SM4RT LIVING

YORK REGION'S INTEGRATED WASTE MANAGEMENT MASTER PLAN

REDUCE
REUSE
RECYCLE
RECOVER

November 2013

Residuals Management Strategy

York Region

Residuals Management Strategy

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Strategy Summary

Objectives:

- To ensure the Region is well prepared and equipped to process and manage additional Residual waste over the long-term.
- To develop a process for evaluating long-term Residual waste management options.

Targets:

- Resource conservation goals through the ability to recover materials and energy;
- Local economic growth opportunities;
- A prescribed process for engagement, consultation and support of the community;
- Specific performance measures that incorporate all other aspects of the integrated waste management system;
- Flexibility to adapt to change waste streams and new programs and initiatives recommended elsewhere in the master plan; and,
- A recognition and priority placed on the waste management hierarchy.

Benefits:

- Options to address the long-term need to identify residuals management capacity;
- Timeline and steps to secure each option;
- Preliminary Criteria and Key Questions to be resolved; and,
- A strategy to initiate a detailed review of long-term disposal options.

1.0 Introduction

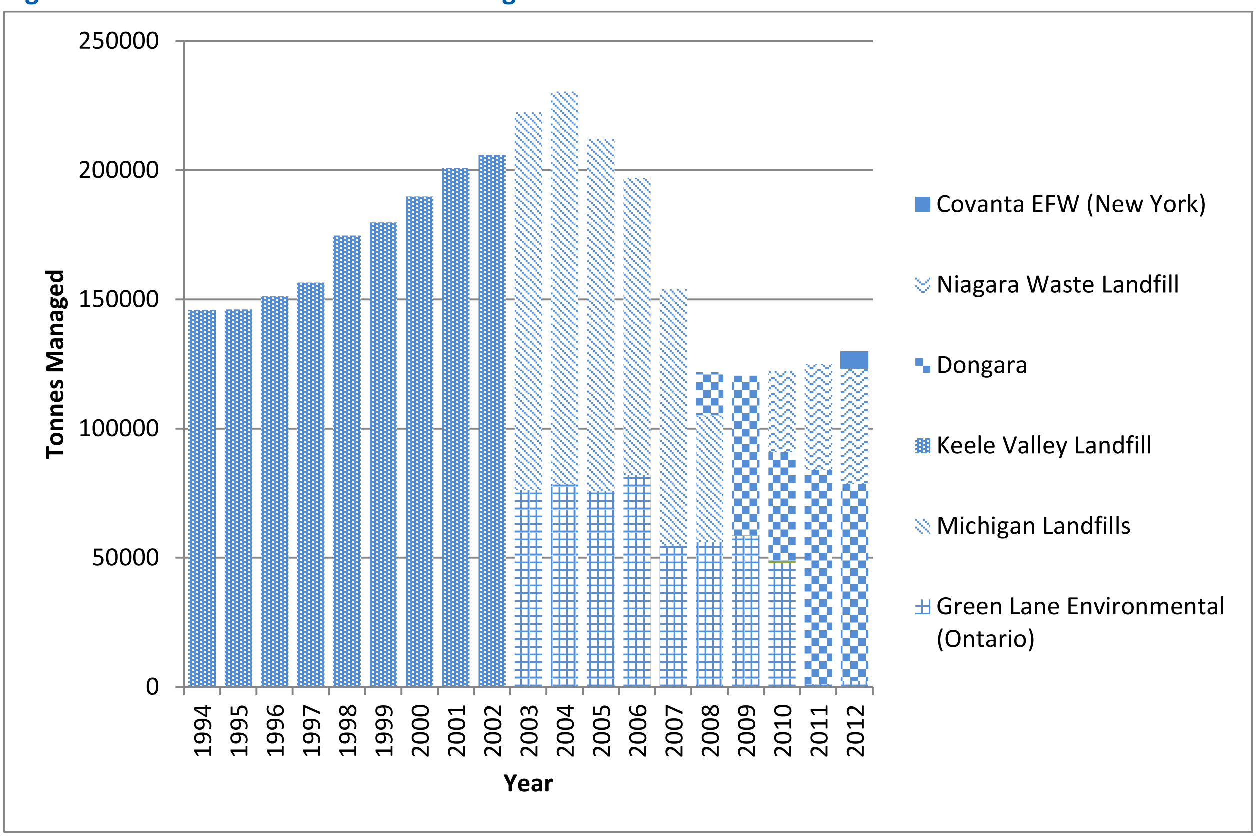
The residuals waste management strategy is one component of York Region's first Integrated Waste Management Master Plan, also known as the SM4RT LIVING Plan. It establishes the planning framework and strategic direction in York Region for the next 40 years and builds on the Region's position as a waste management leader by focusing on driving waste reduction and reuse, while maximizing recycling and energy recovery from the materials that remain.

The primary objectives of this strategy are to:

- **Ensure the Region is well prepared and equipped to process and manage additional Residual waste over the long-term**
- **Develop a process for evaluating long-term residual waste management options**

Over the past20 years, the Region and its local municipal partners have made significant progress towards minimizing the amount of residual waste requiring management. Figure 1 below shows historical waste quantities managed and the significant drop in residual waste that has resulted from the implementation of comprehensive waste diversion programs and initiatives.

Figure 1: Historical Residual Waste Management Trends



The SM4RT Living Plan is intended to continue this trend and minimize the amount of residual waste ultimately requiring management in the future through implementation of the 4Rs (Reduce, Reuse, Recycle and Recover) programs, however, under all foreseeable scenarios, there will still be some residual waste that will need to be managed. Consistency with the 4Rs vision will lead to continually looking at and evaluating residual waste to maximize the resource value of these materials.

As part of its leadership role, the Region and its local municipal partners need to ensure that while focusing on the 4Rs, there is still the necessary supporting infrastructure and contracts to manage the residual waste material that remains.

2.0 Residuals Management Background

Durham York Energy Centre Facility

After many years of study and consultation, York and Durham Regions received approval[1] to construct the first greenfield energy-from-waste facility in Canada in more than 20 years.

The Durham York Energy Centre is situated on a 12-hectare site in the Municipality of Clarington and will have the capacity to process 140,000 tonnes per year of municipal waste with the intent to produce electricity for sale into the market. The estimated cost for the facility is approximately $270 million. York Region's portion of this cost is approximately $68 million. In the initial operating year, the unit cost of the Durham York Energy Centre totals $233/tonne comprised of $42/tonne for operation and maintenance plus $191/tonne for repayment of principal and interest on the capital debt. As the debt is repaid over the duration of the facility operation period, this cost per tonne reduces to approximately $111 per tonne in the year 2035.

[1] In November 2010, the Province's Ministry of the Environment, announced approval of the Durham York Residual Waste Study Environmental Assessment, with conditions. In June 2011, the Ministry of the Environment issued a certificate of approval for the Durham York Energy Centre facility.

Figure 2: Conceptual RenderingDurham York Energy Centre, Clarington, Ontario

This investment represents a premium over other waste disposal options. However, through evaluation of this long-term alternative, it was determined that recovering additional energy and materials from the residual waste was a much better alternative for the environment and worth the additional cost. The facility has a planned operation date of August 2014.

The Region has committed 30,000 tonnes per year of residual waste (post waste diversion programs) to the Durham York Energy Centre in a put or pay contract with Durham Region and Covanta.

Figure 3: Conceptual Rendering Durham York Energy Centre Clarington, Ontario

This initiative is important in terms of the Regions' SM4RT Living Plan for two reasons:

1) It is the first energy-from-waste plant to receive a Certificate of Approval in the Province of Ontario since the Algonquin Power Energy from Waste facility in the Region of Peel received its Certificate of Approval in 1991.
2) This represents an important new addition to the waste management infrastructure in the province and potentially "opens the door" for future facility development as an alternate or complement to landfill disposal.

The Durham York Energy Centre will process only municipally collected household waste left over after both Regions' aggressive diversion efforts (i.e. recycling and composting). The plant therefore represents a component of, rather than a competitor to, the Regions' comprehensive, integrated waste management programs.

This facility will:

- Recover for recycling, 80 per cent of the ferrous metal and 60 per cent of the non-ferrous metal remaining in the residual waste
- Reduce the volume of waste being landfilled by up to 90 per cent, significantly reducing the Region's reliance on landfill disposal

- Generate electricity that can be sold to the electrical grid for distribution at an annual revenue of approximately $8.59 million

The revenues will be split between York and Durham Regions as per the co-owners agreement.

The Regions' investment in this facility clearly distinguishes them as a leader in North America when it comes to energy and material recovery and truly considering waste as a resource.

Dongara Pelletization Facility

Figure 4: Dongara Pelletization Facility, Vaughan

In November 2006, Regional Council signed a contract with Dongara Developments Inc. in Vaughan to process a maximum of 100,000 tonnes per year of residual waste for 20 years. The Dongara Pellet facility, constructed and operated by Dongara Developments Inc., was designed to processes municipal residential waste by removing recyclable materials and then grinding and compressing the remaining processed waste into pellets to be burnedas an industrial energy source. Potential energy markets for the pellets included greenhouses, gasification plants or as a coal replacement in various combustion processes. Dongara encountered difficulties with the Ministry of the Environment around designating the final product as a resource product rather than a waste. The pellets were classified by Ministry of the Environment as waste and all end users were required to be designated as waste management facilities and hold waste facility Certificates of Approval in order to use the pellets. This restriction, combined with low natural gas prices, inhibited Dongara's ability to market pellets in Ontario and in June 2013, Dongara ceased operation.

