Conceptual Design Report

Biosolids Truck Loading Facility and Associated Odour Control System at the Highland Creek Treatment Plant

May 2013

Prepared for

City of Toronto

Prepared by

CH2MHILL.

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Consultant's QA/QC Stamp	
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Submission	Date	Reviewed by QA/QC Staff	Date	Reviewed by Project Manager
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Executive Summary

Introduction

This Conceptual Design Report summarizes the findings of a study completed to assess the requirements of the accepted Council direction for Beneficial Use of Biosolids from the Highland Creek Wastewater Treatment Plant (WWTP). This work involves the construction of a new Truck Loading Facility and the upgrade of the existing anaerobic digestion complex to the degree necessary to support this biosolids management strategy.

Truck Loading Facility

Predicted dewatered biosolids production at the Highland Creek WWTP, for the design year of 2032, totals 123 m^3/d. The anticipated maximum sustained production rate over a seven day period is approximately 210 m^3/d. Design of a new biosolids truck loading facility will be based on this 'maximum week' production rate. The total solids concentration of the dewatered biosolids is expected to be about 27 percent, in line with current experience. The truck loading facility will accommodate 5.5 days of dewatered biosolids storage at the maximum sustained production rate, resulting in a total biosolids storage volume of 1,200 m^3. The facility will enable any single truck to be loaded within a 30 minute period. Prior to discharge, odorous air will be contained and treated in a single stage biofiltration process. The odour control system will handle about 20 m^3/s of odorous air.

Four Truck Loading Facility options were assessed in the Conceptual Design Report on the basis of costs and non-monetary considerations. These options include:

- Option 1 – Master Plan Option (New Truck Loading Facility East of Existing Biosolids Management Building)
- Option 2 – Modified Master Plan Option (New Dewatering and Truck Loading Facility East of Biosolids Management Building)
- Option 3 - New Dewatering and Truck Loading Facility East of New Dechlorination Building.
- Option 4 – New Truck Loading Facility in Area of Existing Heat Treatment Building.

Table ES-1 summarizes the estimated capital, operation and maintenance (O&M), and life cycle costs for these four options.

TABLE ES-1
Summary of Life Cycle Cost Estimates Truck Loading Facility and Odour Control (Excluding Digestion Upgrades) to Accommodate Beneficial Use of Biosolids)

Description	Option 1[1]	Option 2[2]	Option 3[3]	Option 4[4]
Capital Costs	$ 93,090,000	$ 95,710,000	$ 102,011,000	$ 109,012,000
O&M Costs	$ 2,800,000	$ 2,579,000	$ 2,421,000	$ 2,800,000
Life Cycle Costs	**$ 128,760,000**	**$ 128,180,000**	**$ 132,021,000**	**$ 144,066,000**

Note:

1. Option 1 – Master Plan Option (New Truck Loading Facility east of the existing Biosolids Management Building).
2. Option 2 – Modified Master Plan Option (New Truck Loading Facility and dewatering facility east of the existing Biosolids Management Building).
3. Option 3 – New Truck Loading Facility and dewatering facility at a central location, east of the new Dechlorination Building
4. Option 4 – New Truck Loading Facility within the existing Heat Treatment area.

Estimated Option 1 and Option 2 capital costs and life cycle costs are considered equal within the accuracy of the estimates generated for this Report. Further, neither of these options exhibited operational, environmental, or aesthetic advantages or disadvantages that would differentiate one from the other. Because there were no compelling economic or non-monetary reasons for selecting either option, it is recommended that both Option 1 and Option 2 be carried forward into the next stage of project development.

Odour Control

Odour Control is an integral component of the four Truck Loading Facility options discussed in the above paragraphs. The selected approach to odour control that is incorporated in each option includes containment of all odour emitting enclosures and areas, including the truck loading bays; conveyance to an odour treatment facility; treatment of the odorous gases to remove odour causing constituents; and exhausting the treated air streams through the existing stack (Option 1, Option 2, and Option 4) or through a new dedicated stack (Option 3). The approach involves conservative sizing of the odorous air treatment units, which has purposefully been adopted to ensure reliable and effective removal of odour causing constituents. The cost associated with this odour control strategy account for 6 percent to 8 percent of the total capital cost listed in Table ES-1 above.

Anaerobic Digestion Expansion and Upgrade

Design of the Highland Creek WWTP digestion facility recognized the resiliency provided by the thermal oxidation process. The existing digesters at the Highland Creek WWTP are sized on the premise that raw sludge can bypass digestion, passing directly to the thermal oxidation units, when the digestion process is overloaded or when components are out of service for maintenance.

Changing to a beneficial use strategy for Highland Creek WWTP biosolids results in retirement of the existing thermal oxidation system. Hence, the anaerobic digestion system needs to be reinforced to provide the system reliability required to handle normal and adverse operating conditions. Ontario's biosolids management regulations mandate that the digestion process provides 15 days of solids retention time to satisfy biosolids quality requirements. This requirement translates into a need for more digestion capacity at the plant in the near and the long term. Various options for providing this capacity were considered in this study, including:

- Increasing the available digestion capacity through the addition of new digesters (different sizes and configurations were considered in 'Conventional Expansion", Conventional Option with Larger Digesters, Option 1, and Conventional Option with Larger Digesters Option 2)
- Incorporating primary solids thickening to reduce the need for additional digestion volume
- Changing the basic digestion process to an acid-gas configuration, which can achieve equivalent treatment with somewhat less additional digester volume.

The necessary expansions were assumed to occur in two stages – the first expansion would be required in the next few years and was assumed capable of handling the capacity needs until 2032. The second expansion would be undertaken during the years leading up to 2032 and would handle the plant's ultimate capacity requirements. The ultimate capacity of the plant would not be attained until well after 2032. Table ES-2 summarizes the estimated capital, O&M, and life cycle costs for the various options considered.

TABLE ES-2
Digestion Expansion Scenarios

	Option 1A[1]	**Option 1B[2]**	**Option 1C[3]**	**Option 2[4]**	**Option 3[5]**
Capital Costs	$ 82,090,000	$ 59,990,000	$ 74,630,000	$ 50,685,000	$ 56,425,000
Present value of future capital costs[6]	$ 12,700,000	$ 14,300,000	$ 0	$ 13,800,000	$ 23,700,000
Present Value of O&M Costs	$ 54,900,000	$ 50.7	$ 49,900,000	$ 54,100,000	$ 56,900,000
Life Cycle Costs	$ 149,600,000	$ 125,000,000	$ 124,500,000	$ 118,600,000	$ 136,600,000

Notes:

1. Option 1A - Expansion includes 3 new digesters by 2016 and a fourth new digester by 2032, all of the same size and configuration as the existing digesters at the Highland Creek WWTP (volume per digester - 6,610 m^3).
2. Option 1B - Expansion includes 2 new digesters by 2016 and a third new digester by 2032, all greater in size than the existing digesters (volume per digester - 7,780 m^3)
3. Option 1C - Expansion includes 2 new digesters by 2016 that are greater in size than the existing digesters (volume per digester - 15,560 m^3)
4. Option 2 - Option includes construction of primary sludge thickening and one new digester by 2016 and one additional new digester by 2032. The new digesters would be similar in size to the existing units (volume per digester - 6,610 m^3).
5. Option 3 - Option includes the construction of primary sludge thickening and two acid gas reactors by 2016, with one additional new digester by 2032 (volume per acid gas reactor – 1,575 m^3;volume per digester - 6,610 m^3).
6. Future capital costs are those incurred to expand the plant beyond 2032 to handle the ultimate capacity.

The net present value of the option that includes Primary Solids Thickening and Limited Digester Expansion was lowest. Further, primary sludge thickening complements the current on-going secondary sludge thickening project. It allows optimization of the existing digester infrastructure and it would provide opportunities to enhance primary treatment by allowing the solids inventory to be removed from this process expeditiously. The option including primary sludge thickening exhibits a reasonable cost advantage and several process related advantages; hence, it is recommended for implementation.

Waste Gas Burners

The waste gas burners (WGBs) at the Highland Creek WWTP thermally oxidize excess biogas that cannot be used as fuel in the plant's boiler system. The current system consists of three units, each with a capacity of 513 m^3/h.

The WGBs will need to be upgraded to account for increased biogas generation due to projected biosolids increases during the design life of the plant and due to the enhanced gas production associated with longer solids retention times that occur in the expanded digestion process. The estimated peak diurnal biogas production rate at plant capacity is 54,000 m^3/d or about 2,250 m^3/h. The estimated maximum week biogas production rate is 1,500 m^3/h. This peak production rate exceeds the capacity of the existing units, even when no standby capacity is provided. Two upgrading options were considered to reconcile this shortfall, as follows:

- Option 1: Replace the existing units with three larger waste gas burners.
- Option 2: Maintain the existing units and add two additional larger units

Table ES-3 summarizes the estimated capital, O&M, and life cycle costs for the two options considered.

TABLE ES-3
Waste Gas Burner Upgrade Scenarios

	Option 1 – Three New Units[1]	**Option 2 - Maintain Existing Units and Add Two New Units[2]**
Present Value of Capital Costs	\$3,905,000	\$3,071,000
Present Value of O&M Costs	\$2,011,000	\$4,003,000
Life Cycle Costs	**\$5,916,000**	**\$7,074,000**

Notes:
1. Option 1 entails the replacement of existing three units with three new 1500 m^3/h units
2. Option 2 entails the extension of existing structures to accommodate two new 500 m^3/h units, in addition to existing three units. Due to their age, present value of O&M costs also included replacement of the existing units in about 10 years.

The capital cost associated with Option 1 described above are higher than those of Option 2, because all of the equipment is new. However, the O&M costs exhibited by Option 2 are much higher as the replacement of the existing units at the expected end of their design life, within the period considered for this analysis, substantially adds to the price. Further, Option 2 involves maintenance of additional equipment elements because of the number of WGBs involved.

The substantially lower net present value associated with Option 1 has led to the recommendation that this approach be implemented.

Summary

Implementing a Biosolids Management Plan that involves the Beneficial End Use of biosolids from the Highland Creek WWTP mandates that the City of Toronto undertake the construction of a Truck Loading Facility, associated odour control facility, and expansion of the current anaerobic digestion facilities (including the waste gas burners). The total project cost (not including HST) escalated to 2016 dollars, is $150,302,000. The summary of the costs associated with this recommendation is as summarized in Table ES-4.

TABLE ES-4

Summary of Truck Loading Facility and Digester Upgrade Capital Costs[1]

	Costs
Truck Loading Facility[2]	$ 95,714,000
Digester Upgrades[3]	50,585,000
Waste Gas Burner Upgrades[4]	3,905,000
Total	$ 150,302,000

Notes:

1. Costs noted in this table include direct and indirect costs, contingencies, escalation to midpoint in construction (assumed to be 2016) and engineering. They do not include internal City of Toronto costs nor HST.
2. The cost of the Truck Loading Facility is that estimated for Option 2, where the dewatering facility would be relocated to the Truck Loading Facility and the new consolidated facility would be constructed east of the existing Biosolids Management Building.
3. The cost of the Digester Upgrades is based on Option 2 - Option includes construction of primary sludge thickening and one new digester by 2016 and one additional new digester by 2032. The new digesters would be similar in size to the existing units (volume per digester - 6,610 m^3).
4. The cost of the waste gas burner upgrades is based on Option 1 where three new 1,500 m^3/h thermal oxidizing units would be installed to replace the existing units.

Contents

Tables

Figures

1. Introduction

1.1 Project Background

Over the last 10 years, The City of Toronto has been working toward the development and implementation of a Biosolids Management Strategy that meets their overall economic, environmental and social objectives. Key milestones during this period include the following:

- **Biosolids and Residuals Master Plan (BRMP), 2002.** The City initiated this project to assess options and determine a direction for the future management of biosolids and water residuals generated by the City's water and wastewater treatment plants to the year 2025. This report was released for public comment in 2004.
- **BRMP Peer Review, 2005.** The results of the BRMP were subjected to a peer review, specifically to assess the decision making model and methodology.
- **BRMP Update, 2009.** The BRMP was updated to incorporate the recommendations of the peer review and to revise projected quantities and quality to reflect trends since the implementation of the Biosolids and Residuals Master Plan. The consideration of water treatment residuals was dropped from this exercise; thereafter, the project became known as the Biosolids Master Plan (BMP). The BMP was completed in draft and issued for public review in 2009. The recommended alternative for the Highland Creek WWTP remained thermal reduction.
- **Council Directive, 2010.** City Council did not approve the recommended thermal reduction alternative for Highland Creek WWTP, instead directing City staff to implement a beneficial use biosolids management strategy for Highland Creek WWTP, with landfilling as a contingency option.
- **Staff Report, 2011.** A report was forwarded to Council in 2011 outlining the findings of the BMP for Highland Creek WWTP and outlining the implications of proceeding with either fluidized bed incineration or a Truck Loading Facility to undertake a beneficial use program. Council voted to proceed with the biosolids Truck Loading Facility.

In 2012, The City retained CH2M HILL Canada Limited (CH2M HILL) to prepare a conceptual design for a biosolids Truck Loading Facility with accompanying odour control, digestion upgrades and ancillary features at the Highland Creek Wastewater Treatment Plant (WWTP).

1.2 Project Objectives

The project aims to achieve the following objectives:

1. Develop four conceptual layout options for a biosolids Truck Loading Facility, all of which incorporate odour control systems. These four potential options include:
   a. Utilizing the existing Biosolids Management Building to locate the new Truck Loading Facility.
   b. Expanding the existing Biosolids Management Building to accommodate a new Truck Loading Facility.
   c. Constructing a new stand alone Truck Loading Facility within the area of the existing Biosolids Management Facility.
   d. Constructing a new Truck Loading Facility and dewatering facility at a central plant location, east of the new Dechlorination Building.
2. Assess the capacity requirements associated with the Truck Loading Facility in terms of both biosolids handling capabilities and the need of major ancillary systems.
3. Assess the capacity of the existing four anaerobic digesters and associated ancillary equipment (gas handling system, waste gas burners, etc) based on an updated mass balance and the current waste activated sludge (WAS) thickening project; and identify additional requirements if required.
4. Recommend a preferred conceptual design that best meets the City's requirements for the Truck Loading Facility and for the existing anaerobic digestion system.

1.3 Project Deliverables

Project work was segregated into a series of logical steps that allowed review of progress as the project team arrived at specific milestones where major decisions were finalized. The deliverables associated with these work elements were as follows:

- Technical Memorandum (TM) 1: Truck Loading Facility -Assessment of Capacity Requirements
- TM 2: Truck Loading Facility- Siting and Configuration
- TM 3: Anaerobic Digestion and Waste Gas Burner Capacity Assessment

These Technical Memoranda have been compiled and are attached to the final Truck Loading Facility Conceptual Design Report (referred to as Report hereafter) as Appendix A, B and C. This report also includes the evaluation of options for silos/hoppers, odour control requirements and alternatives, and logistical demands of the recommended Truck Loading Facility.

1.4 Reference Documents

The following background information and reference documents provided information that was used to develop this Conceptual Design Report:

- Plant historical operating data between 2009 and 2011
- City of Toronto Highland Creek WWTP Annual Reports (2009 to 2011)
- Highland Creek WWTP Facilities Forecast TSH Consultants (2005)
- Highland Creek WWTP NFPA Code Review and Assessment (TM 14) AECOM (2009)
- Highland Creek WWTP Record Drawings from various contracts
- City of Toronto Biosolids Master Plan Update AECOM (2009)
- Highland Creek WWTP WAS Thickening and Sludge Storage Upgrades Design Report AECOM (2012)
- Engineering Study for Various Process Systems in the Digester Facility at the Highland Creek WWTP CH2M HILL (2012)

2. Design Basis

2.1 Background

This section of the Conceptual Design Report summarizes the derivation of the wastewater loads used to size the various elements of the anaerobic digestion system and the truck loading facility. Technical Memorandum 1, attached to this report as Appendix A, provides further detail.

2.2 Design Populations and Unit Flow Rates

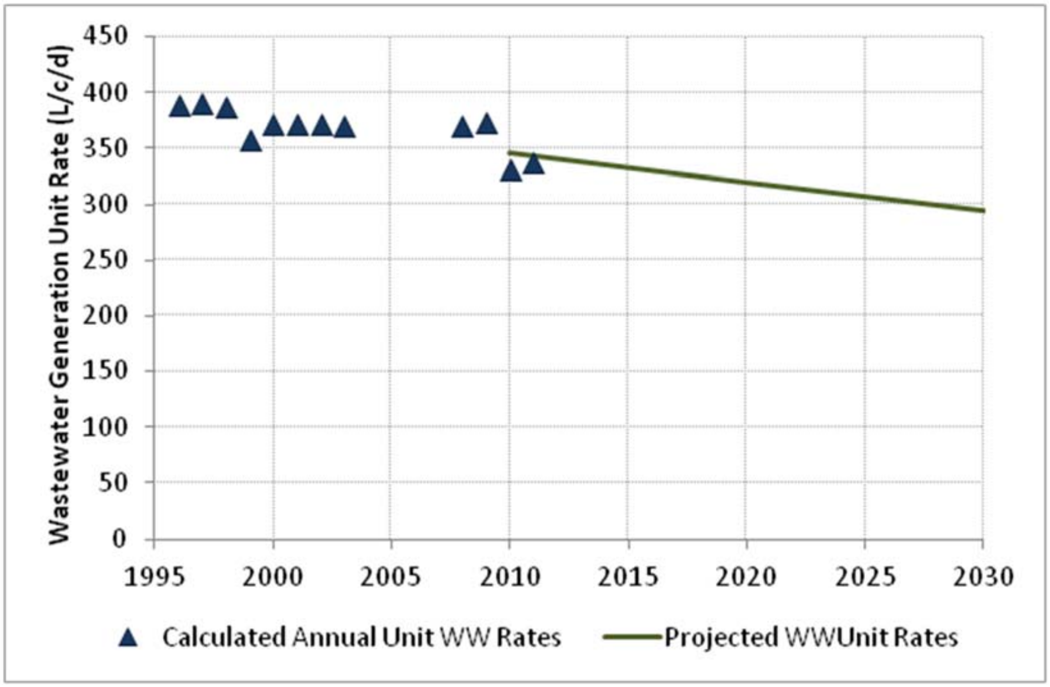
The design year used in this assessment is 2032, as directed by the City of Toronto. This design year is consistent with the design horizon used in other studies, preliminary designs, and detailed designs completed for the plant in the last few years. By 2032, the plant influent flow rate will not reach the permitted plant capacity of 219,000 m^3/d. That magnitude of flow will be attained 10 to 20 years after the design horizon of 2032. The tributary populations and approximate flows for the two conditions are listed in Table 1.

