives were ranked according to the scoring system based on the professional judgment of the project team. The Hybrid Alternative received the highest score (989 out of a possible 1274 points) and is recommended as the long term management strategy at the site.

The Hybrid Alternative would consist of applying various remediation methods (which passed the screening criteria) to individual site management areas. Malroz (1999) previously divided the site into eight distinct site management zones (SMZs) based on features that included land use, topography, groundwater quality, waste depth, waste type, and the presence/absence of active seeps. The eight distinct SMZs and the proposed remediation method used in each are shown in Figure ES-1. This alternative is recommended as the long term management strategy for the site for the following reasons:

- Variable site characteristics are matched to the most suitable remediation method, as opposed to implementing the same remediation method to all parts of the site.
- The existing system has proven to be effective at controlling the point source leachate seep discharges to the river and is contained within and enhanced by this alternative. A leachate collection and treatment system would be installed/maintained in Site Management Zones where point source discharges have occurred in the past.
- This alternative is the most compatible with the existing control systems at the site. Measures to improve the efficiency of leachate collection by minimizing the influx of river water may be possible.
- This alternative is relatively easy to implement at the site, due in part to making use of the existing control systems.
- Operation and maintenance costs associated with this alternative are significant; however, cost reductions may be possible by improving the efficiency of the leachate collection system, thereby decreasing the amount of river water entering the system. Further assessment of the ability of the poplar tree cap and other plantings of shrubs and grasses to reduce leachate volumes via evapotranspiration would allow for an estimate of the potential reduction of the O&M costs associated with leachate collection and treatment system.
- The total NPV cost of this alternative is the second lowest in comparison to the other alternatives. Only Alternative 1: Maintain Existing System has a lower total NPV cost.
- Public acceptance of the alternative is expected to be high due to the continued golf course use, aesthetic improvements, and continued recreational use opportunities.
- Floodplain intrusion and fish habitat disruption would be minimal.

A public open house was the forum used to present the findings to the public.

14/JUNE/2006

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BELLE PARK LANDFILL SITE SEEPAGE CONTROL

FIGURE ES-1
ALTERNATIVE #4
HYBRID ALTERNATIVE

PROJECT No. 122361.TT.DE

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1. Introduction

Background

Cataraqui Park (better known as Belle Park Landfill Site) is a landfilled marshland that extends into the Kingston Inner Harbour from the west bank of the Great Cataraqui River to Belle Island. The site is approximately 44 hectares (108 acres) in size.

Citizens, businesses and institutions in the City of Kingston (City) used this site as a municipal landfill from 1952 to 1974. After the landfill was closed in accordance with Ministry of the Environment (MOE) requirements, the City developed the site into a multiple-use recreational facility that includes a nine-hole golf course, a driving range, tennis courts, and walking paths.

In 1997, the City took measures to assess the risks at the site and to address leachate seepage into the Cataraqui River. Seep management measures have been implemented and expanded since 1997. The current leachate collection system is operating effectively to address leachate discharges into the river; however, this requires extensive operation and maintenance effort.

A common method to control the volume of leachate generated at a landfill site is to cover the waste materials with a low permeability clay cap. The use of a clay cap at the Belle Park Landfill Site will reduce but not prevent leachate generation. The majority of leachate generation is thought to occur as a result of seasonal water level fluctuations within the Cataraqui River. During high water levels, river water moves into and under the Belle Park Landfill Site. As water levels recede, leachate can seep back into the river around the site perimeter if control measures are not taken. A landfill cap will not prevent this seasonal leachate generation and discharge process from occurring.

In May 2003, the City of Kingston retained CH2M HILL to assess long-term leachate management alternatives (including capping) for the Belle Park Landfill Site. Section 2 of this report details the process proposed by CH2M HILL to conduct this assessment. The assessment commenced in May 2003 and progressed until a long list of remediation methods had been identified, subjectively assessed, and then combined to form a long list of comprehensive remediation alternatives. On June 9, 2003, CH2M HILL presented this assessment's results in meetings held with Kingston Environmental Advisory Forum (KEAF) and governmental agencies. CH2M HILL prepared meeting notes for each of these meetings, which are provided in Appendix A.

The City of Kingston temporarily suspended the project in July 2003, pending the results of three studies, which were to be completed between July 2003 and March 2005. At the time, the results of these studies were deemed essential to guiding the selection of management options. Specifically, these studies included the following:

- Project Trackdown Cataraqui River, Kingston, Ontario: Assessment of PCBs in Nearshore Groundwater, Final Report, City of Kingston – Environment Division.

- Constructed Treatment Wetland Feasibility Study, 2004 Interim Report, Malroz Engineering Inc., March 2005.
- Sediment and Benthic Macro Invertebrate Study of the Kingston Inner Harbour, Final Report, Malroz Engineering Inc., March 7, 2005.

The results of these studies are summarized as follows:

- **Project Trackdown Cataraqui River, Kingston, Ontario: Assessment of PCBs in Nearshore Groundwater, Final Report, City of Kingston – Environment Division, February 2005:** The purpose of this study was to determine whether PCBs were present in groundwater in the vicinity of the Belle Park Landfill and if groundwater recharge was a source of the PCBs detected in sediments of the Cataraqui River. The study was conducted between May 2003 and May 2004. The field work consisted of monitoring well installation, four rounds of groundwater sampling for PCBs at low detection limits, and an airborne thermal infrared survey to identify active groundwater discharges.

  The results of the groundwater sampling and analysis revealed that PCB concentrations in the six Belle Park Landfill monitoring wells sampled were as high as 5.5 ng/L with an average concentration of 1.4 ng/L. It is noted that the field blank sample had PCB concentrations (0.06 to 2.2 ng/L), which was on the same order of magnitude as the wells that were sampled.

  The results of the airborne thermal infrared survey for the waters surrounding the Belle Park Landfill site indicated four specific areas of unusually warm water. The hypothesis used to interpret the thermal imagery data was that any areas of groundwater recharge to the river would be detected as localized low temperature areas. The City therefore concluded that the elevated temperatures were not the result of groundwater recharge. The cause of the four elevated water temperature areas was suspected to be caused by solar heating of the shallow and weedy surfaces of those areas.

  The study concluded that PCBs were present at very low levels in the shallow groundwater adjacent to the river in Belle Park. No obvious zones of groundwater discharge to the river surrounding the Belle Park Landfill were detected. This study suggests that groundwater discharging to the river from Belle Park is unlikely to be an ongoing source of PCB contamination.

- **Constructed Treatment Wetland Feasibility Study, 2004 Interim Report, Malroz Engineering Inc., March 2005:** This report documented the findings and observations of a constructed wetland feasibility study. In 2003, a 2,500 m^2 pilot constructed wetland was installed on the north shore of Belle Park. The project involved installing a light-weight organic substrate (straw) mattress in the shallow waters of the Cataraqui River adjacent to the north shore of Belle Park. The theory was that the substrate mattress would serve as a platform for native wetland species, such as cattails, to grow and to establish a wetland buffer zone adjacent to the landfill site. The wetland buffer zone would then act to reduce/attenuate contaminants from diffuse landfill seepage into the Cataraqui River.

  Monitoring during 2003 and 2004 indicated limited success of the pilot project. Only near-shore colonization of the constructed wetlands occurred. The cause for the lack of colonization further from shore was attributed to the sinking of the straw mattress, resulting in water depths in excess of 0.6 m, which is the maximum water depth at which cattail would proliferate. In the spring of 2005, the substrate mattress sank to the bottom of the river during spring flood water levels.

It is important to note that in the summer of 2005, subsequent to the release of this report, wetland vegetation was seen to be establishing itself into the far-shore areas of the wetland. Further visual monitoring of the site would be carried out to determine the long-term vegetative community potential.

The relevant conclusion of this work was that while wetland processes are likely to provide good buffer between the landfill and the river environment, nearshore water depths may restrict the easy construction of such features.

- **Sediment and Benthic Macro Invertebrate Study of the Kingston Inner Harbour, Final Report, Malroz Engineering Inc., March 7, 2005:** A sediment and benthic macro invertebrate study was conducted of the Kingston Inner Harbour by the ASI Group Ltd. for Malroz Engineering Inc. between April 26 and 29, 2004. Samples were collected from near-shore areas around Belle Park, as well as from a reference area upstream of Belle Park.

  Exceedances of the Provincial Sediment Quality Guidelines (PSQG) were found in sediments adjacent to Belle Park, as well as the upstream reference site. There were exceedances of the PSQG at the severe effects level (SEL) of selected parameters (total phosphorus, chromium, copper, iron, lead, zinc) in sediments adjacent to Belle Park that were not detected at SEL levels at the upstream reference site. The levels of some of these parameters were, however, detected at lowest effect levels (LEL) in sediments from the upstream reference site.

  In general, macro invertebrate abundance, family richness, and diversity were similar at both the upstream reference site and areas adjacent to Belle Park. ASI reported that, apart from three transects, there were no differences in species composition and abundance of benthic communities inhabiting the sediments of the near-shore waters surrounding Belle Park and of those at the upstream reference site. ASI concluded that the composition of benthic communities in the study area was determined predominately by the type of sediment and the percentage of silt present. The degree of contamination in sediments adjacent to Belle Park also exerted a minor influence on the benthic community, although the degree of influence was estimated to be generally an order of magnitude less than that of sediment composition.

In April 2005, following the completion of these studies, the City of Kingston requested that CH2M HILL re-commence with the long-term management strategy assessment for the site. This report serves as the Long-term Management Alternatives Report.

Purpose of the Study

The City requires a more effective and efficient long-term leachate management strategy for this site that includes the following attributes:

- Technically feasible and effective at protecting the environment

- Publicly acceptable
- Energy-efficient
- Economically sustainable

Report Outline

Section 2 of this report documents the process that is used to select a recommended long-term management alternative for the site. Section 3 of the report identifies and screens potential remediation methods to address leachate seeps at the site. In Section 4, the remediation methods that meet the screening criteria are combined to form comprehensive remediation alternatives. A detailed evaluation and ranking of the five short listed comprehensive remediation alternatives is provided in Section 5. The conceptual design of the recommended alternative is provided in Section 6.

2. Alternatives Evaluation Process

Long-Term Management Objectives

The City of Kingston is seeking to develop a long-term management plan for the historic Belle Park Landfill. Currently, the interim Temporary Seep Management (TSM) and site monitoring programs have been actively intercepting leachate seeps and pumping the leachate to the municipal sewer for treatment. This has, in turn, successfully mitigated the resulting effect of leachate-impacted groundwater.

The long-term management of the site would concentrate on on-site isolation/containment that limits the transport of landfill leachate and minimizes the opportunity for its production. This translates into the following principal long-term management objective:

> *"To effectively manage the transport and production of leachate-contaminated groundwater and mitigate unacceptable impacts on human health and the environment using sound sustainable engineering principles in accordance with relevant compliance targets, environmental policies, and regulations."*

In association with the principle objective listed above, the following outlines more site-specific objectives related to the primary objective:

1. Reduce/control the impact/risk associated with the landfill to human health or the environment
2. Minimize the deleterious impact of contaminants (in particular ammonia) on the aquatic environment
3. Minimize the visual impact from iron staining
4. Minimize the potential infiltration contribution due to precipitation
5. Comply with appropriate city, provincial, and federal regulations and policies
6. Minimize the risk to human health and the environment during implementation
7. Ascertain that capital cost must be cost-effective to minimize the impact on City taxes
8. Minimize ongoing costs related to perpetual monitoring, operation, and maintenance
9. Maintain the public's ability to access and use the site for the current and future anticipated recreational activities
10. Incorporate sustainable principles that focus on energy-efficient practices and the use of renewable resources
11. Incorporate ecological principles that focus on maintaining or increasing the quality of terrestrial and aquatic habitats, as well as enhancing public enjoyment of the site.

Overview of the Process to Generate and Evaluate Alternatives

Figure 2-1 illustrates the process that CH2M HILL applied to generate potential management alternatives for all areas of the Belle Park Landfill site. Initially, conceptual remediation methods that may address some or all of the issues identified for each management area of the site were identified. These methods were evaluated with a screening process to identify which had the greatest potential to address the management objectives of all or a portion of the site, and either alone combined with other methods. Methods that did not have significant potential as a stand-alone approach or as an enhancement to another viable solution were eliminated early in the process. This resulted in a list of primary remediation methods and enhancing protective features that were retained for further evaluation.

Based on the project team's experience and judgment, the primary remediation methods were combined with enhancing protective features, to create a long-list of comprehensive remediation alternatives that addressed all or most of the current management objectives at the site. These comprehensive remediation alternatives were subsequently evaluated. The alternatives were screened and reduced to a short-list of comprehensive remediation alternatives that were subject to a more detailed evaluation, which led to the identification of a recommended remediation alternative.

Detailed Approach to the Generation of the Short List of Remediation Alternatives

The alternative generation process began with the identification of remediation methods that were able to achieve, in full or in part, the long-term management objectives for the site. The remediation methods included those identified in the Environmental Impact Study (Malroz, 1999), as well as methods that CH2M HILL had either used on similar projects, or identified in the scientific and engineering literature. The remediation methods were compared to two screening (exclusionary) criteria, specifically:

- Effectiveness of the conceptual methods to meet the long-term management objectives for the site
- Compliance with regulatory requirements

These criteria were designed to eliminate improbable conceptual management methods early in the process, so that valuable time and resources were not expended to complete a more detailed evaluation of methods that would not be brought forward. The first exclusionary criterion was the effectiveness of the conceptual management method. This criterion was used to evaluate the method's expected effectiveness in solving the problem identified for the area. For example; can the conceptual management method contribute to reducing contaminant loading to the environment? The second criterion served to evaluate the capacity of the conceptual remediation method to meet relevant regulatory requirements.

Screening of Conceptual Remediation Methods

Each conceptual remediation method was consequently evaluated to determine whether it could (yes) or could not (no) meet the exclusionary criteria presented above. A "no" to any of these criteria eliminated the conceptual remedial method as a primary remediation method. A primary remediation method is defined as a method that has significant potential to serve as a stand-alone remediation alternative requiring minimal additional augmentation or enhancement to maximize the landfill discharge contaminant load reduction. Both criteria carried equal weight in the evaluation process; therefore, their order of appearance does not reflect their relative importance. Table 2.1 further synthesizes the intent of the exclusionary criteria used to generate remediation alternatives.

TABLE 2.1
EXCLUSIONARY CRITERIA – SCREENING OF CONCEPTUAL REMEDIATION METHODS

Exclusionary Criteria	Considerations	Measure
Effectiveness	Does the conceptual remediation method have the potential to solve one or more aspects of the problem?	Yes – The conceptual remediation method on its own has the potential to significantly reduce contaminant loads to the environment. No – The conceptual remediation method on its own does not have the potential to significantly reduce contaminant loads to the environment.
Compliance with Regulatory Requirements	Does the conceptual remediation method have the ability to achieve compliance with applicable agency regulations and guidelines relating to site management?	Yes – The conceptual remediation method on its own will likely result in compliance. No – The conceptual remediation method on its own will not likely result in compliance.

Rejection as a primary remediation method did not exclude further consideration of the method to augment another conceptual remediation method, particularly if the former showed significant potential to control the release or minimize the mobility or volume of seepage. Some methods were retained based on their potential, when combined with other methods, to create a comprehensive solution to the environmental issues in a specific area of the Belle Park Landfill site. Such combinations were termed "Comprehensive Remediation Alternatives". Other methods were retained as potential enhancements, which formed redundancies in the design, such as multiple barriers to various leachate collection technologies and/or treatment technologies. Figure 2-1 illustrates the process used to screen conceptual remediation methods.

FIGURE 2-1
PROCESS FLOW DIAGRAM FOR SELECTION OF THE PREFERRED COMPREHENSIVE REMEDIATION ALTERNATIVE

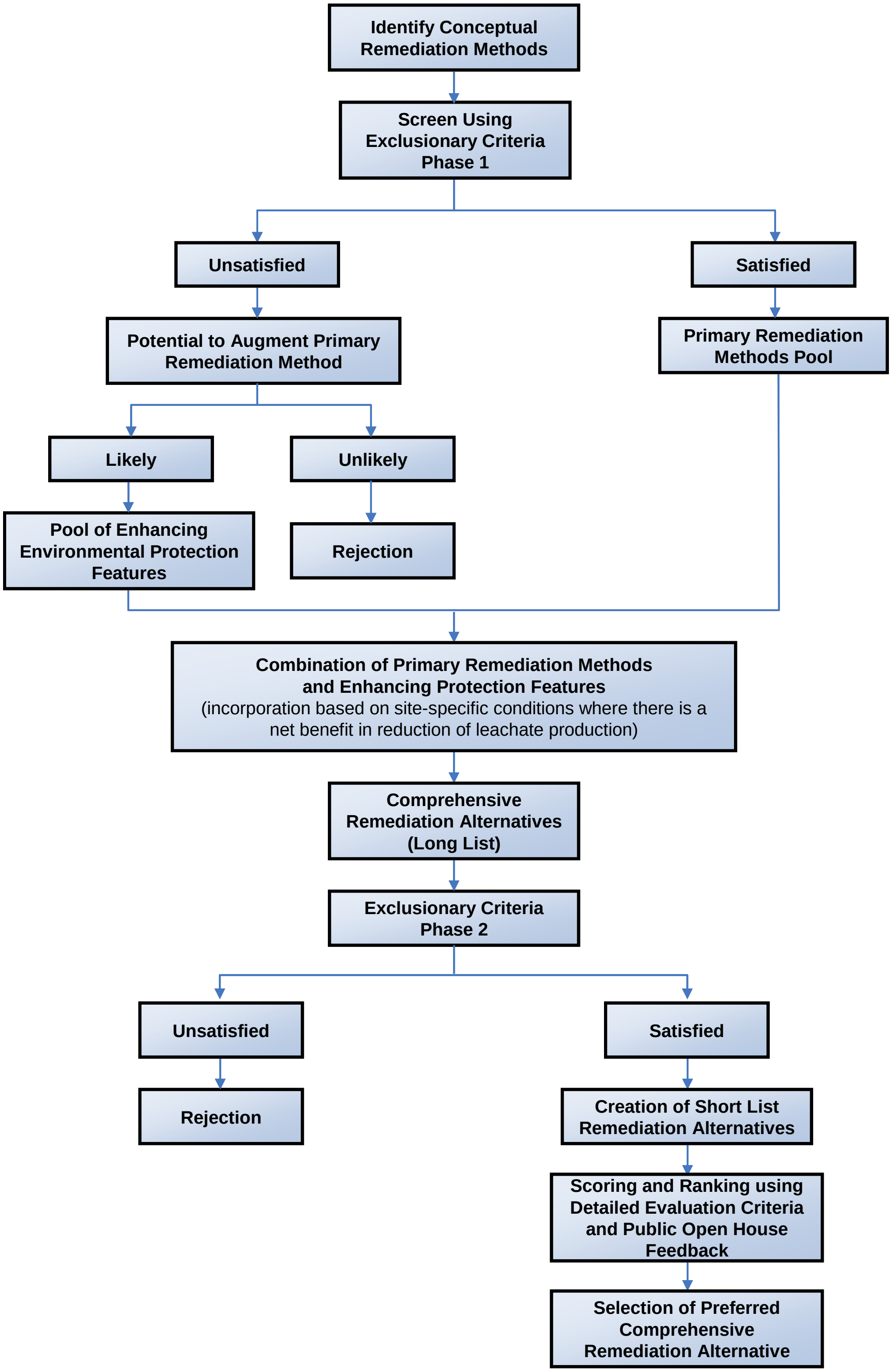


Figure 2-1 schematically illustrates the process used to generate comprehensive remediation alternatives for further consideration. Alternatives were developed from the list of primary remediation methods or enhancing features that passed the screening level evaluation. Comprehensive remediation alternatives were developed to create potential solutions to address the long-term management objective for the site.

Evaluation of Comprehensive Remediation Alternatives

The evaluation process that was developed to select a short list of recommended remediation alternatives for the site relied on a qualitative assessment of the long list of comprehensive remediation alternatives. It allowed the evaluation to focus on the alternatives that were most promising to satisfy the management objectives while avoiding consideration of superfluous alternatives.

Comprehensive remediation alternatives were developed using the process illustrated in the lower portion of Figure 2-1. The first step in selecting a short listed remediation alternative was to compare all comprehensive remediation alternatives (the "long-list") to a second set of screening criteria identified in Table 2.2. The second set of screening criteria, technical effectiveness and public acceptance were identified for the project as "fundamental requirements" for the long-term management solution for the site.

TABLE 2.2
EXCLUSIONARY CRITERIA – SCREENING OF COMPREHENSIVE REMEDIATION ALTERNATIVES

Exclusionary Criteria	Considerations	Measure
Technical Effectiveness	Ability of the alternative to satisfactorily provide an acceptable discharge water quality on a regular and reliable basis.	Yes – The comprehensive remediation alternative has the potential to significantly reduce contaminant loads to the environment and provide an acceptable discharge water quality. No – The comprehensive remediation alternative does not have the potential to significantly reduce contaminant loads to the environment.
Anticipated Public Support	Is the comprehensive remediation alternative likely to receive public support?	Yes – The comprehensive remediation alternative is more likely to receive public support. No – The comprehensive remediation alternative is less likely to receive public support.

This screening step served to screen out comprehensive remediation alternatives that could not meet the project's fundamental requirements. The screening exercise led to the construction of a "short-list" of comprehensive management alternatives from which the recommended management alternative was selected during a workshop with the project team (CH2M HILL and the Technical Steering Committee). It is important to recognize that while the first set of exclusionary criteria shown in Table 2.1 deals mainly with the evaluation of *methods* with the potential to form *part* of a comprehensive solution (such as reduction of a portion of contaminant load to the environment), the second set of exclusionary criteria focuses on the screening of *comprehensive remediation alternatives* and their ability to achieve an overall reduction of contaminant load from the entire site.

The detailed evaluation of the short-listed comprehensive management alternatives was completed by comparing them against a series of evaluation criteria that not only reflected the management objectives of the project but that also captured the essence of environmental assessment criteria when impacts associated with a given project were evaluated.

The detailed evaluation criteria consisted of four categories of criteria listed below:

- Technical proficiency of the alternative
  - Reliability
  - Compatibility with or replacement of the existing system
  - Ease of implementation
- Regulatory Requirements
  - Expected duration for obtaining Approvals
  - Regulatory compliance
- Costs
  - Monitoring, operation, and maintenance
  - Capital
- Social Considerations
  - Anticipated public acceptance
  - Risk to public
  - Recreational use
  - Impact on property values
  - Impact on visual character of the area
- Impact of the Alternative on the Natural Environment
  - Water Quality
  - Wildlife habitat
  - Floodplain
  - Fish habitats

Table 2.3 summarizes the intent of the detailed evaluation criteria, and further descriptions of each category of criteria are provided following Table 2.3. Note that in each case, the measure of the criteria of each short-listed management alternative is based on the scoring system indicated in Table 2.3. Each alternative would be assigned a score ranging between 0 and 10, depending on the ability of the alternative to satisfy the detailed evaluation criteria, as stated in Table 2.3.

TABLE 2.3
DETAILED EVALUATION CRITERIA – COMPREHENSIVE REMEDIATION ALTERNATIVES

Criteria	Considerations	Measure
Technical Considerations		
Maximize Reliability	Ability of the alternative to satisfactorily control discharge quality on a regular and reliable basis	10 – Very reliable, few performance problems 5 – Somewhat reliable, some performance problems 0 – Not reliable, many performance problems similar to pre-1997 with no interception or treatment
Maximize Compatibility with or Replacement of the Existing System	Ability of the alternative to adapt to the existing site conditions and system or replace the existing system	10 – Very compatible, few technical problems 5 – Somewhat compatible, some technical problems 0 – Not compatible, many technical problems
Maximize Ease of Implementation	Ability of the alternative to be easily implemented from a technical perspective (e.g. land availability, timing, approval requirements)	10 – Easily implemented, few problems 5 – Somewhat easily implemented, some problems 0 – Not easily implemented, many problems anticipated
Regulatory Requirements		
Minimize Expected Duration for Obtaining Approvals	The expected duration of the approval process. The current system serves as the base line with a score of 5.	10 – Relatively short period of time required to obtain necessary approval to proceed with conceptual remediation alternative (<1 year) 5–- Intermediate – Moderate period of time required to obtain necessary approval to proceed with conceptual remediation alternative (2-3 years) 0 – Relatively long period of time required to obtain necessary approval to proceed with conceptual remediation alternative (>than four years)
Maximize Regulatory Compliance	The expected level of compliance with applicable laws and regulations	10 – Completely Compliant 5 – Potential for occasional non compliance issues 0 – Not compliant
Costs		
Minimize Operation and Maintenance Costs	Relative measure of O/M costs compared to other comprehensive remediation alternatives. Annual costs are converted to Net Present Value (NPV) costs for comparison purposes. An interest rate of 5% and a planning life cycle of 25 years has been assumed	10 – < $1 M 9 – $1 to $1.5 M 8 – $1.5 to $2.0 M 7 – $2.0 to $2.5 M 6 – $2.5 to $3.0 M 5 – $3.0 to $3.5 M 4 – $3.5 to $4.0 M 3 – $4.0 to $4.5 M 2 – $4.5 to $5.0 M 1 – $5.0 to $5.5 M 0 – >$5.5 M
Minimize Capital Costs	Capital cost of each alternative	10 – <$100,000 9 – $100,000 to $1 M 8 – $1M to $2M 7 – $2M to $3M 6 – $3M to $4M 5 – $4M to $5M 4 – $5M to $6M 3 – $6M to $7M 2 – $7M to $8M 1 – $8M to $9M 0 – >$9 M

TABLE 2.3
DETAILED EVALUATION CRITERIA – COMPREHENSIVE REMEDIATION ALTERNATIVES

Criteria	Considerations	Measure
Social Consideration		
Maximize Public Acceptance	The anticipated potential for the comprehensive remediation alternative to be accepted by the public	10 – Minimal or no potential for some reservation from the public 5 – Potential for some reservation from the public 0 – Potential for significant reservation from the public
Minimize Risk to Public Safety	The potential for the compre-hensive remediation alternative to create a risk to public safety (dust, odours, noise, traffic etc.)	10 – Potential for low/no risk to public safety 5 – Potential for some risk to public safety 0 – Potential for significant risk to public safety
Minimize Constraints to Recreational Use	The potential for the comprehensive remediation alternative to create constraints for recreational opportunities	10 – Minimal or no constraints for recreational opportunity 5 – Potential for some constraints on recreational opportunity 0 – Potential for significant constraints on recreational opportunity
Minimize Negative Impact to Private Properties	The potential for the comprehensive remediation alternative to produce a negative impact to private properties	10 – Minimal or no negative impacts on surrounding private properties 5 – Potential for some negative impacts on surrounding private properties 0 – Potential for significant negative impact to surrounding private properties
Minimize Degradation to Visual Character of the Area	The potential for the comprehensive remediation alternative to negatively impact the visual character of the area	10 – Minimal negative impacts on or improvement of the visual character of an area 5 – Potential to have some negative impacts on the visual character of an area 0 – Potential to severely negatively impact the visual character of an area
Natural Environment		
Maximize Improvement in Water Quality	The potential for the comprehensive remediation alternative to improve the geochemistry of the area	10 – High potential to improve the geochemistry 5 – Some potential to improve the geochemistry 0 – Low potential to improve the geochemistry
Maximize Improvement to Wildlife Habitats	The potential of the comprehensive remediation alternative to improve wildlife habitats	10 – Potential to significantly improve wildlife habitat 5 – Potential to somewhat improve wildlife habitat 0 – Minimal or no improvement to wildlife habitat
Minimize Disruption/Intrusion Upon the Floodplain/ River	The potential of the comprehensive remediation alternative to disrupt/intrude upon the floodplain/river	10 – Minimal/no disruption/intrusion into floodplain/river 5 – Potential to cause some disruption or intrusion into floodplain/river; impacts less severe 0 – Potential to disrupt/intrude upon floodplain/river resulting in potentially significant impacts to the upstream flood control management
Minimize Disturbance to Fish Habitat	The potential of the comprehensive remediation alternative to cause disturbance to or loss of fisheries habitat	10 – Minimal disturbance or no loss of fisheries habitat 5 – Potential to cause some disturbance or loss of fisheries habitat, some mitigation required 0 – Potential to cause disturbance or loss of significant area of fisheries habitat, significant compensation measures required

Technical Considerations

The first technical criterion dealt with the comprehensive remediation alternative's technical reliability in mitigating environmental impacts from the area. Groundwater discharge has been identified as the main loading sources for the influx of contaminants to the West Stream and Cataraqui River. The ability to intercept and reduce the contaminant load of seepage flow forms the basis for the evaluation of the comprehensive remediation alternative's reliability. The alternative's ability to satisfactorily control discharge on a regular and reliable basis over the long-term was considered paramount. The discharges and water inputs can be reduced by selecting or combining some or all of the following design principles:

- Reducing the amount of precipitation that infiltrates the underlying landfill waste
- Reducing the amount of groundwater contacting the underlying landfill waste
- Intercepting seepage flows and pumping/directing them to a treatment system
- Reducing the area of exposed or thinly covered waste materials (from infra red scan)
- Reducing or halting the rate at which groundwater moves through the underlying landfill waste

The second criterion examined the comprehensive remediation alternative's ability to operate in tandem with existing leachate control systems at the site.