Landfill Disposal

Figure 5: Green Lane Landfill, St. Thomas, Ontario

Over time, the amount of residual waste disposed by each local municipality has decreased substantially on a per capita basis. This per capita reduction has reduced the overall need for processing and disposal management.

In addition, through investing in new technologies, such as the Durham York Energy Centre, the Region has further reduced its reliance on landfill disposal. Moving away from landfill to other more sustainable alternatives is consistent with the long-term vision of the SM4RT Living Plan. Part of this movement has been spurred by a lack of available landfill capacity and the need to consider more local alternatives.

On March 14, 2006, Michigan passed legislation – H.B. 5176 – to ban the disposal of Canadian waste in Michigan landfills providing Michigan received federal enabling legislation. In August 2006, an agreement was reached between Ontario municipalities and the Michigan government to end shipments of municipal waste to Michigan landfills by December 31st, 2010. This agreement however, did not include shipments of solid waste from the industrial, commercial, and institutional sector that are managed through private haulers.

Between 2006 and 2008, the Region began to significantly reduce waste exported to Michigan. On December 31, 2007, the Region's contracts with Onyx Arbor Hills (now Veolia) and with Republic Carleton Farms expired but staff were able to extend the contract with Veolia on a conditional short-term basis to July 1, 2008.

With the purchase of the Green Lane Landfill by the City of Toronto in March 2007, the Region renegotiated the terms of its contract and settled on a long-range contract extending to 2012 with two, five year optional extensions that could be exercised by the Region. The Region's contract enables shipping 80,000 tonnes of residual waste per year for 20 years to the facility, with a put or pay minimum provision of 25,000 tonnes per year at an approximate cost of $65 per tonne (including haulage).

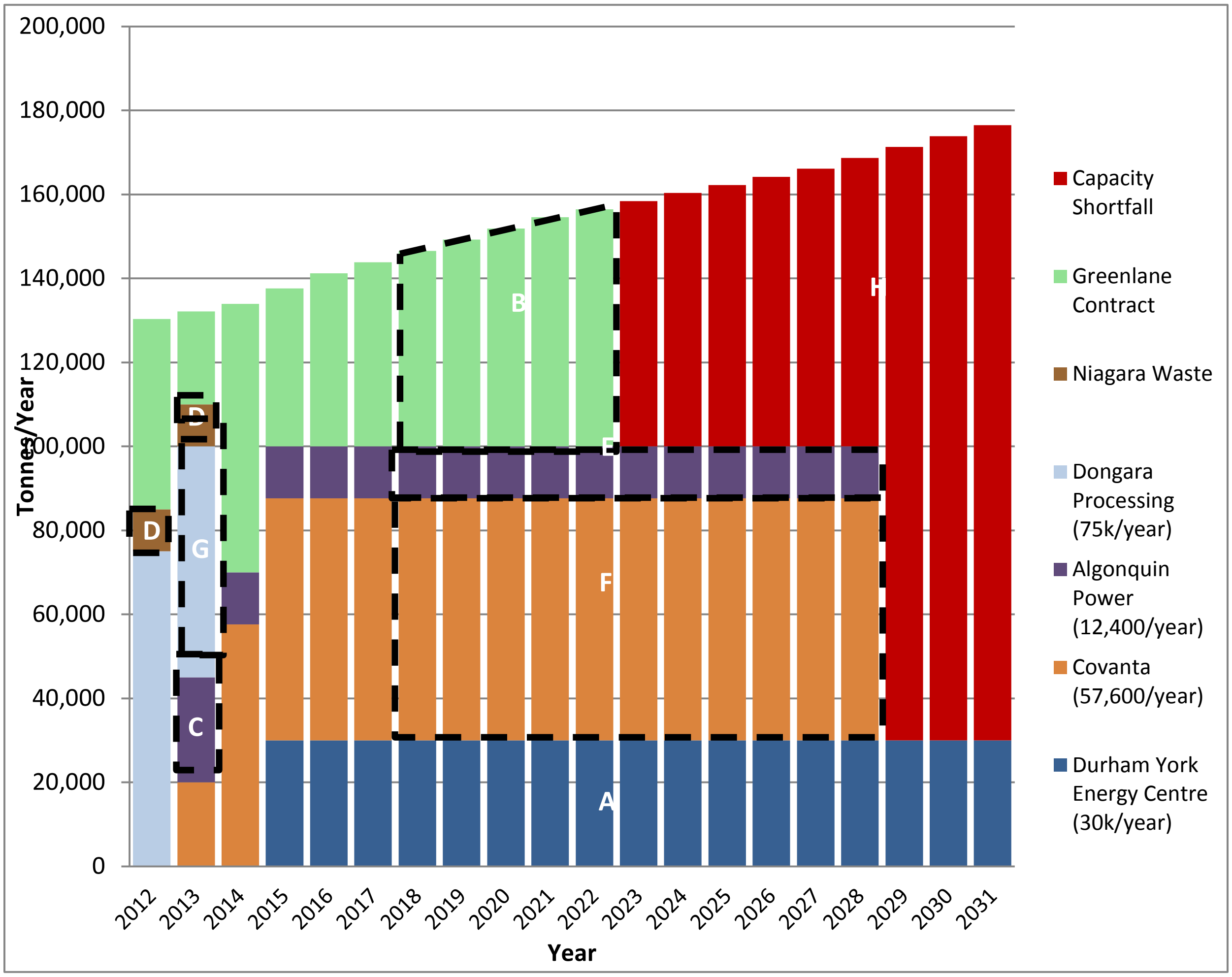
Depending on the local municipality, the cost to collect residual waste materials ranges from $53 per tonne to $56 per tonne.

3.0 Current Residual Waste Facilities and Capacities

3.1 Existing Residuals Material Receiving Facilities

Figure 5 graphically illustrates the residual waste management options currently available to the Region with Dongara discontinuing processing as of 2013.

Figure 6: Residual Waste Processing Needs



A. Represents the 30,000 tonnes per year the Durham York Energy Centre facility will be processing starting in 2014.
B. Represents the contract with Green Lane to 2017 (to a contract maximum of 80,000 tonnes per year) with assumed exercise of the option to extend to 2022 (to a contract maximum of 80,000 tonnes per year)
C. Represents 25 000 tonnes maximum one-year contract with Algonquin Power (plus possible 26 month contract extensions) for SSO and waste
D. Niagara Waste facility provides a near-term contingency to handle source separated organic waste for a maximum of 10,000 tonnes until 2013
E. Represents assumed extension to the Algonquin Power contract at 12,400T/year
F. Represents assumed extension to the Covanta Energy contract at 57,600T/year
G. Dongara shutdown occurs in 2013, only 55,000T shipped for processing

H. Represents the remaining residual waste to be managed beyond the currently defined processing contract commitments

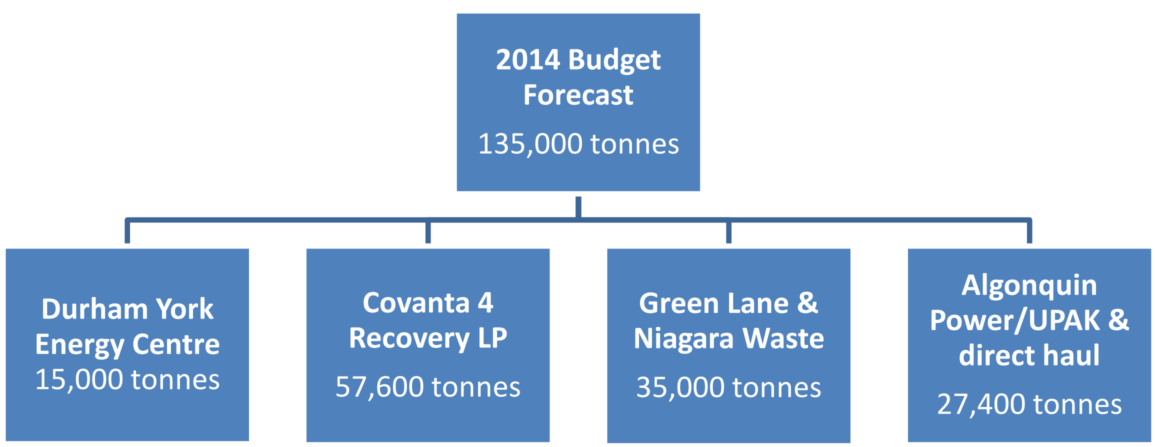
As shown on Figures 5, there is sufficient residual waste processing and disposal capacity available under current contract arrangements to meet the needs of the Region to 2022. Important concerns associated with securing significant quantities of short-term capacity are uncertain availability nearby and the potentially higher cost of short-term spot-market pricing.

Figure 5 also shows that long-term needs for additional capacity to manage residual waste materials occur: a) after 2022, when the extension option for the contract at Green Lane ends; and, b) after 2028, when the Algonquin Power & Covanta contracts end.

3.2 Residuals Management Plan for 2014

The following Figure 7 provides an overview of the proposed waste and cost allocation to manage residual waste materials in York Region.

Figure 7: Residual Waste Management Plan (2014)



With this contractual mix, the Region is on target to have all residual materials heading to a resource recovery alternative and achieve 90 per cent diversion from landfill by 2016.