TABLE 1
Design and Assessment Conditions

Condition	Population	Average Flow (m^3/d)
2032	547,060	178,350
Ultimate	671,780	219,000

The 2032 design population and the unit rate of wastewater generation have been extracted from the Facilities Forecast (TSH, 2005). The unit rate of wastewater generation – 326 Litres per capita per day (L/c/d) – is lower than presently experienced in the plant, but it reflects ongoing declining trends in wastewater generation in the catchment area. Figure 1 illustrates the per capita wastewater generation trend since the 1990s. As is shown in the graph, the unit rate of wastewater generation has dropped from almost 400 L/c/d in the 1990s to below 350 L/c/d in the last few years. This trend is consistent with similar trends noted in other Canadian cities including Calgary, Winnipeg, and Vancouver.

FIGURE 1
Wastewater Generation Unit Rates for the Period 1996 to 2011



2.3 Unit Loading Rates

The unit loading rates are the mass of pollutants attributed to each 'equivalent person' in the catchment area. These loading rates are key to establishing the mass of material that will need to be removed from the wastewater, the quantity of biosolids generated by treatment, and ultimately, the mass and volume of material that needs to be managed. The derivation of these unit loading rates has been based on a review of the past number of years of operating data (1996 to 2003 and 2008 to 2011). Table 2 summarizes the loading rates established from these records.

TABLE 2
Unit Loads for the Period 1996 to 2011

Year[1]	Population	BOD Unit Load (g/c/d)	TSS Unit Load (g/c/d)	Total Phosphorus Unit Load (g/c/d)
1996	433,308	60.9	77.2	1.71
1997	435,663	60.2	80.1	1.68
1998	438,019	66.8	85.2	1.78
1999	440,374	69.1	78.2	1.71
2000	442,730	78.3	78.9	1.67
2001	445,085	71.7	78.1	1.64
2002	451,157	71.3	74.6	1.67

TABLE 2
Unit Loads for the Period 1996 to 2011

Year[1]	Population	BOD Unit Load (g/c/d)	TSS Unit Load (g/c/d)	Total Phosphorus Unit Load (g/c/d)
2003	457,229	61.0	70.6	1.55
2008	489,101	51.9	98.2	2.07
2009	495,928	76.6	110.0	2.01
2010	502,756	81.5	103.5	1.85
2011	509,583	62.5	80.3	1.59
Overall Average		67.6	84.6	1.74
Average 2008 to 2011		68.1	98.0	1.88

Note:
1. Data for the years 1996 to 2003 are taken from the *Facilities Forecast*, TSH, 2005. Data for the years 2008 to 2011 are taken from the *Highland Creek Wastewater Treatment Plant 2011 Annual Report*, City of Toronto, 2012

The BOD unit load has remained relatively constant. The TSS and Total Phosphorus unit loads have increased in recent years. Based on this information, somewhat conservative unit loading rates, ‘rounded up’ from 2009 to 2011 data averages, have been selected for further analysis, as follows:

- BOD Unit Load 68.5 g/c/d
- TSS Unit Load 100 g/c/d
- TP Unit Load 1.9 g/c/d

2.4 Loading Rate Peaking Factors

Throughout the year, flow and influent loads vary due to specific conditions in the catchment area – weather, industrial operation, etc. Maximum monthly loading conditions (maximum 30-day rolling average through a period of record) and maximum weekly loading conditions (maximum 7-day rolling average through a period of record) are key parameters in the sizing of biosolids handling facilities. Based on the data obtained for the 2008 to 2011 period, the peaking factors for the influent loads at the Highland Creek WWTP for BOD and TSS have been derived and are shown in Table 3. The flow peaking factor for the same averaging periods are also indicated. The amplitude of load fluctuations exceeds the variation of flows in this catchment area.

TABLE 3
Peaking Factors

Parameter	Ratio of Maximum Month to Average[1]	Ratio of Maximum Week to Average[2]
Flow Peaking Factor	1.2	1.4
BOD Load Peaking Factor	1.3	1.6
TSS Load Peaking Factor	1.5	1.75

Notes:
1. Maximum month projections are based on the maximum 30-day running average during a specific annual period.
2. Maximum week projections are based on the maximum 7-day running average during a specific annual period.

2.5 Process Loading Rates – Mass Balance

The unit loading rates and peaking factors derived in the preceding sections can be used to determine the influent loads expected from various predicted tributary populations for a number of critical operating periods.

Establishing these critical loading parameters was undertaken for the Highland Creek WWTP by inputting the predicted influent flows and loads for 2032 and for ultimate plant build out into CH2M HILL's computer based plant simulator – Pro2D. This tool generates a whole plant mass balance as a key component of its output. Mass balances for 178 ML/d and 219 ML/d for average, maximum month and maximum week conditions were undertaken. Key process performance criteria were incorporated in the mass balance, which to the extent possible were extracted from actual plant records. These performance criteria are described below:

1. Primary treatment performance: The data from 2009 to 2011 indicated that the median influent TSS concentration was about 282 mg/L and the median primary effluent TSS concentration was about 167 mg/L. These values suggest that the solids removal rate through primary treatment was approximately 35 percent. However, waste activated sludge (WAS) is recycled to the head of the primary clarifiers and when these solids are included in the calculations; the apparent solids removal rate is about 56 percent. Further, ferrous addition at the head of the plant will increase the influent solids, although these solids are not included in the measurement of influent measurements. When these chemically precipitated solids are also included in the assessment of primary treatment performance, total solids removal through this process is estimated to average 60 percent. For the basis of the mass balance calculations, 60 percent primary treatment solids removal was used to predict the material removed through this process, including the chemically precipitated solids. Performance is expected to change when the WAS thickening process is placed in service and could exhibit some seasonal and load related fluctuations. However, 60 percent removal is considered a reasonable estimate given the data available.
2. Primary sludge thickening: Primary sludge will continue to be thickened in situ. Previous performance measurements taken when co-thickened WAS was in the primary clarifiers does not allow a reasonable prediction of the thickening performance that can be achieved when thickening only primary sludge. The

maximum solids concentration that can be obtained is a function of wastewater characteristics, clarifier physical characteristics, and flow variability. The key consideration is the sludge blanket height that can be maintained without compromising clarifier performance. When sludge blanket heights are greater, sludge concentrations increase but there is greater risk of sludge washout during peak flow events. Based on experience at other treatment plants, the primary sludge solids concentration likely will be between 2.0 and 4.5 percent. Work completed by AECOM in 2011, (WAS Thickening Design Report, 2011) predicted a primary sludge solids concentration of 3.3 percent. This value is relatively low and conservative when considering the impact on downstream process units. The concentration of 3.3 percent has been adopted for this work as well.

3. Ferrous addition: Ferrous chloride is added to the primary treatment influent flow to obtain phosphorus removal, as required by the plant's C of A. The average ferrous dosage between 2009 and 2011 was 7.15 mg/L (as Fe) and the average influent phosphorus concentration was 5.2 mg/L (as P). At those concentrations, the molar ratio between iron and phosphorus is (7.15/56)/(5.2/31) = 0.79. At this dosage, the effluent phosphorus concentration measured during 2009 to 2011 averaged 0.52 mg/L. To be somewhat conservative, the molar ratio used to determine the dosage in the mass balance was 0.9, which generally resulted in predicted effluent TP of 0.65 to 0.80 mgP/L.

4. Secondary treatment performance: Secondary treatment performance was modeled using the International Water Association's (IWA) Activated Sludge Model Version 2d (ASM2d) embedded in Pro2D. Based on IWA's models, it also includes provisions for nitrogen and phosphorus removal. The critical parameter that will influence secondary solids generation rates is the solids retention time (SRT). Generally, the Highland Creek WWTP operates at an SRT of about 7.0 days, a value that is sufficiently high to achieve some level of nitrification, especially in warmer months. The assumed SRT used for the mass balance was slightly lower – 5.0 days. This value would be sufficient to maintain nitrification when wastewater temperatures are above 14°C and because it is somewhat lower than the norm, it is conservative in that it will predict slightly higher secondary waste sludge loads.

5. WAS Thickening Performance: Centrifuge thickening regularly achieves a thickened waste activated sludge (TWAS) solids concentration greater than 5 percent TS. Solids capture is dependent upon polymer addition. Generally without polymer, the capture rates are only 85 percent. With polymer addition, capture rates are much higher, usually over 90 percent. For the purpose of this mass balance, it was assumed that the capture rate would be optimized as a result of polymer addition, with a capture rate of 93 percent. The WAS thickening capture rate has little impact on predicted plant performance when the centrate is returned to the liquid stream treatment process. The SRT in the secondary treatment system will depend upon the amount of TWAS removed from the process, not the amount of WAS that is extracted.

   Based on this rationale, the TWAS thickening performance has been based on achieving a thickened solids concentration of 5 percent TS and 93 percent capture.

6. Digestion Performance: The digesters convert influent volatile solids to biogas and anaerobic biomass. The net decrease in volatile solids is termed the volatile solids reduction (VSR) and will vary according to the characteristics of the sludge, the operating conditions and the solids retention time in the digester. Based on 2009 to 2011 data, the current four operating digesters achieve about 47.5 percent VSR at an SRT of about 14 days. However, this SRT is optimistic considering the amount of displaced volume associated with inert solids accumulation. The recent Digester 5 cleaning operation suggests that as much as 30 percent of the digester's volume is unavailable. Given that the actual SRT is likely closer to 10 or 11 days, the measured 47.5 percent VSR is excellent.

   The approach taken to digestion in the derivation of plant mass balances has been to assume that the available volume will be expanded so that it is sufficient to provide a minimum effective SRT of 15 days at the maximum month sludge loads. Based on the inlet sludge characteristics and this SRT, the IWA anaerobic digestion model (ADM) used in Pro2D predicts the VSR for average conditions at the Highland Creek WWTP will be about 52 percent, dropping to slightly less than 50 percent when maximum week loads are applied.

   No allowance has been made for enhancing digestion in the future. Conversion of the digesters to an acid-gas configuration, adding sludge pretreatment (thermal hydrolysis, electric pulsing, homogenization, etc.) would improve the VSR, especially during high loading periods. Further, there has been no allowance for separate primary sludge thickening, which would increase the SRT without the need for physical expansion of the digestion facilities. These optional approaches to improving digestion might be considered in the future prior to conventional expansion of the digestion facilities. This issue is discussed further in a later section of this report.

7. Dewatering Performance: Based on 2009 to 2011 data, the existing centrifuges appear able to achieve 27 percent dewatered sludge solids concentrations (cake solids) with polymer dosages of about 11 kg/tonne of dry solids fed to the centrifuges. Of interest, the maximum solids loads to digestion coincide with peak wet weather events. During these periods, large amounts of silt, sand and other inert solids are scoured from the wastewater collection system and enter the plant. This inert load, when fed to the centrifuges, generally improves performance. There is some evidence of improved performance at Highland Creek; however, the data does not provide sufficient proof that it can be assumed that during maximum week loads the dewatering process can achieve better performance. It has been assumed that during maximum month conditions and maximum week conditions, a cake solids concentration of 27.5 percent would be achieved.

   The capture rate achieved during the 2009 to 2011 period averaged 96 percent. This level of performance has been incorporated in the mass balance.

An output of the mass balance is the predicted loading rates to be used in the assessment and design of the anaerobic digesters, biogas management systems and the Truck Loading Facility. Table 4, Table 5, and Table 6 tabulate these design values for various conditions and design capacities.

TABLE 4
Design Basis for Anaerobic Digestion

Parameter	2032		Ultimate Capacity (219 ML/d)	
Condition	**Average**	**Maximum Month Load**	**Average**	**Maximum Month Load**
Primary Sludge				
Flow, m^3/d	1,160	1,690	1,420	2,110
TS Load, kg/d	38,440	55,860	46,945	69,675
VS Load, kg/d	28,170	40,890	34,385	51,010
TWAS				
Flow, m^3/d	410	560	500	690
TS Load, kg/d	20,275	28,130	25,170	34,470
VS Load, kg/d	14,820	19,800	18,335	24,280
Total Sludge to Digestion				
Flow, m^3/d	1,570	2,260	1,930	2,800
TS Load, kg/d	58,715	83,990	72,115	104,145
VS Load, kg/d	42,990	60,880	52,720	75,290
Basic Design Parameters				
Minimum SRT		15		15
Minimum Volume, m^3		33,900		42,000
VS Loading at Min. Volume, $kg/m^3/d$	1.27	1.80	1.26	1.79

TABLE 5
Design Basis for Biogas Management

Parameter	2032	Ultimate Plant Capacity
Biogas Generation Rate		
Average, m^3/d	21,000	25,235
Maximum Month[1], m^3/d	28,715	35,425
Maximum Week[2], m^3/d	32,830	38,820
Peak Diurnal	45,960	54,350
Methane Fraction (at condition noted)		
Average, percent	0.58	0.58
Maximum Month[1], percent	0.58	0.58
Maximum Week[2], percent	0.58	0.58

Notes:
1. Maximum month projections are based on the maximum 30-day running average during a specific annual period.
2. Maximum week projections are based on the maximum 7-day running average during a specific annual period.

TABLE 6
Design Basis for Truck Loading Facility

Parameter	2032	Ultimate Plant Capacity
Dewatered Biosolids Generation Rate		
Average, m^3/d	123	154
Maximum Month[1], m^3/d	179	222
Maximum Week[2], m^3/d	210[3]	260[4]
Storage Period, days	5.5	5.5
Total Volume, m^3	1,155	1,430

Notes:
1. Maximum month projections are based on the maximum 30-day running average during a specific annual period.
2. Maximum week projections are based on the maximum 7-day running average during a specific annual period.
3. Value of 210 m^3/d is rounded up from 206 m^3/d
4. Value of 260 m^3/d is rounded up from 259 m^3/d

In each case, design of new facilities at the Highland Creek WWTP will be based on predicted 2032 requirements. However, plant planning will allow for reasonable expansion of the facilities to handle the capacity needed to expand the plant to handle ultimate capacity. Future changes in wastewater and sludge treatment technologies will influence the sizing of these facilities, so the flexibility to reasonably change to meet these needs is critical to the success of the plant in the future.

3. Truck Loading Facility Assessment

3.1 Background

This section of the Conceptual Design Report describes and assesses various options that could be adopted for the Truck Loading Facility. The initial consideration relates to the technology options that could be employed to store biosolids. The second focus of this work was to assess the various options for siting and configuration of the new Truck Loading Facility. Technical Memorandum 2, attached to this report as Appendix B, provides more details related to the review of various options that could be considered.

3.2 Dewatered Biosolids Storage Considerations

Biosolids storage must deal with a number of material handling issues that are specific to this type of material, as follows:

- **Material Adhesion**: Dewatered biosolids adhere to the walls of storage containers. Vertical walls or walls with negative slopes are best, but dictate more costly biosolids discharge mechanisms that are able to 'sweep' the floor of the vessel.
- **Material Compressibility**: Dewatered biosolids are generally discharged from centrifuges in fairly granular form and tend to stack with relatively high porosity. However when the material is placed under pressure, the particles deform to fill the voids and transform into a thick paste-like mixture. During conveyance and storage, this transformation leads to issues. In pumped systems, the paste experiences extremely high headlosses (90 to 135 kPa per metre). In systems that use conveyors, the material compresses into corners and is difficult to dislodge. Dewatered biosolids left in silos and hoppers will compress under the material's weight and will ultimately become difficult to remove.
- **Bridging**: Dewatered biosolids can form a 'bridge' over a removal device, especially where sloped walls converge on an opening and an arch of compressed material forms that is sufficiently strong to support the material above. As with adhesion, the best solution to this issue is to use vertical walls and to use conveyance devices that do not strictly depend on gravity for feed to the device. Vibrators or similar elements that are often used for dry, granular products to prevent bridging are of little use in the handling of biosolids because they can actually increase compaction and exacerbate bridging.
- **Material Degradation**: Anaerobically digested biosolids remain biologically reactive even after dewatering. Although the majority of biological degradation occurs in the anaerobic reactors, the reactions will continue to generate the normal end products – carbon dioxide (CO_2) and water (H_2O). Some methane (CH_4), volatile sulphur compounds (H_2S and mercaptans), and volatile amino compounds (NH_3, amino acids) can be emitted. These end products contribute to odours and corrosion. Corrosion is of most concern in the selection of biosolids storage technologies. Corners where product is able to collect without being removed during normal operation are most susceptible to attack. The anaerobic environment that occurs below these accumulations generates sulfides that can contribute to 'microbiologically influenced corrosion

(MIC)'. These concerns lead to the selection of storage technologies that inherently limit the potential for solids accumulation.

- **Angle of Repose:** Due to the structure and adhesive characteristics of dewatered biosolids, they tend to have a steep angle of repose (angle from the horizontal at which a material will remain without erosion of the slope). This characteristic limits the 'filling efficiency' (proportion of available volume that is generally occupied by material) of silos or hoppers, especially when single discharge points are provided over large areas. To improve filling efficiency, multiple filling points, leveling conveyors or a combination of the two are generally incorporated in designs to better utilize the available volume.
- **Abrasive Characteristics:** Digested and dewatered biosolids contain a significant amount of grit and other abrasive material. Storage and conveyance elements need to be selected with slow moving parts and adequate sacrificial material to provide long service life.
- **Size**: The maximum size for silos or hoppers is often dictated by transportation limitations and the desire to minimize site assembly to reduce costs. The maximum dimension for components that are hauled by truck is generally 3.3 metres by 3.3 metres by 12 m long. Within these dimensions, silos/hoppers can be transported by truck to a site, albeit as a "Wide Load". When the dimensions of the structure exceed these limits, site assembly is necessary.
- **Maintainability**: Regardless of a device's rugged construction, a time will occur when mechanical wear leads to its malfunction during operation. Repair may require the removal of any biosolids inventory in storage. Designs that accommodate that removal with minimal other manual labour and within a tight time frame are favoured.

3.3 Biosolids Storage Technology Review

Five types of storage technologies have been identified for biosolids storage that include:

- **Simple Centre Cone Circular Silos**: In this type of silo, solids are introduced to the top of the silo and move downward under the influence of gravity. The bottom section is a cone or truncated pyramid, converging to a single discharge point at the centre of the silo. The advantages and disadvantages of this arrangement are as follows:

Advantages	Disadvantages
• Simplicity due to the limited number of moving parts • Mechanical maintenance within the silo is not necessary • Relatively low cost	• High cone angles must be used to reduce the potential for bridging. • It is difficult to control the discharge rate. • The filling efficiency is moderately limited without providing a leveling device or multiple feed points. • To provide the volume required at HCTP, either a very large number of silos would be needed, they would be extremely tall, or they would have to be of a diameter that would mandate significant field assembly. • Space is not used effectively due to high cone angles and circular shape.