Finally, the ease to construct and implement the comprehensive remediation alternative is examined as a precursor to the following criteria. Issues such as potential impact on the environment during construction, available technologies and materials, and complexity are addressed.

Regulatory Requirements

This criterion outlines the expected extent of the regulatory approval process, along with the compliance criteria and the level of monitoring required to demonstrate the effectiveness of the comprehensive remediation alternative. The regulatory requirements may vary dramatically from alternative to alternative. The utilization of conventional processes can typically be approved within a short period of time using standard approval practices. However, multi-level approvals, extensive mitigation requirements and the utilization of unconventional methods can dramatically increase the level of effort required to demonstrate the effectiveness of the method and the extent of the monitoring.

Costs

The third category of criteria used for the evaluation of management alternatives is cost. Capital and operation and maintenance (O&M) costs for the comprehensive management alternatives are considered. It is recognized that some alternatives may have considerable O&M costs with lower capital costs, while other alternatives may have higher capital costs with little O&M effort required. To allow an equal comparison of the alternatives, Net Present Value (NPV) costs were used. The NPV calculations were based on an assumed effective interest rate of 5 percent and a planning horizon of 25 years. The 25-year period is selected based on the assumption that it is a reasonable period for comparing alternatives and for budgetary planning purposes. It is noted that the 25-year period does not represent the amount of time that leachate management will be required. O&M costs at the site will be incurred beyond the 25-year period.

CH2M HILL has relied on information provided by the City regarding current operating costs, unit costs on similar recently completed projects, material costs from suppliers, and the 2005 Means Heavy Construction Cost Data. Based on available information and for budgetary purposes, our preliminary opinion of capital costs presented can be considered to be correct within a range of +50%/-35%. Our preliminary opinion of O&M costs can be considered order of magnitude only due to the lack of information regarding the performance of untested methods at the site.

Social Considerations

Criteria in this category addressed the management alternatives' ability to meet social needs and expectations such as future recreational use of the property, impacts of the works on private property and the overall visual character of the site.

Natural Environment

This category encompasses all of the natural environmental components not covered in the above subsection. This evaluation examined the alternatives' ability to improve, protect, and/or minimize impact on the following:

- Surface water quality
- Groundwater quality
- Terrestrial habitat
- Floodplains/river
- Fish habitat

Figure 2-1 schematically illustrates the process used for the detailed evaluation of the short-listed comprehensive management alternatives to determine the recommended management alternative.

3. Identification and Screening of Conceptual Remediation Methods

This section develops and evaluates conceptual remediation methods, which will subsequently be combined into alternatives to address leachate-contaminated groundwater at the site. The methods and alternatives are developed and evaluated using the process described in the previous section.

Identification of Conceptual Remediation Methods

Remediation methods that have potential in the management of leachate-contaminated groundwater at the site include the following:

- Waste Removal and Disposal
- Onsite Waste Consolidation
- Engineered Low Permeability Clay Cap/HDPE Liner
- Vegetative Cap
- Containment Barrier Wall
- Leachate Collection
- Leachate Treatment at the local water pollution control plant (WPCP)
- Leachate Treatment at Onsite Conventional WPCP
- Constructed Treatment Wetland
- In-Situ Treatment Using Treatment Walls
- Injection of oxygen releasing compounds (ORCs) into the Waste Material
- Monitored Natural Attenuation
- Risk Assessment

Each of these conceptual remediation methods is discussed below. A list of advantages and disadvantages are presented based on the experience of the team.

Waste Removal and Disposal

This method would consist of excavating all waste materials at the Belle Park Landfill and disposing them at a MOE-approved disposal site. Upon removal of the waste materials, the site could be returned to its natural state or be redeveloped.

Advantages associated with this method include:

- Complete removal of the source of contamination
- Permanent prevention of contaminant discharge to the river
- Operation and maintenance effort and cost is eliminated

Disadvantages associated with this method include:

- Concerns with the practicality of excavating wastes below the water table adjacent to and within the river
- Potential negative impact on river, especially during extreme storm events; degraded local air quality; noise; and truck traffic concerns during implementation
- Complete disruption of existing site uses
- Difficulty in finding a nearby disposal site with sufficient capacity
- Significant regulatory approval requirements
- Potential strong public opposition
- Significant capital costs

Landfill mining, which involves segregation and potential recovery of recyclable materials from the excavated material has been used with limited success at other sites. Due to the composition and nature of the waste materials present in the Belle Park Landfill (based on observations made during drilling and excavation activities), it is unlikely that there would be materials that could be economically extracted.

Onsite Waste Consolidation

Waste consolidation would consist of excavating and consolidating waste materials onsite. This method would decrease the footprint of the landfill site requiring management. The obvious location to consolidate the waste materials is the ski hill area of the site. Waste materials would be excavated and transported to this ski hill area and would be capped. Areas of the site where wastes are removed could be returned to a natural state (wetland) or be backfilled and redeveloped.

Advantages associated with this method include:

- Footprint of landfill site requiring management is reduced

Disadvantages associated with this method include:

- Concerns with the practicality of excavating wastes below the water table adjacent to and within the river
- Potential negative impact on river, especially during extreme storm events; degraded local air quality; noise; and truck traffic concerns during implementation
- Complete disruption of existing site uses
- Significant regulatory approval requirements
- Potential strong public opposition
- Significant capital costs
- Ongoing requirement for management of leachate generated by the landfill wastes.

Engineered Low Permeability Clay Cap/HDPE Liner

Low permeability caps are used at landfill sites to effectively limit the infiltration of precipitation and stormwater runon into the waste materials, thus controlling the volume of leachate generated. In addition, low permeability caps should also sustain adequate vegetative growth and promote proper runoff. Low permeability caps can be constructed using natural clay or using synthetic materials such as high density polyethylene liners (HDPE) or geosynthetic clay liners (GCL).

A clay landfill cap consists of a layer (or layers) of soil of selected low permeability being placed on the surface of the landfill to a design thickness and compaction. Current standards in Ontario for engineered municipal landfills require a minimum of 0.6 m of capping soil overlain by a minimum of 0.15 m of topsoil. Belle Park Landfill's current cover consists of loam-based soils ranging in thickness from minimal cover up to 1.5 m cover depth.

Caps constructed using synthetic materials consist of a top layer of topsoil (typically 0.15 m) underlain by a layer of common fill (thickness varies depending on proposed vegetative cover). Underlying the topsoil and common fill layer is an HDPE liner or GCL that is sandwiched between two layers of sand. The sand layers, typically 0.3 m in thickness, act as a cushion to protect the HDPE or GCL from puncture during placement of the topsoil and common fill layers.

A low permeability cap at the Belle Park Landfill would act to somewhat lower the volume of leachate generated; however, it would not be sufficient alone to prevent contaminant discharge into the river. Some precipitation would always penetrate the cap. In addition, at this site, a significant volume of the seepage into the river originates as the result of groundwater flowing horizontally through the landfill refuse layer towards the river. The water table is within the refuse layer at this site.

Advantages of using a low permeability cap include:

- Leachate volumes would be somewhat reduced
- Proper coverage of waste materials is provided
- Relatively low operation and maintenance costs

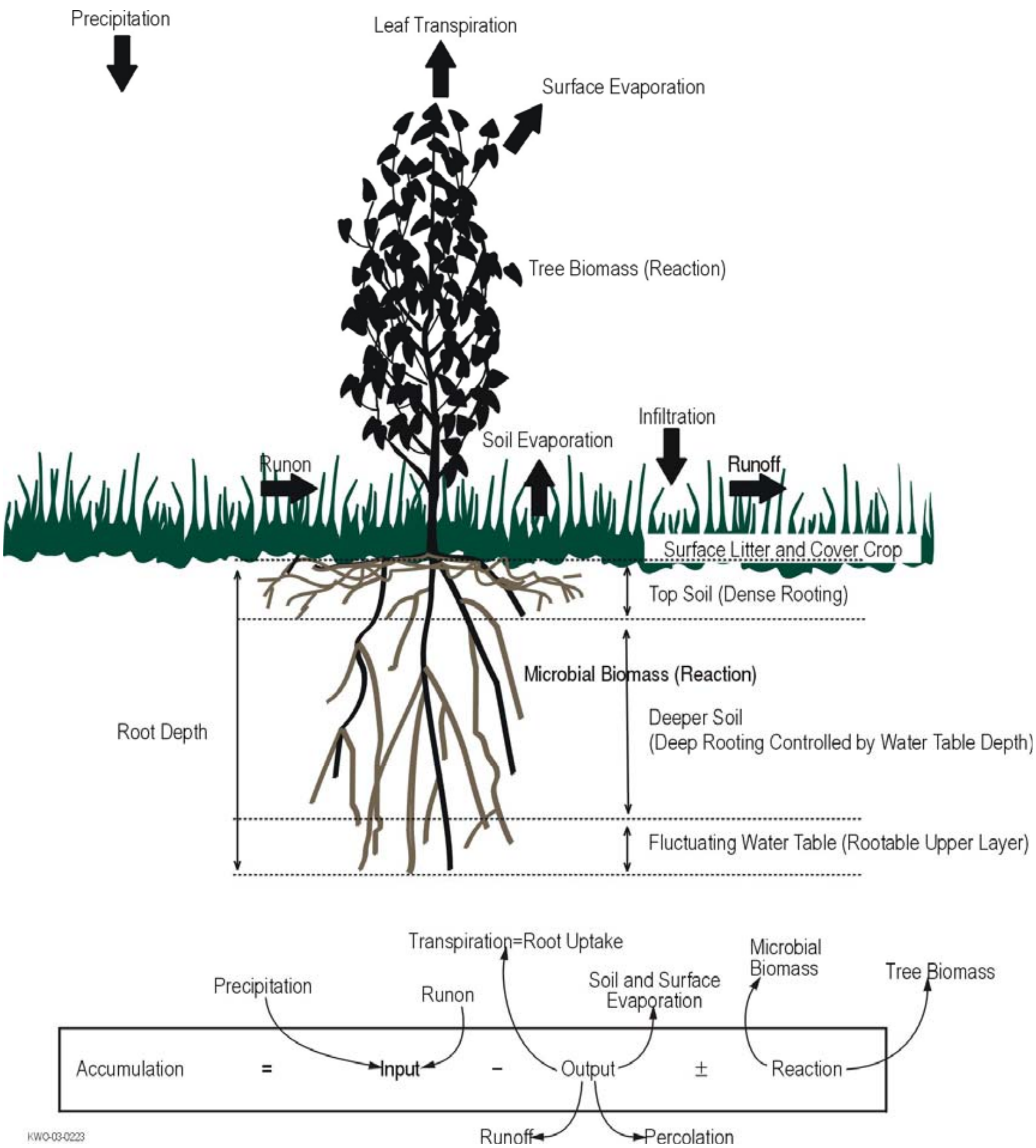
Disadvantages of using a low permeability clay cap include:

- Would not provide significant contaminant discharge reduction to the river
- Disruptive to existing site uses
- Potential loss of flood plain affecting stormwater management (flooding) of the upstream watershed
- Significant capital costs depending on extent of capping
- Leachate pumping and treatment would still be required likely at similar levels to the current conditions
- Requires long-term maintenance of the cap to maintain its integrity

Vegetative Cap

This method utilizes densely planted phreatophytes – deep-rooting plants that obtain water from a permanent ground supply or from the water table. They act as pumps to provide hydraulic control by extracting groundwater through their root system and subsequent evapotranspiration (ET) of the moisture to the atmosphere (Figure 3-1).

FIGURE 3-1
WATER BALANCE MODEL



There are many potential applications of this natural attenuation and treatment technology possible at the Belle Park Landfill site. A vegetated cap system would involve the development of a high-density tree plantation and/or shrub community and/or naturalized (no-mow) grassed areas established on all or selected parts of the landfill area. The high plant density and unmowed areas encourages intense root competition for both moisture and nutrients and increase the ET potential of the site. In response, the roots of the trees/shrubs/grasses explore deeper into the soil column in search of nutrient rich ground water sources. In addition to searching out and extracting existing ground water sources, the dense root network would intercept surface water contributions as it infiltrates into the soil column.

A key element in the development of vegetative caps is the water holding capacity of the existing soil column. Plants would actively extract moisture during the growing season and essentially shut down during the dormant period (typically November to March). The soil column is used to temporarily store the infiltrating precipitation during the dormant period. Another important element in the development of a vegetative cap is the quality of the soil cover. The establishment of ideal growing conditions for the plant material is crucial to the overall viability and performance of the system.

Poplar clones are the prominent plant species used for the establishment of vegetative caps, although other species have been used on a limited basis (such as willow). Extensive cultivation of poplars by the pulp and paper industry has created clonal varieties that are extremely productive (harvestable size within six to 10 years), disease- and insect–resistant, and can be selected based on a variety of environmental preferences (climatic zone, soil type, moisture level, plant form, among others). At maturity, the caps' tall dense structure acts as a visual and odour barrier, and provides wildlife habitat.

Advantages

- Water table at Belle Park Landfill is very close to surface (generally within 1 to 1.5 metres of surface) over most of the site and readily available to a vegetative cap system that can root to depths in excess of 2 to 2.5 metres under ideal growing conditions
- Passive, low energy use
- Provides greatest hydraulic control during summer months when receiving stream is most sensitive and can maintain hydraulic control through the winter due to the storage capability of the soil after the trees have generated a moisture deficit and then go dormant in the fall
- Provides both hydraulic control and treatment of contaminated groundwater
- Low operations and maintenance requirements once system is established (typically takes about three years to become established)
- Capital costs tend to be somewhat lower than conventional capping systems, especially after the initial three years
- Aesthetic enhancement
- Recreational opportunities such as bird watching, walking, picnicking
- Habitat creation (birds and small mammals)
- Permitting agencies have indicated support on other Ontario landfill capping projects (sites include Essa, Stisted, Kingston East)

Disadvantages

- Seasonally based system that is actively extracting water during the growing season only (April to October)
- Integrity and effectiveness of system may be impacted by natural processes that are somewhat uncontrollable (such as wet weather, ice storm, disease/insect infestation, chemical imbalance)
- Direct measurement of influence of vegetative cap can be difficult but there are many forms of monitoring equipment available to establish extraction rates for trees (leaf area measurement, sap flow monitoring, soil moisture monitoring, and a variety of soil water balance models [Hydris, HELP])

Containment Barrier Wall

This option would involve the installation of an impermeable wall around the perimeter of the landfill. The wall would be keyed into the low permeability soil underlying the refuse. This method is not a primary remediation method since a perimeter leachate collection drain is required on the inside of the contained area to prevent leachate from accumulating and overtopping the wall. The collected water would then require further management. The types of containment walls that have been used for containing contaminated groundwater include soil-bentonite slurry wall, Waterloo Barrier™, or using the vibratory beam method to install a containment wall.

The first type of containment wall, soil-bentonite slurry wall, is installed by digging a trench (approximately 1 m width) around the site perimeter. The trench is then filled with a bentonite slurry to maintain the trench walls and form a impermeable cake in the fractures of the trench walls. Finally, a low permeability soil bentonite mixture is backfilled into the trench. Typically, the wall is keyed approximately 1 m into an underlying low permeability layer. This method requires a significant amount of space for the excavating equipment and soil-bentonite mixing area. A significant volume of refuse is likely to be produced during the excavation of the trench.

The second type of containment wall, Waterloo Barrier™, consists of sheet-piling driven into the ground and keyed into an underlying low permeability soil layer. The Waterloo Barrier™ would be installed around the perimeter of the landfill. The Waterloo Barrier™ is an adaptation of the sheet pile wall that addresses the problem of leaky joints. The Waterloo Barrier™ is specially designed with interlocking sealable joints. Installation involves driving sheet piles into the ground, flushing the interlocking joint cavity to remove soil and debris, and injecting sealant into the joints. Depending on site conditions, the cavity may be sealed with a variety of materials including clay-based, cementitious, polymer, or mechanical sealants. Video inspection of the joint cavity prior to sealing ensures that the joint can be sealed. The Waterloo Barrier™ can achieve bulk hydraulic conductivities of less than 10^{-8} cm/s (Mutch et al., 1997). The barrier can easily be installed to depths of 75 ft. The Waterloo Barrier™ typically is higher in cost than a soil-bentonite slurry wall; however, the wall can usually be installed without excavation of contaminated soils or waste materials. The Waterloo Barrier™ also provides a consistent barrier without gaps or weak zones that are sometimes associated with soil-bentonite slurry walls. An implementability concern associated with this type of wall is the potential presence of debris such as concrete in the landfill that could impede the installation of the Waterloo Barrier™.

The third type of containment wall, vibratory beam, is a grouting method suitable for shallow soils. A vibratory pile driver is used to drive a modified H-beam into the subsurface. The pile has injection nozzles at the tip. As the beam is withdrawn, grout is injected through the nozzles into the void. Cement-bentonite grouts are used most often. A continuous barrier can be formed by successively overlapping beam penetrations. This method does not typically involve the excavation of contaminated soil or waste materials. Significantly less area is needed for the installation equipment to install this type of wall as compared to a soil-bentonite slurry wall. Limitations and concerns associated with this method that are applicable to this site include walls being thin (several inches) and subject to hydrofracture, and difficulty in penetrating certain types of refuse such as reinforced concrete pieces. The advantages of using a perimeter containment barrier wall include:

- Contaminant discharge to the river is significantly reduced
- Disruption to existing site uses during installation are minimized depending on installation method, and long-term there is no disruption

The disadvantages of using a perimeter containment barrier wall include the following:

- A perimeter leachate collection system would also be required
- Installation through refuse may be problematic
- Compatibility of wall materials with leachate needs to be assessed

Leachate Collection

This method consists of installing a subsurface leachate collection system along the perimeter of the site. The collected leachate would require treatment either at the Kingston WPCP or an onsite leachate treatment system. Perimeter leachate collection system options include vertical extraction wells, a toe-drain, or a drainage blanket.

The first type of collection system, vertical extraction wells, consist of a series of vertical extraction wells (similar to those used in the existing Temporary Seep Management [TSM] system) installed along the perimeter of the site at pre-established distances. The wells would be connected to a common forcemain (pressurized pipe) that would discharge to some form of treatment system. Without some form of cut-off perimeter barrier wall, a mixture of river water and leachate would be collected by the vertical extraction wells, resulting in a larger quantity of water requiring treatment. The steel sheet-piling walls used in the TSM system have met with some limited success, although it is anticipated that their effectiveness may be reduced due to river water flowing around the ends of the walls and leakage through the wall joints.

The second type of collection system, a toe-drain collection system, consists of a horizontal perforated collection pipe installed in an excavated trench. The trench would be excavated along the site perimeter. The collection pipe is backfilled and surrounded by filter stone. The depth to which the collection piping would be installed would be slightly lower than the low water level in the river. This would create an inward hydraulic gradient that would reduce the potential of contaminated water discharging to the river. The perforated collection pipe would be graded to a collection sump. A submersible pump in the collection sump would transfer the collected groundwater/leachate mixture through a forcemain to some form of treatment system. The volume of river water entering the toe-drain system would be significantly less than a vertical well type of collection system. This alternative could be further optimized by installing a cut-off perimeter barrier wall on the river and West Stream side of the toe-drain. Toe-drain systems are typically more efficient (less river water collected) and favored over vertical well systems when site conditions permit their use. Site conditions at the Belle Park Landfill Site are conducive to the use of a toe-drain system due to the high water table and the limited depth of excavation that would be required.

The third type of collection system, strip drainage blankets, is a relatively new technique to collect contaminated groundwater/leachate. This type of system consists of a prefabricated drainage blanket installed in a narrow trench along the site perimeter. The drainage blanket is a two-component system consisting of a plastic cuspated core and covered by a geotextile filter fabric. The geotextile filter fabric allows ground water to pass through to the core while restricting the soil particles from entering, eliminating clogging of the core and drain pipe. The cuspated core collects the water and channels it to the designed exit or drain (a collection sump). The system would intercept and collect contaminated ground water before it reached the river. CH2M HILL has recently successfully used a drainage blanket system on a project site to intercept contaminated groundwater from entering an adjacent stream. The advantages of this type of collection system over the conventional toe drain system include lower installation cost, smaller equipment requirements, no entry of trench required, smaller trench excavation (less contaminated material excavated for disposal), and the cut-off containment barrier wall is built into the drainage blanket (river water is prevented from entering the system). The applicability of using a drainage blanket system at the Belle Park Landfill Site would depend on the ability to excavate the required trench in the saturated waste materials that would be encountered. This system would also depend on the ability to prevent clogging of the geotextile drain fabric. Significant fouling of filter fabrics was encountered during previous extraction well installations at the site.

In comparing the three types of perimeter leachate collection systems, the drainage blanket system is likely to provide the highest level of containment, providing that installation and drainage performance concerns can be overcome. Installation of a demonstration length of drainage blanket could be undertaken to assess the feasibility of drainage blanket system at this site. The toe drain system is considered a more effective approach over vertical wells.

The advantages of using a perimeter leachate collection system include:

- Seeps and discharge of contaminated groundwater to the river is contained
- The system can be designed to prevent inflow of river water

The disadvantages of using a perimeter leachate collection system include:

- Operation and maintenance requirements for collection and treatment system
- Pilot-scale testing is required to select optimal type of collection system
- Excavation and management of waste materials required

Leachate Treatment at the Kingston WPCP

This remediation method addresses the treatment of groundwater/leachate collected by a perimeter leachate collection system. This treatment method involves discharging the collected groundwater/leachate to the sanitary sewer system for treatment at the Kingston Water Pollution Control Plant (WPCP). This is the current method being used to treat collected groundwater/leachate at the site.

Advantages of using the Kingston WPCP to treat groundwater/leachate include:

- Treatment system and infrastructure are already in place
- Proven treatment method
- Operation and maintenance effort is minimal
- Limited regulatory approvals required
- No disruption to existing site uses

Disadvantages of using the WPCP to treat groundwater/leachate include:

- WPCP capacity is used to treat landfill leachate instead of sanitary sewage (although the capacity of the upgraded WPCP is sufficient to handle landfill leachate volumes)
- Costs required to transfer collected groundwater/leachate to the sanitary sewer

Leachate Treatment at Onsite Conventional WPCP

An onsite WPCP could be designed to remove the specific parameters of concern from the leachate to the identified treatment levels. Selection of the treatment technology would be a function of the overall nature of the leachate (organic strength, other characteristics), the target discharge levels, and the volume to be treated.

Advantages of using an onsite WPCP to treat groundwater/leachate include:

- Treatment system is tailored to remove the specific parameters of concern
- Ability to directly monitor the quality of the treated effluent and calculate loads to the environment

Disadvantages of using an onsite plant to treat groundwater/leachate include:

- Perimeter collection of the leachate is required
- Likely to be relatively complex to operate and would require adequate staffing/training
- Significant capital cost increase over current method of treatment
- Duplicates existing treatment capacity within the City of Kingston
- Optimal treatment performance may be difficult to adjust to varying strength of leachate over time
- Bench-scale or pilot-scale testing may be required for some technologies
- This alternative is likely to require sewage works approval

Constructed Treatment Wetland

Wetlands have a proven capability of reducing a wide range of contaminants. The mechanisms for contaminant reduction that occur within the wetland include sorption onto soils, detritus, and plant material of metals and phosphorus; use of organic material and nutrients as a food source for bacteria and vegetation; and settling of suspended sediment, which can contain large loadings of contaminants. At the Belle Park landfill site, the wetland configuration could be one of or a combination of several approaches. Since the seepage is entering the river from numerous locations around the perimeter of the site, a perimeter wetland could be constructed. This would require the construction of a separating berm offshore within the Cataraqui River extending from the mainland to Belle Island on the north and south side of the landfill and then constructing a wetland within or adjacent to the existing West Stream. Thus, all seepage flow out of the landfill would be required to flow through the wetland, thereby reducing the contaminant load before entering the Cataraqui River.

Another approach would be to intercept the seepage flow using toe drains, wells, and/or barrier walls and pumping the contaminated groundwater flow to a wetland. This could be constructed on the landfill site to become a feature of the end use of Belle Park or adjacent to the landfill within the adjacent waters of the Cataraqui River similar to the description above, but likely adjacent to either the north or south shore of the landfill. A potential location for the treatment wetland would be within the bermed federal dredging disposal area at the north shore of the park, providing the necessary approvals could be obtained.

Advantages associated with the use of constructed wetlands to treat leachate include:

- Passive, low energy use
- Low operations and maintenance requirements compared to conventional treatment systems
- Capital costs tend to be somewhat lower than conventional treatment systems
- Aesthetic enhancement
- Recreational opportunities such as bird watching, walking, picnicking
- Replacing lost wetland habitat
- Permitting agencies have indicated support on other wetland projects

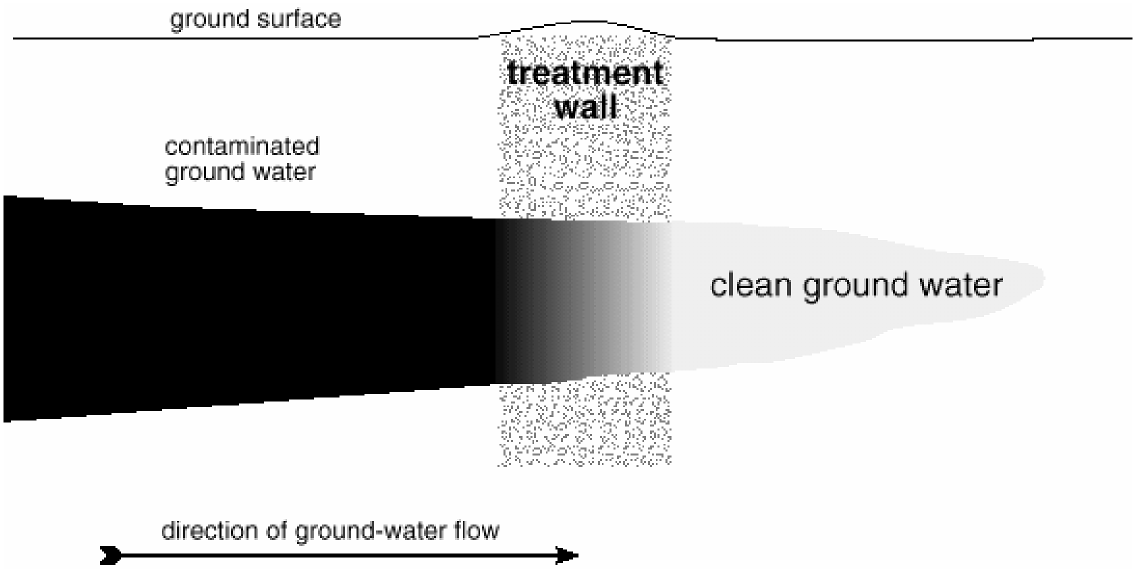
Disadvantages associated with the use of constructed wetlands to treat leachate include:

- Cold weather treatment efficiency is reduced for some contaminants
- Winter operations may be impacted by lowered Cataraqui River water level if constructed offshore and if reliance is on gravity flow into and through the wetland
- Limited cold weather treatment data for specific contaminants may require pilot testing
- Groundwater quality data is likely to change (increased concentration due to reduced impact by river water) once barriers are in place which would impact the treatment facility design
- Permitting can be a challenge depending on location of the wetland and predicted water quality improvement capability

In-Situ Treatment Using Treatment Walls

Treatment walls, also known as *passive treatment walls* or *permeable barriers*, are structures that would be installed underground to treat contaminated groundwater and leachate that is discharging into the Cataraqui River. Treatment walls are put in place by creating a trench across the flow path of contaminated groundwater and leachate. The trench is filled with a treatment media that is selected based on the specific types of contaminants present. As the contaminated groundwater passes through the treatment wall, the contaminants are treated through a variety of mechanisms that include adsorption, precipitation, and biodegradation (Figure 3-2).