4.0 Long-Term Residual Waste Management Options

There are essentially five broad categories of options available to the Region to secure long-term residual waste management capacity, including:

- Option #1 - contracted capacity within Ontario (landfill or energy-from-waste)
- Option #2 - contracted capacity outside Ontario (landfill or energy-from-waste)
- Option #3 - expansion of Durham-York Energy Centre
- Option #4 - other potential 4th R (recovery) options

Each of the above identified options is discussed in the following sub-sections in greater detail.

It is important to note, that none of the options identified above include the development of new in-Region landfill capacity. York Region Council has previously resolved that no new Regional landfill capacity in York Region would be explored in the future[2]. This resolution, in part, led to the Durham York Energy Centre initiative.

4.1 Option #1 - Contracted Capacity within Ontario

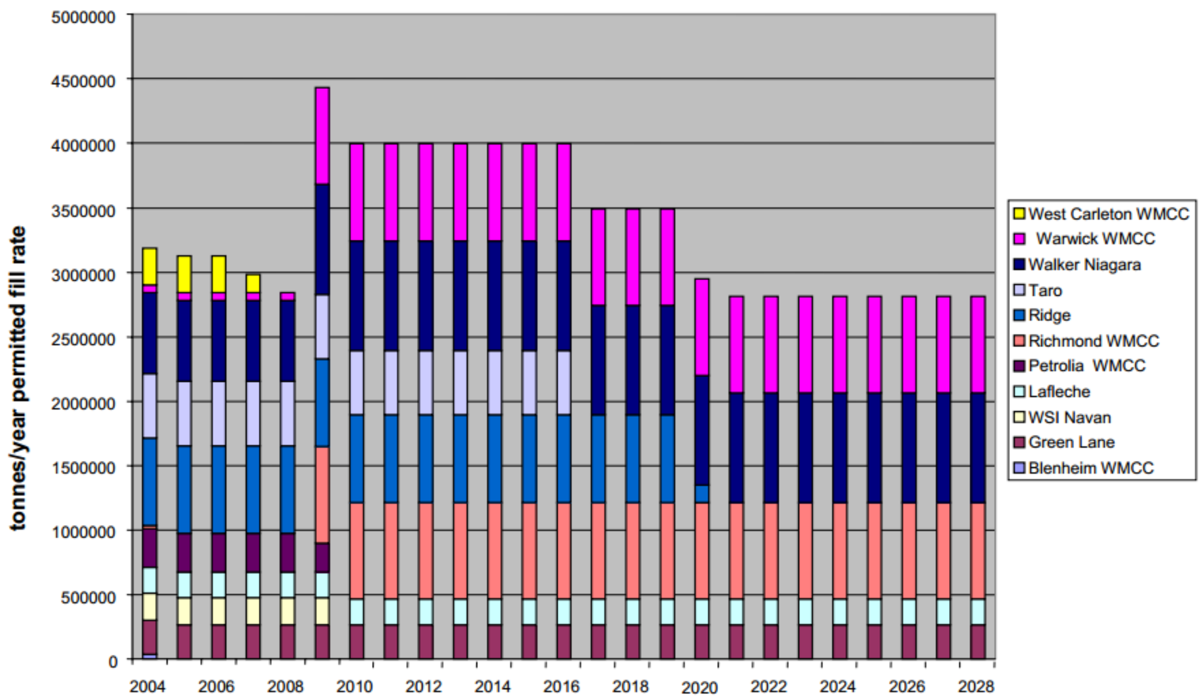
There are two types of contract residual waste management options within Ontario that could be considered by York Region to satisfy its long-term needs. The first is resource recovery/energy-from-waste and the second is landfill disposal. The following sections provide an overview and evaluation of both options. It is important to note that the Region has historically taken the approach that alternatives providing recovery of resources are preferred over non-resource recovery alternatives. This approach is consistent with the 4Rs hierarchy and is reflected in the SM4RT Living Plan, recognizing however that there are some residual waste materials where the only option currently available is landfill.

4.1.1 Ontario-Based Landfill Capacity

An update to available residual waste management capacity has not been completed since 2005 in Ontario. In 2005, the Ontario Waste Management Association completed a review of private sector landfill capacity in the Province of Ontario. Figure 8 below provides a 2005 snapshot profile of available landfill capacity, as well as landfill capacity projected for approval at that time.

[2] January 28, 1999 – Regional Council endorses Report No.1 of of the Solid Waste Management Strategy Committee (Nov. 26, 1998), which includes 10 'Solid Waste Disposal Planning Principles'. Principle no. 1 is 'no new landfill capacity in York Region'

Figure 8: Private Sector Landfill Permitted Fill Rate with All Applications Underway Approved (2005) [3]



Since 2005, applications for the Walker Landfill and Warwick Landfill expansions have been approved.

In addition to the above, there have recently been two events initiated that could result in creation of additional merchant residual waste disposal capacity in Ontario.

- Walker Industries has initiated the development of EA Terms of Reference to establish a new greenfield landfill site in Oxford County; if approved, this facility would add significant (quantity remains to be determined) approved landfill capacity to the Ontario marketplace beginning in 2021.
- Miller Waste and Taggart Group have initiated the development of EA Terms of Reference to establish a new greenfield landfill site in Eastern Ontario (Village of Russell); if approved, this facility would add significant (quantity remains to be determined) approved landfill capacity to the Ontario marketplace

Even with the approved capacity and the new capacity currently in approvals stages, there is still a disposal capacity deficit in Ontario resulting in significant export (in particular with respect to industrial, commercial and institutional waste) to the United States. That being said, recent municipal procurements in Ontario for disposal capacity have resulted in Ontario-based

[3] The Private Sector IC&I Waste Management System in Ontario, Ontario Waste Management Association, 2005.

landfills being successful which indicates there are still private sector landfill operators in Ontario able to manage additional quantities of municipal residual wastes.

Cost Considerations:

Based on 2013 information for York Region, current pricing for landfill disposal capacity in Ontario is $65/tonne.

Timing for Consideration

Given the need for additional capacity to be established by 2022, the process to procure long-term contracted waste disposal capacity for an in-Ontario landfill option should be initiated no later than 2021 to provide sufficient time to complete the necessary procurement and contractual arrangements. This timing presumes that adequate landfill disposal capacity will be commercially available at that time. Should York Region rely on securing long-term contracted landfill disposal capacity in Ontario for 2022, it would be prudent to annually monitor the commercial availability and pricing for landfill disposal in the province, recognizing that it may become necessary to commence procurement earlier than 2022, should the existing landfill capacity deficit worsen.

4.1.2 Ontario Based EFW Capacity

Figure 9: Algonquin Power Energy-From-Waste Facility, Brampton, Ontario

Section 4.3 discusses the option of increasing York's residual waste contribution to the Durham York Energy Centre.

Algonquin Power Energy-from-Waste (APEFW) owns and operates the only large-scale energy-from-waste facility in southern Ontario. Located in Brampton, the facility converts 500 tonnes per day of solid, non-hazardous waste into steam (which is sold to a neighbouring recycled paper mill) and electricity (sold to the grid).

The APEFW facility has been in operation since 1992 and has processed 2.5 million tonnes of waste to date. The facility is continuously upgraded to ensure its technology and environmental controls remain state-of-the-art. The most recent upgrade to the facility occurred in 2010 which will provide for continued operation for an estimated 20 more years.

1) In November 2012, the Ontario Ministry of the Environment approved an amendment to the facility's CofA to allow it to accept waste from businesses and municipalities throughout Ontario with a permitted capacity of up to 187,000 tonnes per year
2) In November 2012, Algonquin Power and U-PAK Group announced an arrangement where they will jointly market and coordinate supply waste to the facility

York Region has secured short-term energy recovery capacity for 2013 for the management of residual waste and source separated organics as needed.

The APEFW facility provides a suitable alternative for residuals management that is consistent with the priorities of the waste management hierarchy and the long-term vision and guiding principles established in the master plan.

Cost Considerations:

Algonquin Power has committed in the new contract to provide energy recovery processing services for residual waste and source separated organics for a price of $66 per tonne including haulage.

Timing for Consideration

Given the need for additional capacity to be established by 2022, the process to procure long-term waste disposal capacity at the APEFW facility should be initiated no later than 2021 to provide sufficient lead-time to complete the necessary procurement and contractual arrangements. This timing presumes that APEFW will have adequate capacity commercially available at that time. Given the limited nature of disposal capacity at APEFW, should York rely on this option for long-term future residual waste management capacity, it would be prudent to annually monitor the commercial availability and pricing for capacity at the APEFW facility.

4.2 Option #2 - Contracted Capacity Outside Ontario

One of the potential long-term alternatives for disposal capacity is to export residual material to New York State (and/or the north-east United States). Currently, there is a significant portion of waste disposal capacity in this area being used by Canadian waste generators, both residential (such as the Region of Durham until the Durham York Energy Centre is constructed) and Industrial, Commercial and Institutional generators.

As of February 2012, there were 26 active Municipal Solid Waste (MSW) landfills in New York State. In 2010, these MSW landfills accepted a total of 6.9 million tonnes of solid waste. At the end of 2010, the landfills had approximately 199 million tonnes of capacity remaining which includes both capacity actually constructed and capacity not yet constructed but permitted to be constructed. This equates to approximately 28.5 years of capacity at 6.9 million tonnes per year[4].