- **Modified Centre Cone Circular Silos:** This type of silo is similar to the simple circular option, but fitted with some mechanical device in the bottom cone that prevents bridging. The device may include a rotating full width auger/conveyor, a rotating sweep arm, or similar. The slope of the bottom cone can be reduced as the device not only prevents bridging but acts to draw the stored biosolids to a centre discharge point. Further, the rotational speed can be manipulated to obtain some control over discharge rates. The advantages and disadvantages of these types of silos are as follows:

Advantages	Disadvantages
• Relatively simple due to the low number of moving parts. • Discharge rates can be controlled and are relatively high (low filling times).	• Moderate cone angles must be used to reduce the potential for bridging. • Mechanical maintenance within the hopper may be necessary to repair the device the removes the biosolids to the central discharge point. • Large storage volumes arranged to suit parallel loading bays generally require a number of silos (eight or more would likely be required for the HCTP), with a commensurate increase in operating elements. • The filling efficiency is limited without providing a leveling device or multiple feed points. • Space is not used as effectively as possible due to cone angles and circular shape.

- **Center Arms Silos**: This type of silo has a near flat floor and uses a center driven arm to sweep the material, generally into a transverse screw conveyor. The advantages and disadvantages of these types of silos are as follows:

Advantages	Disadvantages
• Low number of moving parts. • Discharge rates can be controlled and are relatively high (low filling times for haul vehicles). • Low cone angles lead to better utilization of space, although circular shape is less effective than rectangular shape.	• Mechanical maintenance within the hopper may be necessary. The drive centered under the middle of the silo is difficult to access for maintenance, and like the center-cone silos, a single silo discharge mechanism is provided, so it would be difficult to empty the silo if the discharge mechanism malfunctions. • Large storage volumes arranged to suit parallel loading bays generally mandate a number of silos (eight would be minimum likely for the HCTP), with a commensurate increase in operating elements. • The filling efficiency is limited without providing a leveling device or multiple feed points.

- **Sliding Frame Silos**: This type of silo has a flat floor and includes a single elliptical sliding frame driven by reciprocating hydraulic cylinders to sweep the bottom surface of the silo. The advantages and disadvantages of these types of silos are as follows:

Advantages	Disadvantages
• Low number of moving parts. • The sliding frame is relatively robust and should require minimal maintenance. The drive, external to the side of the silo, is readily accessible. • Bridging is very unlikely to occur given the vertical walls, • Discharge rates can be controlled and are moderate. • Flat floors lead to better utilization of space, although the circular shape is less effective than rectangular shape.	• If mechanical maintenance is required within the hopper is necessary, biosolids would need to be removed manually to access the parts. • Large storage volumes arranged to suit parallel loading bays generally mandate a number of silos (eight or more would likely be required for the HCTP), with a commensurate increase in operating elements. • To provide the volume required at HCTP, either a very large number of silos would be needed, they would be extremely tall, or they would have to be of a diameter that would mandate significant field assembly. • The filling efficiency is limited without providing a leveling device or multiple feed points.

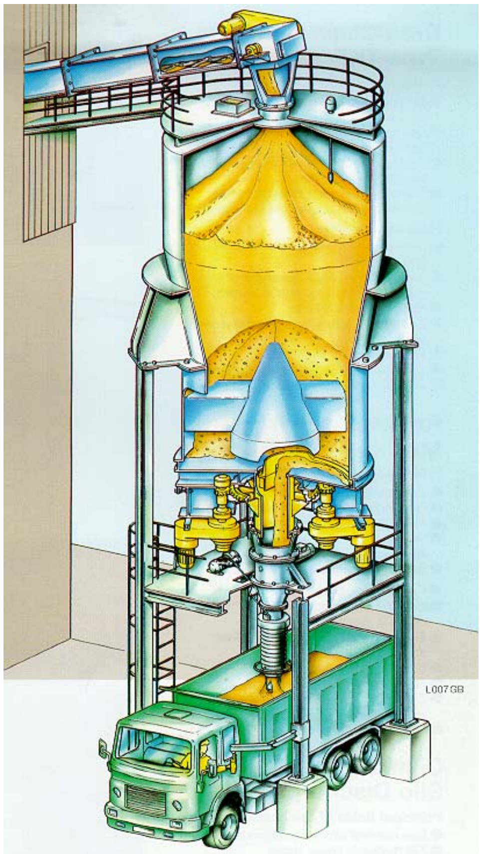
- **V-Bottom Bins with Live Bottoms**: This type of biosolids cake storage system utilizes rectangular or square silos with live bottom arrangements (parallel screw conveyors with motors and gear boxes) to allow the sloped portion of the bin to be minimized, to control the discharge rates and to minimize the potential for bridging. The advantages and disadvantages of these types of hoppers are as follows:

Advantages	Disadvantages
• Live bottom conveyors are relatively simple and robust. • Bridging is unlikely to occur as long as the walls of the hopper section are steep (>60°), • Discharge rates can be controlled and are relatively high (low filling times for haul vehicles). • These hoppers exhibit better utilization of space than circular shapes.	• Mechanical maintenance within the hopper may be necessary, although the drive, external to the side of the silo, is readily accessible. Because live bottom floors have multiple conveyors, most of the stored biosolids can be removed when access to the interior is needed for maintenance. • The filling efficiency is moderately limited without providing a leveling device or multiple feed points.

The first option (simple bottom cone silo) is not suitable for biosolids storage because it does not effectively deal with the bridging issues. Of the other four technologies, all could provide suitable service for the Highland Creek application.

Schematic representations of the more commonly used silo types for biosolids storage are presented in Figure 2. Typical features, downstream and upstream appurtenances and plant reference for installation are described in Table 7.

FIGURE 2
Schematic Illustration of Four Biosolids Storage Technologies



Modified Center Cone Silo

Center Arm Silo

Sliding Frame Silo

V-Bottom Bins

TABLE 7
Typical Features, Appurtenances and Plant References for Four Silo Types

Technology	Features	Typical Upstream and Downstream Appurtenances	Plant Reference and Contact Information
Modified Center Cone Silos	These hoppers are generally of relatively small diameter, although large diameter versions are available. Biosolids are transferred by gravity throughout and to resist bridging, the wall slopes of the bottom cone are very high (greater than 60 degrees), sloping to a central discharge gate. Different bin agitators or vibrating discharge systems can be used to further prevent bridging.	Biosolids pumps or biosolids conveyors are used to convey cake to the top of circular silos. The discharge through a single gate located at the bottom.	75th Street WWTF, Boulder Colorado Centrifuged biosolids are pumped using progressive cavity pumps to one of three rectangular silos. Distribution to each silo is controlled by a pinch valve on the feed lateral and started/shutdown according to the silo weight as measured by a series of load cells. Each silo discharges from a single point (proprietary system – Diamond Gate from RDP), with the gate controlled to discharge a preset mass.
Center Arms Silos	The hopper floor is slightly sloped toward the center and a mechanism rotates just above floor level to move the biosolids to a central conveyor or pump feed point. The rotating arm can be fabricated with ‘scrapers’ or a rotating screw conveyor may be used, either option providing the impetus for the biosolids to be transported to the center discharge point. One option uses hydraulically driven arms that extend into the cake and then retract cyclically to disrupt any bridging that might occur.	Biosolids pumps or biosolids conveyors are used to convey cake to circular silos. Although circular, these silos can be quite large and so it is common that a number of feed points are provided on the roof to distribute the biosolids across the hopper area. Optionally, a bin leveler can be employed, where a rotating rake arm is used to distribute the biosolids across the silo area as the solids build to that level. These silos discharge through one or two floor openings or through a transverse screw conveyor. For applications where the discharge is near the centre (off centre is required since the rotating mechanism is in the centre of the silo).	Solids Dewatering Facility, Clark County Water Reclamation District, Las Vegas, Nevada Eight centrifuges are mounted above four bins. The centrifuges discharge into a series of conveyors that distribute the dewatered biosolids among the active bins. Each bin is fitted with bin levelers and an inverted bin discharger cone. The cone has arms, which rotate through the stored material both disrupting bridging and transferring the cake to the discharge point.
Sliding Frame Silos	Generally, these hoppers are circular (rectangular hoppers with this unloading system are called push floor silos). The hopper floor is flat and an elliptical frame slides from one side to another transferring biosolids cake to a depressed central screw conveyor that withdraws the material to truck loading or other conveyance devices (other conveyors or dewatered biosolids pumps). Because these silos are circular, leveling conveyors are generally not required or used but relatively good filling efficiency is still achieved. The vertical sidewall design optimizes the space (nothing lost for a conical bottom section) and bridging potential is minimized.	Biosolids pumps or biosolids conveyors are used to convey cake to these silos. These hoppers are usually smaller and do not use leveling devices. However, for larger units it is common to employ leveling conveyors or multiple discharge points into the silo to assure good filling efficiency. The discharge from the silo exits to one side through a bottom full width conveyor. This arrangement simplifies structural arrangements but is less compatible with truck loading configurations. This type of silo works very well for intermediate storage where dewatered biosolids are discharged from dewatering devices into the silo and then pumped from that silo to downstream bulk storage or other biosolids processing facilities.	Lakeside WWTP, Mississauga, Ontario A number of sliding frame silos have been installed to receive the biosolids trucked from the Clarkson WWTP to the Lakeside plant and to provide buffer storage prior to incineration. The truck unloading silos discharge through a bottom conveyor to a biosolids cake pump that feeds material to the incinerator feed biosolids hoppers.
V-Bottom Bins	Generally, these hoppers are long and relatively narrow. The height is governed by the volumetric storage requirements. Additional sections can be added to increase the height and volume of the hopper. Biosolids cake is distributed along the length either through a pressurized discharge box with multiple pipes to different zones or through screw conveyors with multiple discharge points. Leveling conveyors are placed in larger hoppers to further distribute the loaded biosolids along the length of the hopper. Leveling conveyors also tend to break up large agglomerations of biosolids that can cause issues. Typically, these hoppers are provided with live bottom systems (two to four parallel conveyors) that transfer biosolids to multiple discharge points and minimize bridging potential.	Biosolids pumps or biosolids conveyors are used to convey cake to hoppers. It is common to size the hopper to suit the dimensions of a truck box and allow for three or four discharge points into the truck trailer from different locations along the live bottom.	Annacis Island WWTP, Metro Vancouver, B.C. At Annacis Island WWTP, four cake pumps transfer dewatered biosolids from the dewatering building to distribution box that feeds a nearby series of four v-bottom rectangular hoppers, each with a volume of about 170 m^3.

The proposed Highland Creek WWTP biosolids storage facility is relatively large. For this reason, it is likely that V-bottom hoppers will be the selected option. This configuration was selected for the Ashbridges Bay Treatment Plant (ABTP), so the City of Toronto has some familiarity with the advantages and disadvantages associated with this means of biosolids storage. As noted above, V-bottom hoppers were also selected for another large plant in Vancouver where their compatibility with truck loading operations and lower costs led to their selection. V-bottom hoppers offer the following benefits:

- V-Bottom Bins with live bottoms can be configured with a number of drop chutes so that truck loading is relatively consistent through the length of the truck trailer.
- Four v-bottom bins would be provided in two parallel trains. Four bins can be arranged to discharge into the most common type of truck box arrangements, as well as to other truck – trailer configurations.
- This system incorporates multiple bottom screw conveyors (live bottoms) so that the storage bins can still be emptied if one screw conveyor malfunctions or for some other reason is removed from service.

Several truck loading options that will be considered incorporate intermediate storage, with dewatered cake pumping used to transfer biosolids to a remote Truck Loading Facility. For this storage function, given its small size and its compatibility with biosolids pumping, sliding frame silos have been tentatively selected.

For the various types of silos and hoppers described in this section, the cost differential does not justify selection of one technology over the other. Although v-bottom bins have been selected as the basis for the conceptual design, the final selection of the storage technology should be deferred until the detailed design when procurement could be based on current pricing and projected operating costs for the above options.

3.4 Truck Loading Facility Siting Options

There are various areas of the plant where a Truck Loading Facility could be situated. A number of these options have been examined with four Truck Loading Facility options being selected for more detailed comparison, as follows:

1. Option 1 – 2011 Biosolids Master Plan Update Option (New Truck Loading Facility East of Existing Biosolids Management Building)
2. Option 2 – Modified 2011 Master Plan Update Option (New Dewatering and Truck Loading Facility East of Existing Biosolids Management Building)
3. Option 3 - New Dewatering and Truck Loading Facility East of New Dechlorination Building
4. Option 4 – New Truck Loading Facility in Area of Existing Heat Treatment Area

These options are described in more detail in the following subsections. Table 8 summarizes the key capacity requirements based on the projected 2032 biosolids quantities and outlines the preliminary design basis for the Truck Loading Facility at the Highland Creek WWTP.

TABLE 8
Truck Loading Facility Design Basis Summary

Parameter	Value
Biosolids Cake Conveyance	
Biosolids cake transferring system capacity	6.0 m^3/hr (average biosolids cake production rate) – 11.1 m^3/hr (maximum centrifuge output capacity)
Biosolids Cake Storage – General	
Storage capacity	5.5 days for max week biosolids cake production rate
Total storage volume (215 m^3/d x 5.5 days)[1]	1,200 m^3
Option 1 and Option 4 (with Intermediate Storage)	
Intermediate storage silo volume (150 m^3 x 2 silos)	300 m^3
Number of V-Bottom Bins at the Truck Loading Facility	4 (two bins per loading bay)
Dewatered biosolids cake storage capacity at V-Bottom Bins	900 m^3 (225 m^3/bin x 4 bins)
Option 2 and Option 3 (without Intermediate Storage)	
Number of V-Bottom Bins at the Truck Loading Facility	4 (two bins per loading bay)
Dewatered biosolids cake storage capacity at V-Bottom Bins	1,200 m^3 (300 m^3/bin x 4 bins)
Biosolids Cake Discharging and Loading	
Number of loading bays	2
Capacity of each truck	30 metric tonnes
Loading time	30 min per truck
Discharge capacity (30 metric tonnes/30 min)	60 wet tonnes/hr per loading bay
Wash-down area	Integrated into the loading bays

Note:

1. The Biosolids Master Plan for Highland Creek WWTP (AECOM, 2011) predicted a peak daily biosolids production rate at the rated capacity for the Highland Creek WWTP of 200 m^3/d. This value is approximately 7 percent less than the value of 215 m^3/d recommended in this TM because different historical data were used to predict the loads for that study and this Report. However, the difference is considered minor.

Common Features

In discussion with the City of Toronto, a number of design features have been incorporated in each siting option analyzed. The key provision agreed was the basic sizing parameter – the facility will provide sufficient storage volume to hold 5.5 days of biosolids production. This sizing allows for ongoing storage of about two days inventory, additional storage to allow for an interruption of up to three days (e.g. long weekend or winter storm), as well as providing an additional half day to re-start the biosolids dewatering processes. Other key design features are as described in the following paragraphs.

1. Where options incorporate the existing biosolids dewatering facility (Option 1 and Option 4), part of the required storage volume would be provided by intermediate storage consisting of two relatively small silos located in the existing Heat Treatment Building.
2. Options 2 and 3 would mount centrifuges directly above the V-bottom hoppers. In these options, the hoppers would provide the total storage volume, not requiring intermediate storage.
3. Other features common to all options include the following:
    a. The Truck Loading Facility will incorporate two bays, which allows two trucks to be loaded simultaneously and facilitates continued operation when hoppers in one bay require maintenance.
    b. The live bottom of the hoppers will be sized to ensure that the discharge of biosolids to the hauling truck trailers could be achieved within 30 minutes (It was assumed that relatively standard trucks would be used with trailer capacities of approximately 30 m^3).
    c. The normal number of loads per day would range from four to seven, depending upon the size of the trucks given the task of hauling biosolids from the site. The anticipated maximum traffic load will increase on some occasions; for example when a weather related disruption in hauling occurs and additional loads need to be removed from site to reduce the inventory.
    d. The road layout will accommodate direct approach and dispatch geometries with space in the approach for staging at least one truck outside of the Truck Loading Facility enclosure.
    e. Biosolids will be distributed to each V-bottom bin through horizontal conveyors with multiple discharge ports.
    f. Redundant equipment will allow one hopper to be removed from service without compromising the function of any other hopper.
    g. Each V-bottom bin will be fitted with six to eight separate discharges to spread the discharged biosolids evenly along the truck trailer bed.
    h. Each V-bottom bin will be equipped with level sensors and load cells, which measure the weight of the material in the bins.

i. The headspace of silos and bins will be contained and extracted to odour control. The odorous air sources from the existing Biosolids Management Facility also will be re-ducted to odour control. Refer to the following section of the Report for a more detailed discussion of odour control.

j. A weigh scale will be located below each V-bottom bin

k. The doors at both ends of the truck bays would be closed during loading to restrict the escape of fugitive odorous air. Trucks will not be able to load until all doors into the truck bays are closed.

l. An interior truck washdown area will be incorporated in the arrangement of the truck loading area to accommodate truck clean-up after loading so that trucks do not exit the facility with visible evidence of splash or spillage. The washdown area will be equipped with wash wands and the splash from the washing activity will be collected in a large sump and returned to the plant for treatment with the influent wastewater.

The following paragraphs summarize the four options that were developed for the plant are described in more detail in the following subsections.

3.4.1 Option 1 – 2011 Biosolids Master Plan Update Option (New Truck Loading Facility East of Existing Biosolids Management Building)

This option includes a new Truck Loading Facility and odour control facility constructed east of the existing Biosolids Management Building. These two elements would be constructed at the west end of the two ash ponds, requiring that they be partially filled to accommodate the new structures. This option would entail the following key elements:

1. The existing dewatering facility (to be refurbished separately) would be maintained.
2. Conveyors would transfer dewatered biosolids to two new intermediate storage silos with sliding frame floors, located in the existing heat treatment areas.
3. The intermediate silos would feed new dewatered biosolids pumping equipment that would transfer the biosolids to the new Truck Loading Facility.
4. The Truck Loading Facility would be oriented along an east-west axis.
5. The pumped Biosolids lines from the intermediate storage area to the Truck Loading Facility would be routed with various other utility lines along an above ground bridge between the existing Biosolids Management Building and the new Truck Loading Facility.