FIGURE 3-2
SCHEMATIC DIAGRAM OF A TREATMENT WALL



The treatment media used in a treatment wall is often mixed with sand or some other porous material to make it less dense than the soil around it. This encourages groundwater to flow through the wall because it provides the path of least resistance. At some sites, an underground funnel system is added to direct the contaminated ground water to the wall. These systems are sometimes referred to as "funnel and gate systems". The funnel and gate system consists of an impermeable barrier wall (serving as the "funnel") that directs the contaminated groundwater to a permeable treatment wall (the "gate").

The specific treatment media chosen for a wall is based on the types of contaminants found at the site. For the Belle Park Landfill Site, iron and ammonia have been identified as contaminants of concern. The use of oxygen releasing compounds (ORCs) in the treatment media has potential for use since both of these contaminants can be treated by providing optimal treatment conditions. The iron in solution can be oxidized to form a solid precipitate, while the ammonia in solution can be biologically converted in the presence of oxygen to nitrate. The nitrate form of nitrogen, while not directly toxic to fish (ammonia form of nitrogen is toxic to fish), is likely to be a by-product of the treatment wall. The nitrate form of nitrogen acts to degrade water quality by contributing to algal blooms and eutrophication and may require added treatment in an anoxic zone using other media.

The advantages of using treatment walls include:

- Operation and maintenance efforts and costs are relatively low
- Relatively passive system once in place that treats contaminants in-situ
- No mechanical or hydro requirements to achieve treatment
- Existing site uses can be maintained

The disadvantages and limitations of treatment walls include:

- Pilot testing is required to select appropriate treatment media(s)
- The use of treatment walls to remove ammonia has not been demonstrated
- By-products of the treatment process (nitrates) may be problematic and require an added treatment stage
- Treatment media may be subject to blinding (pore spaces silting up), particularly by the iron precipitates
- Treatment media would regularly need to be excavated, disposed of, and then replaced based on predicted life of the media
- Monitoring would be required to confirm effectiveness
- Excavation and disposal of waste landfill materials would be required during installation
- Space limitations may limit the applicability of this method

In-Situ Treatment Using Injection of Oxygen Releasing Compounds (ORCs)

This in-situ treatment method consists of injecting ORCs into the waste materials, typically through injection well points installed in the area of contamination. The use of ORCs in permeable reactive barrier walls is also a method of application, as described in the previous section.

The use of ORCs in the treatment media has potential since both of the contaminants of concern, ammonia and iron, can be treated by providing oxidizing conditions. Proprietary ORCs typically include slow release magnesium peroxide. The iron in solution can be oxidized to form a solid precipitate, while the ammonia in solution can be biologically converted in the presence of oxygen to nitrate. The nitrate form of nitrogen, while not directly toxic to fish (ammonia form of nitrogen is toxic to fish), would be a by-product of this process. The nitrate form of nitrogen acts to degrade water quality by contributing to algae blooms and eutrophication and may require added treatment in an anoxic zone using other media.

This method is relatively new and application has typically been in the remediation of petroleum hydrocarbon contamination. In theory, this method may have some merit for the Belle Park Landfill site; however, pilot-scale testing would be a definite requirement.

Advantages associated with in-situ treatment using ORCs include:

- Excavation of waste materials is not required
- Capital and operation and maintenance costs are lower relative to most other methods

Disadvantages associated with in-situ treatment using ORCs include:

- A relatively new method with limited application in treating landfill leachate
- Some disturbance to existing uses depending on injection well grid spacing
- Microbial fouling and iron precipitation at injection point may be problematic
- Difficulty in achieving an even distribution of ORCs in heterogeneous waste materials
- A longer-term passive treatment process
- Contaminant discharges to river would be reduced but may not be eliminated
- Long-term monitoring would be required
- Pilot testing would be required
- Space limitations may also be an issue since waste materials exist close to the edge of the river. There will be no buffer/attenuation zone between the limit of landfilled waste and the edge of the river which is required for treatment to occur.

Monitored Natural Attenuation

Natural attenuation is an environmental site management method that has gained significant acceptance in recent years. The following description of natural attenuation was adapted from the USEPA Office of Solid Waste and Emergency Response.

Natural attenuation employs naturally occurring biological, chemical, and physical processes to reduce environmental contaminants in soils and groundwater. This passive, non-invasive remediation method effectively diminishes inorganic and organic contaminants, notably petroleum based compounds. However, natural attenuation is not the same as a "No Action" alternative; this method requires extensive, long-term site monitoring to ensure it is achieving established remediation goals.

The processes that contribute to natural attenuation through the destruction, stabilization, and transformation of inorganic and organic compounds are all present to some extent in the environment.

- **Biodegradation or bioremediation** – the breakdown of environmental contaminants by soil microorganisms.
- **Dilution** – the lowering of contaminant concentrations as the contaminants migrate away from the source.
- **Dispersion** – the lowering of contaminant concentrations as contaminants are scattered away from the source.
- **Absorption or adsorption** – the reduction of environmental contaminants due to contaminant incorporation and adhesion to soil particles.
- **Volatilization** – the reduction of environmental contaminants through vaporization or evaporation into the atmosphere.
- **Chemical transformation** – the breakdown of contaminants through a series of naturally occurring chemical reactions.

Monitored natural attenuation (MNA) is not a suitable remediation method for all contaminated sites. However, it is a means of addressing contamination under a limited set of circumstances, depending on site-specific data such as type, concentration, and interaction of contaminants and the biological, chemical, and physical characteristics of the site. In addition, this method can be combined with other environmental remediation technologies to address all contaminants at a site.

Where MNA is applicable, long-term monitoring must be conducted until the contaminants are no longer a threat to human health or the environment. The relatively slow progression of natural attenuation requires long-term monitoring to ensure that natural attenuation processes are performing as predicted and meeting established remediation goals.

Monitoring is conducted at frequencies to determine current site conditions, detecting changes in plume migration, resulting degradation byproducts, and increased risks to human health or the environment. In addition, long-term monitoring ascertains geochemical, hydro-geological, and microbiological changes that may decrease the progression rate of natural attenuation. If monitoring indicates natural attenuation is not working sufficiently to achieve established remediation goals within the set timeframe, then a more "active" remedial technology may be required to supplement natural attenuation and meet site remediation objectives. To fully implement the MNA approach, all current active groundwater collection and treatment efforts would be stopped and the system monitored to determine if they would need to be re-activated. The use of MNA at the Belle Park Landfill is doubtful given the litigation history and the results of recent environmental studies for the site.

Advantages of MNA include:

- Generates less remediation waste, reduces exposure, and limits environmental disturbance
- Can be utilized in conjunction with more active methods
- Site evaluation/characterization, that is often complex and costly, has been completed
- Has the potential to reduce remediation costs compared to more active remediation methods

Disadvantages and Limitations of MNA include:

- May require a much longer time frame to achieve established remediation goals
- Site characteristics may change over time, which may require the implementation of a more active remediation method
- Required long-term monitoring might become more extensive over time
- MNA cannot be relied on at this site as an exclusive approach
- Public perception as a Do-Nothing alternative

Risk Assessment

Risk assessment (RA) is a recognized management strategy for sites containing contaminants at concentrations exceeding generic standards, as established in the MOE

Guidelines for Use at Contaminated Sites (1997) and more recently by O.Reg. 153/04. The objective of this process is to establish risk-based criteria based on site-specific factors. Since the generic standards are based on the lowest unacceptable risk level for a variety of exposure scenarios that may or may not be applicable to a site, they may represent more stringent limits than are warranted for a site. In many cases, an RA may demonstrate to the MOE that a reduced level of risk is associated with a particular contaminant. As a result, remedial requirements for managing contaminants may be less onerous than if generic criteria are applied to a site.

It is noted that Welburn Consulting conducted a Site-Specific Risk Assessment (SSRA) was conducted for the site in 1999, using criteria from the MOE's Guideline for Use at Contaminated Sites (1997). In general, the SSRA findings indicated that risks to human health were acceptable, provided exposed wastes remained covered. The ecological portion of the SSRA did not identify any unacceptable risks; however, additional studies were recommended. Subsequent work to the SSRA to investigate the impacts of the site on the surrounding environment included the *Sediment and Benthic Macro Invertebrate Study of the Kingston Inner Harbour* (Malroz, 2005) and the *Project Trackdown Study: Assessment of PCBs in Nearshore Groundwater, Final Report* (City of Kingston, 2005). As Section 1 summarized, the results of these studies in general supported the findings of the SSRA. With respect to the Belle Park Landfill Site, the results of the SSRA may be used to support the comprehensive remediation approach recommended.

Advantages of Risk Assessment as a management strategy include:

- Remediation is risk driven, according to site-specific attributes. The use of risk assessment has the potential to generate less remediation waste, reduce exposure, and limits environmental disturbance
- Can be the sole management strategy or utilized in conjunction with more active methods
- Site evaluation/characterization, that is often complex and costly, has been completed
- Has the potential to reduce remediation costs compared to more active remediation methods

Disadvantages and Limitations of Risk Assessment include:

- Site use limitations are possible
- Public perception as a Do-Nothing alternative

Screening of Conceptual Remediation Methods

The conceptual remediation methods described above were screened using two criteria - effectiveness, and compliance with Government Regulation, which served as the screening criteria for the remediation methods. Table 3.1 details the result of the screening of remediation methods.

In summary, the following remediation methods met the screening criteria as primary remediation methods:

- Waste Removal and Offsite Disposal
- Constructed Treatment Wetland

Although the Engineered Low Permeability Clay Cap/HDPE Liner did not satisfy the screening criteria, it has been retained as a primary remediation method to serve as a conventional benchmark technology for comparison purposes. It would be subjected to the detailed evaluation to serve as a baseline to compare with the other comprehensive remediation alternatives.

While not identified as primary remediation methods, the following remediation methods were identified as having the potential to provide additional enhancing protective features:

- Onsite Waste Consolidation
- Engineered Low Permeability Clay Cap/HDPE Liner
- Vegetative Cap
- Containment Barrier Wall
- Leachate Collection
- Leachate Treatment at the Kingston WPCP
- Leachate Treatment at an Onsite Conventional WPCP
- Constructed Treatment Wetland
- Risk Assessment

These methods, when combined, also have the potential to become primary remediation methods. The following combinations of methods satisfy the technical effectiveness and compliance with government regulations/guidelines screening criteria:

- Perimeter Leachate Containment, Collection, and Treatment
- Maintain Existing Containment System (i.e. Leachate Collection, and Treatment at the Kingston WPCP)
- Hybrid Alternative(s): Various Remediation Methods Used at Individual Site Management Areas

TABLE 3.1
CONCEPTUAL REMEDIATION METHOD – DRAFT

Method	Exclusionary Screening Criteria		Category	
	Effectiveness *Does the conceptual remediation method have the potential to solve one or more aspects of the problem? (i.e. Can it contribute to a significant attenuation of unacceptable impacts on the environment on its own by way of reducing a component of the contaminant load?)*	**Compliance with Government Regulation and Guidelines** *Does the conceptual remediation method have the ability to achieve compliance with applicable agency regulations and guidelines relating to site management?*	**Selected as a Primary Remediation Method?**	**Selected as Enhancing Protection Feature?**
Waste Removal and Offsite Disposal	Yes, this method has the potential to be very effective. Waste removal could be effective in the long term in preventing contaminant discharge to the river.	Yes, compliance would likely be achieved. However, significant regulatory approvals including alteration of a landfill (MOE), fill permit (Conservation Authority), alteration of fish habitat (MNR) would be required including the identification of a existing or possibly a new landfill site to accommodate excavated waste and potentially extensive restoration efforts to re-establish former marsh habitat.	Yes	No
Onsite Waste Consolidation	No, this method alone would not be effective. Method could decrease footprint of area to be managed.	No, compliance would likely not be achieved since waste consolidation may have a limited impact on groundwater volumes or flows. Significant regulatory approvals would be required including alteration of a landfill (MOE), fill permit (conservation authority), alteration of fish habitat (MNR) would be required.	No	Yes
Engineered Clay Cap/HDPE Liner 1) *Over Entire Site* 2) *Over Selected Areas of the Site*	No, this method alone would not be effective. Method could be effective in reducing infiltration of precipitation, a minor contributor to groundwater (max. of 10 to 25% based on existing water balance modeling). However, the method will not impact horizontal movement of groundwater flow through the site that produces much of the leachate generated at the site.	No, compliance could not be achieved since a cap would have no impact on groundwater volumes or flows. Regulatory approvals would be required for altering a closed landfill site (MOE) and fill permit (Conservation Authority).	Yes (due to court order)	Yes
Vegetative Cap	No, this method alone would not be effective. Method could be effective in reducing infiltration of precipitation, a minor contributor to groundwater (max. of 10 to 25% based on existing water balance modeling). However, even with root penetration into the groundwater, this method is likely not going to significantly impact horizontal movement of groundwater flow through the site that produces much of the leachate generated at the site.	No, compliance would not be achieved since a cap may have a limited impact on groundwater volumes and flows.	No	Yes
Containment Barrier Wall 1) *Waterloo Barrier* 2) *Vibratory Beam Wall* 3) *Slurry Wall*	No, this method alone would not be effective. Method could be effective in preventing the flow of leachate into the river if system is extended around the site perimeter but leachate may build-up behind wall and overtop wall.	No, compliance would likely not be achieved since leachate contaminated groundwater would likely be discharged to the Great Cataraqui River if the leachate volume captured by the containment barrier wall exceeds the containment volume.	No	Yes
Leachate Collection 1) *Vertical Extraction Wells* 2) *Perimeter Toe Drain* 3) *Drainage Blanket*	No, this method alone would not be effective. Method could be effective in preventing leachate flow into the river if system is extended around the site perimeter. Shallow water table and the presence of an underlying low permeability layer favour the use of perimeter toe drains or the use of soil drainage blankets as compared to vertical wells.	No, compliance would likely not be achieved without leachate treatment.	No	Yes
Leachate Treatment at the Kingston WPCP	No, this method alone would not be effective. Method could be effective in treating leachate but requires a collection method.	No, compliance would likely not be achieved without leachate collection.	No	Yes
Leachate Treatment at an Onsite Conventional WPCP	No, this method alone would not be effective. Method could be effective in treating leachate but requires a collection method.	No, compliance would likely not be achieved without leachate collection.	No	Yes
Constructed Treatment Wetland	Yes, this method has the potential to be effective. Method could be effective in treating leachate. Configuration of constructed wetland may also facilitate collection of leachate. Pilot testing is recommended. Treatment effectiveness will vary by constituent particularly in the winter months.	Yes, compliance could be achieved. Ongoing monitoring would likely be required to assess regulatory compliance.	Yes	Yes
Insitu Treatment of Leachate Using Treatment Walls	No, this method does not have the potential to be effective for the contaminants of concern.	No, compliance would not be achieved.	No	No
Injection of ORCs into the waste material	No, this method would not be effective. Method is likely not practical given the large landfilled area, diverse waste characteristics (related to hydraulic conductivity) to evenly distribute the ORCs into the waste.	No, compliance would likely not be achieved in the short or medium term.	No	No
Monitored Natural Attenuation	No, this method would not be effective.	No, compliance would not be achieved.	No	No
Risk Assessment	A risk assessment can be used to assess the risk to human and ecological receptors. Based on the site conditions it is unlikely that a risk assessment will conclude that no action is needed.	No, compliance would not be achieved	No	Yes

4. Development and Screening of the Long List of Comprehensive Remediation Alternatives

The long list of comprehensive remediation alternatives for the site that were developed from the methods in the previous section include:

- Maintain Existing Containment System
- Waste Removal and Offsite Disposal
- Constructed Treatment Wetland
- Perimeter Leachate Containment, Collection, and Treatment
- Hybrid Alternative(s): Various Remediation Methods Used at Individual Site Management Areas
- Engineered Low Permeability Clay Cap (Retained as a conventional benchmark technology for comparison purposes)

Each of these comprehensive remediation alternatives are described further below.

Maintain Existing Containment System

This alternative essentially is the status quo alternative. Under this alternative, the existing perimeter collection wells, partial containment walls, and discharge for treatment to the sanitary sewer would continue to operate. Figure 4-1 shows the facilities associated with the existing containment system.

Providing a low permeability clay cap on areas of the site that have limited or no soil cover would continue on an as-required basis. Measures to reduce the operation and maintenance cost and effort could be considered such as providing remote controls and monitoring instrumentation. Selective planting of trees and shrubs would also benefit this alternative for reducing leachate volumes.

Waste Removal and Offsite Disposal

This alternative would consist of excavating waste materials at the Belle Park Landfill and disposing them at a Ministry of the Environment (MOE) approved disposal site. Upon removal of the waste materials, the site could be returned to its natural state or be redeveloped.

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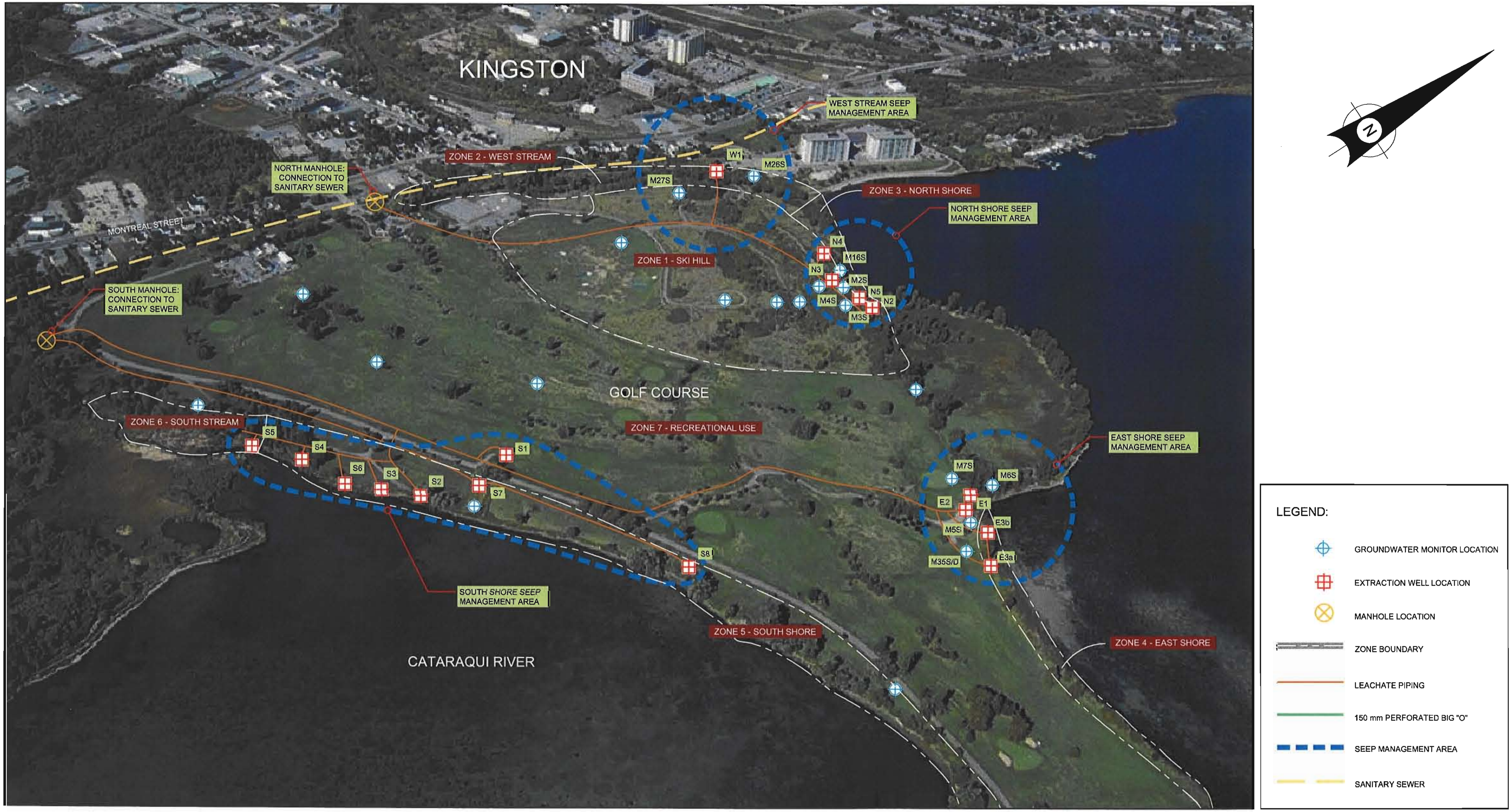

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BELLE PARK LANDFILL SITE SEEPAGE CONTROL

FIGURE 4-1
ALTERNATIVE #1
MAINTAIN EXISTING SYSTEM

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Constructed Treatment Wetland

This alternative would consist of constructing a wetland treatment system around the perimeter of the landfill site. This would require the construction of a separating berm offshore within the Cataraqui River, extending from the mainland to Belle Island on the north and south side of the landfill and then constructing a wetland within the existing West Stream. The constructed wetland treatment system would intercept seepage from the landfill and provide a treatment zone prior to discharge to the Cataraqui River, thereby reducing the contaminant load before entering the Cataraqui River. Figure 4-2 conceptually shows the constructed treatment wetland system.

Optional remediation methods that would act to enhance this alternative by providing additional environmental protection and/or cost savings include onsite waste consolidation, an engineered landfill cap, and/or high density planting of trees and shrubs and providing for no-mow areas on the site. Onsite waste consolidation would act to decrease the footprint of the landfill with the result of requiring a smaller wetland footprint around its perimeter. Capping the landfill using either a conventional clay cap or by high density vegetation plantings would act to decrease the volume of leachate discharging into the treatment wetland and may increase the hydraulic retention time and subsequently the treatment efficiency of the wetland by decreasing the hydraulic loading.

Perimeter Leachate Collection and Treatment

This alternative consists of the installation of a leachate collection system around the entire site perimeter and providing treatment for the collected leachate. This alternative is shown conceptually in Figure 4-3.

The technique that is considered most appropriate to contain and collect the leachate is by using drainage blankets, providing installation difficulties can be overcome, as discussed previously. In addition to efficiently providing a means to collect the leachate, the drainage blanket serves a secondary purpose in that it also provides a containment barrier along the site perimeter. The containment function of the drainage blanket acts to contain the leachate onsite and significantly reduces the flow of river water into the collection system.

To assess the impact of river water influx on the volume of leachate collected at the site, the Hydrogeologic Evaluation of Landfill Performance (HELP) was used. The HELP model is a water balance model that is used, among other things, to estimate the volume of leachate generated at a landfill site. The model uses climate data in conjunction with landfill configuration, area, and soil information to provide a water balance prediction for a given landfill site. The model was run using historical climate data for the City of Kingston, the current typical soil cover conditions, and the full area (44 ha) of the site. The HELP model output (Appendix B) provides a year by year water balance prediction for a 20-year period. The 20-year average annual volume of leachate generated is estimated to be approximately 100,000 m^3 per year or approximately an average of 275 m^3/day of leachate. This estimated leachate generation rate assumes that river water can be prevented from entering the collection system. In comparison, the current partial collection system typically collects leachate at a rate of 1,000 m^3 per day in the summer and 300 m^3/day in the winter, indicating that a significant quantity of river water is currently entering the existing collection system. Therefore, an important objective in the design of this alternative should be to minimize the influx of river water to the leachate collection system.

LEGEND:

PLAN VIEW

- EXISTING WETLAND
- CONSTRUCTED TREATMENT WETLAND
- BREAKWALL AND BERM
- ZONE BOUNDARY
- LEVEL CONTROL / DISCHARGE STRUCTURE

SECTION

- CLAY
- COVER MATERIAL
- WASTE
- NATIVE MATERIAL
- WATER

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FIGURE 4-2
ALTERNATIVE #2
CONSTRUCTED TREATMENT WETLAND

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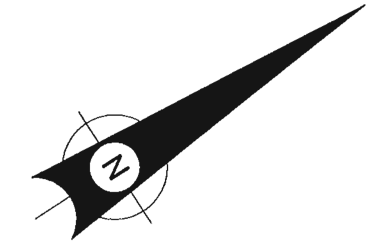
24 MAY 2006



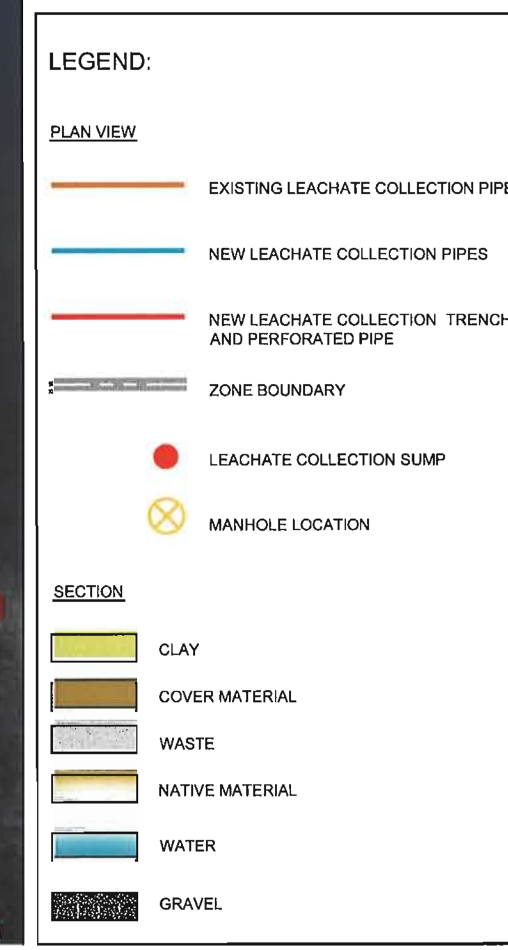


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FIGURE 4-3
ALTERNATIVE #3 - PERIMETER LEACHATE COLLECTION AND TREATMENT

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Three treatment methods have been identified to treat the collected leachate including the Kingston WPCP, an onsite conventional leachate treatment plant, or a constructed wetland treatment system. There is an existing wetland within the federal dredged sediment containment facility along the north edge of Belle Park that could be considered as a potential footprint of an established wetland that could be incorporated into the final design of this alternative if a wetland is to be considered for treatment. However, CH2M HILL recommends that the Kingston WPCP be selected as the treatment method, since the distribution piping is already partially in place and the WPCP has the capacity to treat the volume of leachate collected, particularly if the volume is reduced due to the barrier wall. The City of Kingston indicated that the Ravensview WPCP has sufficient capacity to treat the landfill leachate, in part due to recently completed upgrades to the WPCP.

Optional remediation methods that would act to enhance this alternative by providing additional environmental protection and/or cost savings include onsite waste consolidation, an engineered landfill cap and/or selected areas of dense shrub/tree plantings. Onsite waste consolidation would act to decrease the footprint of the landfill and decrease the length of the perimeter leachate collection system. Capping the landfill using either a conventional clay cap or vegetative plantings would act to decrease the volume of leachate collected and subsequently treated.

Hybrid Alternative(s): Various Remediation Methods Used at Individual Site Management Areas

This alternative would consist of applying various remediation methods (which passed the screening criteria) to individual site management areas. Malroz (1999) previously divided the site into eight distinct site management zones (SMZs) based on features that included land use, topography, groundwater quality, waste depth, waste type, and the presence/absence of active seeps. The eight distinct SMZs are shown in Figure 4-4. This alternative has the advantage of matching the variable site characteristics to the most suitable remediation method, as opposed to implementing the same remediation method to all parts of the site.

The method best suited to each SMZ was determined based on a review of the characteristics of each SMZ as defined previously by Malroz (1999). A review of the performance and effectiveness of full and pilot scale mitigation measures that have been used to date at the site was also used to select the most appropriate method for each SMZ. Table 4.1 summarizes the primary remediation method best suited to each individual SMZ, also shown in Figure 4-4. In addition to the primary remediation method selected for each SMZ, Table 4.1 also identifies enhancing protective features.

Engineered Low Permeability Clay Cap

This alternative consists of placing an engineered low permeability clay cap over the entire site, as shown in Figure 4-5. As the previous section discussed, this alternative did not meet the exclusionary screening criteria as a remediation method; however, it will be retained and evaluated as a comprehensive remediation alternative to serve as a conventional benchmark technology for comparison purposes.