There are also several merchant capacity waste-to-energy facilities in New York state that are capable of receiving and processing (with energy and materials recovery) municipal solid waste. As of February 2012, there were 10 active MSW facilities in New York State. In 2010, these facilities processed approximately 3.5 million tonnes of solid waste and generated approximately 1.8 million megawatt hours of electricity. Additionally, approximately 78,985 tonnes of metals were recovered for recycling[5].

A potential alternative available to York Region is to export residual waste to a landfill or waste-to-energy facility outside of Ontario, however, with this alternative comes the inherent risk of potential border closures, similar to that experienced with the State of Michigan.

Cost Considerations:

Based on recent pricing information, landfill disposal fees in New York State range from $65/tonne to $85/tonne. It is important to note that this range represents published “gate rate” prices and could be less depending on the quantity to be managed.

Timing for Consideration

Given the need for additional capacity to be established by 2022, the process to procure long-term waste disposal capacity outside of Ontario would need to be initiated no later than 2020 to provide sufficient time to complete the necessary procurement and contractual arrangements, as well as facilitate any administrative requirements for cross-border shipment of wastes. This timing presumes that adequate residual waste management capacity in New York State will be commercially available to Ontario clients at that time. Should York Region rely on securing residual waste management capacity in New York State by 2022, it would be prudent to annually monitor the commercial availability and pricing for residual waste management capacity in New York State.

4.3 Option #3 - Expansion of Durham York Energy Centre

A potential option available to York Region is to expand the Durham York Energy Centre to secure additional long-term capacity. The original design concept behind this facility envisioned the potential for expansion in the future and has been sited and is being constructed in a manner that would facilitate an expansion, if required. As part of the current design and construction underway, certain components have been designed and will be constructed initially to support the longer term expansion with only minimal need for redesign and construction of additional components. The planned phasing of expansion includes Phase 2

[4] New York State, Department of Environmental Conservation http://www.dec.ny.gov/chemical/23682.html

[5] New York State, Department of Environmental Conservation http://www.dec.ny.gov/chemical/23683.html

where the facility would be able to accommodate up to 250,000 tonnes/year and Phase 3 where the facility would be able to accommodate up to 400,000 tonnes/year. An expansion to reach the maximum design capacity however, would require more effort to design and construct.

A conceptual overview of the facility components and accommodation for expansion is outlined in Table 1 below. Provisions for the equipment and buildings for the Phase 1 expansion will be included in or adjacent to the initial facility building. Provisions for the equipment and buildings for the Phase 2 expansion will be located to the west of the initial and Phase 1 contiguous buildings. The facility design includes provisions for future supply of hot water district heating with 100 per cent availability to the nearby Courtice WPCP and the future Clarington Energy Business Park.

Table 1: DYEC Provisions for Expansion of Facility Components[6]

Facility Component	Provisions for Phase 1 Expansions (250, 000 tpy)	Provisions for Phase 2 Expansion (400, 000 tpy)
Tipping Floor Building	No Change Required	+1 (Space allotted, no provisions included)
Two Overhead Refuse Cranes	No Change Required	+2 (Space allotted, no provisions included)
Refuse Storage Pit	No Change Required	+1 (Space allotted, no provisions included)
Boiler House Modifications	Design to allow for ease of expansion	+1 (Space allotted, no provisions included)
Electrical Generating Capability	Need to add Phase 1 turbine and turbine generator building adjacent to initial building	Need to add Phase 2 turbine and turbine generator building adjacent to initial building. (Space allotted, no provisions included)
Exhaust Stack	Stack shell sized for the addition of a third boiler train flue	+1 (Space allotted, no provisions included)
Residue Removal and Storage	No Change Required	+1 (Space allotted, no provisions included)
Ferrous and Non-Ferrous Recovery	No Change Required	+1 (Space allotted, no provisions included.)
Control Room	Has space for installation of additional consoles etc. associated with expansion	Has space for installation of additional consoles etc. associated with expansion

[6] Environmental Assessment (EA) Study Document. July 31st, 2009. Section 10: Identification and Description of the Undertaking. Jacques Whitford.

Facility Component	Provisions for Phase 1 Expansions (250, 000 tpy)	Provisions for Phase 2 Expansion (400, 000 tpy)
Utilities	Water and Wastewater lines will have capacity to support throughput capacity	Water and Wastewater lines will have capacity to support throughput capacity
Condenser System	Provisions made for an additional condenser unit	+1 (Space allotted, no provisions included)
Fire Protection	Fire pumps and water supply system sized for 400,000 tpy. Additional sprinklers and detectors added as part of expansion.	Fire pumps and water supply system sized for 400, 000 tpy. Additional sprinklers and detectors added as part of expansion.
Chemical Storage	No Change Required	Provisions for storage of acids, caustic, lime etc. In bulk will be able to support a processing rate of 400,000 tpy or space will be provided on the site for additional storage
Administration Building	No Change Required	No Change Required
Roadways and Parking	No Change Required	Space rovided, no provisions included

Notes:

- +1 - one similar component or unit added
- +2 - two similar components or units added

It is important to note that although the facility is being designed and constructed in a manner facilitating a future expansion, the current permits for the facility put a “cap” that will prevent the facility from receiving more than 140,000 tonnes per year. Any change to the approved throughput capacity would require amendments to these permits as discussed in the following section.

Approvals Required to support DYEC Expansion

Expansion of the DYEC would require approvals under the Ontario Environmental Assessment Act (EAA) and the Ontario Environmental Protection Act.

A facility expansion at the DYEC would take the form of a physical expansion of the existing plant which would be regarded by regulatory authorities and potentially other stakeholders as being very similar to a ‘new’ facility. As such, it is anticipated that the following approvals would be required:

<u>Ontario Environmental Assessment Act</u>

With regard to approvals under the EAA, Ontario Regulation 101/07, sections 11(1)2 and 16, would exempt expansion of the DYEC from Part II of the EA Act, subject to fulfilling the

Environmental Screening process, meaning that the requirements for an environmental assessment could be met through Environmental Screening and an Individual EA would not be required. The Environmental Screening process is a proponent driven self-assessment process, with the focus on identifying and addressing site specific environmental effects of the proposed undertaking. The technical studies and Environmental Screening Report prepared as part of the screening process do not require approval by the Ministry of the Environment. Proponents are encouraged to conduct the environmental screening process concurrently with applications for other approvals, and thus, it could be reasonably assumed that the technical studies undertaken as part of the screening should be undertaken to a level of detail suitable to address the subsequent approvals requirements under the Environmental Protection Act and Ontario Water Resources Act would likely need to be completed in a manner that reflects an "update" to the studies which were completed as part of the original EA and EPA approvals processes..

During the mandatory 60-day review period after the publication and notice of completion of the Environmental Screening Report, any interested person, including an Aboriginal community can submit an elevation request. If an elevation request is submitted within 60 days following publication of the Notice of Completion, the ministry will review the proponent's report(s) in making a decision on the elevation request. If no elevation requests are received during the review period, the proponent completes the process by issuing a "Statement of Completion," submitting a copy to the director and the regional co-ordinator and placing a copy on the project file.

The environmental screening process has a set series of consultation steps that should involve a range of stakeholders (including agencies, Aboriginal peoples etc.) that must be addressed; however proponents are free to expand this consultation process as appropriate. Proponents are required to consult with affected government agencies, including the appropriate Regional office of the ministry, during the course of the review. The ministry, as a key affected government agency, may provide comments or advice to proponents to address the ministry's concerns.

<u>Environmental Protection Act (EPA) and Ontario Water Resources Act</u>

The EPA and OWRA have been amended to create a new instrument of approval to replace Certificates of Approval. The new instrument is the Environmental Compliance Approval (ECA). Existing Certificates of Approval and their terms and conditions continue to apply and may be amended, reviewed, suspended or revoked as if they were an ECA.

Approvals under the EPA and OWRA would be required following the new Environmental Compliance Approval process, and in accordance with applicable guidance documents. At present, applicable guidance documents include the:

1. Guide to Applying for Approval (Air and Noise) [PIBS 4174]
2. Guide for Applying for Approval of Sewage Works [PIBS 7339]
3. Guide for Applying for Approval of Waste Disposal Sites [PIBS 4183] and,

4. Guideline A-7, Air Pollution Control, Design and Operation Guidelines for Municipal Waste Thermal Treatment Facilities.

The first three guides are likely to be replaced in the near future by the proposed guide to applying for an Environmental Compliance Approval that is currently in draft form and issued for comment by the MOE.