3.4.2 Option 2 – Modified Master Plan Option (New Dewatering and Truck Loading Facility East of Biosolids Management Building)

This option includes a new Truck Loading Facility and odour control facility constructed east of the existing Biosolids Management Building. It differs from Option 1 in that the dewatering facility would also be re-located, with new centrifuges installed on an additional floor above the V-bottom hoppers. This option eliminates the need for intermediate storage and dewatered biosolids pumping between the Biosolids Management Building and the new Truck Loading Facility. It also simplifies dewatered biosolids handling, allowing gravity to play a major role in transferring the material between dewatering and truck filling. The new Truck Loading Facility and the associated odour control area would be constructed at the west end of the two ash ponds, requiring that they be partially filled to accommodate the new structures.

3.4.3 Option 3 – New Dewatering and Truck Loading Facility East of New Dechlorination Building

This option includes a new Truck Loading Facility and odour control facility constructed east of the Sludge Storage Tanks (old digesters) and east of the new dechlorination building. It relocates the facility envisioned for Option 2 to this central location. As with Option 2, new centrifuges installed on an additional floor above the V-bottom hoppers. This option has similar benefits to those of Option 2 in that it eliminates the need for intermediate storage and dewatered biosolids pumping between the Biosolids Management Building and the new Truck Loading Facility. It also simplifies dewatered biosolids handling, allowing gravity to play a major role in transferring the material between dewatering and truck filling. The new Truck Loading Facility and the associated odour control area would be constructed east of the existing Sludge Storage Tanks and the new dechlorination building, adjacent to and parallel with the main plant access road.

3.4.4 Option 4 – New Truck Loading Facility in Area of Existing Heat Treatment Building

This option is very similar to Option 1 other than the new Truck Loading Facility would be built in the area of the existing, retired heat treatment area. It includes a new Truck Loading Facility and odour control facility constructed on the east side of the existing Biosolids Management Building. The existing two ash ponds would be unaffected by the construction, other than there would be some upgrading of the perimeter roadway to accommodate trucks circling the site.

Site layout plans for these four options are provided in Figure 3, Figure 4, Figure 5, and Figure 6. Process flow diagrams and detail on sections and elevations for these four options are attached in Appendix B.

FIGURE 3
Option 1, 2011 Biosolids Master Plan Update Option (New Truck Loading Facility East of Existing Biosolids Management Building) – Site Layout

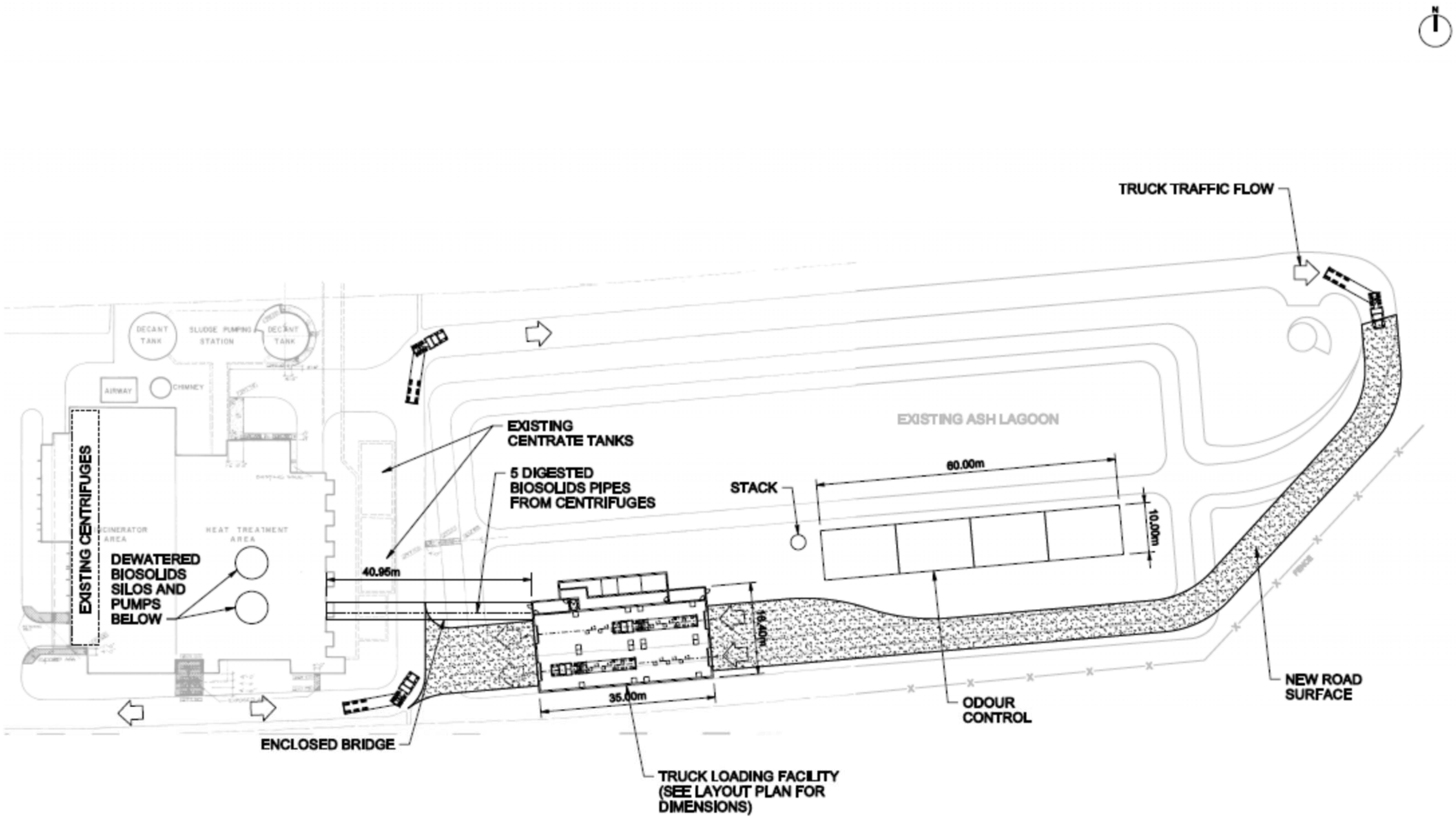


FIGURE 4
Option 2, Modified Master Plan Option (New Dewatering and Truck Loading Facility East of Biosolids Management Building) – Site Layout

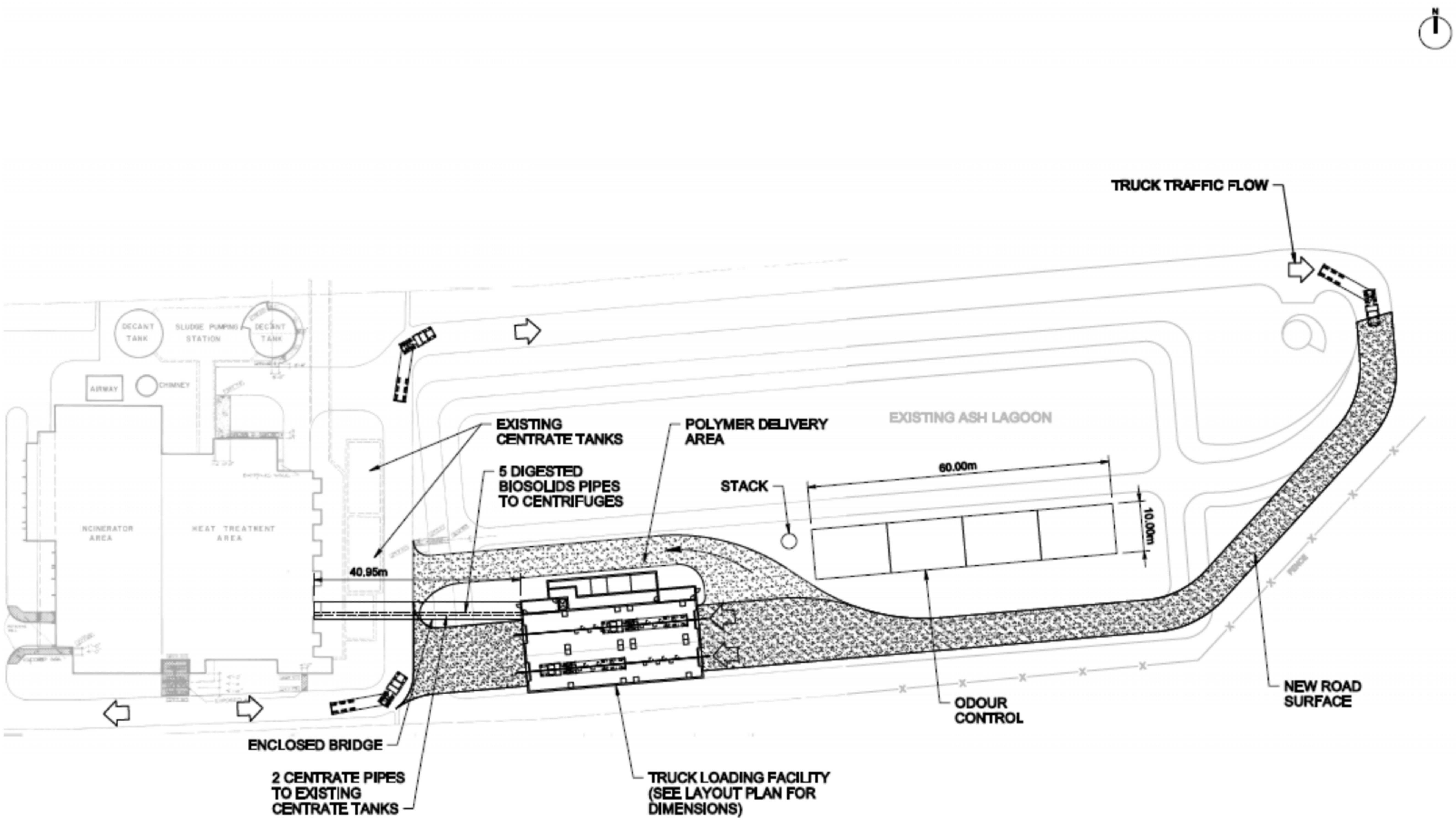


FIGURE 5
Option 3, New Dewatering and Truck Loading Facility East of New Dechlorination Building – Site Layout

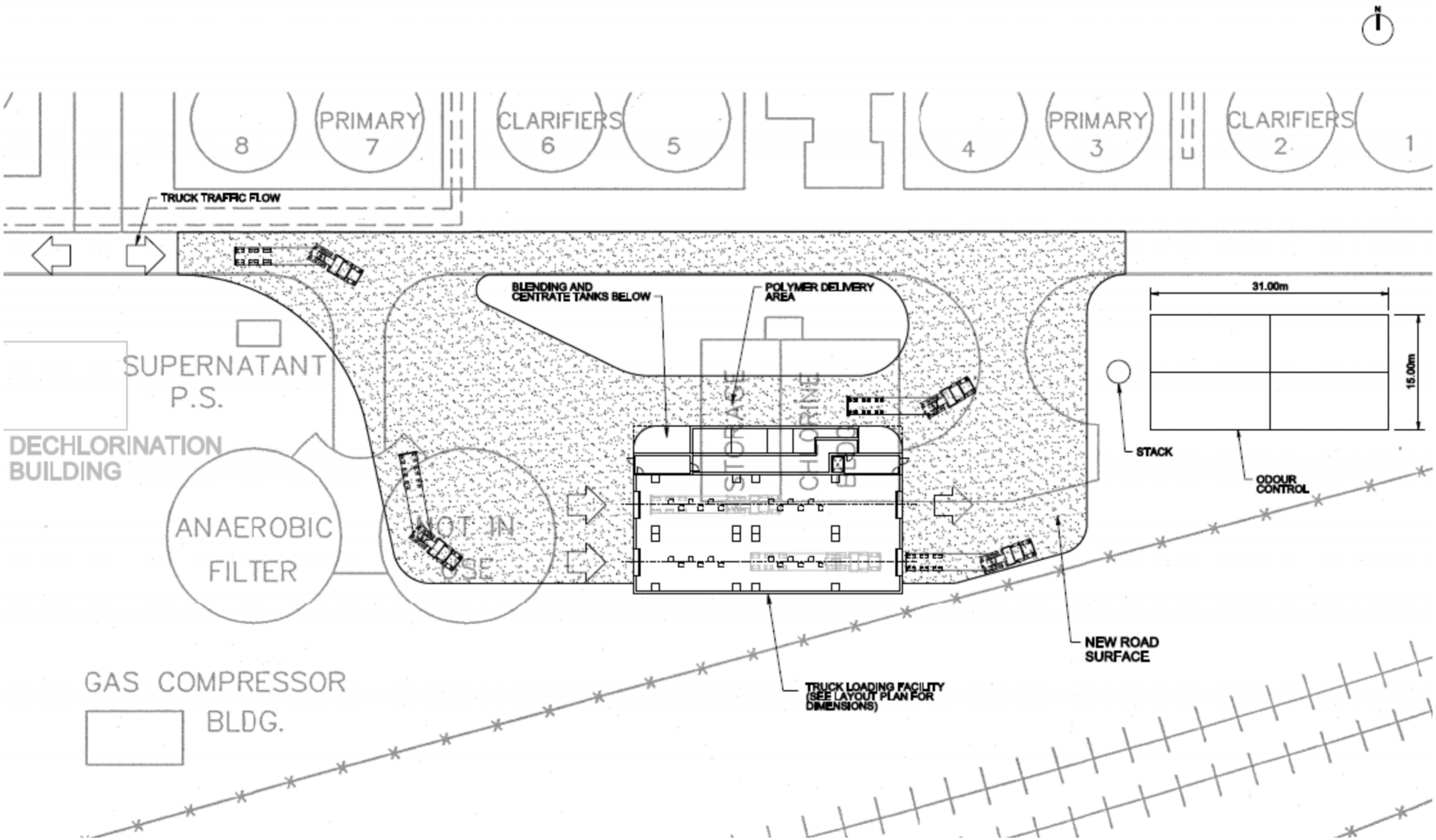
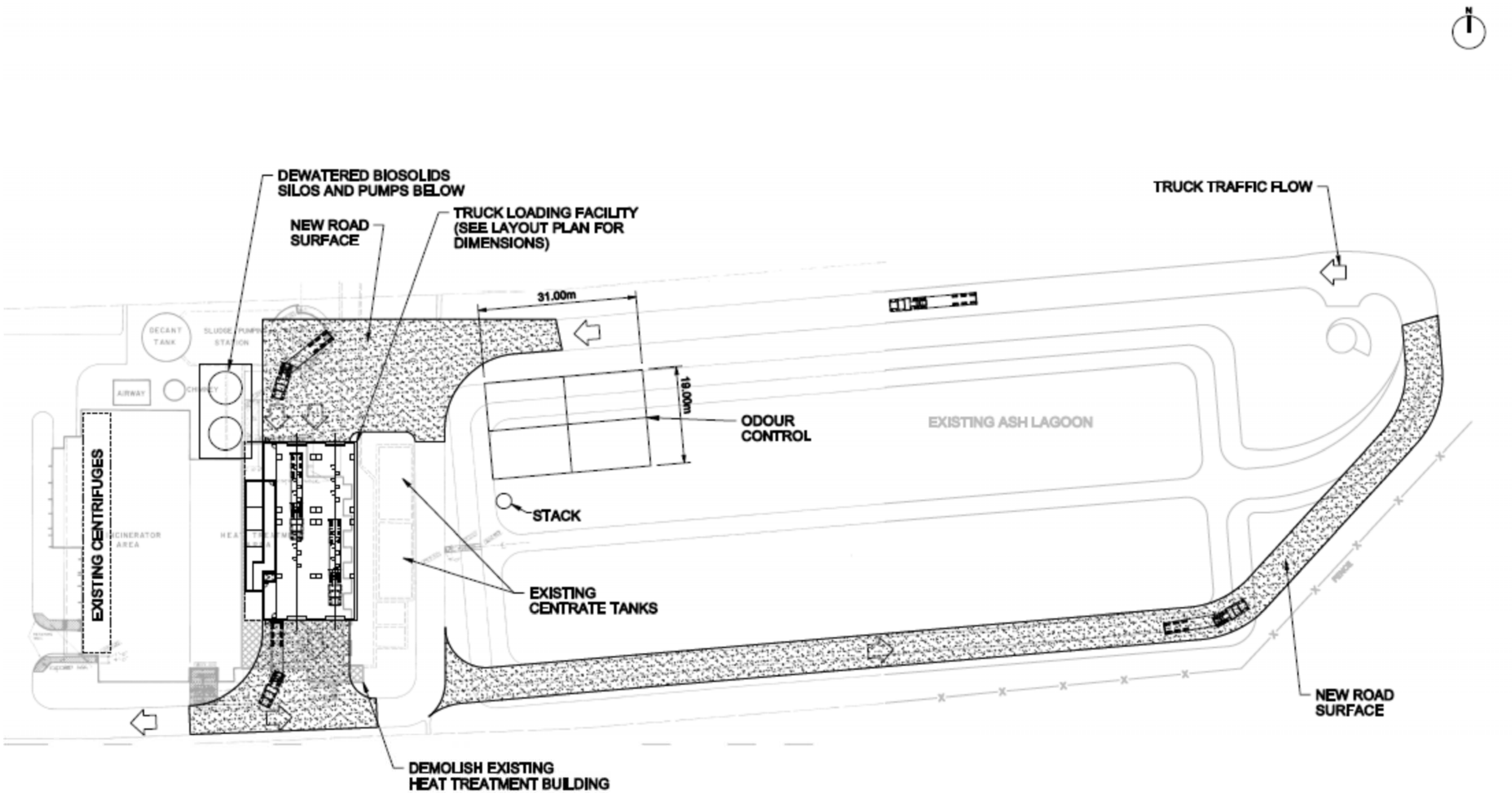


FIGURE 6
Option 4, New Truck Loading Facility in Area of Existing Heat Treatment Building – Site Layout



3.5 Cost Comparison of Truck Loading Option Options

Capital cost estimates have been prepared for the four options considered for the Truck Loading Facility. These estimates are based on vendor proposals for major equipment, unit prices for structural portions of the work and similar elements constructed at other wastewater treatment plants, and allowances for various components based on complexity and scope. The estimate at this point in project development is considered to have Class 4 accuracy, or accurate to within -30 percent / +50 percent. The scope of the cost estimate elements and major assumptions made in the development of these estimates are described and discussed in the following:

3.5.1 Scope

- General Requirements: the contractual requirements for site management (construction trailers, communications, power, lighting, sanitary facilities, safety, etc), as well as for bonding, insurance, and mobilization. It also includes allowances for project management and profit for the General Contractor.
- Civil: excavation and grading, roadwork, roadway lighting, pathways, landscaping, and underground utilities.
- Structural: the foundations, substructure, and superstructure. In this case, the architectural and finishing components of a contractor's bid have also been included – masonry, roofing, waterproofing, finishes, and other special construction.
- Process mechanical: supply and installation of process equipment, including odour control. Process mechanical also includes the process piping.
- Utility mechanical: plumbing and heating, ventilation and air conditioning (HVAC), including utility piping inside the buildings.
- Electrical: power supply, power distribution and control, lighting, and electrical protection.
- Instrumentation and Control: process control elements, building safety monitoring and control, security, SCADA

3.5.2 Major Assumptions

- Option 2 and Option 3 requires relocating the current dewatering facilities from the Biosolids Management Facility to the new Truck Loading Facility. It was assumed that the centrifuges would be relocated to the new facility. Toronto is planning on replacing five of the six operating centrifuges in the next two years. It is these relatively new units that would be moved.
- The civil work would include demolition as required. Option 3 includes demolition of the old anaerobic filters to accommodate construction of the new Truck Loading Facility. For Option 4, demolition includes the removal of the existing heat treatment area as well as demolition of the existing decant tanks to facilitate the access roadway to the Truck Loading Facility.