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FIGURE 4-4
ALTERNATIVE #4
HYBRID ALTERNATIVE

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TABLE 4.1
HYBRID ALTERNATIVE

Zone	Description	Primary Remediation Method	Optional Methods Considered	Enhancing Protective Features
1	Ski Hill	Dense Vegetative Tree/Shrub Plantings		
2	West Stream	Constructed Treatment Wetland	Perimeter Leachate Containment, Collection, and Treatment	Barrier Wall Dense Vegetative Tree/Shrub Plantings
3	North Shore	Perimeter Leachate Containment, Collection, and Treatment	Constructed Treatment Wetland	Barrier Wall Dense Vegetative Tree/Shrub Plantings
4	East Edge (adjacent to Belle Island)	Perimeter Leachate Containment, Collection, and Treatment	Constructed Treatment Wetland	Barrier Wall Dense Vegetative Tree/Shrub Plantings
5	South Shore	Perimeter Leachate Containment, Collection, and Treatment	Constructed Treatment Wetland	Barrier Wall Dense Vegetative Tree/Shrub Plantings
6	South Stream	Constructed Treatment Wetland	Perimeter Leachate Containment, Collection, and Treatment	Barrier Wall Dense Vegetative Tree/Shrub Plantings
7	Golf Course	Dense Vegetative Tree/Shrub Plantings in Selected Areas		Creating no-mow naturalized areas to increase ET
8	Belle Island	No Action		

LEGEND:

CLAY TOP

ZONE BOUNDARY

FUTURE LAND USE TO BE DETERMINED. OPTIONS INCLUDE:

1. GOLF COURSE
2. TRAILS
3. PARKLAND

(BASED ON FUNDING AVAILABILITY)

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FIGURE 4-5
ALTERNATIVE #5
CLAY CAP

Current standards in Ontario for newly developed engineered municipal landfills require a minimum of 0.6 m of capping soil overlain by a minimum of 0.15 m of topsoil, which is required to support a vegetative or grassed cover. Prior to placement of the clay cap, site preparation activities would be required such as clearing and grubbing, grading, and removal/decommissioning of existing facilities. Following site preparation, approximately 264,000 m^3 of clay and 66,000 m^3 of topsoil would be required to be transported to and placed over the site and then the site vegetated to meet current provincial capping standards for newly developed municipal landfills.

Screening of Long List of Comprehensive Remediation Alternatives

The comprehensive remediation alternatives described in the previous section were screened to a short list using the two screening criteria: Technical Effectiveness and Anticipated Public Support. Table 4.2 details results of the screening of comprehensive remediation alternatives.

In summary, the following short list of comprehensive remediation alternatives methods met the screening criteria as primary remediation methods:

- Alternative 1: Maintain Existing Containment System
- Alternative 2: Constructed Treatment Wetland
- Alternative 3: Perimeter Leachate Collection and Treatment
- Alternative 4: Hybrid Alternative - Various Remediation Methods Used for Each SMZ

As previously discussed, the Engineered Low Permeability Clay Cap did not meet the screening criteria but will be retained as Alternative 5 and evaluated as a conventional benchmark technology for comparison purposes.

TABLE 4.2
SCREENING OF LONG LIST OF COMPREHENSIVE REMEDIATION ALTERNATIVES – DRAFT

Comprehensive Remediation Alternatives	Exclusionary Screening Criteria		
	Technical Effectiveness *Ability of the alternative to satisfactorily control discharge quality on a regular and reliable basis.*	**Anticipated Public Support** *Is the comprehensive remediation alternative likely to receive public support?*	**Satisfies Screening Criteria?**
Maintain Existing Containment System	Yes, this alternative has the potential to be effective in satisfactorily controlling discharges to the river in the long term. The existing system is effective in preventing discharge of an estimated 75% of seepage from the site (Malroz ref.). The existing system is inefficient, since a significant amount of water treated is estimated to be river water (Malroz ref.).	Yes, this alternative appears to be compatible with community environmental values and is likely to receive public support once fully explained. This alternative may be viewed (albeit incorrectly) as a Do-Nothing alternative. Do Nothing would include shutting down the current controls.	Yes
Waste Removal and Offsite Disposal	Yes, this alternative would likely be effective, once implemented, in satisfactorily controlling discharges to the river permanently.	No, this alternative would not likely receive public support. There are several public support issues that would need to be addressed. Existing site uses by the public would be discontinued or adjusted (e.g. adding a boardwalk) unless the site is restored to its current state. During waste removal, there would be public concerns related to air quality, truck traffic, disposal location, and negative impact to river water quality. The anticipated high cost of this alternative is another concern that the public may have.	No
Constructed Treatment Wetland With Optional Enhancements[1]	Yes, this alternative has the potential to be effective at controlling seepage to the river. A number of technical concerns will need to be addressed. The area available to provide a wetland zone that will adequately treat seepage may be limited. Pilot-scale testing would be required. Limited treatment during winter months. Iron staining likely to continue during winter.	Yes, this alternative may receive public support. Existing recreational uses would continue and, in fact, be broadened due to the added wetlands feature and potential wetlands walkway along the berm if the City opens this up to public access (liability issues). Wetland is consistent with the natural setting of the site. Wetland is likely to be viewed as aesthetically beneficial.	Yes
Hybrid Alternative(s): Various Remediation Methods Used at Individual Site Management Areas	Yes, this alternative has the potential to be effective at controlling seepage to the river depending on the mix of methods applied. This alternative requires further definition.	Yes, this alternative may receive public support. This alternative would likely not interfere significantly with existing recreational uses of the site and may, in fact, enhance the site features with added vegetation for wildlife habitat.	Yes
Perimeter Leachate Containment, Collection and Treatment[2] With Optional Enhancements[1]	Yes, this alternative has the potential to be effective at controlling seepage to the river. Pilot-scale testing may be required.	Yes, this alternative may receive public support. This alternative would likely not interfere significantly with existing recreational uses of the site.	Yes

Notes: [1] Optional enhancements provide additional environmental protection or cost benefits and include one or more of the following: Onsite Waste Consolidation, Engineered Clay Cap, Dense Vegetative Plantings
[2] Leachate treatment is required using one of the following: Kingston WPCP, Conventional Onsite WPCP, Constructed Treatment Wetland

5. Detailed Evaluation of the Short Listed Comprehensive Remediation Alternatives

As outlined in Section 2, the next step in the assessment process is to evaluate the short-listed comprehensive remediation alternatives presented in Section 4. The detailed evaluation criteria identified in Section 2 are used as a basis for the evaluation and comparison of the alternatives. Table 5.1 summarizes the detailed evaluation of each of the five short-listed comprehensive remediation alternatives, which are discussed in further detail below.

Detailed Evaluation of Each Alternative

Alternative 1: Maintain Existing Containment System

Technical Considerations

The existing system has been proven to be effective at mitigating point source leachate seeps around the perimeter of the landfill. The existing system can be considered reliable, provided that on-going monitoring and maintenance work is carried out.

The existing system does not provide complete containment of the leachate and diffuse seepage to the river does occur. There is the potential for point source leachate seeps to develop at new locations in the future, which may require the expansion of the existing system.

This alternative ranks high in terms of ease of implementation, since it is already installed and fully operational. Minor changes to the existing system could be considered, such as measures to prevent and limit the amount of river water that is collected by the system, measures that can be used to reduce the volume of leachate produced (i.e. dense vegetative plantings), and upgrades to automate the monitoring and control of the existing pumping system and flow measurement network.

Regulatory Considerations

The existing system has been proven to be protective of, and has prevented adverse effects to, the environment, based on eight years of monitoring data and the results of recent benthic and PCB studies of harbour sediments. The existing system is compliant with current federal and provincial environmental regulations.

Cost Considerations

Under this alternative, capital costs would be negligible, as the existing system is already in place and operating. Minor upgrades to optimize the existing containment system could be considered. These could include additional site grading to promote runoff from low-lying areas and additional barrier walls to reduce the amount of river water that is entering the

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Table 5.1
Composite Scoring of Short Listed Comprehensive Remediation Alternatives

Evaluation Criteria	*Criteria Weight (A)*	Alternative 1: Maintain Existing Containment System			Alternative 2: Constructed Treatment Wetland			Alternative 3: Perimeter Leachate Collection and Offsite Treatment			Alternative 4: Hybrid Alternative			Alternative 5: Clay Cap		
		Assigned Score (B)	Composite Score = (A) x (B)	Comment	Assigned Score (C)	Composite Score = (A) x (C)	Comment	Assigned Score (D)	Composite Score = (A) x (D)	Comment	Assigned Score (E)	Composite Score = (A) x (E)	Comment	Assigned Score (F)	Composite Score = (A) x (F)	Comment
Technical Considerations																
Maximize Reliability (baseline is assigned 0 [zero], i.e. no interception/treatment – pre-1997)	8.3	7	58.1	Reliable based on recent testing. There is the potential for future leachate seepage at new breakout locations. There is not complete containment and	8	66.4	Highly reliable during spring, summer, and fall but poor ammonia removal during the winter. A long hydraulic retention time or added aeration will help provide required water quality improvement.	10	83	Installation of a barrier wall and collection system will provide the highest level of contaminant reduction to the river of all the alternatives.	9	74.7	Installation of selected additional barrier wall sections tied in with the current collection system, poplar tree plantations, and wetlands will provide a very high level of contaminant reduction to the river and will be very close to that of	7	58.1	On its own, capping does not address the seepage problem since the groundwater flow issue represents the majority of the current contaminant problem. It has been assumed that the existing system will continue to be operated and therefore
Compatibility with Existing Systems	6.7	10	67	This is the existing system.	5	33.5	Existing system will not be required. However, the existing system could be utilized during the winter period only or as a backup, as required.	5	33.5	Some of the existing piping/infrastructure/electrical may be incorporated into the design.	9	60.3	Existing piping will be maintained and added to. Could also provide winter backup for the natural treatment areas.	8	53.6	The existing system, which is currently addressing the majority of the contaminant problem, could continue to be operated to provide some reasonable level of protection.
Maximize Ease of Implementation	7.7	9	69.3	Minor changes may be required, otherwise already implemented.	5	38.5	Construction of berm into the river around the perimeter of the project site will provide some challenge, but not insurmountable. The south shore is a high energy area (wind/waves).	5	38.5	Tree removal and piping, manhole, and pump installation may have some small level of complexity. Excavation and management of waste onsite/offsite must be addressed.	7	53.9	Some small challenge to this approach will be related to the implementation of the wetland within the West Stream and the impact on the golf course during the installation of the stands of poplar trees.	4	30.8	This is a straightforward clearing and grubbing, and earth moving exercise. Disposal and management of the large volume of waste trees and brush may be a challenge depending on the management method. Requires importing of soil and working around the current collection system and then revegetating the entire site. Regrowth will be a long-term effort. Locating a clay borrow source may be difficult without significant trucking. Traffic issues with the large volume of truck traffic
Regulatory Considerations																
Minimize Duration of Approval (baseline is assigned 5 [five], i.e. current conditions)	7.7	5	38.5	While this alternative may appear to be a "do nothing" approach by the agencies and public, the 8 years of monitoring data has demonstrated that this system has been effective and can be a long-term solution. The system provides for interception and treatment of the majority of the leachate with some diffuse seepage producing a minimal discharge to the environment.	3	23.1	The approval process may be a challenge since the MOE has had a mixed reaction to constructed treatment wetland projects in the past – assuming worst case scenario if wetland is to be relied on through the winter months. C of A may be granted on a provisional basis since this approach represents a major change to the current approach and since it would be releasing the treated water to the environment directly rather than being treated at a conventional WWTP. The wetland system may also require a backup system that could be the current system.	8	61.6	Due to the reliability of this approach and the system would not be discharging to the environment, MOE approval efforts are anticipated to be minimized.	7	53.9	Due to the reliability of this approach, MOE approval efforts are anticipated to be minimized with some added effort to qualify the use of the wetland and poplar tree technologies. The system provides for interception and treatment of the majority of the leachate with some diffuse seepage producing a minimal, but less than in Alternative #1, discharge to the environment. This approach may require the demonstration of reduced groundwater flow due to interception by the poplar tree roots that are anticipated will likely reduce pumping requirements reducing the cost of O&M.	1	7.7	With a cap alone, the approval process will likely reject this approach since it does not address the problem to a sufficient degree. Loss of or impact on the floodplain will extend to the 76 m contour and based on previous experience with the installation of the wetland along the north shore.
Maximize Regulatory Compliance	8.3	8	66.4	Already compliant based on testing.	7	58.1	Compliance is possible.	10	83	Due to the reliability of this approach, compliance is expected to be maximized.	9	74.7	Due to the reliability of this approach, compliance is expected to approach the maximum criteria.	1	8.3	Minimal regulatory compliance will be realized.
Cost Considerations																
Minimize O&M Costs (Net Present Value) 10 – <$1.0 M 9 – $1.0 M to $1.5 M 8 – $1.5 M to $2.0 M 7 – $2.0 M to $2.5 M 6 – $2.5 M to $3 M 5 – $3.0 M to $3.5 M 4 – $3.5 M to $4.0 M 3 – $4.0 M to $4.5 M 2 – $4.5 M to $5.0 M 1 – $5.0 M to $5.5 M 0 – >$5.5 M	7.5	3	22.5	NPV O&M costs: $4.2 M	8	60	NPV O&M Costs:$1.8 M (Assuming the passive wetland approach is used, O&M will be minimal. If aeration is incorporated and/or the existing system continued to be used through the winter months, O&M costs are increased. For costing, it has been assumed that the existing system will be required to be operated in the winter months.)	0	0	NPV O&M Costs: $7.3M (Additional pumping stations and power costs will add to the O&M requirements.	3	22.5	NPV O&M Costs: $4.4 M (The requirement to keep close vigil on the poplar trees to ensure they receive adequate water and are not impacted by rodents and disease in the first few years, as well as O&M on the wetland in the first years to ensure adequate growth and coverage of the wetland will add in the short term to the current O&M costs. However, the reduced generation of leachate due to infiltration reduction and interception of groundwater is likely to reduce pumping and hence O&M costs. May be able to shut off pumps during high ET periods if groundwater impact is minimal.)	2	15	NPV O&M Costs: $4.9 M (O&M will be mowing, erosion repairs, cap integrity monitoring, summer desiccation prevention, etc.)
Minimize Capital Costs 10 – <$100,000 9 – $100,000 to $1 M 8 – $1 M to $2 M 7 – $2 M to $3 M 6 – $3 M to $4 M 5 – $4 M to $5 M 4 – $5 M to $6 M 3 – $6 M to $7 M 2 – $7 M to $8 M 1 – $8 M to $9 M 0 – >$9 M	8.0	9	72	Capital Costs: $0.5 M (Site grading and automation upgrades required.)	6	48	Capital Costs: $4.0 M (Cost of implementation will be relatively high due to the need to work in open water)	7	56	Capital Costs: $2.4M	7	56	Capital Costs: $2.6 M (Added cost will be for tree planting, topsoil, and site preparation for the ski hill and golf course area, limited golf course reconstruction efforts, the construction of a treatment wetland in the south and west stream area, and testing alternative methods of leachate collection.)	1	8	Capital Costs: $8.4 M (Costs of completely capping the site as per current provincial landfill regulatory requirements for new or expanding sites.)
Social Considerations																
Maximize Public Acceptance	7.0	7	49	Public is currently accepting of existing system.	9	63	Public will generally be in favour of the improved recreational uses.	8	56	Similar to existing system.	7	49	Depending on the extent to which the poplar tree plantation encroaches on the golf course to maximize the leachate flow reduction, the golf course layout could be reduced to some extent.	1	7	Public acceptance will be negatively affected by increased truck traffic and disruption to existing site uses during the implementation stage
Maximize Public Safety	8.6	10	86	No added public risk once the system is installed.	8	68.8	Some risk to public safety if perimeter berm is open to the public (water access).	10	86	No added public risk once the system is installed.	10	86	No added public risk once the system is installed.	8	68.8	Since there will be no access during construction, no public safety will be compromised. Once the site is revegetated and public enjoyment amenities added, risk will likely be as it is currently. The new cap and limited vegetation could encourage offroad vehicle use.
Minimize Constraints to Current Recreational Use	8.8	9	79.2	Minimal impact on recreational use are currently experienced and are not expected to change.	10	88	Improves recreational use for walking and wildlife viewing, and general public enjoyment.	7	61.6	Once installed, there should be little if any constraint to the recreational use. However, the golf course will be required to be shut down for about one season during the construction.	9	79.2	Once installed, there should be little if any constraint to the recreational use, but rather an improvement due to added habitat features.	5	44	There will be a fairly long period of time before the site is revegetated, thus reducing the recreational use of the site. If the golf course is not rebuilt, the recreational use is reduced further.
Minimize Negative Impact to Private Property (baseline is assigned 5 (five), i.e. current conditions)	7.0	5	35	No change to current impact.	7	49	Wetlands have been known to add to property value.	5	35	No change to current impact.	6	42	No change to current impact. In fact, there may be an improvement to property values.	1	7	The construction process and the long revegetation process will likely have a negative effect on the adjacent private property.
Minimize Degradation to Visual Character (baseline is assigned 5 (five), i.e. current conditions) (Minimization is based on the short term of 5 years)	7.0	5	35	No change to current impact.	7	49	Wetlands add to the visual character.	5	35	No change to current impact.	6	42	No change to current impact. In fact, there may be an improvement to visual character.	1	7	Visual character will suffer for a period of time and then slowly be revived.
Natural Environment Considerations																
Maximize Improvement in Water Quality	7.6	8	60.8	Currently provides sufficient contaminant control.	8	60.8	Would provide sufficient contaminant control.	10	76	Maximizes water quality improvement capability.	9	68.4	Approaches maximum water quality improvement capability.	1	7.6	Little positive impact will be noted in the geochemistry. In fact, it will become degraded without the current collection system.
Maximize Improvement to Wildlife Habitat (baseline is assigned a value of 5 [five], i.e. current conditions) (Improvement is based on the short term of 5 years)	8.8	5	44	No improvement to habitat is currently a part of this alternative.	9	79.2	An entirely new habitat type will be created with the construction of the wetland.	5	44	No improvement to habitat.	9	79.2	Added wetland and poplar stands provide increased wetland and terrestrial habitat and diversity.	1	8.8	Terrestrial habitat will be in a degraded state until revegetation occurs and matures. This will likely be 10's of years. The site will also be mowed and manicured to allow for monitoring of the vegetated cap.
Minimize Disturbance to Floodplain (based on impact to entire Cataraqui River floodplain)	9.2	10	92	No change to current impact.	7	64.4	There will be some encroachment into the river that will reduce the water surface area of the river likely a small fraction of a percentage point.	10	92	No change to current impact.	9	82.8	Some small changes to current impact since some wetland sections may be developed into the Cataraqui River similar to those constructed along the north shore.	4	36.8	The toe of the cap would likely extend out into the river.
Minimize Disturbance of and Destruction to Existing Fish Habitat	9.2	10	92	No change to current impact.	2	18.4	Near shore fish habitat will be disturbed by the wetland construction, but can also be replaced during construction. There will be a net gain in fish habitat in the long term.	10	92	No change to current impact.	7	64.4	Little change to current impact with the exception of the West Stream conversion to a wetland may change the fish species using this water corridor as well as accessibility to the wetland by fish may be somewhat hampered.	5	46	Nearshore fish habitat will be covered where the cap extends into the river but could be restored. Stormwater runoff during construction and before vegetation is firmly established will negatively impact fish habitat if sediment controls become compromised.
TOTAL COMPOSITE SCORE			**967**			**868**			**933**			**989**			**415**	

Notes:
1. Criteria Weight (A) is the weighting assigned to each of the Evaluation Criteria during a workshop by attendees representing MOE, CRCA, MNR, KEAF, City Parks
2. Assigned Score (B), (C), (D), (E), (F) is the score assigned by the project team (CH2M HILL, Malroz, and City Environment Division based on engineering experience and understanding of the site constraints
3. Composite Score is the product of the Criteria Weight x Assigned Score
4. Each alternative represents a stand alone approach. The capping option (Alternative 5) was carried through to the alternatives section from the methods section at the request of the MOE during the June 28, 2005 workshop due the sentencing requirement that the City provide a capping plan to the MOE

existing containment system. An allowance of $500,000 in capital costs has been assumed for these minor changes.

O&M costs associated with the existing system include annual environmental monitoring, as well as costs associated with the maintenance of the existing system (monitoring of system performance, electricity, maintenance and repair/replacement of leachate pumps, maintenance of leachate collection piping and manholes, treatment of collected leachate at the WPCP, repair/placement of soil cover, address any potential future point source leachate seeps).

The City of Kingston reports that current operating costs are $75,000 per year for the annual environmental monitoring and $220,000 per year for the maintenance of the leachate collection system. Therefore, using these current estimated costs, the total annual operating costs associated with the existing system are estimated to be approximately $295,000. The net present value (NPV) costs associated with operation and maintenance of the existing system is estimated to be approximately $4.2 M (rounded to the nearest $100 K). The total NPV of capital and O&M costs is estimated at $4.7 M for this alternative.

The NPV calculations were based on an assumed effective interest rate of 5 percent and a planning horizon of 25 years. The 25-year period was selected based on the assumption that it is a reasonable period for budgetary planning purposes. This assumption will be used to estimate the NPV costs for each of the alternatives. Table 5.2 summarizes the costs associated with this alternative.

Social Considerations

In general, the public appears to be accepting of the existing system, provided it continues to be protective of the environment. The possibility of future point source leachate seeps at new locations could result in negative public perception with respect to the effectiveness of the existing system, particularly in the winter months when iron staining is obvious. Some members of the public may incorrectly perceive this to be a "Do Nothing" alternative.

Current uses of the site for golf, tennis, and hiking would be temporarily interrupted during regarding, seeding, and vegetation establishment under this alternative. Impacts to property values and the visual character obviously do not change from existing conditions under this alternative.

Natural Environment Considerations

The existing system is currently protective of the environment. Annual monitoring does not indicate that surface water quality is adversely impacted by the landfill. Since this alternative represents the status quo, there is no improvement to existing conditions with respect to fish and wildlife habitat improvement unless added vegetation is installed. There is no grading work or infilling associated with this alternative with the exception of some small areas due to minimal cover resulting in no changes to the floodplain impact. This alternative does not require changes to or destruction of existing fish habitat.

TABLE 5.2
ALTERNATIVE 1: MAINTAIN EXISTING SYSTEM COST BREAKDOWN

Item	Description	Subtotal Cost	Total Cost
A. Capital Costs			
1.	Estimated costs associated with minor upgrades to existing containment system	$500,000	
Total Capital Costs		$500,000	$500,000
B. O&M Costs			
1.	Annual Monitoring of the Belle Park Environment	$75,000	
2.	Annual Leachate Collection System Maintenance	$220,000	
Total Annual O&M Costs		$295,000	
Net Present Value of O&M Costs		$4,158,000	$4,158,000
Total NPV of Capital and O&M Costs			**$4,658,000**

Notes: 1. NPV costs represent net present value costs that have been calculated using an effective annual interest rate of 5% over a 25-year budget cycle.

Alternative 2: Constructed Treatment Wetland with Optional Enhancements

Technical Considerations

Constructed treatment wetlands have been proven to be highly effective during the active growing season. A concern with this alternative is that ammonia treatment would be minimal during the winter months. Over sizing the constructed wetland to provide longer retention times and possibly winter storage could be considered and/or adding aerators to the wetland are options that can be used to partially address winter operation concerns. Using this alternative, the existing leachate collection system (for example, Alternative #1) is not required; however, it could be retained as a backup system during the winter months. Retaining and maintaining the existing system would increase the cost associated with this alternative.

A challenge to implementing this alternative is the relatively deep waters surrounding the landfill site. Ideal water depths for a constructed wetland range from 300 mm to 600 mm and water depths in excess of several metres exist around portions of the far shore site perimeter. A wetland treatment feasibility study being conducted at the site has identified water depth as being a key issue with respect to the effectiveness of a full-scale constructed treatment wetland.

It is anticipated that an impermeable protective dike would need to be constructed in the river around the perimeter of the landfill site to provide a means to control water depths. This would help to ensure that the wetland can become established and would have a controlled outflow so that adequate retention times are achieved. The constructed dike would also protect the wetland from flooding and waves (particularly on the exposed south shore). Due to the depth of water and the length of the site perimeter, construction of this berm constitutes a major component of this alternative.

Regulatory Considerations

Due to the scope and nature of work anticipated with this alternative, regulatory requirements are extensive and the duration of approvals may be prolonged. Since this alternative requires the placement of significant volumes of material into the Cataraqui River to construct the protective berm and wetland, this project would likely need to follow the requirements of the federal Environmental Assessment Act. This alternative would affect fish habitat, change a navigable water body, and result in changes to the existing floodplain. This project would trigger approval requirements of the Department of Fisheries and Oceans (DFO), Canadian Coast Guard, Ministry of Natural Resources (MNR), MOE, and the Cataraqui River Conservation Authority (CRCA).

A Certificate of Approval would also be required for this alternative since the wetland would be classified as a treatment works and treated water would be released directly to the Cataraqui River from one or more point discharges. The C of A approval process could be a challenge since constructed wetlands have reduced treatment capacity for specific parameters during winter operation. The C of A would likely be granted on a provisional basis and would require long-term monitoring of effluent quality to confirm that the treatment wetland is providing an adequate level of treatment throughout the year. MOE concurrence with this alternative over the capping alternative would be required.

Cost Considerations

Capital costs associated with this alternative include construction of the protective perimeter berm and the construction of the treatment wetland itself. Engineering costs for this alternative were estimated at 15% of the total capital cost. Engineering and design work would include design of a protective containment berm that can withstand the appropriate (i.e. 100-year) design storm, design of the constructed wetland, tendering, construction administration, and oversight and inspection services during the construction phase. An allowance of $125,000 has also been made to address the extensive regulatory approvals process that is anticipated under this alternative.

Capital cost is estimated at $4.0M. O&M costs associated with this alternative include annual monitoring of the performance of constructed wetland which will likely be a requirement of the provisional C of A for this system. An annual allowance of $10,000 has been made to address maintenance of and repairs to the protective berm. A contingency of $100,000 has also been made in the event that the existing system needs to be utilized during the winter season. The costs associated with this alternative are summarized in Table 5.3. The net present value (NPV) costs associated with operation and maintenance of the existing system is estimated to be $1.8 M. The total NPV of capital and O&M costs is estimated at $5.8M for this alternative.

Social Considerations

It is anticipated that the public acceptance for this alternative would generally be high. Existing site uses such as golf and tennis can continue uninterrupted. Hiking and wildlife viewing would be enhanced after the wetland becomes established. Wetlands are generally considered to enhance the visual character of the area, which usually leads to increased property values.

A potential public concern issue is the increased truck traffic that would occur at the site during the construction of the perimeter containment berm. If the City allows access to it, the perimeter berm may pose some risk to public safety, due to water depths adjacent to the berm and the remoteness of it in case of emergency.

Natural Environment Considerations

This alternative would provide sufficient contaminant control and would be protective of surface water quality, provided winter operation challenges are addressed. The constructed wetland would act to replace a portion of the natural wetland habitat that existed prior to the existence of the landfill site.

During the construction stage, this alternative would be disruptive to fish habitat. The protective containment berm and constructed wetland, however, can be designed in a manner that would likely result in improvements to fish habitat over existing conditions. This alternative would result in the alteration of the existing floodplain. It is anticipated that this impact would not result in an increased flood risk, given the size of the affected floodplain in comparison to the overall size of the floodplain in the vicinity of the Belle Park Landfill Site. However, modelling would be required to confirm this assumption.

TABLE 5.3
ALTERNATIVE 2: CONSTRUCTED TREATMENT WETLAND COST BREAKDOWN

Item	Description	Subtotal Cost	Total Cost
A. Capital Costs			
1.	Construction of Protective Perimeter Berm		
	Supply and Place 62,500 m^3 of Earth	$950,000	
	Supply and Place Protective Armour Stone/Rip Rap (18,000 m^3)	$350,000	
	Supply and Place Overflow Structures (8)	$200,000	
2.	Constructed Treatment Wetland		
	a) Supply of Fill (80,000 m^3)	$1,200,000	
	b) Planting/Seeding 6.5 ha @ $20,000 per ha	$130,000	
3.	Conversion of the 2 ha West Stream to a Constructed Wetland (structures, earthworks, plantings) @ $100,000/ha	$200,000	
4.	Costs Associated with Dewatering in Preparation for Berm Installation, Challenges of Working within the River (health and safety, creating an impermeable dyke, fisheries considerations, etc.)	$300,000	
5.	Engineering Costs (15%)	$500,000	
6.	Regulatory Approvals (25% of engineering costs)	$125,000	
Total Capital Costs		**$3,955,000**	**$3,955,000**

TABLE 5.3
ALTERNATIVE 2: CONSTRUCTED TREATMENT WETLAND COST BREAKDOWN

Item	Description	Subtotal Cost	Total Cost
B. O&M Costs			
1.	Annual Monitoring of Effluent Quality and Water Level Controls	$10,000	
2.	Annual Maintenance of Protective Berm	$10,000	
3.	Contingency: Operation of Existing Containment System (winter)	$110,000	
Total Annual O&M Costs		**$130,000**	
Net Present Value of O&M Costs		$1,830,000	$1,830,000
Total NPV of Capital and O&M Costs (Excluding GST)			**$5,805,000**

Notes: 1. NPV costs represent net present value costs that have been calculated using an effective annual interest rate of 5% over a 25-year budget cycle.