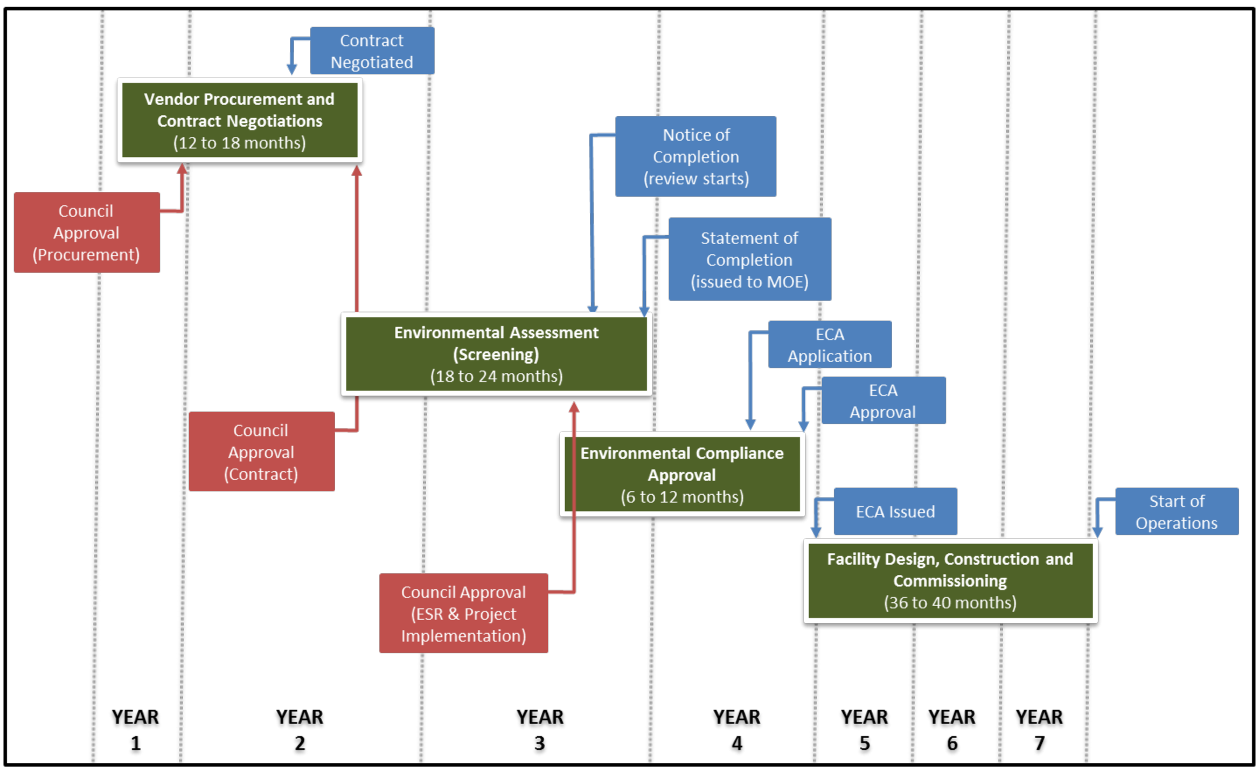
Cost Considerations:

Given that the facility is currently under construction, the true cost to construct is not yet known at this time, only the estimated cost to complete. In addition, since the timing of a potential expansion is to be confirmed, accurate cost estimates cannot be prepared given the potential fluctuations in materials and construction costs.

Timing for Consideration:

The following Figure 10 provides an overview of the timeline for implementation of the DYEC expansion option.

Figure 10: Potential DYEC Expansion Timeline



A few key items to note when considering the DYEC facility expansion strategy: A time span of seven years is estimated to be required to move this option from initial decision to start of operations.

1) It is anticipated that construction and commissioning of the current initial phase of the DYEC will be completed by 2014. Subsequent expansion after 2014 allows real-life

operating and monitoring data from the existing facility to be used as the basis for impact assessments. This has the benefit of being able to demonstrate what theoretical modelling has already predicted –the facility poses no undue risk to human or ecological health.

2) A complete set of lessons learned on development of the facility can be compiled to facilitate the construction of the expanded facility. Opportunities can be considered to optimize and/or improve the facility and/or its operations.

4.4 Option #4 - Other Potential 4th R options

There are currently a wide range of conventional and potential "emerging" options to manage post-diversion residual waste that can recover energy and other products from residual waste. These technologies include both thermal and combustion processes, as well as chemical and biological processes and fuel development alternatives. The important considerations in assessing these technologies include the stage of development, demonstrated reliability of the processes associated with each technology, costs, and potential risks and benefits.

Cost Considerations:

Capital and operating cost estimates for less established or emerging technologies are developed using higher contingencies (>20-25 per cent) to reflect the many unknowns associated with a lack of widespread commercial operations of these technologies in North America. For this reason, most of the available cost information for new and emerging technologies is considered indicative values not suitable for final budgeting or financing. Should this type of technology be considered in the future, cost and risk information would need to be carefully evaluated in a commercially confidential procurement process where specific details can be disclosed by potential technology vendors.

Timing for Consideration:

The timing for consideration of conversion technologies is similar to that of expansion of the DYEC, however, with the addition of the need to undergo a site identification process and vendor procurement process in advance of environmental approvals. For these activities (which could be completed in parallel to save time), a minimum of two additional years should be added to the schedule resulting in the need to start the project development process approximately nine years prior to the occurrence of an anticipated implementation trigger. This time frame is consistent with that historical experience for many of the more substantial, long-term solid waste projects that have been completed in Ontario.

5.0 Triggers

The following provides an overview of "triggers" (in chronological order) currently identified that would result in the need for implementation of contingency measures and/or planning for new capacity.

- **Trigger #1 – Loss of Existing Contracted Capacity**

Unfortunately, only Options #1 & #2 identified in the preceding section provide the timeliness to address a loss of existing contracted capacity in advance of their current contracted end-of-term; should this situation occur, the Region will need to move quickly to procure both emergency capacity and interim capacity until a new long-term option can be identified

- **Trigger #2 – End of Contract Term**

  It has been identified that long-term needs for additional capacity to manage residual waste materials occur after 2022, when the extension option for the contract at Green Lane ends

The following sections have been prepared to identify the process by which consideration of long-term options to resolve the anticipated occurrence of trigger#2 conditions (i.e. end of contract term) would be achieved. Trigger # 1 (i.e. loss of existing contracted capacity) cannot be dealt with in the same evaluation approach as the occurrence of trigger #1 would be an urgent or emergency condition with a limited set of situation-specific and timely options available.

6.0 Long-Term Options Evaluation Approach

6.1 Process Overview

The following provides an overview of an evaluation strategy that should be applied to secure long-term residuals management capacity to meet a trigger condition. This process has been developed to narrow the list of options defined above through the process of answering some questions which focus on key priorities and criteria including:

- Is it consistent with the Vision and Guiding Principles?
- Is the approach/technology affordable and does it provide good value to the Region?
- Will the approach/technology be sufficiently reliable to manage/process the Region's waste over the long term (at least 25 years)?
- Is the implementation schedule acceptable?
- Will it meet current and future environmental regulatory requirements?
- Is the approach/technology protective of the environment and promote environmental sustainability?
- Does the approach/technology complement and enhance existing waste diversion and resource recovery efforts?
- Is it a local ("made in York Region") solution?
- What are the costs and risks associated with the approach/technology?

Once a "trigger" has been identified, these key questions and fundamental principles should be reviewed with the public, stakeholders and agencies as part of the evaluation process to help establish priorities of the community in a future waste management system. These questions would ultimately be answered through the completion of a step-wise evaluation approach that should include the following steps:

STEP 1 Establishing and Assessing the Long-Term Residuals Management Requirements

The first key element in developing a long-term waste disposal option is to understand what the quantity and composition of the materials to be managed will be over the planning term. This step has been completed as part of the master planning process, however, these projections will need to be updated once the formal evaluation process has been initiated to ensure the most accurate and up-to-date information is being used. As well, the success of other initiatives identified in the Master Plan that have already been implemented must be taken into consideration.

STEP 2 Establishing the Methodology and Criteria to Evaluate Residual Waste Management Options

A critical aspect of the evaluation is establishing the methodology upon which the selection process will proceed. It is important that the proposed evaluation criteria are robust, effective and capture all key relevant factors and principles of the Region and local municipalities.

STEP 3 Establishing the List of Available Residual Waste Management Options

The options identified above represent the current list at the time of consideration, however, this list may need to be expanded/refined depending on timing of the evaluation.

STEP 4 Screening to Identify Established and Emerging Technology Classes and Development of Potential Residual Waste Disposal System Options

Using screening criteria (to be developed in Step 2), the lists of waste disposal system options should be identified. The following provides a preliminary list of screening criteria for consideration:

a. **Commercial Readiness**. The degree to which the option/technology and the proposed components have been demonstrated on mixed Municipal Solid Waste (MSW), including status of reference or demonstration facilities (i.e., where else is this being done for a similar application?)

b. **Applicability to Specific Waste Stream**. The degree to which the proposed option/technology is suitable for the targeted waste stream in the Region

c. **Ability to Complement Existing Waste Diversion efforts**. The degree to which the proposed technology does not compete with and can potentially enhance existing waste diversion programs in place in the Region

d. **Consistency with Regional Planning Principles**. The degree to which the option/technology satisfies the Vision and Guiding Principles established in this Master Planning process.

STEP 5 Identification of the Preferred Residual Waste Management Option

Once a list of system options is identified a more detailed evaluation is completed, taking into account the life cycle impacts of the options, including: technical, environmental, social, economic/financial; and legal requirements. There is an opportunity at this step to also utilize the decision-making framework, developed as part of the SM, as a component of this evaluation.

STEP 6 Identification of the Next Steps to Implement the Preferred Option

This final step in the process includes an assessment of the critical aspects related to implementation of the preferred option, including: siting requirements; permitting and approval considerations; timelines for implementation; and a comparison of the advantages and disadvantages of a Region owned versus a supply agreement with a privately owned facility.

A flow chart has been provided below that shows the steps for the evaluation process.