- For Option 1, Option 2 and Option 4; the existing blending tanks and the centrate tanks would remain in service. For Option 3, because of its location, new blend tanks and centrate tanks would be constructed.

The detailed capital costs developed for each option are detailed in TM2, attached to this report as Appendix 2. Table 9 summarizes these estimates. Table 10 summarizes the scope associated with the costs of developed for the various work elements.

TABLE 9
Summary of Capital Cost Estimates for Truck Loading Facility Including Odour Control (Excludes Digestion Upgrades to Accommodate for Beneficial Use of Biosolids)

Description	Option 1[2]	Option 2[3]	Option 3[4]	Option 4[5]
Civil work (sitework, excavation, demolition, Tie-ins, underground utilities, etc)	$ 4,975,000	$ 3,175,000	$ 7,150,000	$ 9,375,000
Structural (substructures, superstructures, supports, architectural elements, etc)	$12,825,000	$ 17,487,000	$ 16,987,000	$ 16,825,000
Process Mechanical (process equipment, process piping, conveyance elements, process ancillaries)	$ 17,120,000	$ 15,940,000	$ 15,590,000	$ 16,620,000
Building Mechanical (Heating, Ventilation and Air Conditioning (HVAC), plumbing, utility piping, etc)	$ 2,850,000	$ 3,100,000	$ 3,100,000	$ 2,850,000
Electrical (Power supply and distribution, wiring, power monitoring, transient protection, etc).	$ 4,581,000	$ 4,236,000	$ 4,236,000	$ 4,581,000
Instrumentation and Control (monitoring devices, local equipment controls, SCADA, life protection and safety systems, control wiring and networks)	$ 3,818,000	$ 3,530,000	$ 3,530,000	$ 3,818,000
Subtotal Direct Cost[1]	$ 46,169,000	$ 47,469,000	$ 50,593,000	$ 54,068,000
Indirect Cost (Contractor's profit, bonds, insurance, etc.)	12,092,000	12,433,000	13,251,000	14,161,000
Subtotal Direct + Indirect Cost	58,261,000	59,901,000	63,844,000	68,230,000
Contingency (30%)	17,478,000	17,970,000	19,153,000	20,469,000
Escalation[1] - 2016 dollars	7,377,000	7,585,000	8,084,000	8,640,000
Total Construction Cost (Excluding Engineering and HST)	**$ 83,116,000**	**$ 85,455,000**	**$ 91,081,000**	**$97,337,000**
Engineering Cost (12 % of Total Construction Cost)	9,974,000	10,255,000	10,923,000	11,680,000
Total Estimated Capital Cost, Including Construction, Engineering and excluding HST	**$ 93,090,000**	**$ 95,710,000**	**$102,011,000**	**$109,012,000**

Notes:

1. Estimates are shown in 2012 dollars (Direct Cost), with escalation to midpoint in construction indicated separately (2016). It has been assumed that projects would be tendered in 2015 and constructed by 2017. Some totals may be appear incorrect; when compared to cost presented in Appendices 2,4,6, 8; due to rounding errors.
2. Option 1 – Master Plan Option (New Truck Loading Facility east of the existing Biosolids Management Building).
3. Option 2 – Modified Master Plan Option (New Truck Loading Facility and dewatering facility east of the existing Biosolids Management Building).
4. Option 3 – New Truck Loading Facility and dewatering facility at a central location, east of the new Dechlorination Building
5. Option 4 – New Truck Loading Facility within the existing Heat Treatment area.

TABLE 10
Cost Description and Comparison of Capital Cost Estimates[1]
(Excludes Digestion Upgrades to accommodate for Beneficial Use of Biosolids)

Description	Option 1[2]	Option 2[3]	Option 3[4]	Option 4[5]
Civil				
• Includes south and north ash lagoon removal and fill. • Demolition work • Tie-in allowances to the existing biosolids management facility	Same cost as Option 2 for removal of north and south ash lagoons. Includes higher demolition cost than Option 2 for existing heat exchanger removal and minor allowances for tie-in of centrate to existing centrate tank.	Same cost as Option 1 for removal of north and south ash lagoons. Includes lower demolition cost than Option 1 to allow for bridge connection to existing Biosolids Management facility. Includes same tie-in allowances as Option 1 for centrate tie-in to existing centrate tank.	Second most expensive option as it includes widening the main plant road. Includes demolition cost for removal of old chlorine building, anaerobic filter building and east tank of anaerobic filter.	Most expensive option: allows for removal of north and south ash lagoons. Includes higher demolition cost to demolish the Heat Treatment Area and the Decant Tanks.
Building Structural				
• Includes building structure and odour control stack	Less expensive than Option 2 as it involves the construction of shorter (20 m high) building and includes an odour control stack and structure for an enclosed bridge between the truck loading area and the existing Biosolids Management Facility.	Most expensive Option as it involves the construction a higher building- 26 m high building. Also includes an odour control stack and structure for an enclosed bridge between the truck loading and the existing Biosolids Management Facility.	Comparable with Option 3 as it includes the construction of a 26 m building. It also includes new centrate and blending tanks.	Includes the construction of 20 m high building and includes an odour control stack and major cost for structural supports needed to keep the basement level.
Process Mechanical				
• Equipment, • conveying systems • Includes truck loading equipment such as v-bottom bins storage and silos; odour control biofilter and dewatered biosolids screw conveyors. • Also includes lifting devices such as bridge crane/ monorail.	Most expensive Option as it includes v-bottom bins storage as well as intermediate storage, with two silos and four dewatered biosolids pumps. Includes a slighter bigger biofilter and dewatered biosolids screw conveyors. Includes all the mechanical equipment, piping and devices of intermediate silo storage.	Same as Option 3. Option 2 includes v-bottom bins storage and no intermediate storage or dewatered sludge pumping. Includes a smaller biofilter.	Same as Option 2.	Similar to Option 1 but some savings are achieved as the centrate tank is adjacent to the truck loading facility, so there are lower conveyance costs.
Building Mechanical				
• Includes make up air units, dehumidification units, duct work, exhaust fan and heaters to allow for a functional building	Option includes heating, ventilation and air conditioning equipment for building that is 20 m high.	Option includes heating, ventilation and air conditioning equipment for building that is 28 m high.	Same as Option 2.	Same as Option 1.

TABLE 10
Cost Description and Comparison of Capital Cost Estimates[1]
(Excludes Digestion Upgrades to accommodate for Beneficial Use of Biosolids)

Description	Option 1[2]	Option 2[3]	Option 3[4]	Option 4[5]
Electrical				
• Supply and installation of electrical devices and wiring	Basic electrical scope includes power supply, power distribution and control. The 5 KV services between the main plant power supply and the Biosolids Management area is sized to accommodate the future load as incinerators and heat treatment power supply is available for truck loading facility.	Includes power supply, power distribution and control. The 5 KV services between the main plant power supply and the Biosolids Management area is sized to accommodate the future load as incinerators and heat treatment power supply is available for truck loading facility. Higher costs than Option 1 due to increased number of equipment.	Same as Option 2, the total plant load will not exceed the present load, so no change to the main service is envisioned.	Same as Option 1.
Instrumentation and Control				
• Includes PLC systems, software and hardware for the control of the truck loading facility	Includes I&C for entire area, including that needed to accommodate the intermediate silo storage. Also includes PLC system, software and hardware.	Includes I&C for entire area including instrumentation for truck loading facility without intermediate storage. Also includes PLC system, software and hardware.	Same as Option 2.	Same as Option 1.

Note:

1. Presented in Table 9
2. Option 1 – Master Plan Option (New Truck Loading Facility east of the existing Biosolids Management Building).
3. Option 2 – Modified Master Plan Option (New Truck Loading Facility and dewatering facility east of the existing Biosolids Management Building).
4. Option 3 – New Truck Loading Facility and dewatering facility at a central location, east of the new Dechlorination Building
5. Option 4 – New Truck Loading Facility within the existing Heat Treatment area.
6 Details are presented in Appendix 2- of TM 2: Truck Loading Facility – Siting and Configuration.

The annual Operation and Maintenance (O&M) estimates were developed for each option on the basis of data available from other locations and input from the City of Toronto (labour rates, electrical rates, etc). The facet of the estimates that received most emphasis was related to those components of the O&M activities where there would be significant differentiation between the various options. The following assumptions were used as the basis for the preparation of the O&M estimates:

- The dewatering facility O&M power, labour, and equipment maintenance costs have been included and are based on 7 day per week operation and 24 hours per day.
- The intermediate storage O&M power, labour, and maintenance costs have been included and are based on 7 day per week operation and 24 hours per day.

- The truck loading facility O&M power, labour and maintenance costs have been included and are based on 7 day per week operation, but for only 10 hours per day.
- Trucking costs have not been included (common to each option).
- Power costs are based on a unit electrical rate of $0.09/kWh
- Labour costs are based on hourly rates of $75/h and include salary, payroll burden and overheads
- Equipment maintenance costs are based on annual costs equal to 2.5 percent of the total equipment cost.

The estimated Operation and maintenance cost estimates for the four options, developed on this basis, are summarized in Table 11.

TABLE 11
Summary of Operation and Maintenance Cost Estimates[1]

Description	Option 1	Option 2	Option 3	Option 4
Power Consumption	$ 477,000	$ 402,000	$ 402,000	$ 477,000
Labour	$ 1,147,000	$ 983,000	$ 983,000	$ 1,147,000
Maintenance – Mechanical Equipment, Electrical, SCADA and I&C	$ 597,000	$ 562,000	$ 562,000	$ 597,000
Polymer Consumption, Natural Gas	$ 578,000	$ 631,000	$ 474,000	$ 578,000
Total Estimated O&M Cost, Excluding HST	**$ 2,800,000**	**$ 2,579,000**	**$ 2,421,000**	**$ 2,800,000**

Note:
1. Some totals may appear incorrect due to rounding errors.

The life cycle costs of the four options also have been derived based on capital expenditures being expended between 2013 and 2017, with operation extending from 2017 to 2035. These life cycle costs have not included HST costs, and are based on an escalation rate of 3 percent and a borrowing rate of 6 percent. These life cycle costs are summarized in Table 12.

TABLE 12
Summary of Life Cycle Cost Estimates[1] (Excluding Digestion Upgrades to Accommodate Beneficial Use of Biosolids)

Description	Option 1[2]	Option 2[3]	Option 3[4]	Option 4[5]
Capital Costs	$ 93,090,000	$ 95,710,000	$ 102,011,000	$ 109,012,000
O&M Costs	$ 2,800,000	$ 2,579,000	$ 2,421,000	$ 2,800,000
Life Cycle Costs[6]	**$ 128,760,000**	**$ 128,180,000**	**$ 132,021,000**	**$ 144,066,000**

Note:

1. Some totals may appear incorrect due to rounding errors.
2. Option 1 – 2011 Master Plan Update Option (New Truck Loading Facility east of the existing Biosolids Management Building).
3. Option 2 – Modified 2011 Master Plan Update Option (New Truck Loading Facility and dewatering facility east of the existing Biosolids Management Building).
4. Option 3 – New Truck Loading Facility and dewatering facility at a central location, east of the new Dechlorination Building
5. Option 4 – New Truck Loading Facility within the existing Heat Treatment area.
6. Life cycle costs are expressed in 2015 dollars

The estimated life cycle costs for Options 1 and Option 2 are considered roughly equivalent. At the accuracy of the estimates used to develop these values, the life cycle costs for Option 1 and Option 2 do not provide sufficient differentiation to select between them. The life cycle costs associated with Option 3 and Option 4 are 4 to 10 percent higher than the other two options. This differential is sufficient to conclude that Option 3 and Option 4 would exhibit higher costs than Option 1 and Option 2.

3.6 Non-Monetary Comparison of Truck Loading Options

Various non-monetary considerations have been identified that differentiate between the various options. Table 13 summarizes those considerations.

TABLE 13
Truck Loading Facility – Non-Monetary Factors

Factor	Discussion
Visual Impact	Option 1 and Option 2 have more visual impact than the other two options. Option 3 involves a building as high as that in Option 2, but moves it to the interior of the site where it would be less evident from the surrounding properties. To the degree possible, Option 4 utilizes the shell of the existing Heat Treatment Building to house the Truck Loading Facility, so minimal changes to the visual impact of the site would occur.
Truck Traffic	Truck traffic to and from the site will be the same for any option. Truck traffic through the site is less likely to cause any issues with operations for Option 1, Option 2, and Option 4. In Option 3, the truck traffic could interfere with normal plant operations because the trucks would be routed through the main plant site.
Onsite Trucking Logistics	In all cases, existing roads will need to be widened and the corners provided with larger radii to facilitate truck movement. Option 3 requires a greater amount of work.
Operation Impact during Construction	Option 3 construction and process work would have the least impact on existing operations – most of the work could be completed off line. However, the site is within the existing main plant area so there would be some interference due to construction traffic. The other options require some work in the existing Biosolids Management Building.
Operations Access	Option 3 offers the best operator access to the facility because it is located within the existing plant area and could be integrated into the plant tunnel system. Option 4 is also relatively accessible to operations staff.
Power Requirements	Option 1, Option 2 and Option 4 could all be served from the existing feed to the Biosolids Management Building. Option 3 would require a new 5 kV feed from the plant substation.
Plant Security	Option 3 has some security concerns because private trucks would enter and circulate through the main plant site.

3.7 Preferred Option

The following paragraphs discuss the differences between the four options under consideration.

1. Option 1 and Option 2 are the least life cycle cost options on the basis of their net present values (NPVs).The capital cost of Option 1 is slightly lower but this difference is offset by slightly higher O&M costs. The NPV value of Option 3 is marginally higher than that of Option 1 and Option 2. The NPV of Option 4 is significantly higher than that of Option 1 and Option 2.
2. Option 2 has the least potential impact on existing operations during construction, although Option 1 only requires construction of intermediate storage in the existing, non-operational Heat Treatment Area; so the difference in construction disruption would be minimal.
3. Option 2 would be the easiest to operate because it does not require intermediate storage and dewatered biosolids pumping.
4. Option 1 has slightly less visual impact than Option 2 due to the lower building employed for this arrangement.

Minimal differences exist between Option 1 and Option 2, while they both are lower in NPV than Option 3 and Option 4. The comparison of non-monetary considerations does not significantly favour Option 1 or Option 2. For the purpose of planning, it is recommended that the estimated costs for Option 2, which are slightly higher than those of Option 1, be used. However, as there are no compelling reasons evident to select Option 1 or Option 2, it is recommended that both options be carried forward to the next stage of project development for further more detailed analysis prior to selecting the final approach.

4. Odour Control

4.1 General

When air comes into contact with biosolids, a number of compounds volatilize and enter the air stream, including hydrogen sulfide (H_2S), reduced sulfur compounds such as mercaptans and methylated sulfides, reduced organic nitrogen compounds such as amines, and other volatile organic compounds (VOCs). Even though the concentration of these compounds is relatively low, they impart a distinctive odour to the contacted air; hence, odourous air is generated. The exhaust airstream from any area where air comes into contact with biosolids needs to be contained and treated to ensure it does not cause unacceptable impacts within the plant and in neighbouring properties.

For the proposed Truck Loading Facility, odorous air sources include the air drawn from the new process units in the Truck Loading Facility and the general exhaust air from the truck loading area itself. As noted, these odorous air streams need to be contained and treated prior to discharge to the environment.

In the existing Biosolids Management Facility, odorous air is extracted from several sources (centrifuges, sludge storage tanks, etc) where air comes into contact with the biosolids. This odorous air is collected and used for make-up air in the existing two thermal oxidation units. Through this thermal process, the odorous compounds are destroyed, so do not contribute to plant odours. Since the change to beneficial use of biosolids would include decommissioning of the thermal oxidation units, these existing odorous air streams will need to be diverted to the new odorous air treatment system implemented as part of the Truck Loading Facility. Allowances for the treatment of this odorous air stream are included in the selection and sizing of the odorous air system for the total area included in this Report.

4.2 Odour Control Technologies

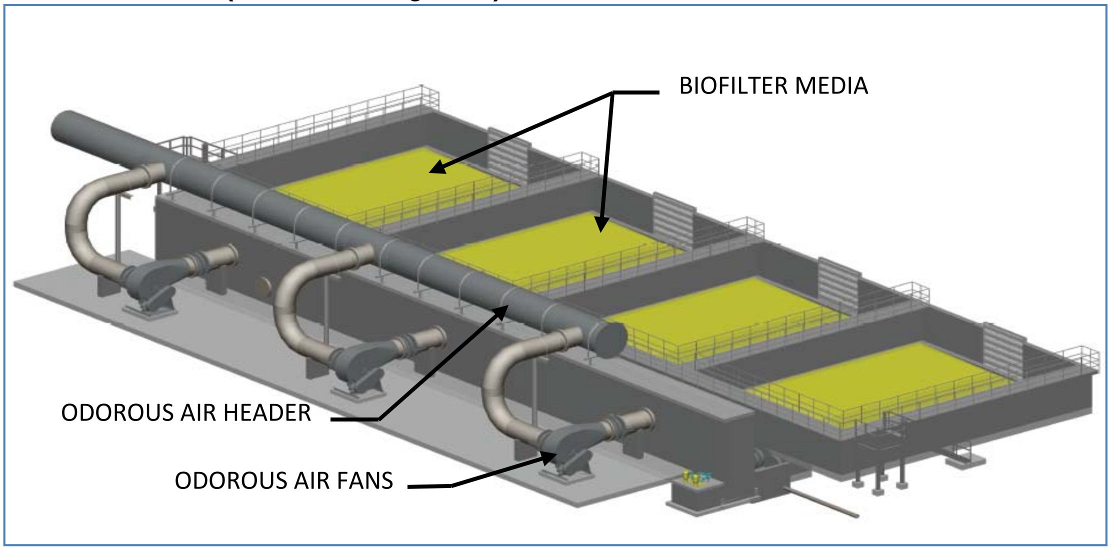
There are numerous techniques available to treat odorous air. These include adsorption, chemical scrubbing, and biological processes. For large volumes of odorous air with low levels of odorous constituents (less than 20 ppm of H_2S), biological processes are generally employed to reduce chemical costs. Two types of biological treatment are available – biofilters and bio-trickling filters. Biofilters have been used by Toronto in the past for odour control. Bio-trickling filters are becoming more regularly used in the wastewater treatment industry and are suitable for higher concentration air streams. They are often used upstream of biofilters to remove the bulk of the contaminants, with biofilters providing final polishing. However, biofilters remain the most common biological odour control technology.