Alternative 3: Perimeter Leachate Containment, Collection, and Treatment

Technical Considerations

This alternative consists of a leachate containment and collection system around the entire perimeter (approximately 3 km) of the landfill site. This alternative would result in the collection of point source as well as diffuse leachate seepage into the Cataraqui River. This alternative would be highly reliable, provided that on-going monitoring and maintenance work is carried out.

The infrastructure associated with the existing collection system could be incorporated into this alternative. Components of the existing containment system that could be utilized include power supply, existing wells, pumps, manholes, barrier walls, leachate pumping stations and forcemain piping.

In terms of implementing this alternative, no major obstacles are anticipated. Implementation issues associated with this alternative include tree removal requirements in certain areas of the site and the management/disposal of waste materials that are excavated during the installation of trenches, wells, and leachate collection piping.

Regulatory Considerations

There are no major concerns under this alternative with respect to regulatory considerations. Since complete leachate containment and collection is possible under this alternative, regulatory compliance would be achieved. Since the collected leachate would be treated at the WPCP and not to an onsite treatment system, there are no MOE regulatory approvals anticipated.

Cost Considerations

Under this alternative, capital costs associated with this alternative include extending the existing leachate collection system around the entire perimeter of the site. For the purposes of costing at this stage, it has been assumed that the existing leachate collection/containment system would continue to be used and service approximately 500 m of the estimated 3,000 m of site perimeter.

Alternative methods (to vertical extraction wells) of leachate collection and containment should be considered to minimize the amount of "clean" river water that enters the system. As Section 3 discussed, these could include the use of either horizontal toe drain systems or strip drainage blanket systems. Demonstration testing of these methods is recommended prior to implementing an alternative method full-scale.

Following the demonstration testing, the preferred method would be extended around the approximately 3 km of the site perimeter. Assuming that a strip drainage blanket system was demonstrated to be effective, capital costs would include installation of the strip drainage blanket, collection sumps and pumps, power supply to each pumping station, and adding to the existing leachate forcemain piping to the WPCP. Excavation work required under this alternative would result in an estimated 6,000 m^3 of soil/waste mixture. It is assumed that this waste will be managed onsite. Onsite management of excavated soil/ waste material would need to be confirmed from a regulatory perspective. The total capital costs for this alternative are estimated to be $2.4 M. As a comparison, the cost to date of the existing containment system, which services approximately 500 m of site perimeter, is $600,000.

Engineering costs for this alternative were estimated at 15% of the total capital cost. Engineering and design work would include design of the perimeter leachate collection system and associated works, tendering, construction administration, and oversight and inspection services during the construction phase.

O&M costs associated with this alternative include annual monitoring of the performance of the collection system, annual maintenance, and the cost of leachate treatment at the Kingston WPCP. The O&M costs of the operation of a full-scale leachate collection system have been estimated at double the current O&M costs of the existing system. Although this alternative provides leachate containment around the estimated 3 km site perimeter (compared to the current system which services 500 m), it is anticipated that considerable savings are possible due to the decreased volumes of leachate being pumped. Evaluation of the performance of this alternative on a demonstration scale would allow for a better estimate of the O&M costs of a full-scale system. The estimated annual O&M costs of this alternative are $515,000, which translates to a NPV O&M cost of $7.3 M. The total NPV cost of this alternative is estimated to be $9.7 M. The costs associated with this alternative are summarized in Table 5.4.

Social Considerations

In general, this alternative is anticipated to receive relatively high public acceptance. This alternative may eliminate the possibility of public complaints due to future point source leachate seeps and iron staining at new locations since they would no longer occur once the containment system is in place and operational.

The public may have a concern with respect to the costs associated with this alternative. Current uses of the site for golf, tennis, and hiking would remain once the alternative is implemented. It is anticipated that portions of or all of the golf course may be required to be closed for at least one season to allow for the completion of extensive construction. Staging of the work may be possible to allow limited use of the golf course during the construction work. Impacts to property values and the visual character would not change from existing conditions under this alternative once construction is completed.

Natural Environment Considerations

This alternative would provide complete contaminant control and would be completely protective of surface water degradation due to landfill leachate impacts. There would be no improvement to existing conditions with respect to fish and wildlife habitat improvement. There is a limited amount of infilling (approximately 6,000 m^3) if excavated soil/waste materials from the drainage blanket and leachate header trenches are managed onsite. The impacts to the floodplain would be minimal. This alternative does not require changes to or destruction of existing fish habitat.

Potential improvements to natural environment conditions are possible if dense vegetation plantings were added to this alternative as an enhancement. These plantings would provide infiltration control and would help to lower the volumes of leachate collected and treated.

TABLE 5.4
ALTERNATIVE 3: PERIMETER LEACHATE CONTAINMENT, COLLECTION, AND TREATMENT COST BREAKDOWN

Item	Description	Subtotal Cost	Total Cost
A. Capital Costs			
1.	Demonstration Testing of Alternative Leachate Collection/Containment Methods	$200,000	
2.	Leachate Collection System		
	a) Install 7,500 m^2 of Strip Drainage Blanket Including Crushed Stone Backfill	$900,000	
	b) Install 15 Leachate Collection Sumps Including Pumps	$300,000	
	c) Power Supply/Level Controls to Leachate Collection Sumps	$200,000	
	d) Install Additional Forcemain (2,000 m)	$300,000	
	e) Management of Excavated Waste Material Onsite (6,000 m^3)	$90,000	
	f) Site Restoration	$100,000	
3.	Engineering Costs (15%)	$310,000	
Total Capital Costs		**$2,400,000**	**$2,400,000**
B. O&M Costs			
1.	Annual Monitoring of System	$75,000	
2.	Annual Maintenance of System	$440,000	
Total Annual O&M Costs		**$515,000**	
Net Present Value of O&M Costs		$7,250,000	$7,250,000
Total NPV of Capital and O&M Costs (Excluding GST)			**$9,650,000**

Notes: 1. NPV costs represent net present value costs that have been calculated using an effective annual interest rate of 5% over a 25-year budget cycle.

Alternative 4: Hybrid Alternative – Various Remediation Methods Used for Each Site Management Zone (SMZ)

Technical Considerations

This alternative would consist of applying various remediation methods to each of the eight previously defined site management zones (SMZs). This alternative will likely be reliable and effective at mitigating leachate impacts on the river, as well as point source leachate seeps around the perimeter of the landfill. This alternative does not provide complete containment of the leachate; however, diffuse seepage to the river would be lessened in comparison to the existing system.

This alternative ranks moderately in terms of ease of implementation. The existing system (with possible improvements) is proposed for three of the seven site management zones requiring action. Constructed treatment wetlands and dense vegetative plantings/poplar tree capping would be used to address the remaining four site management zones. This work is relatively easy to implement and is now more commonly used as a leachate management strategy at other landfill sites. It would be necessary to demonstrate the effectiveness of the poplar tree capping prior to implementing this component of the overall strategy on a full scale. The City currently has several pilot studies underway on the site to test this approach.

Regulatory Considerations

Provided the MOE concurs with this alternative, there would be few other regulatory requirements. Altering the West and South Stream areas would require CRCA permits and approvals.

Cost Considerations

Under this alternative, a poplar tree cap would be installed over SMZ 1 (Ski Hill). Capital costs to install the tree cap include the placement of topsoil (assumed thickness of 60 cm) over the Ski Hill, site preparation work prior to planting, and the installation of poplar tree cuttings and mulch at a planting density 3 trees/m^2. Operation and maintenance of the tree cap will include thinning, pruning, and replanting. Harvesting of the trees on a regular basis could be considered for every 15 to 25 years, but would not be necessary, as the poplar clones will live to be 60+ years old. Natural succession of local tree species could be allowed to occur to maintain a treed cover.

The capital costs associated with installing a constructed treatment wetland in SMZs 2 (West Stream) and 6 (South Stream) include installing a constructed treatment wetland and a flow control structure at the point of discharge to the Cataraqui River. O&M costs associated with this alternative include annual monitoring of the performance of the constructed wetland.

The existing perimeter leachate treatment system would continue to be operated in SMZs 3, 4, and 5. As a result, there are no capital costs required in these SMZs; however, improvements to the existing system could be considered to lower the amount of river water that is currently entering. A demonstration length (approximately 200 m) of strip drainage blanket should be considered to evaluate this alternative method of leachate collection. For the purposes of costing, a $200,000 allowance has been included for testing only of potential alternative methods of leachate collection. Upon completion of demonstration testing, a cost/benefit analysis could be conducted to determine if the cost of installing an alternative method of leachate collection would be offset by cost reductions in operating costs (due to lower pumping rates). If the installation of an alternative method of leachate collection is deemed economically and technically viable in the future, then additional cost reductions are possible under this alternative, and full scale application could be considered in the future for SMZs 3, 4, and 5.

O&M costs associated with the existing leachate collection system are expected to decrease due to the decreased volumes of leachate once the poplar tree cap becomes established. Lower leachate volumes are anticipated due to the increase in evapotranspiration (ET) by the poplar tree cap. It is possible that leachate pumping will be reduced during the May to October period when ET rates are high. The actual reduction will depend on factors such as tree coverage area and tree planting locations which would be determined in the final design stage. For the purposes of costing this alternative, it has been assumed that annual O&M costs associated with the existing leachate collection system would be reduced on the order of 15% in comparison to the current O&M costs.

A poplar tree cap is the method selected under this alternative for the golf course/recreational area. Unlike the ski hill area, the trees would not be planted over the entire golf course. The poplars would be planted in a manner that would allow continued operation of and possibly enhance the existing golf course. Trees would be planted in strategic locations such as strips along fairways and adjacent to the river edge, and groupings adjacent to putting greens and tee-off locations. Trees plantings could be complimented by planting shrubs where tall growth is not preferred and open areas adjacent to the fairways could be seeded with native/no-mow grasses to increase the ET potential of the site. This alternative considers the reconfiguration of the golf course to maximize ET. It is estimated that the planted trees would cover approximately 10% of the estimated 26 ha golf course/recreation area. Similarly to the ski hill area, capital costs would include placement of topsoil (assumed thickness of 60 cm), site preparation work prior to planting, and the installation of poplar tree cuttings and mulch at a planting density three trees/m^2. Operation and maintenance of the tree cap will include thinning, pruning, and replanting. Harvesting of the trees on a regular basis could be considered for every 15 to 25 years, but would not be necessary as the poplar clones will live to be 60+ years old. Natural succession of local tree species could be allowed to occur to maintain a treed cover.

Engineering costs for this alternative have been estimated at 15% of the capital costs. Engineering costs include design of the constructed wetlands, layout and design of the poplar tree cap, design of the reconfigured golf course, evaluation of the performance of the demonstration leachate collection system, tendering, construction administration and inspection/monitoring.

The total capital costs of the Hybrid Alternative are estimated to be $2.6 M. The NPV of the O&M costs is estimated to be $4.4 M. Therefore, the total NPV cost for this alternative is estimated to be $7.0 M. Table 5.5 summarizes the costs associated with this alternative.

Social Considerations

Public acceptance for this alternative is expected to be relatively high. Additional trees/ shrubs planted on the ski hill and golf course, naturalized grassed areas, and the constructed treatment wetland will likely improve the aesthetics of the site. There is the potential to improve the layout and configuration of the golf course to help optimize the ET rates. This alternative poses no public risk during or after implementation. Current recreational uses can continue and are enhanced. Property values are not likely to be negatively affected and may in fact increase due to aesthetic improvements to the site. This alternative also offers a high potential benefit to the development of a waterfront walking trail as maturing trees will provide a physical screen and will protect walkers from errant golf balls.

Natural Environment Considerations

This alternative would be protective of surface water quality and would approach that of Alternative 3. The addition of the two constructed treatment wetland areas and the increased tree cover would improve and enhance wildlife habitat. The construction of the treatment wetland areas may result in a negligible impact to a small portion of the floodplain. There could be an impact on existing fish habitat in the west and south stream. These streams would be converted from a stream to a wetland. Fish species that currently access and use these water corridors may change.

TABLE 5.5
ALTERNATIVE 4: HYBRID ALTERNATIVE COST BREAKDOWN

Item	Description	Subtotal Cost	Total Cost
A. Capital Costs			
1.	Site Management Zone 1: Ski Hill		
	Topsoil (50,000 m^3)	$1,000,000	
	Site Prep	$100,000	
	Tree planting and mulching (27,000 trees)	$80,000	
2.	Site Management Zones 2, 6: West and South Stream		
	Constructed Treatment Wetland		
	2.5 ha @ $100,000 per ha	$250,000	
	Flow Control Structures (2)	$50,000	
3.	Site Management Zones 3, 4, 5: North, East, South Shores		
	a) 200 m Long Demonstration System	$200,000	
4.	Site Management Zone 7: Golf Course/Recreational Area		
	Topsoil (15,000 m^3)	$300,000	
	Site Prep	$30,000	
	Tree Planting and Mulching (9,000 trees)	$25,000	
	Golf Course Layout Redesign/Construction	$250,000	
5.	Engineering Costs (15%)	$300,000	
Total Capital Costs		**$2,585,000**	**$2,585,000**

TABLE 5.5
ALTERNATIVE 4: HYBRID ALTERNATIVE COST BREAKDOWN

Item	Description	Subtotal Cost	Total Cost
B. O&M Costs			
1.	Annual Monitoring	$75,000	
2.	Annual Maintenance of Existing Leachate Collection System	$185,000	
3.	Annual Maintenance of Poplar Tree Cap and Wetland	$25,000	
Total Annual O&M Costs		**$285,000**	
Net Present Value of Annual O&M Costs		$4,015,000	$4,015,000
Tree Harvesting/Replanting Each 25-Year Period (10.6 ha) NPV Cost		350,000	$350,000
Total NPV of Capital and O&M Costs (Excluding GST)			**$6,950,000**

Notes: 1. NPV costs represent net present value costs that have been calculated using an effective annual interest rate of 5% over a 25-year budget cycle.

Alternative 5: Low Permeability Clay Cap

Technical Considerations

The installation of a low permeability clay cap alone will likely significantly reduce the volume of leachate that is generated as the result of the infiltration of precipitation into the landfill cover. However, due to the horizontal flow of leachate-impacted groundwater into the river, significant leachate seeps could continue to occur after capping. Groundwater levels fluctuate at the site depending on the river water level. During high river water levels (such as spring and late fall), there is an inward gradient from the river into the landfill subsurface. River water essentially flows from the river into and through the landfilled waste causing leachate level in the landfill to rise. During lower surface water levels (such as late summer and winter) the gradient reverses outward and landfill leachate seeps into the river. A clay cap would not prevent this from happening and leachate seeps could continue to occur.

To address leachate seeps during low surface water levels, the existing containment system could be used as required. This alternative has some negative aspects associated with the ease of implementation. This alternative requires shipping a significant volume of capping and topsoil material (estimated 330,000 m^3). Locating a suitable clay borrow source may be difficult without excessive trucking effort. If the existing leachate collection system is to be maintained, modifications will likely be required to maintain access to manholes and control valves. A significant volume of tree brush requires disposal/chipping. The heavy volume of truck traffic hauling capping materials to the site would need to be managed.

Regulatory Considerations

Regulatory approvals to cap the site would be minimal However MOE, MNR, and DFO concurrence with this alternative as a stand-alone approach to solving the problem is unlikely in the long-term, since leachate discharge to the river would continue to occur. Capping the site alone will likely not result in compliance with the relevant acts and regulations administered by the MOE, MNR, and DFO. Future legal proceedings against the City of Kingston are possible under this alternative.

Cost Considerations

Capital costs associated with this alternative include decommissioning and removing the existing recreational facilities including the golf course/buildings, tennis courts, and walking trails. Alterations to the existing leachate collection system would be required such as extending access manholes and valve chambers. Existing trees and brush would need to be removed from the site during clearing and grubbing operations. Approximately 264,000 m^3 (60 cm thick) of suitable clay cap soil would need to be hauled to the site, graded and compacted. To support a grassed vegetative cover, approximately 66,000 m^3 of topsoil would be supplied and placed to a thickness of 15 cm. The site would then need to be hydroseeded, mulched, and fertilized. Trees and shrubs would be required to add natural features to the site for public enjoyment and wildlife habitat creation. The cost of reconstructing the golf course, tennis courts, walking trails, and access roads have not been included in the costing but could be readily estimated if required. Engineering costs have been estimated at 10% of the capital costs (due to the decreased level of complexity associated with the design of this alternative) and would include tendering, construction administration, compaction and material testing, final grading plan design, and construction inspection.

O&M costs associated with this alternative include annual groundwater and surface water monitoring. Maintenance of the clay cap would be required and would include repair of erosion damage and maintenance of the grassed cover. It is anticipated that the existing leachate collection system would need to be maintained to address leachate seeps. Based on the HELP modeling discussed in Section 4, it is expected that the existing leachate collection system would have to maintain pumping rates only slightly less than current rates due to the large volumes of river water that are currently being pumped. The clay cap would do little to alleviate this problem; therefore, the current O&M costs associated with the leachate collection system have been used for this alternative.

The capital costs for this alternative have been estimated at $8.4 M. Annual O&M costs are estimated to be $345,000 per year which translates to a NPV for O&M costs of approximately $4.9 M. The total NPV cost of this alternative is $13.3 M. As a reference point, the cost of rebuilding the golf course and buildings as well as tennis courts, trails, and access roads is likely to be in the $5–7 M range but has not been included in the cost opinion. Table 5.6 summarizes the costs associated with this alternative.

Social Considerations

Public acceptance of this alternative is anticipated to be very low. The long-term and possibly permanent disruption to the existing recreational uses would negatively affect public support. In addition, the increased truck traffic, noise, and potential dust generation could negatively influence public acceptance particularly among residents in the immediate vicinity of the site.

Public safety should not be compromised by this alternative, provided truck traffic can be properly routed and managed. Property values and the visual character of the area would be negatively influenced for several years until the vegetative cover became established.

Natural Environment Considerations

Water quality would be degraded under this alternative unless the current leachate collection system is maintained. Terrestrial habitat would be destroyed under this alternative and would not return to the current conditions until trees and shrubs are replaced and have matured over a decade or more. The 750-mm thick cap would decrease the floodplain, albeit negligible in comparison to the entire floodplain. Sediment controls would be required during implementation to prevent sediment transport into the river by stormwater runoff. Fish habitat would be negatively affected if sediment controls are compromised. Near shore fish habitat would be destroyed where the cap extends into or near the edge of the river but could be restored.

TABLE 5.6
ALTERNATIVE 5: LOW PERMEABILITY CLAY CAP COST BREAKDOWN

Item	Description	Subtotal Cost	Total Cost
A. Capital Costs			
1.	Decommission existing recreational facilities and modify existing leachate collection system	$100,000	
2.	Site Clearing and Grubbing	$100,000	
3.	Supply and Place 60 cm Low Permeability Clay (264,000 m^3)	$5,300,000	
4.	Supply and Place 15 cm Topsoil (66,000 m^3)	$1,300,000	
5.	Hydroseeding (44 ha)	$200,000	
	Trees and shrubs for aesthetics (@$20K/ha for 20 ha)	$400,000	
6.	Restoration of Disturbed Shoreline Areas	250,000	
6.	Engineering Costs (10%)	$750,000	
Total Capital Costs		**$8,400,000**	**$8,400,000**
B. O&M Costs			
1.	Annual Monitoring	$75,000	
2.	Annual Maintenance of Cap	$50,000	
3.	Annual Maintenance of Existing Leachate Collection System	$220,000	
Total Annual O&M Costs		**$345,000**	
Net Present Value of O&M Costs		$4,850,000	**$4,850,000**
Total NPV of Capital and O&M Costs (Excluding GST)			**$13,250,000**

Notes: 1. NPV costs represent net present value costs that have been calculated using an effective annual interest rate of 5% over a 25-year budget cycle.

Scoring and Ranking

Upon comparison of the alternatives, it is evident that no alternative best satisfies all of the detailed evaluation criteria. To aid in selecting a recommended alternative, a semi-quantitive evaluation matrix was developed. The evaluation matrix provides a scoring system to rank the various alternatives in terms of their ability to satisfy the detailed evaluation criteria. The evaluation matrix measures the combination of the ability of an alternative to meet a given evaluation criteria, as well as the overall importance of that evaluation criteria to the relevant stakeholders.

Each of the detailed evaluation criteria identified in Section 2 have been assigned an average importance weighting ranging between 0 (not important) and 10 (extremely important) using feedback obtained from KEAF and the regulatory agencies (MOE, MNR, and CRCA) at a meeting held on June 28, 2005 (meeting notes are provided in Appendix C). For each alternative, a score between 0 (does not satisfy) and 10 (completely satisfies) has been assigned by CH2M HILL, based on professional judgment and collective input during various meetings and workshops from the agencies, KEAF, and the City, for each of the detailed evaluation criteria. The assigned score has been multiplied by the average importance weighting for each evaluation criterion to arrive at a composite score. The composite scores for each criterion have then been summed for each alternative to obtain a total composite score.

Table 5.1 summarizes the evaluation matrix and the total composite score for each of the comprehensive remediation alternatives. The Hybrid Alternative achieved the highest total composite score (989 out of a total possible score of 1274) followed by Maintain Existing Containment System (967). The Clay Capping Alternative received the lowest total composite score at 415.

Public Open House

An open house was held on June 27, 2006 to present the findings of this report to the public. A summary of comments received and path forward is as follows:

(This section will be filled in after the open house comments have been received)

Appendix D presents the open house materials (newspaper announcement, questionnaire, display boards, list of participants, and comments from the public).

Selection of the Recommended Comprehensive Remediation Alternative

Based on the results of the detailed evaluation, the Hybrid Alternative is recommended as the recommended alternative. Some of the key factors considered in making this selection include:

- Variable site characteristics are matched to the most suitable remediation method, as opposed to implementing the same remediation method to all parts of the site.
- The existing system has proven to be effective at controlling the point source leachate seep discharges to the river and is contained within and enhanced by this alternative. A leachate collection and treatment system would be installed/maintained in Site Management Zones where point source discharges have occurred in the past.

- This alternative is the most compatible with the existing control systems at the site. Measures to improve the efficiency of leachate collection by minimizing the influx of river water may be possible.
- This alternative is relatively easy to implement at the site, due in part to making use of the existing control systems.
- Operation and maintenance costs associated with this alternative are significant; however, cost reductions may be possible by improving the efficiency of the leachate collection system, thereby decreasing the amount of river water entering the system. Further assessment of the ability of the poplar tree cap and other plantings of shrubs and grasses to reduce leachate volumes via evapotranspiration would allow for an estimate of the potential reduction of the O&M costs associated with leachate collection and treatment system.
- The total NPV cost of this alternative is the second lowest in comparison to the other alternatives. Only Alternative 1: Maintain Existing System has a lower total NPV cost.
- Public acceptance of the alternative is expected to be high due to the continued golf course use, aesthetic improvements, and continued recreational use opportunities.
- Floodplain intrusion and fish habitat disruption would be minimal

Limitations Regarding Cost Opinion

CH2M HILL has relied on information provided by the City of Kingston and price estimates from suppliers or other sources. In providing opinions of probable construction cost, the Client understands that CH2M HILL has no control over the cost or availability of labour, equipment or materials, or over market conditions or the potential demolition Contractor's method of pricing. CH2M HILL makes no warranty, express or implied, that the bids or the negotiated cost of the work would not vary from the opinion of probable construction cost. Requirements were based on existing reports and non-intrusive visual inspection of the site. However, based on available information and for budget purposes, our preliminary opinion of capital costs presented can be considered to be correct within a range of +50%/-35%. Our preliminary opinion of O&M costs due to the lack of information regarding the performance of untried methods at the site and can be considered order of magnitude only.

Appendix A

Notes from Meetings with Kingston Environmental Advisory Forum (KEAF) and Governmental Agencies

Process for Selection of Long-Term Management Strategy for Belle Park Landfill Site

ATTENDEES: Paul MacLatchy (City of Kingston)
Beth Sills (City of Kingston)
John Allen (MOE)
Victor Castro (MOE)
Ross Cholmondeley (MNR)
Richard Vaningen (DFO)
Simon Lunn (Parks Canada)
Stephen Knechtel (Cataraqui Region C.A.)
Steven Rose (Malroz)
Eckhard Pastrik (CH2M HILL)
John Pries (CH2M HILL)
Susan Liver (CH2M HILL)

FROM: Eckhard Pastrik

DATE: June 20, 2003

Please advise the writer of any errors or omissions within two weeks of issue of these meeting notes.

By	Item	Action
PM	PM welcomed the group and provided an overview of the background of the Belle Park site. 1997-1998 emergency, “stop gap” measures were instigated to collect and manage leachate. The TSM strategy in place is effective and mitigating the impact of the leachate but is expensive to operate and maintain. CH2M HILL has now been retained to work with Melroz to develop a long-term strategy for the site. The development of the strategy will use the Class EA approach as a mechanism to ensure public support for the selected approach.	
EP	EP reviewed the long-term management objectives for the project: 1. Reduce/control the impact/risk associated with the landfill to human health or the environment 2. Prevent the deleterious impact of contaminants (in particular ammonia) on the aquatic environment 3. Minimize the visual impact from iron staining 4. Minimize the potential infiltration contribution due to precipitation 5. Comply with appropriate regulations and policies 6. Minimize the risk to human health or the environment during implementation 7. Be cost effective 8. Minimize ongoing perpetual monitoring, operation, and maintenance 9. Maintain public use to some degree on the site 10. Incorporate sustainable principles that focus on energy efficient practices and the use of renewable resources	

By	Item	Action
EP	EP provided an overview of the process to generate and evaluate alternatives (see Figure 1). A table with 12 potential methods was presented (see attached Table 1.1) and the advantages and disadvantages of each method were described. **Participants of the meeting were asked to review this list and submit any additional methods they are aware of which have been omitted or overlooked.**	**All**
EP	EP described the process to evaluate the potential methods. The potential methods were classified into two categories based on the following exclusionary criteria: 1(Effectiveness (potential to solve one or more aspects of the problem) 2) Compliance with Government Guidelines and Regulations. The evaluation resulted in the methods being classified as a primary method (method on its own had the potential to solve one or more aspects of the problem and meet regulatory compliance) or a enhancement feature (method provides some level of improvement but as a stand alone method would not meet both exclusionary criteria). This is the stage of the process that the project team is currently at. The draft results of the analysis is outlined in Table 1.1.	
EP	Upon endorsement of the long list of methods from agencies, the City and project steering committee (KEAF) a long list of comprehensive alternatives will be generated consisting of combinations of methods (see Figure 2). A second set of exclusionary criteria will be applied to the evaluation of the comprehensive alternatives (See Figure 3) to generate a short list. Upon selection of a short list of comprehensive alternatives a detailed evaluation of the short list will be carried out based on a set of new more specific evaluation criteria. The detailed evaluation criteria will be based on technical, social considerations, regulatory requirements, cost and environmental considerations, to name just a few. A recommended alternative will be generated based on a numerical weighting system for the detailed evaluation criteria.	
SM	SM described the key parameters of concern being NH3 and iron (iron is an aesthetic issue causing visual staining). Leachate is emitted from point sources (seeps) which have been intercepted and from diffuse shoreline migration. An estimated two-thirds of the flow from the site is currently being intercepted based on MODFLOW modelling results. A research paper completed in the 1970's suggested that leachate leaves the site within 8-20m of the shoreline (fluctuating seasonally depending on river elevation and ice coverage).	
PM	An evaluation of the PCB and PAH levels in the leachate resulted in trace quantities of each. More detailed evaluation to ultra low levels will be carried out and compared to Cataraqui River data.	
EP	There will be a public meeting in September to present the methods and potential short-listed comprehensive alternatives. This summer the project team will generate the long list and the decision matrix.	
PM	VC asked the rationale for the heavy public involvement, as it is not a requirement for landfills. PM replied that there is strong public interest in the site, there is an anticipation of involvement and that it is important to the City to have public acceptance of the strategy. The City intends to maintain the site as a public space and possibly part of an extended trail system.	