Figure 11: Overview of Long-Term Residuals Management Options Evaluation Process

Step 1

- Establishing and Assessing the Long-Term Residuals Management Requirements

Step 2

- Establishing the Methodology and Criteria to Evaluate Residual Waste Management Options

Step 3

- Establishing the List of Available Residual Waste Management Options

Step 4

- Screening to Identify Established and Emerging Technology Classes and Development of Potential Residual Disposal System Options

Step 5

- Identification of the Preferred Residual Waste Management Option

Step 6

- Identification of the Next Steps to Implement the Preferred Option

There are different methods (qualitative or quantitative or a combination of both) that can be used to evaluate the potential technologies and options. In undertaking this type of evaluation, there is no requirement to apply any specific methodology. The proposed methodology and approach used in the above proposed evaluation is commonly applied, and consistent with, the more exhaustive and stringent systems analysis requirements undertaken to address the approval requirements of the Ontario Environmental Assessment Act and the Individual Environmental Assessment process.

Should the preferred approach be to use an existing facility under a waste supply contract, there would be internal due diligence work required on the proposed facility(ies). This due diligence would include at a minimum: confirmation of all necessary regulatory permits and approvals, including discussion with the Ontario Ministry of the Environment and/or the appropriate regulatory agency(ies); site visit(s); financial due diligence; as well as any other verification required to confirm the facility will be able to manage the waste material in a manner consistent with the contractual requirements.

Preliminary Review of Options

The following presents a preliminary review of options currently defined for York Region to manage its residual solid wastes in the context of the two trigger #2 conditions (i.e. end of contract term) defined in this report associated with end of contract term.

This preliminary review focuses on the fundamental questions listed in Section 6.0, which describe criteria to form the basis for the recommended future evaluation process. It should be recognized that the nature of the triggers, the focusing criteria, priorities, key influencing conditions and opportunities will undoubtedly change between now and the time period that completion of a detailed evaluation of residual waste management options is needed. As such, this review should be considered a cursory overview only and is presented as a "snap-shot" to illustrate how the currently defined options may be considered and potentially viewed in evaluation of residual waste management strategies.

Table 2 summarizes the preliminary review of the options currently defined in the context of the trigger condition after 2022, when the extension option for the contract at Green Lane ends.

Table 2: Trigger 2 (2022) - Preliminary Review of Options and Criteria

	Option 1 – Contracted within Ontario		**Option 2 – Contracted outside Ontario**		**Option 3 – DYEC Expansion**	**Option 4 – Other 4th R Option**
Role in York's Waste Management Hierarchy:	*Recovery*	*Landfill*	*Recovery*	*Landfill*	*Recovery*	*Recovery*
Criteria						
Consistent with vision and guiding principles	✓	○*	✓	○*	✓	✓
Affordability and Value	?	✓	?	✓	✓	?
Long-term reliability	✓	✓	✓	✓	✓	?
Implementation Schedule	?	✓	?	?	?	?
Current and future regulatory requirements	✓	✓	✓	✓	✓	?
Protective of the environment and promotion of environmental sustainability	✓	×	✓	×	✓	✓
Compliments and enhances existing diversion and resource recovery efforts	✓	○*	✓	×	✓	✓
Local solution	×	×	×	×	○	?
Costs and Risks	?	✓	?	?	✓	?

Note: The Dongara Pelletization facility has ceased operations as of 2013 and extension of this contract for residuals management is not an option at this time

Degree that option suits criteria

High ✓
Moderate ○
Inconsistent ×
Not determined at this time ?
Suits criteria on as supplementary option *

This preliminary review suggests that expansion of the DYEC is in closest alignment with the criteria, however there is some uncertainty with respect to the ability to implement this option within the time frame necessary, dependent on when a decision to proceed is arrived at. Although not as closely aligned with the criteria, pursuing additional contracted recovery capacity (within and outside of Ontario) and/or additional landfill disposal capacity within Ontario may also provide York Region with workable options. While the Region's waste hierarchy prefers to see residual waste processed for energy and material recovery, in the near-term, practical constraints may limit the ability to implement this approach. In the near-term (i.e. 2022 to 2028) the Region may need to secure additional landfill disposal and/or energy-from-waste processing capacity under contract, to meet a portion of its residual waste management needs. It is recommended that York proceed to evaluate these options in accordance with the process described in Section 6.1.

7.0 Residuals Management Strategy

The following provides an overview of the proposed Residuals Management Strategy. This strategy is somewhat unique when compared to other strategies in the SM4RT Living Plan as it is based on a specific date where new capacity is required and then defines a process by which to get there.

Step 1: Continue to Monitor Residual Waste Marketplace and Current York Region Residuals Management Contracts.

As identified in Section 5.0 above, there is the potential for a "trigger" to be realized based primarily on the current contracted nature of the existing residuals management capacity. It is important to continue to monitor the performance of these contracts and the associated management facilities to ensure both contract and environmental performance requirements. Should an issue arise with one of these contracts/facilities, the need to consider short term capacity (as described in Section 5.0) would need to be assessed immediately. To be proactive, the Region should regularly monitor the residual waste marketplace in Ontario so that should a trigger be realized to be in a position to react in a timely manner.

Step 2: Complete a Detailed Assessment of Long-Term Residual Waste Management Options

Given the potential timeframe for implementation, in order to give sufficient time to consider all options identified above, a long-term residuals planning study process should be initiated in 2014. Section 6.0 of this document outlines the proposed approach for completing this detailed assessment and evaluation of options.

Step 3: Implementation of the Preferred Long-Term Residual Waste Management Option

In order to meet the 2028 timeline for full operation, depending on the preferred option identified, implementation should be completed in accordance with schedule outlined in Table 4.

Step 4: Consideration of a Disposal Ban in York Region

In recent decades, there has been unprecedented growth in new chemicals and electronics being produced for consumer and industrial use in North America. At their end-of-life, these waste materials require appropriate management. These wastes, primarily categorized as municipal hazardous solid wastes (MHSW) and waste electronics and electrical equipment (WEEE) can cause significant environmental degradation and pollution if not treated correctly. To ensure that these types of wastes are recycled properly and managed soundly, some municipalities have placed bans on these materials in the residual waste stream. Material bans are often established at the point of collection and/or facility receipt to prevent disposal of materials which can be diverted. In order to be successful, it is critical to ensure that alternative options are available (Hazardous waste facility or Environmental Centre) for the banned material before introducing the ban. Some jurisdictions have now begun using their regulatory powers to compel businesses to be more proactive in reducing hazardous waste from landfills. There are a number of municipalities in Canada that have implemented a range of disposal bans on everything from leaf and yard waste to blue box recyclables to MHSW and WEEE.

York Region, with the support of provincial government regulations has authority under the Ontario Municipal Act to enact bylaws and regulations to ban materials at curbside that are considered MHSW and WEEE. York Region should consider banning of these materials at the curbside to ensure these materials are disposed of in the safest most environmentally sound way. It is important for York Region and its local municipal partners to consider a policy banning these products not only because they can cause air and water pollution, but because they can also pose threats when processed thermally. A common concern regarding energy from waste are air contaminants and emissions created when certain materials are thermally processed, particularly heavy metals including; mercury, lead and cadmium. Although, energy from waste technology has improved steadily over the last few decades in relation to air emissions and the emissions from these facilities have been demonstrated to be safe, continuous emphasis on removing potential chemicals of concern from the waste stream is important.

One way that that the Region could ensure reduced chemicals in the waste stream would be to develop a policy to ban MHSW and w WEEE from the curbside waste stream. A strong policy and enforcement strategy involving bans of MHSW and WEEE materials at the curbside will promote a solid waste management system that is environmentally safe and reliable.

To assist with this process, York Region and its local municipal partners may want to consider a pilot where they choose one item to ban, say batteries for example. By choosing only one item, the Region and its local municipal partners can take the appropriate time to co-ordinate and ensure the collection and operations' staff are on board. The pilot could run for one year and the Region could determine steps moving forward. Lessons learned would also be helpful if additional items were to be added to the banned item list.

Bans can only be realistically considered if there are other options available for the materials. In the case of York Region, the Community Environmental Centres, MHSW and WEEE drop-off depots, and numerous community partners with take back programs serve as an alternate disposal locations for these materials and a supporting tool for implementing such a ban.

8.0 Implementation

The following provides an overview of the approach to implementation of this strategy.

Partnerships

Each of the options identified includes some form of partnership arrangement that will be required in order to secure the necessary residual management capacity as outlined in Table 3 below.

Table 3: Partnership Requirements

Option	Partnership Arrangement
Option #1 - Contracted Capacity within Ontario	A partnership arrangement will be required with the owner/operator of the facility to secure the necessary contracted capacity
Option #2 - Contracted Capacity Outside Ontario	A partnership arrangement will be required with the owner/operator of the facility to secure the necessary contracted capacity
Option #3 - Expansion of Durham York Energy Centre	A partnership with Durham Region is already in place with respect to this facility. In order to expand the facility a revision to the partnership agreement would be required between York and Durham, as well as the agreement with the operator.
Option #4 - Other Potential 4R options	Given that the majority of these technologies are proprietary, a partnership with the technology developer would be required at a minimum

Resources, Timeline and Targets

The following provides an outline of the resources (staff and financial) required, as well as a preliminary timeline for implementation, performance targets and monitoring.