Biofiltration is a sustainable treatment technology that employs biological processes. Odorous air is introduced at the bottom of a biofilter, comprised of natural or engineered synthetic media material. The odorous air flows upward through the filter bed. The media supports biological growth and the environment is optimized by irrigating the filter at rates that maintain optimal moisture levels. Biofiltration does not produce environmentally harmful by-products – no hazardous chemicals are used in the treatment process (chemical scrubbers require caustic and hypochlorite). Further, they do not produce hazardous waste (such as spent activated carbon that may require disposal as hazardous waste). Other advantages include low maintenance, effective treatment of a broad range of odour causing compounds, and lower operational cost relative to other odour control technologies. Given their track record in other similar situations; for this preliminary design, the use of enclosed biofilters is recommended. Enclosing a biofilter allows better environmental control in the treatment system. The exhaust air from biofilters has a distinctive biological odour, which is minimally offensive, but noticeable. To reduce the impact of this emission on neighbouring areas, the biofilter would be enclosed and the treated air collected from the headspace for discharge through a relatively short stack. This approach has been successfully employed in a number of projects including the Calgary's Pine Creek WWTP, the Duffin Creek WWTP, the Barrie WWTP, the Amhersburg WWTP, Hamilton's Woodward Ave WWTP, Burlington's Skyway WWTP and the Loudoun County, Virginia wastewater treatment plant (among other US applications).

In an enclosed biofilter, maintenance is done by entering the filter from a manhole above the media. The only regular maintenance would be the checking of the media irrigation system, which would likely be done annually. Access to the headspace is somewhat limited (1.5 to 2.0 metre headspace); however, given the minimal frequency of access, this height is sufficient. Major maintenance would include media removal at relatively infrequent intervals (once every 10 years). To facilitate this task, a large access hatch is generally provided on one side of the media enclosure, of sufficient size to allow entry of a small mechanized loader (Bobcat or similar).

Figure 7 schematically represents a four cell system similar to the system envisioned for the Highland Creek WWTP.

FIGURE 7
Biofilter Schematic (without showing cover)



4.3 Odorous Air Generation Rates

For the purpose of conceptual design, the potential odorous air sources have been identified and categorized.

The categories relate to the relative level of contamination of the air streams, as follows:

Severe Levels of Odorous Constituents	Odour units (dilutions to threshold) in excess of 20,000 D/T and/or sulfide or reduced sulfur compound concentrations in excess of 20 ppm.
High Levels of Odorous Constituents	Odour units (dilutions to threshold) less than 20,000 D/T but in excess of 2,000 D/T and/or sulfide or reduced sulfur compound concentrations below 20 ppm but in excess of 2 ppm.
Moderate Levels of Odorous Constituents	Odour units (dilutions to threshold) less than 2,000 D/T but in excess of 500 D/T and/or sulfide or reduced sulfur compound concentrations below 2 ppm but in excess of 0.1 ppm.
Low Levels of Odorous Constituents	Odour units (dilutions to threshold) less than 500 D/T but in excess of 50 D/T and/or sulfide or reduced sulfur compound concentrations below 0.1 ppm but in excess of 0.01 ppm.

The expected sources of foul air and their category are listed in Table 14.

TABLE 14
Odourous Air Inventory

Source	Air flow, m^3/s	Level of Odorous Constituents	Comments
Existing Sources			
Centrate	2.0	Severe	Extraction rate from centrate holding needs to be greater than liquid filling rate and sufficient to maintain negative pressure under all conditions. Odorous constituent concentrations will be relatively high.
Blending Tanks	0.2	Severe	Extraction rate from centrate holding needs to be greater than liquid filling rate and sufficient to maintain negative pressure under all conditions. Odorous constituent concentrations will be very high and dependent upon the intensity and type of mixing employed.
Dewatering Centrifuges	2.2	High	Air is drawn from the centrifuges through the dewatered biosolids chute at rates sufficient to maintain the unit under negative pressure at all times. The required air extraction rate varies according to vendor. Odorous constituent concentrations will be very high.
New Sources			
Truck Loading Facility[1]	12	Weak to Moderate	Includes air extracted from head space of storage bins (moderately strong), truck loading area exhaust (relatively weak), and general room air from area surrounding storage (relatively weak)
First Stage Biosolids Storage Silo and Pumps	3	Moderate	As will be discussed in latter sections of this report, some Truck Loading Facility options (Options 1 and 4) require two stage biosolids storage. In these instances, the silos and other biosolids

TABLE 14
Odourous Air Inventory

Source	Air flow, m^3/s	Level of Odorous Constituents	Comments
			enclosures employed will be exhausted to odorous air treatment. This odorous air stream will have moderate levels of odorous constituents.
Total Existing and New Sources	17 or 20		The Biofilter will be sized to treat 20 m^3/s air flow rates for Options 1 and 4 and 17 m^3/s air flow rates for Option 2 and 3 (refer to Section 5 for a description of truck loading options).

Note:
1. Taken from ‘Ashbridges Bay Wastewater Treatment Plant (ABTP)-Existing TLF Biofilter Upgrades, dated June 2010.

These odorous airflow rates are relatively conservative, based on exhausting areas with odorous air at sufficient flow rates to maintain negative pressure in the space (air will leak into the space rather than out of space).

4.4 Odour Control Basis of Design

The various odorous air flows will be combined prior to treatment in a biofilter. Because of the relative strength of these odorous air sources, a conservative design approach has been adopted for the biofilter. This approach involves the use of a biofilter with an empty bed retention time that is almost double that employed for less concentrated air flows – 45 seconds. Table 15 provides the design basis derived for odour control for the various Truck Loading Facility options.

TABLE 15
Design Basis for Odour Control Treatment

Parameter	Options with Intermediate Storage	Options without Intermediate Storage
Odorous air flow rates, m^3/s	20	17
Maximum sulfide concentration, ppm	10	10
Biofilter		
Type	Enclosed, synthetic media	Enclosed, synthetic media
Empty bed retention time, s	45	45
Performance		
Sulfide removal, percent	99	99
Odour removal, percent	90	90

5. Anaerobic Digestion and Waste Gas Burner Assessment

5.1 Background and Regulatory Requirements

The anaerobic digestion facilities will need to stabilize biosolids to the degree necessary for agricultural land application. The acceptance of digested biosolids for agricultural land application in Ontario is based on achieving some pathogen removal through biosolids treatment. The standard applied is based on achieving residual *E. coli* densities of 2,000,000 per gram of biosolids (Ministry of Environment, (2002). *Nutrient Management Act*). The Ministry of the Environment recommends that digestion provide a minimum of 15 days of solids retention time at mesophilic temperatures (35°C to 37°C, Ministry of Environment (2008), *Design Guidelines for Sewage Works*). Given that most digesters are once through processes, the solids retention time (SRT) equals the hydraulic retention time (HRT). Generally, this requirement is interpreted as requiring that the digestion process provides an SRT of 15 days, on the basis of maximum month loads to the process, with the largest unit out of service. The current digesters do not have the volumetric capacity necessary to provide 15 days of storage.

The existing digestion process provides some solids reduction; however, the existing digestion facility was not designed to enable land application of biosolids and does not include sufficient volumetric capacity to satisfy the above regulatory requirements related to beneficial use. Further, in the event of a peak solids loads, process malfunction, or the need to remove a digester for maintenance; raw sludge bypasses anaerobic digestion directly to thermal oxidation. When the thermal oxidation process is de-commissioned as part of the beneficial use biosolids management strategy, the digestion facility will need to be expanded to ensure that it can handle the predicted solids loads under all conditions, even those less frequent adverse conditions.

Due to the above change in functional requirements, the existing digesters do not have sufficient volumetric capacity to handle the predicted solids loads in the short or in the long term. To address this shortcoming, various expansion options have been considered.

5.2 Existing Digester Facilities

There are four existing anaerobic digesters at the Highland Creek WWTP, all put into service in approximately 2003, and numbered Digester 5 to Digester 8. The digesters are relatively conventional ‘pancake’ shaped units, each with a total volume of 6,610 m^3. Design data for the existing digesters is summarized in Table 16.

TABLE 16
Summary of Existing Digesters and Associated Major Process Components

Item	Description
Total number of digesters	4 (all primary anaerobic digesters)
Digester Dimensions	33.5 m diameter 7.5 m sidewater depth Volume per digester, 6,610 m^3, not including the bottom cone
Total Digester Volume	26,440 m^3, (6,610 m^3 x 4 digesters)
Digester covers	Fixed fabricated steel covers with safety relief valves
Raw Sludge Feed	16 raw sludge pumps (8 in Old Plant, 4 in Phase I, and 4 in Phase IV) 2 flow meters (1 for Old Plant, and 1 for Phases I&IV Plants) 4 automated main sludge feed control valves (1 per digester)
Digested Sludge Removal and Transfer	4 variable speed sludge transfer pumps and associated automated inlet valves (1 per digester)
Sludge Heating System	4 dual pass sludge heat exchangers (1 per digester) 4 sludge recirculation pumps (1 per digester)
Digester Gas – Mixing System	5 gas mixing compressors (4 duty 1 standby) Digester gas mixing draft tubes
Waste Gas Burners (WBGs)	3 WGBs, each with a rated capacity of 513 m^3/hr
Digester Gas Utilization Systems	
High pressure boosters	3 High Pressure booster compressors, each with a rated capacity of 480 Nm^3/hr
Boilers	5 boilers, each sized to handle 870 Nm^3 /hr biogas.

Digester 5 was inspected in early 2012. Although it was found in relatively good condition after nine years of operation, grit and debris accumulation in the bottom of the tank accounted for about 18 percent of the total volume.

The average raw sludge flow to the anaerobic digesters from 2009 to 2011 was 3,590 m^3/d. Hence, the four existing digesters provide an SRT below 10 days. The completion of the secondary sludge thickening project that is currently underway will increase the SRT in the digesters because thickening the secondary sludge will substantially reduce the volume of secondary sludge below the current amount. The daily biosolids volumes will decrease because of this increase in solids concentrations. Nonetheless, current and future biosolids loading rates will exceed the ability of the existing digesters to provide the volume necessitated by an SRT of 15 days, at maximum month loads, with one unit out of service.

5.3 Future Digestion Capacity Requirements

The projected raw sludge volumes for the year 2032 and for the ultimate plant capacity have been presented in Section 2. Based on the raw sludge volumes contained in Section 2, the existing digesters will have substantial capacity shortfalls. Table 17 below shows the predicted volumetric loads for 2032 and for the ultimate plant capacity in terms of a 15 day maximum month load. The maximum week data has been assessed to validate that short term peaks would not compromise digester operation.

TABLE 17
Design Basis for Anaerobic Digestion Facility

Parameter	2032			Ultimate Capacity (219 ML/d)		
Condition	**Average**	**Maximum Month Load**	**Maximum Week Load**	**Average**	**Maximum Month Load**	**Maximum Week Load**
Primary Sludge						
Flow, m^3/d	1,160	1,690	2,000	1,420	2,110	2,460
TS Load, kg/d	38,440	55,860	66,155	46,945	69,675	81,035
VS Load, kg/d	28,170	40,890	48,465	34,385	51,010	59,260
TWAS						
Flow, m^3/d	410	560	630	500	690	780
TS Load, kg/d	20,275	28,130	31,470	25,170	34,470	39,025
VS Load, kg/d	14,820	19,800	22,050	18,335	24,280	27,325
Total Sludge to Digestion						
Flow, m^3/d	1,570	2,260	2,630	1,930	2,800	3,240
TS Load, kg/d	58,715	83,990	97,625	72,115	104,145	120,060
VS Load, kg/d	42,990	60,880	70,505	52,720	75,290	86,585
Volume Requirements						
15 day SRT		33,900			42,000	

The existing four digesters provide a firm (largest unit out of service) process volume of 19,830 m^3, well below the volume requirements noted in Table 15.

Digestion capacity could be increased by:

1. Adding digesters to the existing digestion complex,
2. Decreasing the raw sludge flow rates further by thickening the primary sludge (secondary sludge thickening is currently being implemented),
3. Changing the basic process configuration to an enhanced digestion process that is able to achieve equivalent digestion in a shorter SRT, or,
4. Some combination of all of these potential upgrade methodologies.

The following paragraphs summarize a number of the approaches that could be adopted to increase the digestion capacity sufficiently that it will be able to satisfy MOE requirements.

5.4 Conventional Digester Expansion

The digesters could be expanded by building new tankage similar to that currently employed (volume = 6,610 m^3 per digester). Adopting this approach would involve constructing three new digesters before 2032 and one thereafter to handle the anticipated load from the ultimate capacity of the plant. The basic design parameters associated with this approach are summarized in Table 18.

TABLE 18
Design Details – Expansion of Existing Digesters with Units of the Same Size

Design Condition	2032	Ultimate Capacity(219 ML/d)
Existing Digesters		
Number	4	4
Volume, m^3	6,610	6,610
New Digesters		
Number	3	4
Volume, m^3	6,610	6,610
Total Volume, m^3	46,270	52,880
Firm Capacity, m^3	39,660	46,270

The second approach would employ larger digesters that better fit the projected capacity requirements. It would be possible to reduce the ultimate number of additional digesters. Either the digesters could be increased in size to result in either two or three new digesters. The possible designs are summarized in Tables 19 and 20.

TABLE 19
Design Details – Expansion of Existing Digesters with Three Larger Units

Design Condition	2032	Ultimate Capacity (219 ML/d)
Existing Digesters		
Number	4	4
Volume, m^3	6,610	6,610
New Digesters		
Number	2	3
Volume, m^3	7,780	7,780
Total Volume, m^3	42,000	49,780
Firm Capacity, m^3	34,220	42,000

TABLE 20
Design Details – Expansion of Existing Digesters with Two Larger Units

Design Condition	2032	Ultimate Capacity (219 ML/d)
Existing Digesters		
Number	4	4
Volume, m^3	6,610	6,610
New Digesters		
Number	2	2
Volume, m^3	15,560	15,560
Total Volume, m^3	57,560	57,560
Firm Capacity, m^3	42,000	42,000

The option with only two new digesters would result in much larger digesters and substantial over-building in the short term, although a much smaller digester footprint in the long term.

5.5 Digester Expansion Coupled with Primary Sludge Thickening

A large fraction of the volumetric sludge load to the digestion facility is primary sludge, anticipated to be withdrawn from the primary treatment process at a solids concentration of about 3.3 percent. The previous history of co-thickening has resulted in minimal data being available that might justify somewhat higher primary sludge concentrations; however, the assumed value is reasonable. Regardless, mechanical thickening of primary sludge would realistically increase the solids concentration to a minimum of 5.5 percent and an average solids concentration over 6 percent. Thickening to a concentration of 5.5 percent would lower the daily volume of sludge by about 40 percent from that anticipated if the feed primary sludge concentration was 3.3 percent.

Mechanical primary sludge dewatering can be accomplished using one of several processes including centrifuges, gravity belt thickeners, or rotary drum thickeners. A newly commissioned primary sludge thickening facility at Hamilton's Woodward Avenue WWTP has shown the ability to consistently achieve thickened primary sludge solids concentrations above 6 percent. If a similar upgrade was implemented at the Highland Creek TP, using one of the available mechanical thickening processes in parallel with the centrifuge thickening equipment currently being installed for WAS thickening, it is believed that a minimum solids concentration of 5.5 percent would be achievable for the primary sludge.

Gravity belt thickeners have been tentatively selected for primary sludge thickening for several reasons, as follows:

- Gravity belt thickeners can handle higher hydraulic loads per unit than rotary drum thickeners, so fewer units would be required.
- Gravity belt thickeners can be enclosed, so odours are contained
- Gravity belt thickener power consumption is much less than that of centrifuges and approximately the same as that of rotary drum thickeners
- Compared to centrifuges, gravity belt thickeners are not as prone to wear due to abrasive material in primary sludge.
- Gravity belt thickening does not require pre-screening of sludge as is the case when thickening primary sludge with centrifuges
- Gravity belt thickeners are able to achieve 6 percent or greater thickened primary sludge concentrations with reasonable polymer dosages
- Gravity belt thickeners (and rotary drum thickeners) generally incur much lower capital costs than centrifuges.

Most of the benefits noted above for gravity belt thickeners in comparison to centrifuges are shared with rotary drum thickeners. The process selection should be revisited at a future date prior to finalizing the design. It is unlikely that costs will be the deciding factor when choosing between gravity belt thickeners and rotary drum thickeners – experience has shown that the cost difference between these two processes is minimal.

If primary sludge thickening was implemented, it is presumed that primary sludge would be withdrawn from the clarifiers at a solids concentration of about 1.5 percent. Withdrawing the sludge at lower concentrations than currently practiced will enhance primary treatment performance, especially during peak flow events. When the inventory of solids in the clarifier is lowered, solids do not scour from primary clarifiers as readily. Given that the sludge would be withdrawn in more dilute form than is presently the case, the design of the primary sludge thickening facility would be as summarized in Table 21.

TABLE 21
Design Basis for Primary Sludge Thickening

Parameter	2032			Ultimate Capacity (219 ML/d)		
Condition	**Average**	**Maximum Month Load**	**Maximum Week Load**	**Average**	**Maximum Month Load**	**Maximum Week Load**
Primary Sludge						
Flow, m^3/d	2,160	3,460	4,320	3,460	3,460	4,320
Solids Concentration, percent	1.78	1.62	1.53	1.36	2.00	1.88
TS Load, kg/d	38,440	55,860	66,155	46,945	69,675	81,035
VS Load, kg/d	28,170	40,890	48,465	34,385	51,010	59,260
Gravity Belt Thickening						
Maximum Hydraulic Loading Rate, $m^3/m/h$	45	45	45	45	45	45
Belt Width, m	2.0	2.0	2.0	2.0	2.0	2.0
Number of Units (duty/standby)			2/2			2/2
Thickened Primary Sludge						
Flow, m^3/d	640	1,015	1,200	785	1,270	1,475
Solids Concentration, percent	6.0	5.5	5.5	6.0	5.5	5.5
TS Load, kg/d	38,440	55,860	66,155	46,945	69,675	81,035
VS Load, kg/d	28,170	40,890	48,465	34,385	51,010	59,260

The primary sludge flows are based on operating the two duty GBTs at about 80 percent of the rated loading capability under average conditions and increasing the flows to nearer the rated capacity when primary sludge loads exceed the maximum month values. The primary sludge will concentrate in the primary clarifiers to at least 2 percent solids concentrations without causing deterioration in primary treatment efficiency.