By	Item	Action
VC	VC questioned the assumption that natural attenuation is not an acceptable method. This would have to be demonstrated through appropriate risk assessment and biological monitoring. It was noted that a hybrid solution of active and passive management techniques in the different areas might be desirable. **PM to follow up with VC on working together on an impact assessment. PM to follow up with VC to establish context of existing benthic work done by Royal Military College (RMC).** **EP to revisit this aspect of the approach with the project team**	**PM** **EP**
S Lunn	SL noted that the affect of potential methods on native fauna should be considered. For example, would a barrier wall impair the movement of birds nesting on the shore entering the water? He also asked whether any inventory information should be collected this summer and highlighted the potential to involve local volunteers such as the Kingston Field Naturalists and school groups **SL and BS agreed to discuss further opportunities for inventories this summer.**	**S Lunn** **BS**
JA	JA asked what the criteria for success would be. PM noted that the overall objective would be to maintain and sustain current compliance. The diversity of the site may have several different management levels that are risk related (passive management in low risk areas and active management in high-risk areas).	
EP	A follow up meeting with this group is proposed for mid summer. A tentative date of August 6, 2003 is proposed for the finalizing of the long list of methods and classifying them as a primary method and/or an enhancement feature.	**All**

Figure 1
Generate, Screen, and Categorize Conceptual Remediation Methods.

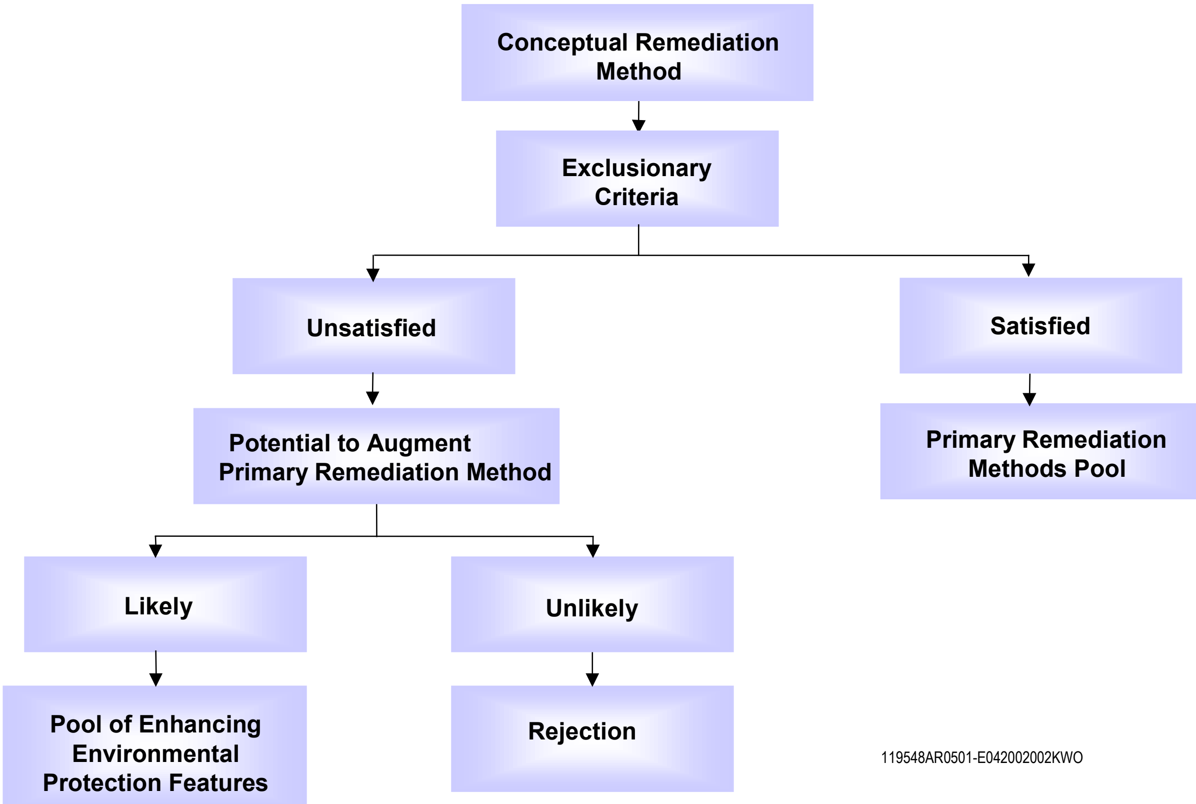


Figure 2
Develop Comprehensive Remediation Alternatives

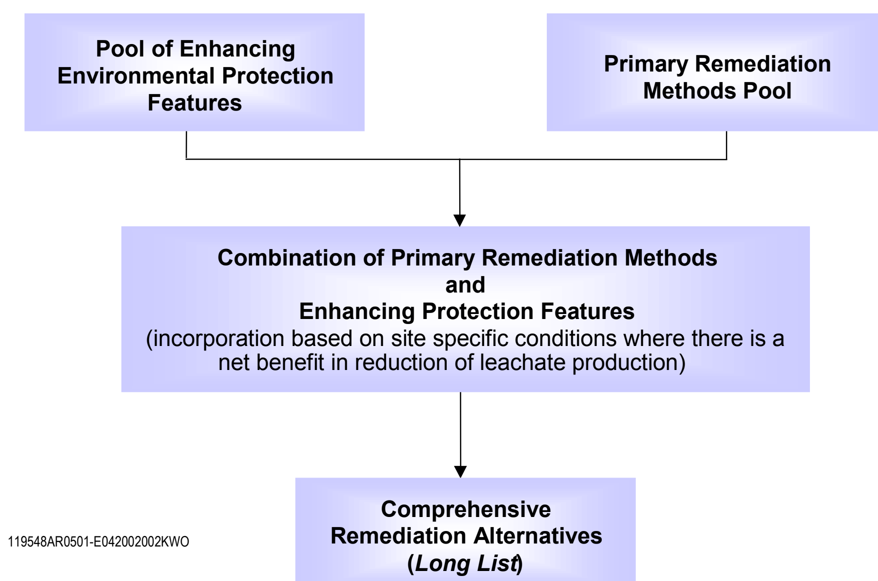
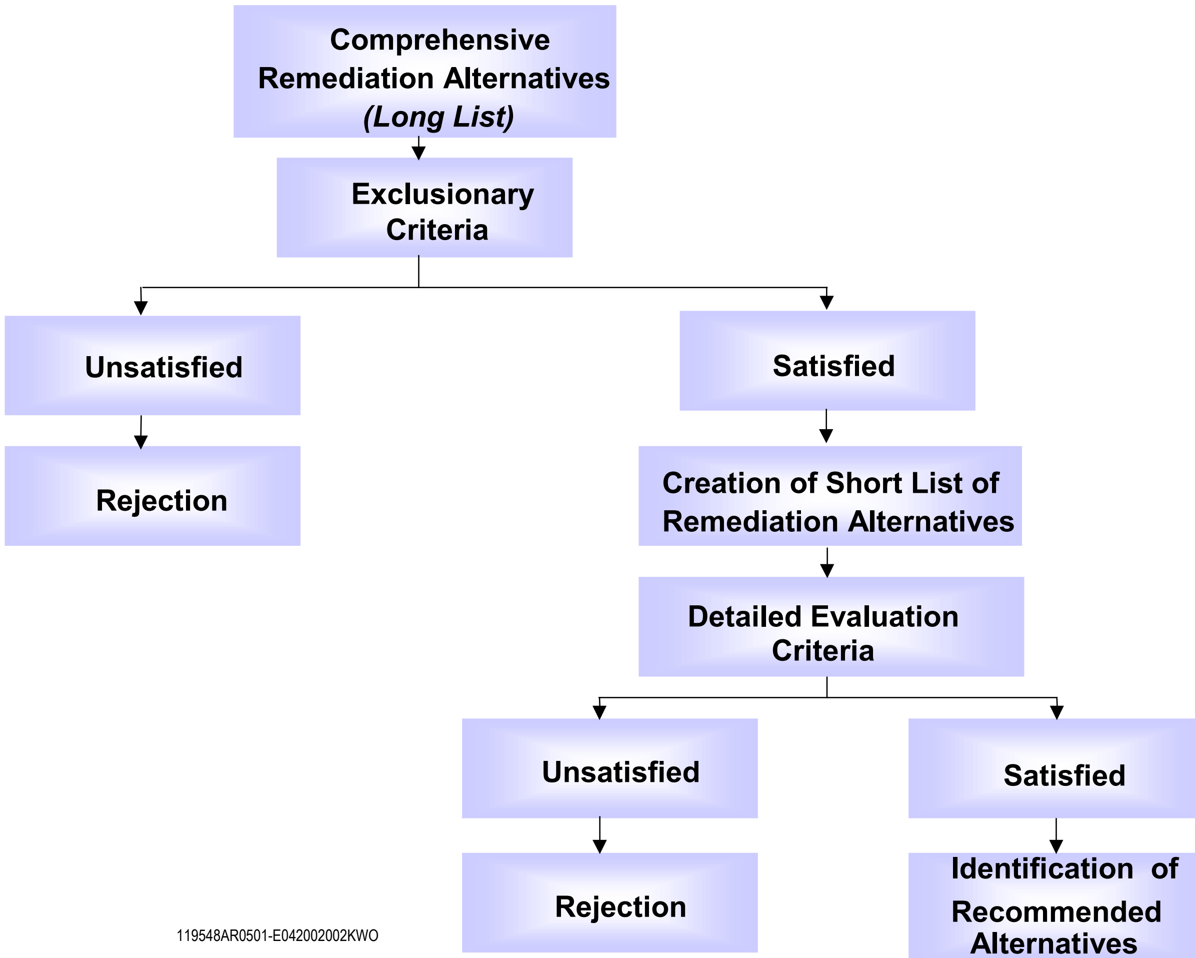


Figure 3
Screen Comprehensive Remediation Alternatives



119548AR0501-E042002002KWO

TABLE 1.1
CONCEPTUAL REMEDIATION METHODS - DRAFT

Remediation Method	Exclusionary Screening Criteria		Category	
	Effectiveness *Does the conceptual remediation method have the potential to solve one or more aspects of the problem? (i.e. Can it contribute to a significant attenuation of unacceptable impacts on the environment on its own by way of reducing a component of the contaminant load?)*	**Compliance with Government Regulation & Guidelines** *Does the conceptual remediation method have the ability to achieve compliance with applicable agency regulations and guidelines relating to site management?*	**Selected as a Primary Remediation Method?**	**Selected as Enhancing Protection Feature?**
Waste Removal and Offsite Disposal	Yes, this method has the potential to be very effective. Waste removal could be effective in the long term in preventing contaminant discharge to the river.	Yes, compliance would likely be achieved. However, significant regulatory approvals including alteration of a landfill (MOE), fill permit (Conservation Authority), alteration of fish habitat (MNR) would be required including the identification of a existing or possibly a new landfill site to accommodate excavated waste and potentially extensive restoration efforts to re-establish former marsh habitat.	Yes	No
Onsite Waste Consolidation	No, this method alone is likely not to be effective. Method could decrease footprint of area to be managed.	No, compliance would likely not be achieved since waste consolidation may have a limited impact on groundwater volumes or flows. Significant regulatory approvals would be required including alteration of a landfill (MOE), fill permit (conservation authority), alteration of fish habitat (MNR) would be required.	No	Yes
Engineered Clay Cap/HDPE Liner a) *Over Entire Site* b) *Over Selected Areas of the Site*	No, this method alone is likely not to be effective. Method could be effective in reducing infiltration of precipitation, a minor contributor to groundwater (max. of 10 to 25% based on existing water balance modeling), and potentially reduce constituent load associated with it. However, the method is likely not going to significantly impact on groundwater elevation or flow through the site.	No, compliance would likely not be achieved since a cap may have a limited impact on groundwater volumes or flows. Regulatory approvals would be required for altering a closed landfill site (MOE) and fill permit (Conservation Authority).	No	Yes
Vegetative Cap	No, this method alone is likely not to be effective. Method could be effective in providing hydraulic control by intercepting infiltration of precipitation, a minor contributor to groundwater (max. of 10 to 25% based on existing water balance modeling), as well as potentially extracting groundwater and evapotranspiring the moisture to the atmosphere. Utilization of nutrients by the vegetation may also reduce leachate constituent loads. The system would only be effective during the growing season and ineffective during the dormant months.	No, compliance would not be achieved since a cap may have a limited impact on groundwater volumes and flows.	No	Yes
Containment Barrier Wall a) *Waterloo Barrier* b) *Vibratory Beam Wall* c) *Slurry Wall*	No, this method alone is likely not to be effective. Method could be effective in preventing the flow of leachate into the river if method is extended around the site perimeter but leachate may build-up behind wall and overtop wall. All suggested methods would be effective	No, compliance would likely not be achieved since leachate contaminated groundwater may be discharged to the Great Cataraqui River if the leachate volume captured by the containment barrier wall exceeds the containment volume.	No	Yes
Leachate Collection a) *Vertical Extraction Wells* b) *Perimeter Toe Drain* c) *Drainage Blanket*	No, this method alone would not be effective. Method could be effective in preventing leachate flow into the river if method is extended around the site perimeter. Shallow water table and the presence of an underlying low permeability layer suggests that the use of a perimeter toe drain or soil drainage mat is potentially a more efficient method of collecting leachate than the vertical wells.	No, compliance would likely not be achieved without leachate treatment.	No	Yes
Leachate Treatment at the Kingston WPCP	No, this method alone is likely not to be effective. Method could be effective in treating leachate but requires a collection method.	No, compliance would not be achieved without leachate collection. As a treatment method alone, regulatory compliance would likely continue to be achieved at the WPCP (current leachate extraction volume represents approximately 1% of WPCP waste water flows).	No	Yes
Leachate Treatment at an Onsite Conventional Treatment Plant	No, this method alone would not be effective. Method could be effective in treating leachate but requires a collection method.	No, compliance would not be achieved without leachate collection. As a treatment method alone, regulatory compliance would likely be achieved at an on-site conventional treatment plant through the selection of an appropriate treatment technology based on specific leachate characteristics and constituent loads. On-going monitoring would likely be required for treatment process to assess regulatory compliance.	No	Yes

APPENDIX B

HELP MODEL OUTPUT

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************

PRECIPITATION DATA FILE:     C:\HELP3\help3\BELLP1.D4
TEMPERATURE DATA FILE:       C:\HELP3\help3\BELLET1.D7
SOLAR RADIATION DATA FILE:   C:\HELP3\help3\BELLS1.D13
EVAPOTRANSPIRATION DATA:     C:\HELP3\help3\BELLEVA1.D11
SOIL AND DESIGN DATA FILE:   C:\HELP3\help3\BELLSOIL.D10
OUTPUT DATA FILE:            C:\HELP3\help3\bellout1.OUT

TIME:  17:37     DATE:   3/15/2006

******************************************************************************

     TITLE:  Belle Park Landfill

******************************************************************************
     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.
                                    LAYER  1
                                     --------

                         TYPE 1 - VERTICAL PERCOLATION LAYER
                             MATERIAL TEXTURE NUMBER   6
           THICKNESS                   =     15.00   CM
           POROSITY                    =      0.4530 VOL/VOL
           FIELD CAPACITY              =      0.1900 VOL/VOL
           WILTING POINT               =      0.0850 VOL/VOL
           INITIAL SOIL WATER CONTENT  =      0.4573 VOL/VOL
           EFFECTIVE SAT. HYD. COND.   =  0.720000011000E-03 CM/SEC
         NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
                FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.

                                     LAYER  2
                                     --------

                         TYPE 1 - VERTICAL PERCOLATION LAYER
                             MATERIAL TEXTURE NUMBER   9
           THICKNESS                   =     50.00   CM
           POROSITY                    =      0.5010 VOL/VOL
           FIELD CAPACITY              =      0.2840 VOL/VOL
           WILTING POINT               =      0.1350 VOL/VOL
           INITIAL SOIL WATER CONTENT  =      0.3436 VOL/VOL
           EFFECTIVE SAT. HYD. COND.   =  0.190000006000E-03 CM/SEC


                                     LAYER  3
                                     --------

                         TYPE 1 - VERTICAL PERCOLATION LAYER
                             MATERIAL TEXTURE NUMBER  18
           THICKNESS                   =    200.00   CM
```

```
     POROSITY                    =      0.6710 VOL/VOL
     FIELD CAPACITY              =      0.2920 VOL/VOL
     WILTING POINT               =      0.0770 VOL/VOL
     INITIAL SOIL WATER CONTENT  =      0.2920 VOL/VOL
     EFFECTIVE SAT. HYD. COND.   =  0.100000005000E-02 CM/SEC
```

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

```
   NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
            SOIL DATA BASE USING SOIL TEXTURE # 6 WITH A
            FAIR STAND OF GRASS, A SURFACE SLOPE OF  1.%
            AND A SLOPE LENGTH OF  270. METERS.

   SCS RUNOFF CURVE NUMBER              =     66.10
   FRACTION OF AREA ALLOWING RUNOFF     =    100.0    PERCENT
   AREA PROJECTED ON HORIZONTAL PLANE   =     44.0000 HECTARES
   EVAPORATIVE ZONE DEPTH               =     50.0    CM
   INITIAL WATER IN EVAPORATIVE ZONE    =     19.778  CM
   UPPER LIMIT OF EVAPORATIVE STORAGE   =     24.330  CM
   LOWER LIMIT OF EVAPORATIVE STORAGE   =      6.000  CM
   INITIAL SNOW WATER                   =      0.838  CM
   INITIAL WATER IN LAYER MATERIALS     =     82.437  CM
   TOTAL INITIAL WATER                  =     83.276  CM
   TOTAL SUBSURFACE INFLOW              =      0.00   MM/YR
```

EVAPOTRANSPIRATION AND WEATHER DATA

```
   NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
            ALBANY                NEW YORK

        STATION LATITUDE                           =  44.13 DEGREES
        MAXIMUM LEAF AREA INDEX                    =   2.00
        START OF GROWING SEASON (JULIAN DATE)      =    123
        END OF GROWING SEASON (JULIAN DATE)        =    282
        EVAPORATIVE ZONE DEPTH                     =  50.0  CM
        AVERAGE ANNUAL WIND SPEED                  =  14.00 KPH
        AVERAGE 1ST QUARTER RELATIVE HUMIDITY      =  68.00 %
        AVERAGE 2ND QUARTER RELATIVE HUMIDITY      =  66.00 %
        AVERAGE 3RD QUARTER RELATIVE HUMIDITY      =  74.00 %
        AVERAGE 4TH QUARTER RELATIVE HUMIDITY      =  74.00 %

   NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
            COEFFICIENTS FOR    ALBANY              NEW YORK
```

NORMAL MEAN MONTHLY PRECIPITATION (MM)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
70.0	63.0	77.0	79.0	78.0	75.0
60.0	83.0	93.0	89.0	96.0	102.0