Roles and Responsibilities

The proposed arrangement for the completion of this strategy is as follows:

York Region:	Lead
Local Municipalities:	Support/Comment
Community Partner:	Stakeholder
Other:	Stakeholder

Resources

As a minimum baseline, staffing resources and budget allocated to the residual program should keep pace with future growth projections to maintain the recovery success of this important program. At the appropriate time when significant program changes are required to be contemplated such changes should include corresponding adjustments to staffing and budgets necessary to support the program. At a minimum, this will require at least 0.5 FTE resource dedicated to the long-term residuals option evaluation process and will require input from a range of internal staff and external experts to support this process.

Preliminary Timeline for Implementation

The following provides a summary of the timelines described above for consideration and implementation of a long-term residuals management solution for the Region.

Table 4: Timelines for Implementation

Option	2020	2021	2022	2023	2024	2025	2026	2027	2028
Option #1 - Contracted Capacity within Ontario									
Option #2 - Contracted Capacity Outside Ontario									
Option #3 - Expansion of Durham York Energy Centre									
Option #4 - Other Potential 4th R options									

Targets

The targets for the residual waste management program will need to be established through the detailed options evaluation to be completed at the appropriate time. At a minimum, to maintain consistency with the overall Vision and Guiding Principles of the Master Plan, the proposed targets should include:

- Target of five per cent reduction of residual waste (or 4, 367 tonnes) to be managed through implementation of all Master Plan initiatives
- Resource conservation goals through the ability to recover materials and energy
- Local economic growth opportunities
- A prescribed process for engagement, consultation and support of the community
- Specific performance measures that incorporate all other aspects of the integrated waste management system
- Flexibility to adapt to changing waste streams and new programs and initiatives recommended elsewhere in the master plan
- A recognition and priority placed on the waste management hierarchy

Performance Measurement

There are two primary metrics to measure performance of this particular strategy:

- Identification of a preferred long term residual waste management option
- Successful implementation of the preferred option

The overall residuals management component of the system should also be measured by:

- Cost/tonne
- GHG reduction when compared to landfill only alternative
- Electricity generated
- Materials recovered

9.0 Key Benefits of this Strategy

The residuals management strategy presented herein provides the following key benefits:

- Potential reduction of 4,367 tonnes of residual waste to be managed
- Options to address the long-term need to identify residuals management capacity
- Timeline and steps to secure each option
- Preliminary criteria and key questions to be resolved
- A strategy to initiate a detailed review of long-term disposal options

ATTACHMENT A – CONVERSION TECHNOLOGY DESCRIPTIONS

The following provides an overview of a range of technologies, herein referred to as "conversion technologies" that have been implemented successfully, technologies that have been tried but failed to successfully and/or economically handle a municipal solid waste (MSW) stream on a commercial scale, and those that are currently considered theoretical technologies.

- Mechanical biological treatment (MBT)
- Refuse-derived fuel (RDF) with stoker firing
- RDF with fluidized bed combustion
- Catalytic depolymerization
- Hydrolysis
- Pyrolysis
- Gasification
- Plasma arc gasification

While example vendors are listed that propose particular technologies, the listed vendors are neither represented as all vendors that offer the technology nor necessarily the best vendors that offer the technology. The specifics of individual vendors' technology would be considered for a more in-depth review should a specific technology be selected for implementation.

The following technologies are described in more detail below:

Mechanical Biological Treatment (MBT)

Mechanical biological treatment (MBT) is a variation on composting and materials recovery. This technology is generally designed to process a fully commingled MSW stream. Processed materials include marketable metals, glass, other recyclables, and a refuse-derived fuel (RDF) that can be used for combustion. Limited composting is used to break the MSW down and dry the fuel. The order of mechanical separating, shredding, and composting can vary.

This technology has been used extensively in Europe, but not in North America. It is an effective waste-management method and can be built in various sizes. The RDF produced by an MBT process must be handled in some way: fired directly in a boiler; converted to energy via some thermal process (e.g., combustion, gasification, etc.); or selling it to a third party (e.g. cement kiln).

This technology has been used in Europe, including Herhof GmbH facilities in Germany. There has not been widespread commercial application of this technology on mixed MSW streams in North America. The majority of the applications for this technology are in the agricultural and meat processing industries. The Bedminster Bioconversion in-vessel, mechanical, rotating drum technology (also referred to as "rotary digesters") used at the Edmonton Composting Facility is an example of a commercially available MBT technology that processes residential waste. The City of Toronto is also considering developing a commercial-scale MBT facility at its Green Lane Landfill Site located southwest of London.

Refuse Derived Fuel (RDF) Processing

An RDF processing system prepares MSW by using shredding, screening, air classifying and other equipment to produce a fuel product for either on-site combustion, off site combustion, or use in another conversion technology that requires a prepared feedstock. As with mechanical biological treatment (MBT), the goal of this technology is to derive a better fuel (limited variations in size and composition) that can be used in a more conventional solid-fuel boiler as compared to a mass-burn boiler. The theory is that the smaller boiler and associated equipment would offset the cost of the processing equipment. The fuel goes by various names but generally is categorized as a refuse-derived fuel (RDF).

All of the post-recycling municipal waste stream can be processed by this technology with limited presorting.

This same technology, perhaps with some differences such as finer shredding, is required to prepare MSW as a feedstock for other conversion technologies (discussed in later sections).

RDF technology is a proven technology that is used at a number of plants in the U.S., Europe and Asia (generally larger plants with capacities greater than 1,500 tonnes per day). There are also a number of commercial-ready technologies that can convert the waste stream into a stabilized RDF pellet that can be fired in an existing coal-boiler or cement kiln. The Dongara facility that was located in York Region was an example of such a RDF technology. Some other RDF plants are Ames, IA; Southeastern Public Service Authority, VA; French Island, WI; Mid-Connecticut; Honolulu, HI; and West Palm Beach, FL. There is limited use of this technology in Europe or Asia.

<u>Vendors/System Designers</u>: Energy Answers, RRT, Dongara, Westroc Energy, Ambient Eco Group and Cobb Creations

RDF with Stoker Firing

This technology uses a spreader stoker type boiler to combust RDF. A front-end processing system is required to produce a consistently sized feedstock. The RDF is typically blown or mechanically injected into a boiler for semi-suspension firing. Combustion is completed on a travelling grate. Thermal recovery occurs in an integral waterwall boiler. Air-pollution control (APC) equipment on existing units includes good combustion practices, dry scrubbers for acid gas neutralization, carbon injection for control of mercury and complex organics (e.g., dioxins), and fabric filters for particulate removal. These facilities are capable of meeting stringent air emission requirements. New units would likely require additional NOx control such as selective non-catalytic reduction (SNCR), selective catalytic reduction (SCR) or flue gas recirculation.

This technology is used at the following facilities mentioned above: Southeastern Public Service Authority, VA; Mid-Connecticut; Honolulu, HI; and West Palm Beach, FL.

<u>Boiler Vendors</u>: Alstom; Babcock and Wilcox; Babcock Power

RDF w/ Fluidized Bed Combustion

This technology uses a bubbling or circulating fluidized bed of sand to combust RDF. A front-end processing system is required to produce a consistently sized feedstock. Heat is recovered in the form of steam from waterwalls of the fluidized bed unit as well as in downstream boiler convection sections. The required APC equipment is generally similar to that described above for spreader stoker units. Lime can be added directly to the fluidized bed to help control acid gases such as sulfur dioxide (SO_2). RDF may be co-fired with coal, wood (as in the case of the French Island facility shown), or other materials.

This technology is in limited commercial use in North America for waste applications with one operating facility in Wisconsin. Fluidized bed combustion is more commonly used today for combustion of certain other biomass materials and coal than it was at the time most of the existing RDF facilities were developed. This technology would be suitable for combustion of RDF alone or together with biomass and other combustible materials that are either suitably sized (nominally eight cm) or can be processed to a suitable size.

<u>Fluidized Bed Boiler Vendors</u>: Environmental Products of Idaho (EPI), Von Roll Inova, Foster Wheeler and Ebara.

Catalytic Depolymerization

In a catalytic depolymerization process, the plastics, synthetic-fibre components and water in the MSW feedstock react with a catalyst under non-atmospheric pressure and temperatures to produce a crude oil. This crude oil can then be distilled to produce a synthetic gasoline or fuel-grade diesel. There are four major steps in a catalytic depolymerization process: pre-processing, process fluid upgrading, catalytic reaction, and separation and distillation. The pre-processing step is very similar to the RDF process where the MSW feedstock is separated into process residue, metals and RDF. This process typically requires additional processing to produce a much smaller particle size with less contamination. The next step in the process is preparing this RDF. The RDF is mixed with water and a carrier oil (hydraulic oil) to create RDF sludge. This RDF sludge is sent through a catalytic turbine where a reaction under high temperature and pressure produces a light oil. The light oil is then distilled to separate the synthetic gasoline or diesel oil.

This catalytic depolymerization process is somewhat similar to that used at an oil refinery to convert crude oil into usable products. This technology is most effective with processing a waste stream with a high plastics content and may not be suitable for a mixed MSW stream. The need for a high-plastics-content feedstock also limits the size of the facility.

There are no large-scale commercial catalytic depolymerization facilities operating in North America that use a purely mixed MSW stream as a feedstock. There are some facilities in Europe that utilize this or a similar process to convert waste plastics, waste oils, and other select feedstocks. One vendor claims to have a commercial-scale facility in Spain that has been in operation since the second half of 2009. However, operating data or an update on the status of this facility could not be obtained.