The assumed capture through gravity belt thickeners used to prepare this table was 100 percent. Actually, the capture rate would be about 95 percent, so solids loads through the entire treatment system would increase to reflect the internal recycle of primary sludge solids. For the purpose of this analysis, this recycle has been ignored as it will have minimal impact on process sizing.

Digester expansion requirements would be substantially reduced with the addition of primary sludge thickening because of the reduced sludge quantities, on a volumetric basis. The modified design basis for sizing the digesters would be as shown in Table 22.

TABLE 22
Design Basis for Anaerobic Digestion Facility, with Primary Sludge Thickening

Parameter	2032			Ultimate Capacity (219 ML/d)		
Condition	**Average**	**Maximum Month Load**	**Maximum Week Load**	**Average**	**Maximum Month Load**	**Maximum Week Load**
Thickened Primary Sludge						
Flow, m^3/d	640	1,015	1,200	785	1,270	1,475
TS Load, kg/d	38,440	55,860	66,155	46,945	69,675	81,035
VS Load, kg/d	28,170	40,890	48,465	34,385	51,010	59,260
TWAS						
Flow, m^3/d	410	560	630	500	690	780
TS Load, kg/d	20,275	28,130	31,470	25,170	34,470	39,025
VS Load, kg/d	14,820	19,800	22,050	18,335	24,280	27,325
Total Sludge to Digestion						
Flow, m^3/d	1,050	1,575	1,830	1,285	1,950	2,255
TS Load, kg/d	58,715	83,990	97,625	72,115	104,145	120,060
VS Load, kg/d	42,990	60,880	70,505	52,720	75,290	86,585
Volume Requirements						
15 day SRT		23,625			29,250	
12 day SRT			21,960			27,060
Governing Volume		23,625			29,250	
Loading Rates, kgVS/m^3/d		2.6	3.2		2.6	3.2

The expansion needs for 2032 and for the ultimate plant expansion would be as summarized in Table 23.

TABLE 23
Design Details – Expansion of Existing Digesters with Primary Sludge Thickening and Two New Digesters

Design Condition	2032	Ultimate Capacity(219 ML/d)
Existing Digesters		
Number	4	4
Volume, m^3	6,610	6,610
New Digesters		
Number	1	2
Volume, m^3	6,610	6,610
Total Volume, m^3	33,050	39,660
Firm Capacity, m^3	26,440	33,050

The new digesters could even be slightly smaller than the existing; however, there would be minimal savings involved over the long term. There would be no advantage to using larger digesters as was explored for conventional expansion of the facility.

5.6 Digester Expansion Coupled with Enhanced Digestion

There are a large number of processes available that enhance digestion, in many cases allowing for the tankage to be designed on the basis of lower SRTs than generally employed for conventional anaerobic digestion. Available options include:

- **Thermophilic Digestion:** Changing the operating temperature of the anaerobic digesters from 35°C to 55°C enables the digesters to be sized at an SRT of 12.0 to 13.0 days versus the conventional mesophilic digestion SRT of 15 days. The higher temperature operation allows thermophilic digesters to achieve similar or better performance at the lower SRTs than mesophilic units. The additional heat required is substantial and other changes would be necessary in the system to ensure process stability – changes to ensure consistent feed rates to the digesters, improved condensate removal, and added insulation to retain heat. Further, the hotter product will have an impact on dewatering performance. A major advantage of this process is that it substantially improves pathogen deactivation. However, to get a ‘Class A’ biosolids product (similar to the CP1 NASM product defined in the Nutrient Management Act, 2002), the digestion facility would have to incorporate some form of series operation (termed Extended Thermophilic Digestion).

- **Staged Digestion**: There are many types of staged digestion that enhance stabilization. The most commonly applied is acid/gas digestion in which small reactors are employed to provide about 2 days SRT prior to conventional digestion. The ‘gas’ digesters can be sized for lower SRTs than conventional units – typically 12 days. Although it is possible to operate one or both of the stages at thermophilic temperatures, it is more common to operate both at mesophilic temperatures when improving VSr and biogas production are the major objectives. Pathogen removal is not improved through normal acid/gas digestion configurations; however, there is a proprietary system that involves an acid stage comprised of six small tanks in series that purports to achieve much better pathogen removal.

  Temperature phased anaerobic digestion (TPAD) is a type of staged digestion that is comprised of a 3- to 5-day thermophilic anaerobic reactor followed by an 8 to 10 day mesophilic anaerobic reactor. This proprietary arrangement achieves some pathogen removal due to the thermophilic stage; however, it has not proven pathogen removal to the degree necessary for Class A validation.

- **Mechanical, Chemical, or Mechanical/Chemical Homogenization:** There are numerous processes in use that employ various processes to disrupt cellular protoplasm so that it is much easier to digest. These processes include ultra-sound, electric pulsation, mechanical homogenization, and chemically enhanced mechanical homogenization. They claim to enhance VSr and biogas production; however, their effectiveness is minimal at longer SRTs (over 20 days).

- **Thermal Hydrolysis**: In this process, sludge is dewatered to approximately 16 percent TS and pretreated by heating to 160°C at a pressure of about 4 bar. The pretreated sludge is diluted to between 10 and 12 percent with effluent water to lower the temperature and ammonia content prior to conventional digestion. Typically, the digesters are sized for an SRT of 15 day; although 12 days appears sufficient in most cases. Because of the high sludge concentrations, the volume requirement for digestion is generally 30 to 50 percent of the norm. VSr improves, even for longer digestion SRTs and dewaterability is substantially enhanced. Further, the treated biosolids are pathogen free due to the high temperatures used in the process. However, thermal hydrolysis is complex and energy requirements are significant. In cases where cogeneration is not practiced, the energy balance generally is not favourable toward thermal hydrolysis. The biggest benefit would be that no digestion capacity expansion would be necessary within the lifetime of the plant should this process be implemented as a pretreatment step. Further, the centrifuges presently being installed for WAS thickening could be modified and used for pre-dewatering. Additional units would still be required to handle the primary sludge as well.

- **Recuperative Thickening**: In this process, a portion of the digested sludge is dewatered and recycled to the inlet of the anaerobic digesters. Effectively, recuperative thickening un-couples the hydraulic retention time and solids retention time so that the digesters can achieve greater SRTs without added volume. Generally, the anaerobic digestion SRT can be increased by 25 to 50 percent without having an impact on stabilization performance. In many cases, this process is implemented by returning a dedicated solids stream from dewatering. However in the case of Highland Creek, the separation distance would prevent the use of the existing dewatering centrifuges for recuperative thickening.

For the purposes of assessing existing digester capacity, acid/gas digestion has been selected for consideration. This process would reduce digester tankage requirements by 20 percent, although requiring three or four acid reactors be installed upstream. This process illustrates the impact of a moderate change to the digestion process, although it is recognized that further analysis would be needed to select the most appropriate process for implementation.

Acid/gas digester capacity requirements have been derived while also allowing for primary sludge thickening. The SRT in the digesters would be reduced to 12.5 days. With primary sludge thickening incorporated at the same time as an acid/gas reconfiguration of the digestion system, the digester firm capacity would be 19,700 m^3 for the design year of 2032 and 24,400 m^3 for the plant's ultimate capacity. The design would be as summarized in Table 24.

TABLE 24
Design Details – Expansion of Existing Digesters with Primary Sludge Thickening and Conversion of System to Acid Gas Digestion

Design Condition	2032	Ultimate Capacity (219 ML/d)
Existing Digesters		
Number	4	4
Volume, m^3	6,610	6,610
New Acid Reactors		
Number	3	4
Reactor Volume, m^3	1,575	1,575
New Digesters		
Number	0	1
Volume, m^3	-	6,610
Total Volume, m^3	26,440	33,050
Firm Capacity, m^3	19,830	26,440

This scenario, because it negates the need for a digester in the short term and requires only one new digester in the long term, will exhibit much better economics than other acid-gas digestion options.

5.7 Comparison of Digestion Expansion Scenarios

The capital costs of the first stage of five expansion scenarios for the digesters are summarized in Table 25. A comparison of capital, O&M costs, and non-monetary factors is summarized in the following Table 26.

TABLE 25
Summary of Capital Cost Estimates[1] for Digestion Expansion Scenarios, Sized for 2032 Requirements

Description	Option 1A[2]	Option 1B[3]	Option 1C[4]	Option 2[5]	Option 3[6]
Civil work (sitework, excavation, demolition, Tie-ins, underground utilities, etc)	$ 1,431,800	$ 1,047,500	$1,303,100	$ 885,000	$ 985,200
Structural (substructures, superstructures, supports, architectural elements, etc)	22,181,600	16,227,700	20,189,600	13,711,000	15,264,800
Process Mechanical (process equipment, process piping, conveyance elements, process ancillaries)	10,021,000	7,331,200	9,120,400	6,194,000	6,895,600
Building Mechanical (Heating, Ventilation and Air Conditioning (HVAC), plumbing, utility piping, etc)	2,716,500	1,987,200	2,472,300	1,679,000	1,869,200
Electrical (Power supply and distribution, wiring, power monitoring, transient protection, etc).	2,051,500	1,501,000	1,867,100	1,268,000	1,411,600
Instrumentation and Control (monitoring devices, local equipment controls, SCADA, life protection and safety systems, control wiring and networks)	1,879,900	1,375,300	1,711,000	1,162,000	1,293,600
Subtotal Direct Cost[1]	$ 40,669,000	$ 29,752,000	$ 37,014,000	$ 24,900,000	$ 27,985,000
Indirect Cost (Contractor's profit, bonds, insurance, etc.)	10,652,000	7,793,000	9,694,000	6,821,000	7,329,000
Subtotal Direct + Indirect Cost	$ 51,321,000	$ 37,545,000	$ 46,708,000	$ 31,721,000	$ 35,314,000
Contingency (30%)	15,396,000	11,264,000	14,012,000	9,516,000	10,594,000
Escalation[1] - 2016 dollars	6,498,000	4,754,000	5,914,000	4,017,000	4,472,000
Total Construction Cost (Excluding Engineering and HST)	$ 73,216,000	$ 53,563,000	$ 66,635,000	$ 45,255,000	$ 50,380,000
Engineering Cost (12 % of Total Construction Cost)	8,784,000	6,427,000	7,995,000	5,430,000	6,045,000
Total Estimated Capital Cost, Including Construction, Engineering and excluding HST	$ 82,000,000	$ 59,990,000	$ 74,630,000	$ 50,685,000	$ 56,425,000

Notes:
1. Estimates are shown in 2012 dollars (Direct Cost), with escalation to midpoint in construction indicated separately (2016). It has been assumed that projects would be tendered in 2015 and constructed by 2017. Some totals may be appear incorrect due to rounding errors.
2. Option 1A – Three new 6610 m^3 digesters.
3. Option 1B – Two new 7,780 m^3 digesters.
4. Option 1C – Two new 15,560 m^3 digesters
5. Option 2 – Primary Sludge thickening and one new 6,610 m^3 digester
6. Option 3 – Primary Sludge Thickening and acid reactors.

TABLE 26
Digestion Expansion Scenarios

Description	**Conventional**		**Conventional, Larger Digesters Option 1**		**Conventional, Larger Digesters Option 2**		**Conventional with Primary Sludge Thickening**		**Acid Gas Digestion, Existing Digester Size, with Primary Sludge Thickening**	
Design Condition	2032	Ultimate	2032	Ultimate	2032	Ultimate	2032	Ultimate	2032	Ultimate
Max Month Primary Sludge Flow, m^3/d	1,690	2,110	1,690	2,110	1,690	2,110	1,015	1,270	1,015	1,270
Max Month WAS Flow, m^3/d	560	690	560	690	560	690	560	690	560	690
Max Month Blended Sludge Flow, m^3/d	2,260	2,800	2,260	2,800	2,260	2,800	1,575	1,960	1,575	1,960
Acid Reactor Minimum SRT, d	-	-	-	-	-	-	-	-	2	2
Digester Minimum SRT, d	15	15	15	15	15	15	15	15	12.5	12.5
Acid Reactors										
Number, Duty/Standby	-	-	-	-	-	-	-	-	2/1	3/1
Volume per reactor, m^3									1,575	1,575
Digesters, Existing										
Number	4	4	4	4	4	4	4	4	4	4
Volume per reactor, m^3	6,610	6,610	6,610	6,610	6,610	6,610	6,610	6,610	6,610	6,610
Digesters, New										
Number	3	4	2	3	2	2	1	2	0	1
Volume per reactor, m^3	6,610	6,610	7,780	7,780	15,560	15,560	6,610	6,610	-	6,610
Total Digester Volume, m^3	46,270	52,880	42,000	49,780	57,560	57,560	33,050	39,660	26,440	39,660
Firm Digester Volume, m^3	39,660	46,270	34,220	42,000	42,000	42,000	26,440	33,050	19,830	33,050
Capital Costs (000's)										
Primary Sludge Thickening[1]							$ 18,015	$ 0	$ 18,015	$ 0
Acid Reactors[2]									$ 38,410	$ 12,470
Digesters	$ 82,000	$ 26,670	$ 59,990	$ 28,050	$ 74,630	$ 0	$ 32,670	$ 26,700	$ 0	$ 30,670
Total Capital Cost (000's)	$ 82,000	$ 26,670	$ 59,990	$ 28,050	$ 74,630	$ 0	$ 50,685	$ 6,700	$ 56,425	$ 43,140
Present Value of Capital Cost (000's)[3]	$ 94,730		$ 74,290		$ 72,040		$ 64,520		$ 79,670	

TABLE 26
Digestion Expansion Scenarios

Description	Conventional	Conventional, Larger Digesters Option 1	Conventional, Larger Digesters Option 2	Conventional with Primary Sludge Thickening	Acid Gas Digestion, Existing Digester Size, with Primary Sludge Thickening
Present Value of O&M Costs (000's)	\$ 54,850	\$ 50,710	\$ 52,450	\$ 54,110	\$ 56,920
Total NPV	\$ 149,580	\$ 125,000	\$ 124,490	\$ 118,630	\$ 136,590
Non-Monetary					
Number of processes	1	1	1	2	3
Polymer required, T/y	0	0	0	35.1/42.8	35.1/42.8
Digester Mixing Power, kW[5]	325/370	295/350	405/405	295/355	280/355
More biogas/Higher VSr	Neutral	Neutral	Neutral	Neutral	Yes
Foam resistant	No	No	No	No	Yes

Notes:

1. Primary sludge thickening based on provision of four gravity belt thickeners in initial installation and no additional units for ultimate plant capacity.
2. Acid reactors would each be 12 m in diameter with a 14.0 m SWD
3. Present value of capital cost based on Stage 1 expansion being completed between 2013 and 2015 while the Stage 2 Expansion would occur between 2030 and 2032. Discount rate is 3 percent.
4. Present value of O&M costs based on the following:
   - Power costs at \$0.09/kWh, power usage based on 9 W/m^3 of input for digesters with no primary sludge thickening and 10 W/m^3 for digesters with primary sludge thickening. Includes recirculation pumping. Primary sludge thickening power consumption based on 0.006 kWh/kg of sludge thickened.
   - Labour costs based on staff required to operate and maintain all digesters, sludge thickening and ancillaries.
   - Polymer costs based on 2.5 kg
5. Power for digester mixing based on 7 W/m^3 for digesters without primary sludge thickening and 8 W/m^3 for digesters with primary sludge thickening. Total power for digesters included 2 W/m^3 for recirculation pumping.
6. Labour costs are based on \$75/h and are meant to include salary burdens, supervision, overheads, and other related payroll costs.

5.8 Recommended Digestion Expansion Scenario

5.8.1 General

The least cost option in terms of capital cost is the implementation of primary sludge thickening. This option requires the least additional digester volume. The cost for primary sludge thickening is more than offset by the savings in digester construction.

Primary sludge thickening would incur some operating costs for polymer addition. Based on the predicted 2032 sludge quantities, a dosage of 2.5 kg/Tonne dry solids, and a polymer cost of $6/kg, the annual cost would be about $210,000. However, there are some offsetting savings for reduced digester mixing costs because there are fewer digesters. For mixing without primary sludge thickening, it has been assumed that the energy input would need to be 6.5 W/m^3. For mixing with primary sludge thickening, because of the more viscous material, the average energy input would be 7.5 W/m^3. However, the volumes that require mixing are substantially different. Based on the 2032 requirements, the total energy required for the base case option would be about 300 kW versus 229 kW for digestion with primary sludge thickening. The 71 kW differential would translate into an annual energy consumption differential worth about $56,000. Regardless, the present value of the option with primary sludge thickening is substantially below the life cycle costs of the options with no primary sludge thickening.

The savings in digester construction associated with acid gas digestion do not compensate for the cost that would be incurred for acid reactor construction. Since the plant does not have cogeneration, the additional biogas that might be generated is of minimal value and the reduction in biosolids (due to greater VSR) would not offset the capital cost disadvantage.

5.8.2 Primary Sludge Thickening

Given the costs associated with constructing new digesters, the preferred option is primary sludge thickening with limited expansion of the digesters. Primary sludge thickening would be incorporated using gravity belt thickeners (although rotary drum thickening might be considered as the project is developed further). Four gravity belt thickeners would be installed in a new facility located near the main entrance to the plant on the north side of the main access road. The design basis for primary sludge thickening would be as summarized in Table 27.