```
   NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
            COEFFICIENTS FOR    ALBANY              NEW YORK
```

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES CELSIUS)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
-7.0	-6.0	0.0	6.0	12.0	17.0
20.0	20.0	15.0	9.0	3.0	-3.0

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ALBANY NEW YORK
AND STATION LATITUDE = 44.13 DEGREES

****

ANNUAL TOTALS FOR YEAR 1

	MM	CU. METERS	PERCENT
PRECIPITATION	993.00	436920.094	100.00
RUNOFF	206.770	90978.953	20.82
EVAPOTRANSPIRATION	555.448	244397.250	55.94
PERC./LEAKAGE THROUGH LAYER 3	230.779663	101543.047	23.24
CHANGE IN WATER STORAGE	0.002	0.682	0.00
SOIL WATER AT START OF YEAR	824.374	362724.562	
SOIL WATER AT END OF YEAR	824.376	362725.250	
SNOW WATER AT START OF YEAR	8.383	3688.463	0.84
SNOW WATER AT END OF YEAR	8.383	3688.463	0.84
ANNUAL WATER BUDGET BALANCE	0.0004	0.160	0.00

****

****

ANNUAL TOTALS FOR YEAR 2

	MM	CU. METERS	PERCENT
PRECIPITATION	1050.30	462132.000	100.00
RUNOFF	247.423	108866.070	23.56
EVAPOTRANSPIRATION	501.842	220810.531	47.78
PERC./LEAKAGE THROUGH LAYER 3	330.062347	145227.437	31.43
CHANGE IN WATER STORAGE	-29.027	-12772.029	-2.76
SOIL WATER AT START OF YEAR	824.376	362725.250	
SOIL WATER AT END OF YEAR	774.640	340841.750	
SNOW WATER AT START OF YEAR	8.383	3688.463	0.80
SNOW WATER AT END OF YEAR	29.091	12799.917	2.77
ANNUAL WATER BUDGET BALANCE	0.0000	0.000	0.00

****

****

ANNUAL TOTALS FOR YEAR 3

	MM	CU. METERS	PERCENT
PRECIPITATION	1213.10	533763.750	100.00
RUNOFF	238.697	105026.609	19.68
EVAPOTRANSPIRATION	612.032	269294.156	50.45
PERC./LEAKAGE THROUGH LAYER 3	310.473511	136608.344	25.59
CHANGE IN WATER STORAGE	51.898	22835.166	4.28
SOIL WATER AT START OF YEAR	774.640	340841.781	
SOIL WATER AT END OF YEAR	776.769	341778.406	
SNOW WATER AT START OF YEAR	29.091	12799.917	2.40
SNOW WATER AT END OF YEAR	78.860	34698.457	6.50
ANNUAL WATER BUDGET BALANCE	-0.0011	-0.501	0.00

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ANNUAL TOTALS FOR YEAR 4

	MM	CU. METERS	PERCENT
PRECIPITATION	909.80	400312.062	100.00
RUNOFF	235.887	103790.391	25.93
EVAPOTRANSPIRATION	436.493	192057.031	47.98
PERC./LEAKAGE THROUGH LAYER 3	230.969421	101626.547	25.39
CHANGE IN WATER STORAGE	6.450	2837.917	0.71
SOIL WATER AT START OF YEAR	776.769	341778.406	
SOIL WATER AT END OF YEAR	801.685	352741.187	
SNOW WATER AT START OF YEAR	78.860	34698.453	8.67
SNOW WATER AT END OF YEAR	60.394	26573.578	6.64
ANNUAL WATER BUDGET BALANCE	0.0004	0.192	0.00

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ANNUAL TOTALS FOR YEAR 5

	MM	CU. METERS	PERCENT
PRECIPITATION	800.30	352132.031	100.00

RUNOFF	220.832	97166.211	27.59
EVAPOTRANSPIRATION	518.799	228271.766	64.83
PERC./LEAKAGE THROUGH LAYER 3	112.104156	49325.828	14.01
CHANGE IN WATER STORAGE	-51.436	-22631.889	-6.43
SOIL WATER AT START OF YEAR	801.685	352741.187	
SOIL WATER AT END OF YEAR	787.277	346401.719	
SNOW WATER AT START OF YEAR	60.394	26573.578	7.55
SNOW WATER AT END OF YEAR	23.366	10281.160	2.92
ANNUAL WATER BUDGET BALANCE	0.0003	0.112	0.00

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ANNUAL TOTALS FOR YEAR 6

	MM	CU. METERS	PERCENT
PRECIPITATION	963.60	423984.125	100.00
RUNOFF	195.914	86202.250	20.33
EVAPOTRANSPIRATION	505.003	222201.141	52.41
PERC./LEAKAGE THROUGH LAYER 3	263.032227	115734.180	27.30
CHANGE IN WATER STORAGE	-0.349	-153.604	-0.04
SOIL WATER AT START OF YEAR	787.277	346401.750	
SOIL WATER AT END OF YEAR	767.901	337876.656	
SNOW WATER AT START OF YEAR	23.366	10281.160	2.42
SNOW WATER AT END OF YEAR	42.392	18652.633	4.40
ANNUAL WATER BUDGET BALANCE	0.0004	0.160	0.00

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ANNUAL TOTALS FOR YEAR 7

	MM	CU. METERS	PERCENT
PRECIPITATION	1134.10	499003.937	100.00
RUNOFF	109.239	48064.980	9.63
EVAPOTRANSPIRATION	645.854	284175.906	56.95
PERC./LEAKAGE THROUGH LAYER 3	314.852509	138535.109	27.76
CHANGE IN WATER STORAGE	64.155	28228.021	5.66

SOIL WATER AT START OF YEAR	767.901	337876.656	
SOIL WATER AT END OF YEAR	786.105	345886.000	
SNOW WATER AT START OF YEAR	42.392	18652.633	3.74
SNOW WATER AT END OF YEAR	88.344	38871.309	7.79
ANNUAL WATER BUDGET BALANCE	-0.0002	-0.096	0.00

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ANNUAL TOTALS FOR YEAR 8

	MM	CU. METERS	PERCENT
PRECIPITATION	1108.90	487915.844	100.00
RUNOFF	176.419	77624.555	15.91
EVAPOTRANSPIRATION	597.493	262897.094	53.88
PERC./LEAKAGE THROUGH LAYER 3	391.427887	172228.281	35.30
CHANGE IN WATER STORAGE	-56.441	-24833.949	-5.09
SOIL WATER AT START OF YEAR	786.105	345886.000	
SOIL WATER AT END OF YEAR	783.858	344897.375	
SNOW WATER AT START OF YEAR	88.344	38871.309	7.97
SNOW WATER AT END OF YEAR	34.150	15025.999	3.08
ANNUAL WATER BUDGET BALANCE	-0.0003	-0.139	0.00

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ANNUAL TOTALS FOR YEAR 9

	MM	CU. METERS	PERCENT
PRECIPITATION	861.70	379148.094	100.00
RUNOFF	107.824	47442.363	12.51
EVAPOTRANSPIRATION	573.552	252362.937	66.56
PERC./LEAKAGE THROUGH LAYER 3	189.184830	83241.328	21.95
CHANGE IN WATER STORAGE	-8.861	-3898.717	-1.03
SOIL WATER AT START OF YEAR	783.858	344897.375	
SOIL WATER AT END OF YEAR	771.335	339387.437	
SNOW WATER AT START OF YEAR	34.150	15025.999	3.96

SNOW WATER AT END OF YEAR	37.812	16637.221	4.39
ANNUAL WATER BUDGET BALANCE	0.0004	0.176	0.00

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ANNUAL TOTALS FOR YEAR 10

	MM	CU. METERS	PERCENT
PRECIPITATION	840.50	369820.094	100.00
RUNOFF	84.163	37031.609	10.01
EVAPOTRANSPIRATION	579.508	254983.359	68.95
PERC./LEAKAGE THROUGH LAYER 3	91.540031	40277.613	10.89
CHANGE IN WATER STORAGE	85.289	37527.316	10.15
SOIL WATER AT START OF YEAR	771.335	339387.437	
SOIL WATER AT END OF YEAR	759.536	334196.000	
SNOW WATER AT START OF YEAR	37.812	16637.221	4.50
SNOW WATER AT END OF YEAR	134.900	59355.961	16.05
ANNUAL WATER BUDGET BALANCE	0.0005	0.205	0.00

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ANNUAL TOTALS FOR YEAR 11

	MM	CU. METERS	PERCENT
PRECIPITATION	725.90	319395.969	100.00
RUNOFF	140.671	61895.207	19.38
EVAPOTRANSPIRATION	470.830	207165.359	64.86
PERC./LEAKAGE THROUGH LAYER 3	197.493576	86897.172	27.21
CHANGE IN WATER STORAGE	-83.095	-36561.676	-11.45
SOIL WATER AT START OF YEAR	759.536	334196.000	
SOIL WATER AT END OF YEAR	789.450	347357.812	
SNOW WATER AT START OF YEAR	134.900	59355.961	18.58
SNOW WATER AT END OF YEAR	21.892	9632.483	3.02
ANNUAL WATER BUDGET BALANCE	-0.0002	-0.080	0.00

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ANNUAL TOTALS FOR YEAR 12

	MM	CU. METERS	PERCENT
PRECIPITATION	730.10	321244.156	100.00
RUNOFF	173.180	76199.258	23.72
EVAPOTRANSPIRATION	457.759	201413.750	62.70
PERC./LEAKAGE THROUGH LAYER 3	136.430023	60029.215	18.69
CHANGE IN WATER STORAGE	-37.269	-16398.166	-5.10
SOIL WATER AT START OF YEAR	789.450	347357.812	
SOIL WATER AT END OF YEAR	748.934	329531.156	
SNOW WATER AT START OF YEAR	21.892	9632.483	3.00
SNOW WATER AT END OF YEAR	25.139	11060.969	3.44
ANNUAL WATER BUDGET BALANCE	0.0002	0.091	0.00

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ANNUAL TOTALS FOR YEAR 13

	MM	CU. METERS	PERCENT
PRECIPITATION	798.70	351428.062	100.00
RUNOFF	184.385	81129.336	23.09
EVAPOTRANSPIRATION	499.530	219793.266	62.54
PERC./LEAKAGE THROUGH LAYER 3	116.769409	51378.539	14.62
CHANGE IN WATER STORAGE	-1.984	-873.075	-0.25
SOIL WATER AT START OF YEAR	748.934	329531.156	
SOIL WATER AT END OF YEAR	772.089	339719.062	
SNOW WATER AT START OF YEAR	25.139	11060.969	3.15
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.016	0.00

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ANNUAL TOTALS FOR YEAR 14

	MM	CU. METERS	PERCENT
PRECIPITATION	880.00	387199.969	100.00

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 RUNOFF                                  78.482        34532.211      8.92

 EVAPOTRANSPIRATION                     521.469       229446.266     59.26

 PERC./LEAKAGE THROUGH LAYER  3         251.396759    110614.578     28.57

 CHANGE IN WATER STORAGE                 28.652        12606.936      3.26

 SOIL WATER AT START OF YEAR            772.089       339719.062

 SOIL WATER AT END OF YEAR              790.864       347980.281

 SNOW WATER AT START OF YEAR              0.000            0.000      0.00

 SNOW WATER AT END OF YEAR                9.877         4345.716      1.12

 ANNUAL WATER BUDGET BALANCE              0.0000          -0.011      0.00

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                    ANNUAL TOTALS FOR YEAR   15
------------------------------------------------------------------------------
                                          MM         CU. METERS    PERCENT
                                      ----------     ----------    -------
 PRECIPITATION                          818.90       360315.969    100.00

 RUNOFF                                  95.951        42218.281     11.72

 EVAPOTRANSPIRATION                     488.081       214755.859     59.60

 PERC./LEAKAGE THROUGH LAYER  3         243.170868    106995.180     29.69

 CHANGE IN WATER STORAGE                 -8.303        -3653.319     -1.01

 SOIL WATER AT START OF YEAR            790.864       347980.281

 SOIL WATER AT END OF YEAR              784.932       345369.906

 SNOW WATER AT START OF YEAR              9.877         4345.716      1.21

 SNOW WATER AT END OF YEAR                7.506         3302.776      0.92

 ANNUAL WATER BUDGET BALANCE             -0.0001          -0.043      0.00

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                    ANNUAL TOTALS FOR YEAR   16
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                                          MM         CU. METERS    PERCENT
                                      ----------     ----------    -------
 PRECIPITATION                         1179.40       518936.156    100.00

 RUNOFF                                 200.656        88288.531     17.01

 EVAPOTRANSPIRATION                     549.313       241697.766     46.58

 PERC./LEAKAGE THROUGH LAYER  3         351.930969    154849.625     29.84

 CHANGE IN WATER STORAGE                 77.500        34099.977      6.57
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SOIL WATER AT START OF YEAR	784.932	345369.906	
SOIL WATER AT END OF YEAR	779.944	343175.375	
SNOW WATER AT START OF YEAR	7.506	3302.776	0.64
SNOW WATER AT END OF YEAR	89.994	39597.289	7.63
ANNUAL WATER BUDGET BALANCE	0.0006	0.256	0.00

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ANNUAL TOTALS FOR YEAR 17

	MM	CU. METERS	PERCENT
PRECIPITATION	728.90	320715.969	100.00
RUNOFF	215.456	94800.656	29.56
EVAPOTRANSPIRATION	496.380	218407.375	68.10
PERC./LEAKAGE THROUGH LAYER 3	87.660164	38570.473	12.03
CHANGE IN WATER STORAGE	-70.597	-31062.498	-9.69
SOIL WATER AT START OF YEAR	779.944	343175.344	
SOIL WATER AT END OF YEAR	756.292	332768.656	
SNOW WATER AT START OF YEAR	89.994	39597.293	12.35
SNOW WATER AT END OF YEAR	43.049	18941.482	5.91
ANNUAL WATER BUDGET BALANCE	-0.0001	-0.037	0.00

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ANNUAL TOTALS FOR YEAR 18

	MM	CU. METERS	PERCENT
PRECIPITATION	1167.70	513787.937	100.00
RUNOFF	301.863	132819.516	25.85
EVAPOTRANSPIRATION	569.219	250456.562	48.75
PERC./LEAKAGE THROUGH LAYER 3	243.632294	107198.211	20.86
CHANGE IN WATER STORAGE	52.986	23313.738	4.54
SOIL WATER AT START OF YEAR	756.292	332768.687	
SOIL WATER AT END OF YEAR	788.057	346745.062	
SNOW WATER AT START OF YEAR	43.049	18941.480	3.69

SNOW WATER AT END OF YEAR	64.270	28278.844	5.50
ANNUAL WATER BUDGET BALANCE	-0.0002	-0.096	0.00

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ANNUAL TOTALS FOR YEAR 19

	MM	CU. METERS	PERCENT
PRECIPITATION	1000.30	440132.031	100.00
RUNOFF	218.751	96250.531	21.87
EVAPOTRANSPIRATION	486.718	214156.016	48.66
PERC./LEAKAGE THROUGH LAYER 3	256.759979	112974.391	25.67
CHANGE IN WATER STORAGE	38.071	16751.180	3.81
SOIL WATER AT START OF YEAR	788.057	346745.062	
SOIL WATER AT END OF YEAR	788.201	346808.562	
SNOW WATER AT START OF YEAR	64.270	28278.844	6.43
SNOW WATER AT END OF YEAR	102.197	44966.523	10.22
ANNUAL WATER BUDGET BALANCE	-0.0002	-0.075	0.00

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ANNUAL TOTALS FOR YEAR 20

	MM	CU. METERS	PERCENT
PRECIPITATION	954.50	419980.031	100.00
RUNOFF	244.990	107795.680	25.67
EVAPOTRANSPIRATION	604.220	265856.906	63.30
PERC./LEAKAGE THROUGH LAYER 3	194.738800	85685.070	20.40
CHANGE IN WATER STORAGE	-89.449	-39357.676	-9.37
SOIL WATER AT START OF YEAR	788.201	346808.562	
SOIL WATER AT END OF YEAR	800.949	352417.406	
SNOW WATER AT START OF YEAR	102.197	44966.523	10.71
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0001	0.048	0.00

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AVERAGE MONTHLY VALUES (MM) FOR YEARS 1 THROUGH 20

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	61.86	68.50	83.32	85.47	72.75	72.66
	55.82	69.57	97.77	83.09	102.29	89.88
STD. DEVIATIONS	25.67	25.25	33.97	32.59	33.45	28.42
	21.61	21.74	53.78	38.93	45.36	44.01
RUNOFF						
TOTALS	4.383	5.421	133.952	33.679	0.395	0.000
	0.000	0.000	0.196	0.152	0.008	5.691
STD. DEVIATIONS	12.750	9.183	56.706	46.201	1.753	0.000
	0.000	0.000	0.791	0.667	0.035	12.856
EVAPOTRANSPIRATION						
TOTALS	13.498	12.379	13.019	58.996	80.125	87.127
	78.554	64.986	51.225	37.001	23.617	12.952
STD. DEVIATIONS	2.304	2.027	3.644	20.026	24.168	17.955
	27.179	18.657	17.622	5.778	3.885	2.482
PERCOLATION/LEAKAGE THROUGH LAYER 3						
TOTALS	4.6084	0.0000	2.7064	48.6512	54.4235	4.4563
	0.6368	0.0000	3.0905	17.9485	33.3181	57.3808
STD. DEVIATIONS	8.3808	0.0000	9.3619	30.9550	41.3089	10.7399
	0.8171	0.0000	6.6526	25.1610	25.9424	39.1781

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 20

	MM		CU. METERS	PERCENT
PRECIPITATION	942.98	(158.662)	414913.4	100.00
RUNOFF	183.878	(62.4532)	80906.16	19.500
EVAPOTRANSPIRATION	533.477	(56.9610)	234730.06	56.573
PERCOLATION/LEAKAGE THROUGH LAYER 3	227.22046	(87.64758)	99977.000	24.09587
CHANGE IN WATER STORAGE	-1.590	(2.0845)	-699.78	-0.169

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             PEAK DAILY VALUES FOR YEARS    1 THROUGH   20
   ------------------------------------------------------------------------
                                                   (MM)       (CU. METERS)
                                                ----------    ------------
      PRECIPITATION                               92.20         40568.000

      RUNOFF                                     104.178        45838.2617

      PERCOLATION/LEAKAGE THROUGH LAYER  3         8.353445      3675.51587

      SNOW WATER                                 228.50        100541.2660

      MAXIMUM VEG. SOIL WATER (VOL/VOL)                     0.4536

      MINIMUM VEG. SOIL WATER (VOL/VOL)                     0.1200
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                FINAL WATER STORAGE AT END OF YEAR   20
    ----------------------------------------------------------------------
                LAYER          (CM)          (VOL/VOL)
                -----         ------         ---------
                  1            3.0977          0.2065

                  2           15.5002          0.3100

                  3           61.4970          0.3075

              SNOW WATER       0.000

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APPENDIX C

NOTES FROM JUNE 28, 2005 MEETING

Kingston's Belle Park Landfill Site
Assessment of Long-Term
Management Options
June 28, 2005

Summary of Input from Stakeholders

Agencies Present:
CRCA
MOE
MNR
KEAF
City of Kingston (Parks Division)

Agency Stakeholder Question 1: Project Objectives (Mission)
Page 2-1 of the Interim Project Summary Report provides a principal long term objective for the project as well as more detailed and subordinate objectives.

- *Are the objectives sufficiently clear?*
- *Are there valuable objectives that are missing from the list?*

The consensus of the agency stakeholders was that the objectives were clear and complete. Provided below is a summary of the discussion that took place regarding the objectives:

MNR **–** asked about the iron impact on the environment vs only the aesthetic impact of iron. The City responded by saying that iron staining is an issue that needs to be addressed and that studies have indicated that the impact is only aesthetic in nature. Given that there is a range of iron staining, the impacts associated with the staining varies. The City has a process in place to weekly monitor the shoreline and react to any staining events.

CRCA **–** asked about the contaminants of concern for the site. The City and CH2M HILL discussed the parameters ammonia and iron as the contaminants of concern.

KEAF **–** asked if the objectives should be expanded to "Increase the use of the park" for recreation/education (community and research). Given KEAF's involvement in the development of educational depots in Belle Park KEAF feels that the site should be developed for further recreational uses as well as having a strong educational focus on site remediation. CH2M HILL responded that it is possible that the enhancements that would accompany the long range management plan could result in multiple and complimentary uses of the park.

CRCA – commented that depending on the option selected, all of the objectives listed may not be met. CH2M HILL responded by saying that the option selected could include several enhancements to meet a maximum number of objectives.

MOE – questioned if a barrier wall would be a benefit. CH2M HILL responded by saying that a barrier wall would reduce the input from the river and that this could reduce the operation and maintenance costs associated with the current pumping system. This assumes that the barrier wall collection system, which will draw groundwater from a larger portion of the river edge than is currently drawn, generates less flow than the current system that collects water from a limited extent of the Belle Park river edge but is drawing river water as well. CH2M HILL further suggested that they could run the HELP model excluding the influence of the river to determine the theoretical pumping requirements.

Agency Stakeholder Question 2: Detailed Evaluation Criteria

Table 2.3 of the report provides information on the detailed criteria used to evaluate the long list of potential management options.
For each of the 16 detailed evaluation criteria in Table 2.3, indicate the relative importance of each providing a score ranging between 0 (not important) and 10 (extremely important) based on your agency's perspective.
The stakeholder agencies only provided ranking for those criteria that were relevant to their operations

Stakeholder Agency Question 2: Detailed Evaluation Criteria								
Number	**Criteria**	**CRCA**	**KEAF**	**MNR**	**MOE**	**City (Parks)**	***Average***	**Comment**
1	***Maximize*** **Reliability**	10	6		10	7	***8.3***	
2	***Maximize*** **Compatibility with or Replacement of Existing System**	5	7			8	***6.7***	CRCA: only because fewer technical problems and will result in more control
3	***Maximize*** **Ease of Implemetation**		8		8	7	***7.7***	
4	***Minimize*** **Duration of Approval Process**		9		9	5	***7.7***	
5	**Permitting to Satisfy all Agencies**		7	10	10	6	***8.3***	MNR:process must meet MNR permitting requirements
6	***Minimize*** **Operation and Maintenance Costs**		6			9	***7.5***	
7	***Minimize*** **Capital Costs**		7			9	***8.0***	
8	***Maximize*** **Public Acceptance**	5	7	7	7	9	***7.0***	
9	***Minimize*** **Risk to Public Safety**	8	6	10	10	9	***8.6***	MNR: consumption of fish resources, water quality etc.
10	***Minimize*** **Constraints to Recreational Use**	5	10	10		10	***8.8***	MNR: preservation of area for outdoor recreational activities (i.e. fishing, birdwatching, etc.)
11	***Minimize*** **Negative Impact to Private Properties**	8	5	5	10	7	***7.0***	CRCA: CRCA cares about loss of natural heritage, minmization of natural hazards, but not about property value MNR: protection of natural flora and fauna on private land
12	***Minimize*** **Degradation to Visual Character of the Area**	3	10		7	8	***7.0***	
13	***Maximize*** **Improvement in Geochemistry**	10	6	5	10	7	***7.6***	
14	***Maximize*** **Improvement to Terrestrial Habitat**	8	10	10	9	7	***8.8***	CRCA: improvements to aquatic habitats also important and maybe a balancing aspect to loss of some floodplan (i.e. creation of shoreline wetland does both) MNR: of obvious importance to MNR
15	***Minimize*** **Disruption/Intrusion Upon the Floodplain/River**	10	10	10	9	7	***9.2***	MNR: of obvious importance to MNR
16	***Minimize*** **Disturbance to Fish Habitat**	10	10	10	10	6	***9.2***	MNR: of obvious importance to MNR
	Average	***7.5***	***7.8***	***8.6***	***9.1***	***7.6***	***7.9***	

Agency Stakeholder Question 3: Potential Site Management Methods (individual methods)

Table 3.1 of the report provides a compilation of potential methods for site remediation/management options at Belle Park.

- *Are the screening criteria in Table 3.1 appropriate and complete?*
- *Is anything proposed in the list "entirely unacceptable" or unfeasible from a permitting perspective to your agency?*
- *Are there other possible options for site management that are reasonable and have not been included on the list?*

There was consensus that the screening criteria (Table 3.1) were appropriate and complete with the exception of adding the removal of the 'ski hill' to reduce the hydraulic gradients and the pumping volumes (discussed as part of Question 4 – see below). With the exception of KEAF, the agency stakeholders did not consider any of the options proposed to be "entirely unacceptable". KEAF felt that the following three options were unacceptable: total removal and disposal, vegetative cap and engineered clay cap. KEAF felt that these options were too radical and expensive and that there was an opportunity to work with the existing environment and use a combination of different strategies.

Discussions related to other possible options for site management and additional comments are provided below:

- Is it possible to use a more cost effective method for constructing a barrier wall? Response by CH2M HILL is that barrier walls are tested approaches and the most cost effective system that will meet the project objectives will be considered, if this becomes a method of choice for this project.
- The waste removal option is unacceptable. This method will not be considered further.
- The treatment walls are considered unproven/unfeasible technology. This method will not be considered further.
- The monitored natural attenuation option was considered to be an option that would not be accepted given the current legal situation. This method will not be considered further.
- The clay cap option over the entire site is not acceptable to Parks because of the disruption to the Golf Course, other recreation as well as the natural features. This method will not be considered further, although some specific smaller areas may be capped if this is considered to be an enhancement for the final alternative selected.
- The capping option must continue to be evaluated as a baseline. It has status because of the sentencing requirements.

- While the Risk Assessment option was identified in the text it is not listed on Table 3.1 it will be added.

Agency Stakeholder Question 4: Potential Comprehensive Site Management Approaches (multi-component systems)

Table 4.1 of the report provides a compilation of management approaches that consist of one or more individual methods from Table 3.1.

- *Are the screening criteria used in Table 4.1 appropriate and complete?*
- *Is anything proposed in the list "entirely unacceptable or unfeasible from a permitting perspective to your agency?*
- *Are their other possible options for site management that are reasonable and have not been included on the list?*

The stakeholder agencies agreed that the screening criteria provided in Table 4.1 are appropriate and complete with the exception of adding the removal of the 'ski hill' to reduce the hydraulic gradients and the pumping volumes. There was nothing in the list that was considered to be unacceptable or unfeasible.

Other possible options and a summary of additional discussions are provided below:

- The City provided a qualified yes that it is appropriate to maintaining the existing system long-term. If the existing system was to remain in place the City would like to see some enhancements added to the site.
- CRCA raised the question of what would be the impact if the ski hill was removed. The City and CH2M HILL agreed that this may result in diminished hydrostatic pressure at the north and east shore pumping stations. However, the hydrostatic pressure exerted from the lands west of Belle Park may have a greater influence on the pumping if a barrier wall were not put in place. Installing a barrier wall and adding a poplar or clay cap with improved grading to reduced infiltration, would likely have a greater positive effect in reducing the pumping requirements. CH2M HILL suggested that the challenges associated with digging up waste and relocating it are the same as those related to the methods that considered removing all the waste to an offsite location and consolidating the waste onsite. This will be considered further in the analysis if the project team determines this method to be a viable enhancement.
- The concept of landfill mining to reduce volumes was discussed. Malroz commented that given the nature of the waste deposited it was unlikely that there would be materials that could be economically extracted. This will not be pursued further.

Stakeholder Agency Question 5: Overall Selection Process

- Is the evaluation and selection process clear and easily understood?
- Is the evaluation and selection process valid?

It was agreed by the Stakeholder agencies that the process was valid, clear and easily understood. The following comments were added to provide additional clarity and benefit for the public open house:

- Process is fine as long as approval requirements (C of A) are followed
- It was suggested that one big graphic showing the flow of the entire process would be helpful and that the two sets of exclusionary criteria be distinguished further. This is attached to these meeting minutes for comment. If no comments are received from within one week of sending out the minutes, the team will assume agreement.
- Page 2.6 of the report says that the criteria carry equal weight. This needs to be modified to reflect this process and the realization that some criteria are more important than others. This information has been provided in the table in Question 2.
- The next step of the process is to host a public open house in September or October 2005. It was suggested that the cost estimates for the options would need to be incorporated into the document for the public open house.

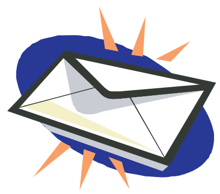
APPENDIX D

OPEN HOUSE MATERIAL

Assessment of Long-Term Management Alternatives, Belle Park Landfill Site, Kingston, Ontario

Welcome!

Please sign in



Please take an information bulletin and review the display materials

City staff and their consultant, CH2M HILL, are available to discuss your questions and concerns

Public, agency, and stakeholder opinions are very important and will influence this study; please fill out a comment sheet

Thanks to all!!

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Purpose

ASSESSMENT OF LONG-TERM MANAGEMENT ALTERNATIVES, BELLE PARK LANDFILL SITE, KINGSTON, ONTARIO

BACKGROUND

Cataraqui Park (better known as Belle Park Landfill Site) is a landfilled marshland that extends into the Kingston Inner Harbour from the west bank of the Great Cataraqui River to Belle Island. The site is approximately 44 hectares (108 acres) in size.

Citizens, businesses, and institutions in the City of Kingston (City) used this site as a municipal landfill from 1952 to 1974. After the landfill was closed, in accordance with Ministry of the Environment requirements, the City developed the site into a multiple use recreational facility that includes a nine-hole golf course, tennis courts, and walking paths.

Since 1997, the City has taken a number of measures at the site to assess the risks and to address leachate seepage into the Cataraqui River. Seep management measures have been implemented and expanded since 1997. The current leachate collection system is operating effectively to address leachate discharges into the river; however, high annual operation and maintenance costs are incurred.

The City requires a more effective and efficient long-term leachate management strategy for this site that is:

- Technically feasible and effective at protecting the environment
- Publicly acceptable
- Energy efficient
- Economically sustainable

In 2003, the City authorized CH2M HILL to conduct an Assessment of Long-Term Management Alternatives for the site.

APPROACH

The approach taken to determine the preferred alternative is outlined as follows:

1. Identify potential long-term management alternatives
2. Screen and develop a short list of long-term management alternatives
3. Evaluate and cost short listed alternatives in detail
4. Select the preferred alternative

SHORT LISTED LONG-TERM MANAGEMENT ALTERNATIVES

The short listed alternatives are presented below:

- Alternative 1: Maintain Existing Seep Management System
- Alternative 2: Constructed Treatment Wetland
- Alternative 3: Perimeter Leachate Collection, and Treatment
- Alternative 4: Hybrid Alternative
- Alternative 5: Clay Cap

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Review of the Benefits and Challenges of Various Components of the Proposed Wetland

ASSESSMENT OF LONG-TERM MANAGEMENT ALTERNATIVES, BELLE PARK LANDFILL SITE, KINGSTON, ONTARIO

Evaluation Criteria	Criteria Weight (A)	Assigned Score (B)	Composite Score = (A) x (B)	Alternative 1: Maintain Existing Containment System – Comment	Assigned Score (C)	Composite Score = (A) x (C)	Alternative 2: Constructed Treatment Wetland – Comment	Assigned Score (D)	Composite Score = (A) x (D)	Alternative 3: Perimeter Leachate Collection and Offsite Treatment – Comment	Assigned Score (E)	Composite Score = (A) x (E)	Alternative 4: Hybrid Alternative – Comment	Assigned Score (F)	Composite Score = (A) x (F)	Alternative 5: Clay Cap – Comment
Technical Considerations																
Maximize Reliability (baseline is assigned 0 [zero], i.e. no interception/treatment – pre-1997)	8.3	7	58.1	Reliable based on recent testing. There is the potential for future leachate seepage at new breakout locations. There is not complete containment and allows for diffuse seepage.	8	66.4	Highly reliable during spring, summer, and fall but poor ammonia removal during the winter. A long hydraulic retention time or added aeration will help provide required water quality improvement.	10	83	Installation of a barrier wall and collection system will provide the highest level of contaminant reduction to the river of all the alternatives.	9	74.7	Installation of selected additional barrier wall sections tied in with the current collection system, poplar tree plantations, and wetlands will provide a very high level of contaminant reduction to the river and will be very close to that of Alternative 3.	7	58.1	On its own, capping does not address the seepage problem since the groundwater flow issue represents the majority of the current contaminant problem. It has been assumed that the existing system will continue to be operated and therefore reliability will be similar to the existing system.
Compatibility with Existing Systems	6.7	10	67	This is the existing system.	5	33.5	Existing system will not be required. However, the existing system could be utilized during the winter period only or as a backup, as required.	5	33.5	Some of the existing piping/infrastructure/ electrical may be incorporated into the design.	9	60.3	Existing piping will be maintained and added to. Could also provide winter backup for the natural treatment areas.	8	53.6	The existing system, which is currently addressing the majority of the contaminant problem, could continue to be operated to provide some reasonable level of protection
Maximize Ease of Implementation	7.7	9	69.3	Minor changes may be required, otherwise already implemented.	5	38.5	Construction of berm into the river around the perimeter of the project site will provide some challenge, but not insurmountable. The south shore is a high energy area (wind/waves).	5	38.5	Tree removal and piping, manhole, and pump installation may have some small level of complexity. Excavation and management of waste onsite/offsite must be addressed.	7	53.9	Some small challenge to this approach will be related to the implementation of the wetland within the West Stream and the impact on the golf course during the installation of the stands of poplar trees.	4	30.8	This is a straightforward clearing and grubbing, and earth moving exercise. Disposal and management of the large volume of waste trees and brush may be a challenge depending on the management method. Requires importing of soil and working around the current collection system, and then revegetating the entire site. Regrowth will be a long-term effort. Locating a clay borrow source may be difficult without significant trucking. Traffic issues with the large volume of truck traffic must be managed.
Regulatory Considerations																
Minimize Duration of Approval (baseline is assigned 5 [five], i.e. current conditions)	7.7	5	38.5	While this alternative may appear to be a "do nothing" approach by the agencies and public, the 8 years of monitoring data has demonstrated that this system has been effective and can be a long-term solution. The system provides for interception and treatment of the majority of the leachate, with some diffuse seepage producing a minimal discharge to the environment.	3	23.1	The approval process may be a challenge since the MOE has had a mixed reaction to constructed treatment wetland projects in the past – assuming worst case scenario if wetland is to be relied on through the winter months. C of A may be granted on a provisional basis since this approach represents a major change to the current approach and since it would be releasing the treated water to the environment directly rather than being treated at a conventional WWTP. The wetland system may also require a backup system that could be the current system.	8	61.6	Due to the reliability of this approach and that the system would not be discharging to the environment, MOE approval efforts are anticipated to be minimized.	7	53.9	Due to the reliability of this approach, MOE approval efforts are anticipated to be minimized, with some added effort to qualify the use of the wetland and poplar tree technologies. The system provides for interception and treatment of the majority of the leachate with some diffuse seepage producing a minimal, but less than in Alternative #1, discharge to the environment. This approach may require the demonstration of reduced groundwater flow due to interception by the poplar tree roots that are anticipated will likely reduce pumping requirements reducing the cost of O&M.	1	7.7	With a cap alone, the approval process will likely reject this approach since it does not address the problem to a sufficient degree. Loss of or impact on the floodplain will extend to the 76 m contour and based on previous experience with the installation of the wetland along the north shore.
Maximize Regulatory Compliance	8.3	8	66.4	Already compliant based on testing.	7	58.1	Compliance is possible.	10	83	Due to the reliability of this approach, compliance is expected to be maximized.	9	74.7	Due to the reliability of this approach, compliance is expected to approach the maximum criteria.	1	8.3	Minimal regulatory compliance will be realized.
Cost Considerations																
Minimize O&M Costs (Net Present Value) 10 – <$1.0 M 9 – $1.0 M to $1.5 M 8 – $1.5 M to $2.0 M 7 – $2.0 M to $2.5 M 6 – $2.5 M to $3 M 5 – $3.0 M to $3.5 M 4 – $3.5 M to $4.0 M 3 – $4.0 M to $4.5 M 2 – $4.5 M to $5.0 M 1 – $5.0 M to $5.5 M 0 – >$5.5 M	7.5	3	22.5	NPV O&M costs: $4.2M	8	60	NPV O&M Costs:$1.8 M (Assuming the passive wetland approach is used, O&M will be minimal. If aeration is incorporated and/or the existing system continued to be used through the winter months, O&M costs are increased. For costing, it has been assumed that the existing system will be required to be operated in the winter months.)	0	0	NPV O&M Costs: $7.3 M (Additional pumping stations and power costs will add to the O&M requirements.	3	22.5	NPV O&M Costs: $4.4 M (The requirement to keep close vigil on the poplar trees to ensure they receive adequate water and are not impacted by rodents and disease in the first few years, as well as O&M on the wetland in the first years to ensure adequate growth and coverage of the wetland, will add in the short term to the current O&M costs. However, the reduced generation of leachate due to infiltration reduction and interception of groundwater is likely to reduce pumping and hence O&M costs. May be able to shut off pumps during high ET periods if groundwater impact is minimal.)	2	15	NPV O&M Costs: $4.9 M (O&M will be mowing, erosion repairs, cap integrity monitoring, summer desication prevention, etc.)
Minimize Capital Costs 10 – <$100,000 9 – $100,000 to $1 M 8 – $1 M to $2 M 7 – $2 M to $3 M 6 – $3 M to $4 M 5 – $4 M to $5 M 4 – $5 M to $6 M 3 – $6 M to $7 M 2 – $7 M to $8 M 1 – $8 M to $9 M 0 – >$9 M	8.0	9	72	Capital Costs: $0.5 M (Site grading and automation upgrades required.)	6	48	Capital Costs: $4.0 M (Cost of implementation will be relatively high due to the need to work in open water)	7	56	Capital Costs: $2.4 M	7	56	Capital Costs: $2.6 M (Added cost will be for tree planting, topsoil, and site preparation for the ski hill and golf course area, limited golf course reconstruction efforts, the construction of a treatment wetland in the south and west stream area, and testing alternative methods of leachate collection.)	1	8	Capital Costs: $8.4 M (Costs of completely capping the site as per current provincial landfill regulatory requirements for new or expanding sites.)
Social Considerations																
Maximize Public Acceptance	7.0	7	49	Public is currently accepting of existing system.	9	63	Public will generally be in favour of the improved recreational uses.	8	56	Similar to existing system.	7	49	Depending on the extent to which the poplar tree plantation encroaches on the golf course to maximize the leachate flow reduction, the golf course layout could be reduced to some extent.	1	7	Public acceptance will be negatively affected by increased truck traffic and disruption to existing site uses during the implementation stage
Maximize Public Safety	8.6	10	86	No added public risk once the system is installed.	8	68.8	Some risk to public safety if perimeter berm is open to the public (water access).	10	86	No added public risk once the system is installed.	10	86	No added public risk once the system is installed.	8	68.8	Since there will be no access during construction, no public safety will be compromised. Once the site is revegetated and public enjoyment amenities added, risk will likely be as it is currently. The new cap and limited vegetation could encourage offroad vehicle use.
Minimize Constraints to Current Recreational Use	8.8	9	79.2	Minimal impact on recreational use are currently experienced and are not expected to change.	10	88	Improves recreational use for walking and wildlife viewing, and general public enjoyment.	7	61.6	Once installed, there should be little if any constraint to the recreational use. However, the golf course will be required to be shut down for about one season during construction.	9	79.2	Once installed, there should be little if any constraint to the recreational use, but rather an improvement due to added habitat features.	5	44	There will be a fairly long period of time before the site is revegetated, thus reducing the recreational use of the site. If the golf course is not rebuilt, the recreational use is reduced further.
Minimize Negative Impact to Private Property (baseline is assigned 5 (five), i.e. current conditions)	7.0	5	35	No change to current impact.	7	49	Wetlands have been known to add to property value.	5	35	No change to current impact.	6	42	No change to current impact. In fact, there may be an improvement to property values.	1	7	The construction process and the long revegetation process will likely have a negative effect on the adjacent private property.
Minimize Degradation to Visual Character (baseline is assigned 5 (five), i.e. current conditions) (Minimization is based on the short term of 5-years)	7.0	5	35	No change to current impact.	7	49	Wetlands add to the visual character.	5	35	No change to current impact.	6	42	No change to current impact. In fact, there may be an improvement to visual character.	1	7	Visual character will suffer for a period of time and then slowly be revived.
Natural Environment Considerations																
Maximize Improvement in Water Quality	7.6	8	60.8	Currently provides sufficient contaminant control.	8	60.8	Would provide sufficient contaminant control.	10	76	Maximizes water quality improvement capability.	9	68.4	Approaches maximum water quality improvement capability.	1	7.6	Little positive impact will be noted in the geochemistry. In fact, it will become degraded without the current collection system.
Maximize Improvement to Wildlife Habitat (baseline is assigned a value of 5 [five], i.e. current conditions) (Improvement is based on the short term of 5 years)	8.8	5	44	No improvement to habitat is currently a part of this alternative.	9	79.2	An entirely new habitat type will be created with the construction of the wetland.	5	44	No improvement to habitat.	9	79.2	Added wetland and poplar stands provide increased wetland and terrestrial habitat and diversity.	1	8.8	Terrestrial habitat will be in a degraded state until revegetation occurs and matures. This will likely be 10's of years. The site will also be mowed and manicured to allow for monitoring of the vegetated cap.
Minimize Disturbance to Floodplain (based on impact to entire Cataraqui River floodplain)	9.2	10	92	No change to current impact.	7	64.4	There will be some encroachment into the river that will reduce the water surface area of the river likely a small fraction of a percentage point.	10	92	No change to current impact.	9	82.8	Some small changes to current impact since some wetland sections may be developed into the Cataraqui River similar to those constructed along the north shore.	4	36.8	The toe of the cap would likely extend out into the river.
Minimize Disturbance of and Destruction to Existing Fish Habitat	9.2	10	92	No change to current impact.	2	18.4	Near shore fish habitat will be disturbed by the wetland construction, but can also be replaced during construction. There will be a net gain in fish habitat in the long term.	10	92	No change to current impact.	7	64.4	Little change to current impact with the exception of the West Stream conversion to a wetland may change the fish species using this water corridor as well as accessibility to the wetland by fish may be somewhat hampered.	5	46	Nearshore fish habitat will be covered where the cap extends into the river but could be restored. Stormwater runoff during construction and before vegetation is firmly established will negatively impact fish habitat if sediment controls become compromised.
TOTAL COMPOSITE SCORE			**967**			**868**			**933**			**989**			**415**	

Notes:
1. Criteria Weight (A) is the weighting assigned to each of the Evaluation Criteria during a workshop by attendees representing MOE, CRCA, MNR, KEAF, City Parks
2. Assigned Score (B), (C), (D), (E), (F) is the score assigned by the project team (CH2M HILL, Malroz, and City Environment Division based on engineering experience and understanding of the site constraints
3. Composite Score is the product of the the Criteria Weight x Assigned Score
4. Each alternative represents a stand alone approach. The capping option (Alternative 5) was carried through to the alternatives section from the methods section at the request of the MOE during the June 28, 2005 workshop due the sentencing requirement that the City provide a capping plan to the MOE

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Summary and Path Forward

SUMMARY

Alternative 4: The Hybrid Alternative received the highest composite score and is recommended for the following reasons:

- Variable site characteristics are matched to the most suitable remediation methods.
- The current system has proven to be effective at controlling the point source leachate seep discharges to the river.
- It is compatible with the existing control systems at the site.
- It is relatively easy to implement at the site due, in part, to making use of the existing control systems.
- Operation and maintenance cost reductions are possible using this alternative
- The total NPV cost of this alternative is the second lowest in comparison to the other alternatives.
- Public acceptance of the alternative is expected to be high due to the continued golf course use, aesthetic improvements, and continued recreational use opportunities.
- Floodplain intrusion and fish habitat disruption would be minimal.

NEXT STEPS

The next steps for this project are:

- Gather comments from the public open house
- Incorporate public comments into the selected management strategy
- Finalize the “Assessment of Long-Term Management Alternatives” report
- Present the findings to Council
- Detailed design of selected alternative
- Implementation and construction of the selected alternative

CONTACT INFORMATION

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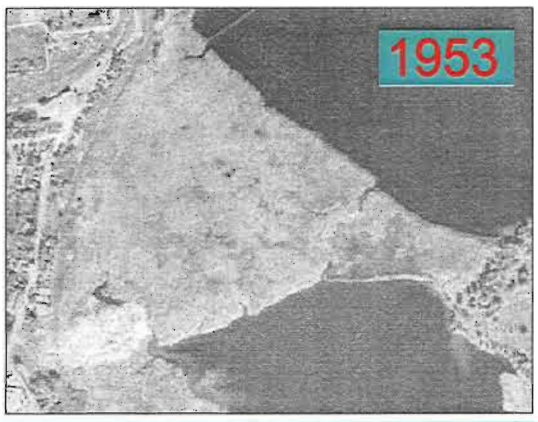
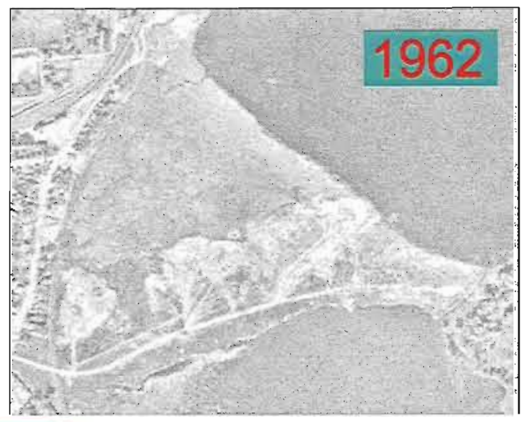
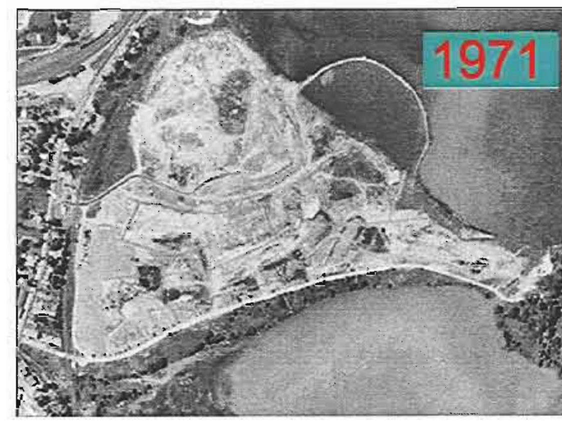
Kingston website: www.cityofkingston.ca

BELLE PARK LANDFILL SITE

HISTORICAL TRANSFORMATIONS

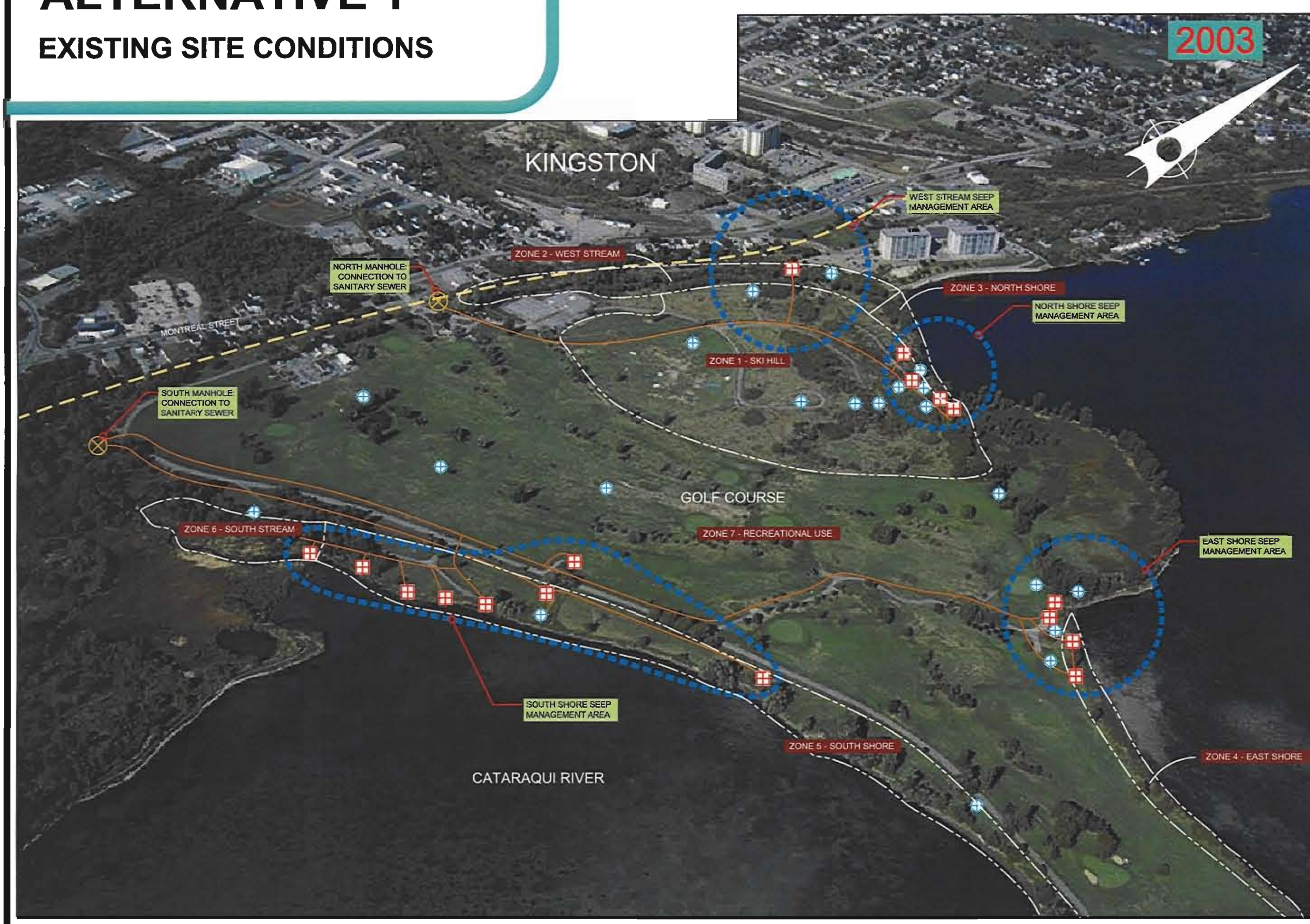






ALTERNATIVE 1

EXISTING SITE CONDITIONS



GROUNDWATER PUMPING

PIPE INSTALLATION

LEGEND:

- GROUNDWATER MONITOR LOCATION
- EXTRACTION WELL LOCATION
- MANHOLE LOCATION
- ZONE BOUNDARY
- LEACHATE PIPING
- 150 mm PERFORATED BIG "O"
- SEEP MANAGEMENT AREA
- SANITARY SEWER

CITY OF KINGSTON

BELLE PARK LANDFILL SITE SEEPAGE CONTROL

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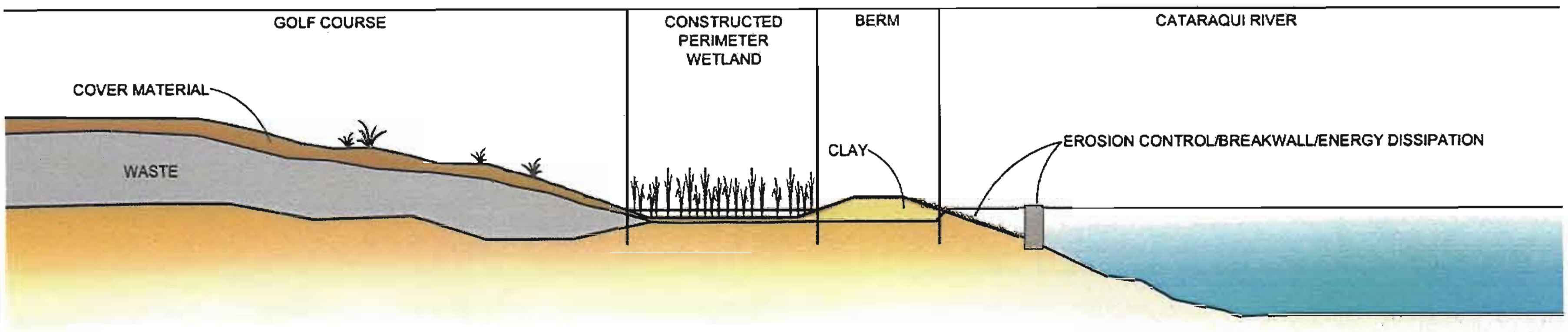
BELLE PARK LANDFILL SITE



SECTION A-A'

ALTERNATIVE 2
CONSTRUCTED PERIMETER TREATMENT WETLAND

TREATMENT WETLANDS

LEGEND:
- EXISTING WETLAND
- CONSTRUCTED TREATMENT WETLAND
- BREAKWALL AND BERM
- ZONE BOUNDARY
- LEVEL CONTROL / DISCHARGE STRUCTURE

CITY OF KINGSTON

BELLE PARK LANDFILL SITE SEEPAGE CONTROL

KINGSTON CANADA

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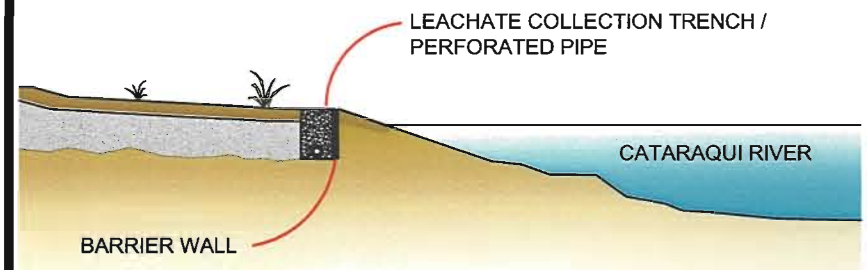
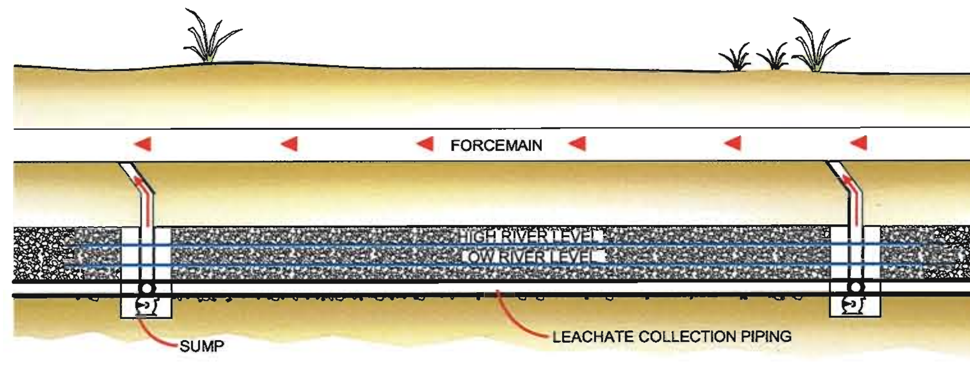
BELLE PARK LANDFILL SITE



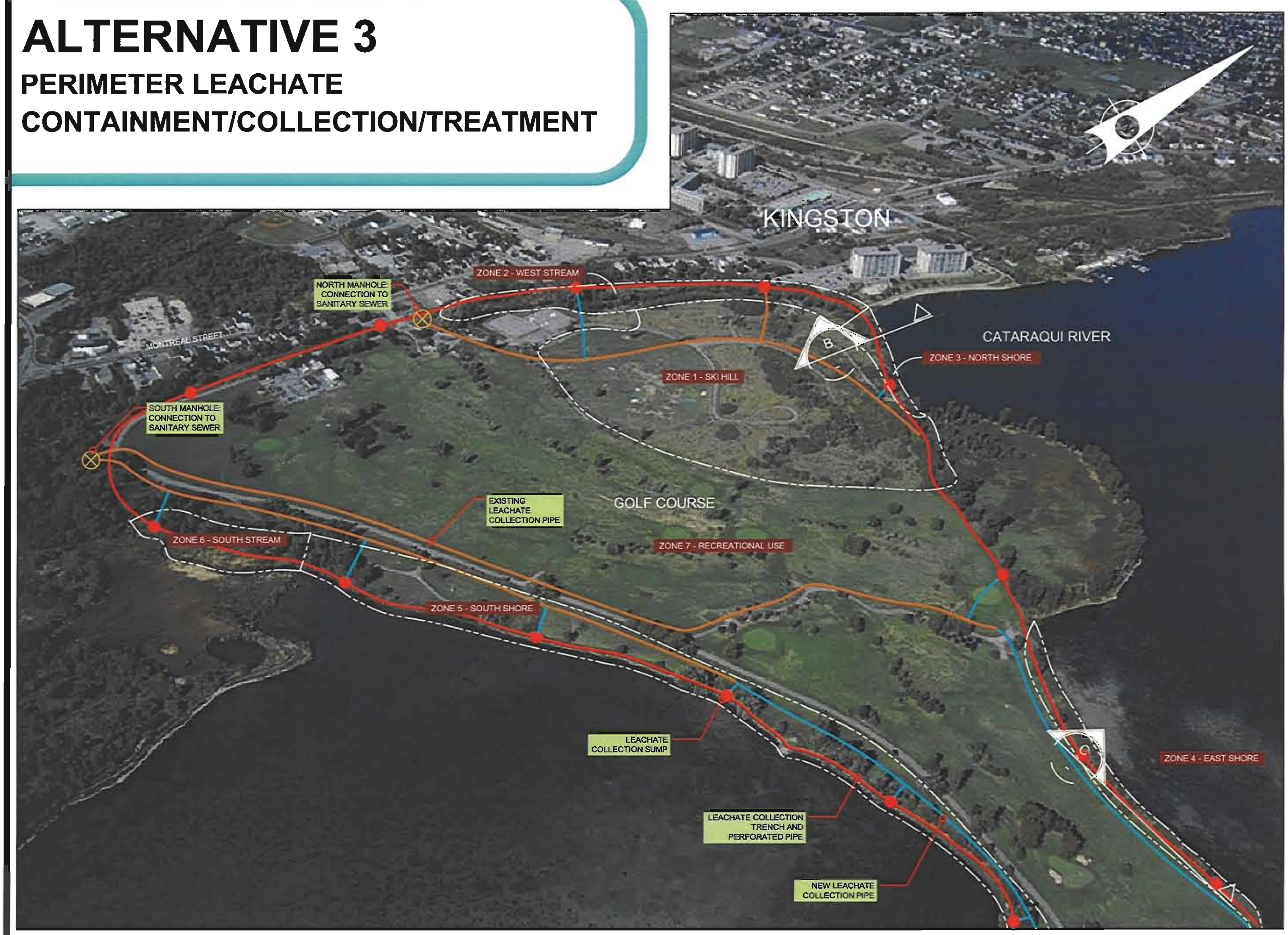
SECTION B-B'



SECTION C-C'

ALTERNATIVE 3

PERIMETER LEACHATE
CONTAINMENT/COLLECTION/TREATMENT



INSTALLATION OF TYPICAL PERIMETER LECHATE COLLECTION TRENCH

INSTALLATION OF TYPICAL PERIMETER LECHATE COLLECTION TRENCH - DETAIL

LEGEND:

- EXISTING LEACHATE COLLECTION PIPES
- NEW LEACHATE COLLECTION PIPES
- NEW LEACHATE COLLECTION TRENCH AND PERFORATED PIPE
- ZONE BOUNDARY
- LEACHATE COLLECTION SUMP
- MANHOLE LOCATION

CITY OF KINGSTON
BELLE PARK LANDFILL SITE SEEPAGE CONTROL

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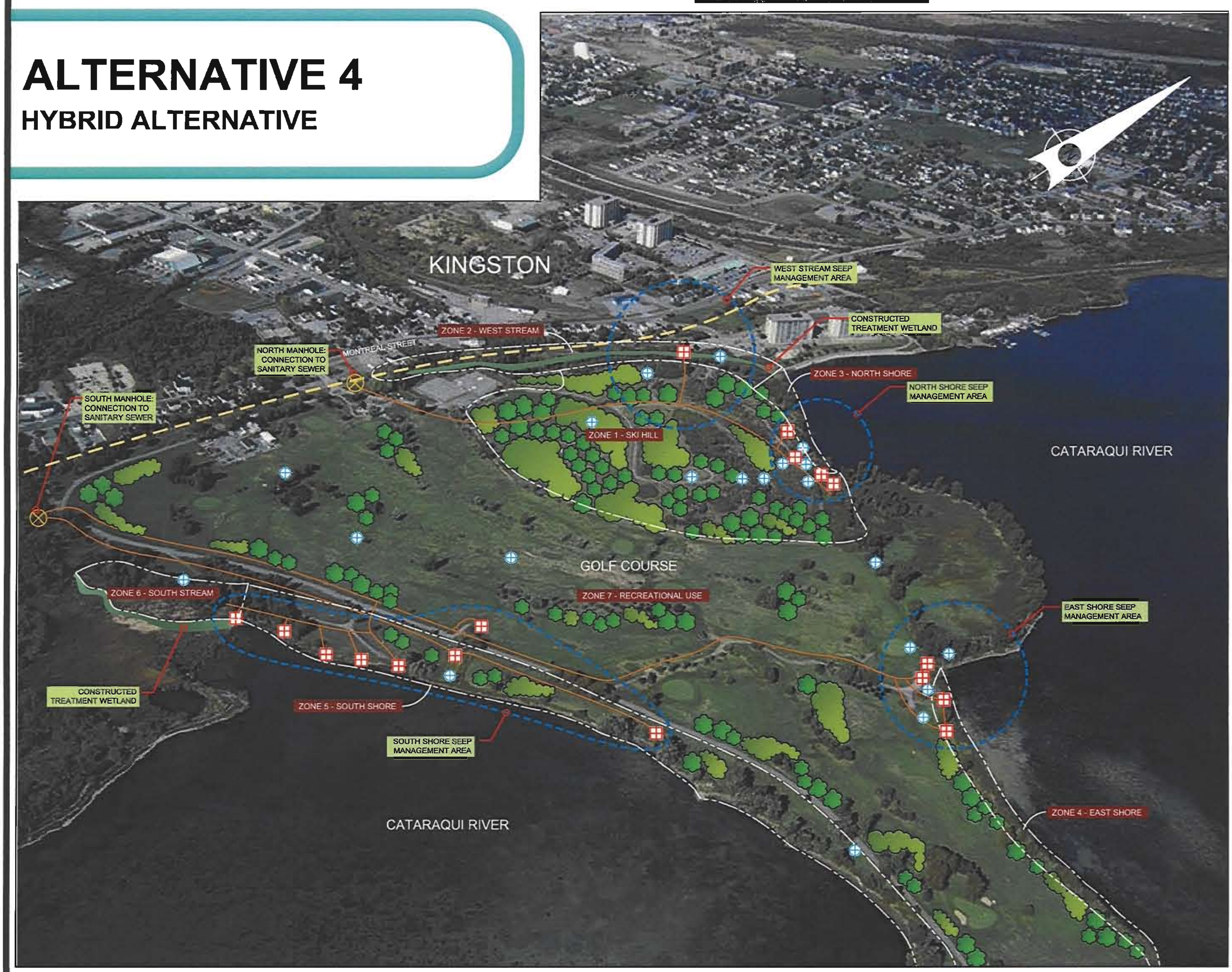
BELLE PARK LANDFILL SITE

WETLAND VEGETATION

DECIDUOUS TREES FOR INFILTRATION CONTROL

ALTERNATIVE 4
HYBRID ALTERNATIVE



INSTALLATION OF TYPICAL PERIMETER LEACHATE COLLECTION PIPE

LEGEND:

- PERIMETER TREATMENT WETLAND
- TREE/SHRUB PLANTINGS
- GROUNDWATER MONITOR LOCATION
- EXTRACTION WELL LOCATION
- MANHOLE LOCATION
- ZONE BOUNDARY
- LEACHATE PIPING
- 150 mm PERFORATED BIG "O"
- SEEP MANAGEMENT AREA
- SANITARY SEWER

CITY OF KINGSTON

BELLE PARK LANDFILL SITE SEEPAGE CONTROL

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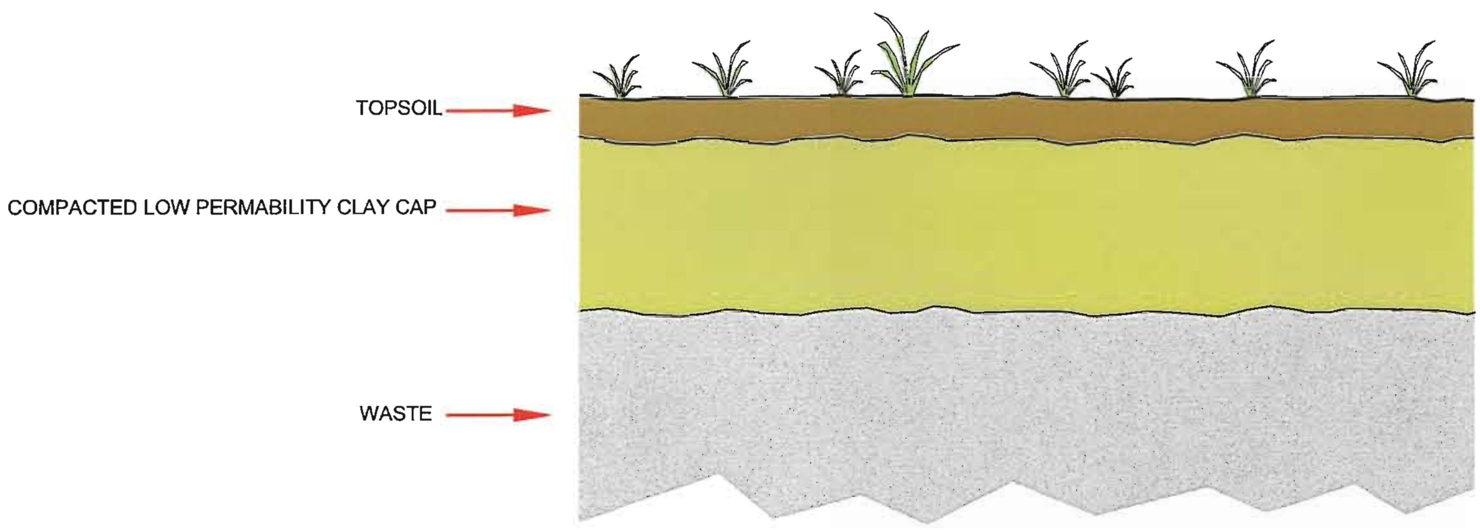
BELLE PARK LANDFILL SITE



ALTERNATIVE 5
CLAY CAP

COMPLETED LANDFILL CAPPING OPERATION

LEGEND:

CLAY TOP

ZONE BOUNDARY

FUTURE LAND USE TO BE DETERMINED. OPTIONS INCLUDE:

1. GOLF COURSE
2. TRAILS
3. PARKLAND

(BASED ON FUNDING AVAILABILITY)

CITY OF KINGSTON

BELLE PARK LANDFILL PARK SEEPAGE CONTROL

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