There are also technology vendors that utilize a process that is thermal in nature (e.g., gasification, pyrolysis) to convert the MSW stream to a syngas that is further treated by a chemical process, such as depolymerization or an associated refining process (e.g., Fischer Tropsch synthesis), to generate a synthetic gasoline or diesel fuel. The City of Edmonton project in Alberta, Canada that uses the Enerkem technology is an example of a commercial-scale facility that will use such a process. The City of Edmonton has conducted some pilot testing, and the commercial-scale project is currently in construction (scheduled to be operational by 2014).

Some examples of vendors that provide catalytic depolymerization-type technologies include: ConFuel K2, AlphaKat/KDV, Enerkem, Changing World Technologies and Green Power Inc.

Hydrolysis

There is much interest and development in the area of cellulosic ethanol technology to move from corn-based ethanol production to the use of more abundant cellulosic materials. Applying these technologies to waste materials using hydrolysis is part of that development.

The hydrolysis process involves the reaction of the water and cellulose fractions in the MSW feedstock (e.g., paper, food waste, yard waste, etc.) with a strong acid (e.g., sulfuric acid) to produce sugars. In the next process step, these sugars are fermented to produce an organic alcohol. This alcohol is then distilled to produce a fuel-grade ethanol solution. Hydrolysis is a multi-step process that includes four major steps: pre-treatment, hydrolysis, fermentation and distillation. Separation of the MSW stream is necessary to remove the inorganic/inert materials (glass, plastic, metal, etc.) from the organic materials (food waste, yard waste, paper, etc.). The organic material is shredded to reduce the size and to make the feedstock more homogenous. The shredded organic material is placed into a reactor where it is introduced to the acid catalyst. The cellulose in the organic material is converted into simple sugars. These sugars can then be fermented and converted into an alcohol which is distilled into fuel-grade ethanol. The byproducts from this process are carbon dioxide (from the fermentation step), gypsum (from the hydrolysis step) and lignin (non-cellulose material from the hydrolysis step). Since the acid acts only as a catalyst, it can be extracted and recycled back into the process.

There have been some demonstration and pilot-scale hydrolysis applications completed using mixed MSW and other select waste streams. However, there has been no widespread commercial application of this technology in North America or abroad. A commercial-scale hydrolysis facility has been permitted for construction in Monroe, New York in the U.S., but this project is currently on-hold.

Some examples of vendors that offer some form of the hydrolysis technology include: Masada OxyNol, Biofine and Arkenol Fuels.

Pyrolysis

Pyrolysis is generally defined as the process of heating MSW in an oxygen-deficient environment to produce a combustible gaseous or liquid product and a carbon-rich solid residue. This is similar to what is done to produce coke from coal or charcoal from wood. The feedstock can be the entire municipal waste stream, but, in some cases, pre-sorting or processing is used to obtain a refuse-derived fuel. Similar to gasification, once contaminants have been removed, the gas or liquid derived from the process can be used in an internal combustion engine or gas turbine or as a feedstock for chemical production. Generally, pyrolysis occurs at a lower temperature than gasification, although the basic processes are similar.

Pyrolysis systems have had some success with wood waste feedstocks. Several attempts to commercialize large-scale MSW processing systems in the U.S. in the 1980s failed, but there are several pilot projects at various stages of development. There have been some commercial-scale pyrolysis facilities in operation in Europe (e.g. Germany) on select waste streams. Vendors claim that the activated carbon byproduct from the pyrolysis is marketable, but this has not been demonstrated.

<u>Some examples of vendors that offer the pyrolysis technology include</u>: Brightstar Environmental, Mitsui, Compact Power, PKA, Thide Environmental, WasteGen UK, International Environmental Solutions (IES), SMUDA Technologies (plastics only) and Utah Valley Energy.

Gasification

Gasification converts carbonaceous material into a synthesis gas or "syngas" composed primarily of carbon monoxide and hydrogen. Following a cleaning process to remove contaminants, this syngas can be used as a fuel to generate electricity directly in a combustion turbine, or fired to create steam that can be used to generate electricity via steam condensing turbine. The syngas generated can also be used as a chemical building block in the synthesis of gasoline or diesel fuel. The feedstock for most gasification technologies must be prepared into RDF developed from the incoming MSW, or the technology may only process a specific subset of waste materials such as wood waste, tires, carpet, scrap plastic, or other waste streams. Similar to Fluidized Bed Combustion, these processes typically require more front end separation and more size reduction, and result in lower fuel yields (less fuel per tonne of MSW input). There exists one technology, Thermoselect®, which does not require preprocessing of the incoming MSW similar to a mass burn combustion system.

The feedstock reacts in the gasifier with steam and sometimes air or oxygen at high temperatures and pressures in a reducing (oxygen-starved) environment. In addition to carbon monoxide and hydrogen, the syngas consists of water, smaller quantities of CO2, and some methane. Processing of the syngas can be completed in an oxygen-deficient environment, or the gas generated can be partially or fully combusted in the same chamber. The low- to mid-Megajoule syngas can be combusted in a boiler, or following a cleanup process, a gas turbine or engine or used in chemical refining. Of these alternatives, boiler combustion is the most common, but the cycle efficiency can be improved if the gas can be processed in an engine or gas turbine, particularly if the waste heat is then used to generate steam and additional electricity in a combined cycle facility.

Air pollution control equipment similar to that of a mass burn unit will be required if the syngas is used directly in a boiler. If the syngas is conditioned for use elsewhere, the conditioning equipment will need to address acid gases, mercury, tars and particulates.

Gasification has been proven to work on select waste streams, particularly wood wastes. However, the technology does not have a lot of commercial-scale success using mixed MSW when attempted in the U.S. and Europe. Japan has several operating commercial-scale gasification facilities that claim to process at least some MSW. In Japan, one goal of the process is to generate a vitrified ash product to limit the amount of material having to be diverted to scarce landfills. In addition, many university-size research and development units have been built and operated on an experimental basis in North America and abroad.

Examples of a number of potential gasification vendors include: Thermoselect, Ebara, Primenergy, Brightstar Environmental, Erergos, Taylor Biomass Energy, SilvaGas, Technip, Compact Power, PKA and New Planet Energy.

Plasma Arc Gasification

Plasma arc technology uses carbon electrodes to produce a very-high-temperature arc ranging between 3,000 to 7,000 degrees Celsius that "vaporizes" the feedstock. The high-energy electric arc is struck between the two carbon electrodes, creating a high temperature ionized gas (or "plasma"). The intense heat of the plasma breaks the MSW and the other organic materials fed to the reaction chamber into basic elemental compounds. The inorganic fractions (glass, metals, etc.) of the MSW stream are melted to form a liquid slag material which when cooled and hardened encapsulates toxic metals. The ash material forms an inert glass-like slag material that may be marketable as a construction aggregate. Metals can be recovered from both feedstock pre-processing and from the post-processing slag material.

Similar to gasification and pyrolysis processes, the MSW feedstock is pre-processed to remove bulky waste and other undesirable materials, as well as for size reduction. Plasma technology produces a syngas; this fuel can be combusted and the heat recovered in a heat recovery steam generator, or the syngas can be cleaned and combusted directly in an internal combustion engine or gas turbine. Electricity and/or thermal energy (i.e. steam, hot water) can be produced by this technology. Vendors of this technology claim efficiencies that are comparable to conventional mass burn technologies (600-700+ kWh/tonne (net)). Some vendors are claiming even higher efficiencies (900-1,200 kWh/tonne (net)). These higher efficiencies may be feasible if a combined cycle power system is proposed. However, the electricity required to generate the plasma arc, as well as the other auxiliary systems required, brings into question whether more electrical power or other energy products can be produced than what is consumed in the process.

This technology claims to achieve lower harmful emissions than more conventional technologies, like mass burn and RDF processes. However, air pollution control equipment similar to other technologies would still be required for the clean-up of the syngas or other off-gases.

Plasma technology has received considerable attention recently, and there are several large-scale projects being planned in North America (e.g. Saint Lucie County, Florida; Atlantic County, New Jersey). In addition, there are a number of commercial-scale demonstration facilities in North America, including the Plasco Energy Facility in Ottawa, Ontario and the Alter NRG demonstration facility in Madison, Pennsylvania in the U.S. PyroGenesis Canada, Inc., based out of Montreal, Quebec, also has a demonstration unit (approximately 10 tonnes/per day) located on Hulburt Air Force Base in Florida that has been in various stages of start-up since 2010.

Examples of a number of potential gasification vendors include: Startech, Geoplasma, PyroGenesis Canada, Inc., Westinghouse, Alter NRG, Plasco Energy, Integrated Environmental Technologies and Coronal.

Combined Technologies

Gasification systems have been proposed to be combined with other technologies to attempt to produce a liquid fuel. The Enerkem Alberta Biofuels project in Edmonton proposes to use gasification followed by catalytic synthesis of the syngas to produce ethanol. A gasification facility proposed by Interstate Waste Technologies (IWT) in Taunton, Massachusetts that ran into approval difficulties owing to a statewide incineration ban had also proposed converting the syngas to ethanol.

These are facilities that would be considered demonstration facilities because the technology has not previously been proven commercially on a municipal solid waste feedstock.

Examples of combined technology vendors include: Enerkem, IWT