TABLE 27
Design Basis for Primary Sludge Thickening

Parameter	2032			Ultimate Capacity (219 ML/d)		
Condition	Average	Maximum Month Load	Maximum Week Load	Average	Maximum Month Load	Maximum Week Load
Primary Sludge						
Flow, m^3/d	2,160	3,460	4,320	3,460	3,460	4,320
Solids Concentration, percent	1.78	1.62	1.53	1.36	2.00	1.88
TS Load, kg/d	38,440	55,860	66,155	46,945	69,675	81,035
VS Load, kg/d	28,170	40,890	48,465	34,385	51,010	59,260
Gravity Belt Thickening						
Maximum Loading Rate, m^3/m/h	45	45	45	45	45	45
Belt Width, m	2.0	2.0	2.0	2.0	2.0	2.0
Number of Duty Units	-	-	2	-	-	2
Number of Standby/Maint Units	-	-	2	-	-	2
Washwater rate, m^3/h/GBT	-	-	12	-	-	12
Thickened Primary Sludge						
Flow, m^3/d	640	1,015	1,200	785	1,270	1,475
Solids Concentration, percent	6.0	5.5	5.5	6.0	5.5	5.5
TS Load, kg/d	38,440	55,860	66,155	46,945	69,675	81,035
VS Load, kg/d	28,170	40,890	48,465	34,385	51,010	59,260
Primary Sludge Feed Tank						
Number	2			2		
HRT, h	6			6		
Volume per tank, m^3	540			540		
Mixing type	Intermittent Aeration			Intermittent Aeration		
Mixing input, W/m^3	10			10		
TPS Holding Tank						
Number	1			1		
HRT, h	4			4		
Volume per tank, m3	200			200		
Mixing type	Intermittent Aeration			Intermittent Aeration		
Mixing input, W/m^3	20			20		
TPS Pumps						
Number	3			4		
Type	Progressive Cavity			Progressive Cavity		
Capacity, m^3/h	25			25		
Head	60			60		

Figure A layout and a more detailed cost estimate for the new primary sludge thickening facility is included in Appendix C of this Report.

5.8.3 Anaerobic Digestion Expansion Description

The primary sludge thickening option entails the construction of one new digester. A second new digester would be required after 2032 to handle the ultimate capacity of the plant. The new digesters would be identical to the existing units and would be constructed with the improvements to the mixing system, as recommended in a previous study (CH2M HILL, 2012), incorporated in the initial construction.

The design parameters associated with the new digestion facilities are as summarized in Table 28.

TABLE 28
Design Basis for Primary Sludge Thickening

Parameter	2032			Ultimate Capacity (219 ML/d)		
Condition	**Average**	**Maximum Month Load**	**Maximum Week Load**	**Average**	**Maximum Month Load**	**Maximum Week Load**
Thickened Primary Sludge						
Flow, m^3/d	640	1,015	1,200	785	1,270	1,475
Solids Concentration, percent	6.0	5.5	5.5	6.0	5.5	5.5
TS Load, kg/d	38,440	55,860	66,155	46,945	69,675	81,035
VS Load, kg/d	28,170	40,890	48,465	34,385	51,010	59,260
Thickened WAS						
Flow, m^3/d	410	560	630	500	690	780
Solids Concentration, percent	5.0	5.0	5.0	5.0	5.0	5.0
TS Load, kg/d	20,275	28,130	31,470	25,170	34,470	39,025
VS Load, kg/d	14,820	19,800	22,050	18,335	24,280	27,325
Blended Sludge						
Flow, m^3/d	1,570	2,260	2,630	1,930	2,800	3,240
Solids Concentration, percent	5.6	5.3	5.3	5.6	5.3	5.3
TS Load, kg/d	58,715	83,990	97,625	72,115	104,145	120,060
VS Load, kg/d	42,990	60,880	70,505	52,720	75,290	86,585
Existing Digesters						
Number	4			4		
Volume per tank, m^3	6,610			6,610		
Mixing type	Hydraulic			Hydraulic		
Mixing input, W/m^3	8			8		
Recirculation pumping, L/s	25			25		
HEX Capacity, MW	1.0			1.0		
New Digesters						
Number	1			2		

TABLE 28
Design Basis for Primary Sludge Thickening

Parameter	2032	Ultimate Capacity (219 ML/d)
Volume per tank, m^3	6,610	6,610
Mixing type	Hydraulic	Hydraulic
Mixing input, W/m^3	8	8
Recirculation pumping, L/s	25	25
HEX Capacity, MW	1.0	1.0

A preliminary layout for the existing and new anaerobic digesters and pumphouse is included in Figure 8 and a preliminary layout of the primary sludge thickening area is included Figure 9.

FIGURE 8
Digester Expansion – Site Layout

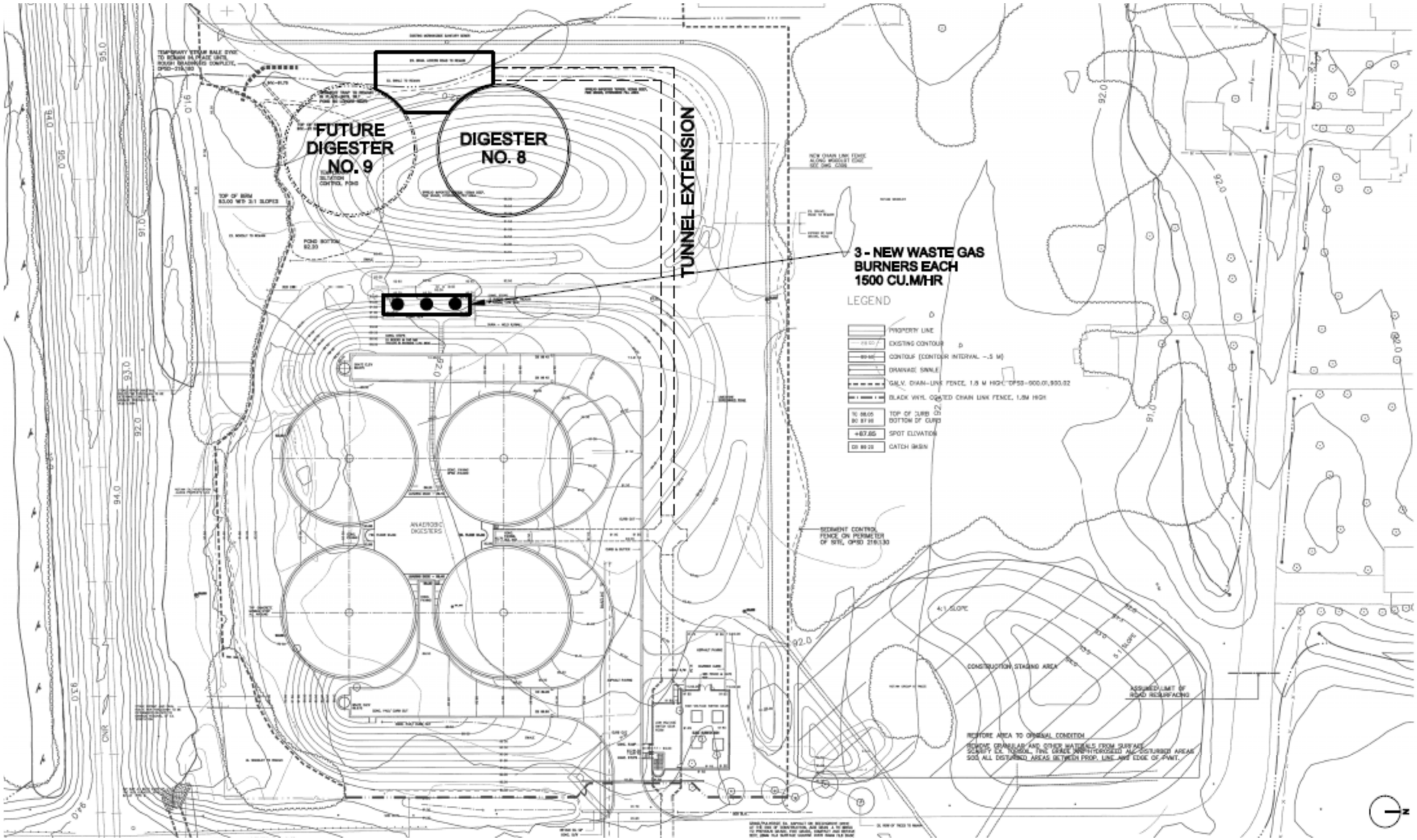
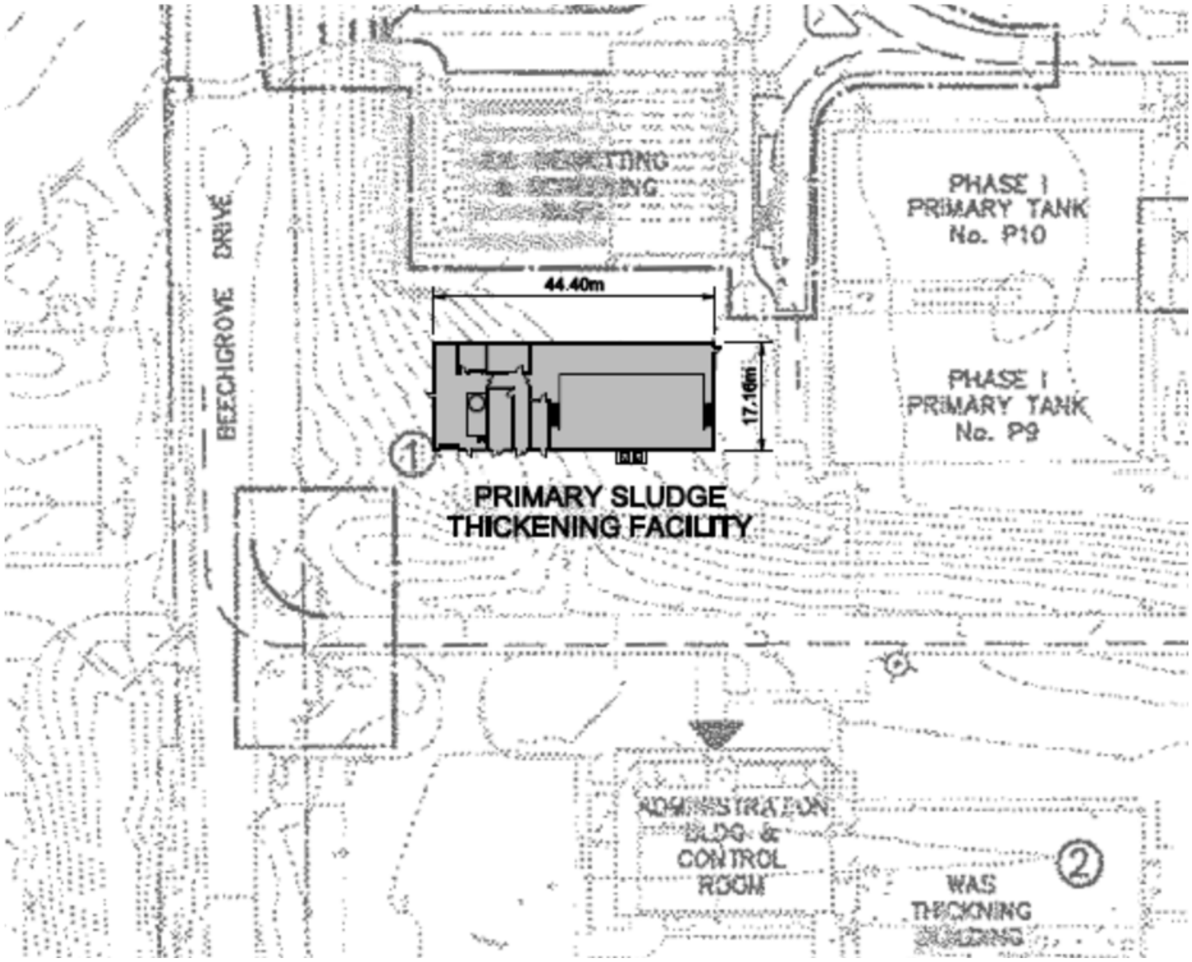


FIGURE 9
Primary Sludge Thickening – Site Layout



5.9 Existing Digester Mixing Systems

As noted previously, the existing four anaerobic digesters are mixed by a confined gas mixing system (bubble guns). The compressed air needed for these systems is provided by a series of compressors located in the Digester Building between the digesters. The mixing system was critical component of the digestion system that was investigated in a 2012 report by CH2M HILL entitled *Waste Gas Burners and Other Digestion Related Systems*. A major finding of this report was that the existing mixing system was insufficiently sized to provide adequate mixing, especially considering the implementation of upstream processes that would result in higher concentration feed sludge to the process. Further, the mixing guns were prone to plugging due to debris entrained in the sludge and did a relatively poor job of re-suspending grit. A digester internal inspection done in 2012 highlighted the fact that almost 20 percent of the digester volume was filled with grit and that two of the seven mixing guns were plugged by debris.

The study evaluated various options for digester mixing systems including:

- Replacing the existing gas mixing compressors with larger units and augmenting the number of ‘bubble guns’ in the digesters.
- Replacing the existing confined gas mixing system with a hydraulic mixing system Replacing the existing gas mixing system with a mechanical mixing system (draft tubes)
- Using a relatively new and innovative technology available from a well-known vendor – Linear Motion Mixing™ that demands much less energy than more conventional systems.

These options were assessed on the basis of life cycle costs and non-monetary considerations. Hydraulic and mechanical mixing systems were chosen for further development and comparison. The confined gas mixing system option was deemed to be too problematic and costs were substantial to expand biogas compression equipment. The Linear Motion Mixing alternative appears promising, but it has only recently been introduced in the industry. Because it offers some benefits in terms of costs and performance, it should be re-considered prior to advancing on project development. However, considering its relatively brief track record at the time that the 2012 report was being prepared, it was deemed imprudent to select this alternative as the basis for plant planning.

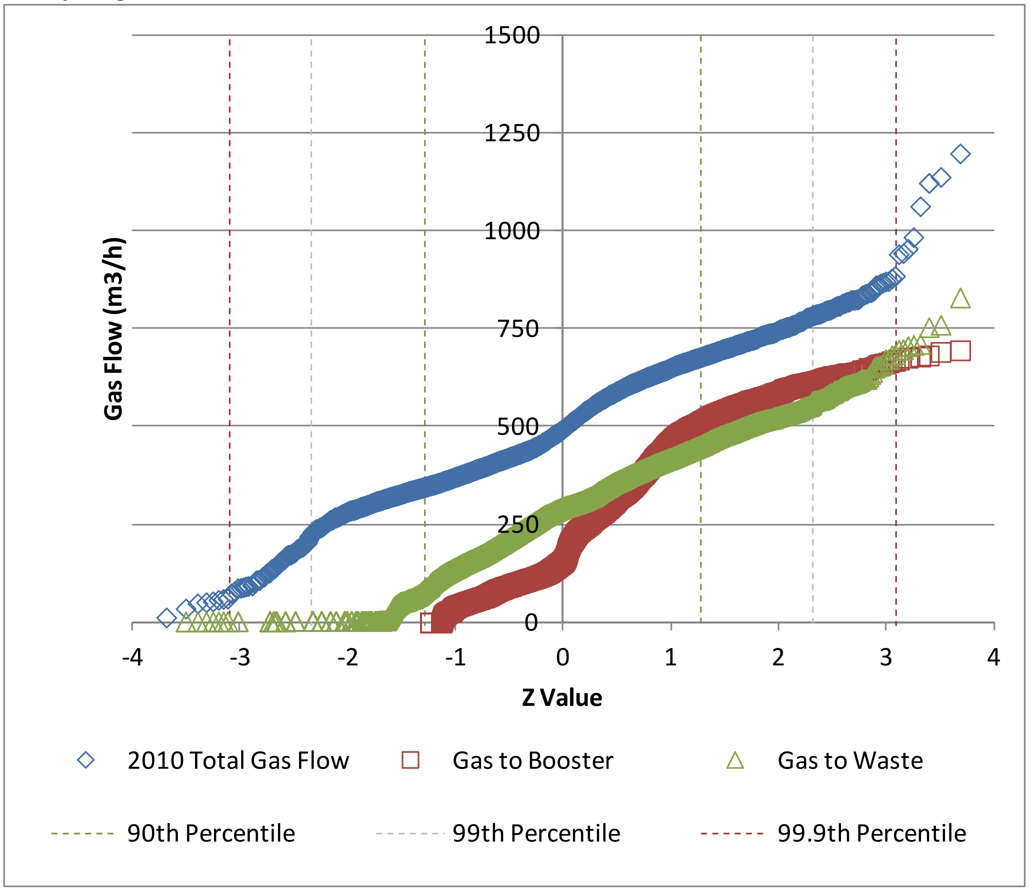
The recommended option was to replace the existing confined gas mixing systems with hydraulic mixing systems, similar to the approach taken to refurbishing digesters at Ashbridges Bay. The hydraulic mixing system alternative proved to be more cost effective than mechanical mixing systems and the non-monetary considerations did not substantially favour either of these options.

This work would be undertaken as a separate project to address existing shortcomings in parallel with the expansion work planned for the biosolids system to enable the plant to meet its requirements for its Beneficial Use Biosolids Strategy.

5.10 Waste Gas Burners

The plant has three existing waste gas burners (WGBs), each with a capacity of 513 m^3/h. Preferentially, biogas is directed to the plant boiler systems; however, the WGBs are used whenever the boiler system is unable to accept the gas due to low heat demands through the process or due to malfunctions in the biogas conveyance system that feeds the boilers. Figure 10 illustrates the biogas flows to the WGBs and the boiler system through 2010.

FIGURE 10
Hourly Biogas Flow, 2010



During 2010, the maximum gas flows approached 1,250 m^3/h; however, the plant boilers never consumed more than 720 m^3/h. The peak waste rate was over 75 percent of the biogas flow. Given that the WGBs are an emergency outlet, it is prudent to design the system to handle the entire biogas flow, so that there is always capacity to dispose of the biogas safely, even in the event of simultaneous generation of peak biogas flows and the failure of the biogas utilization system.

Gas generation rates are currently relatively low for several reasons, including:

- The digester SRT is relatively low, resulting in low volatile solids removal (VSr) through the anaerobic process. Biogas generation is linked directly to VSr.
- When sludge loads are high, raw sludge is bypassed around the anaerobic digestion process directly to incineration.
- The raw sludge entering anaerobic digestion is relatively dilute. A fraction of the biogas that is generated remains dissolved in the digested biosolids; hence, when flows are more dilute, a greater

biogas fraction exits the digester as dissolved constituents in the biosolids rather than in the biogas fraction.

A previous study completed by CH2M HILL in 2012 predicted that the maximum biogas generation rate would increase to about 1,421 m^3/h (maximum week value) at a plant capacity of 219 ML/d. The more extensive modeling undertaken for this Report suggests slightly higher values – 1,595 m^3/h maximum week value. Table 29 replicates Table 4 from Section 2, where the gas flows were initially listed.

TABLE 29
Design Basis for Biogas Management

Parameter	2032	Ultimate Plant Capacity
Biogas Generation Rate		
Average, m^3/d	21,000	25,235
Maximum Month[1], m^3/d	28,715	35,425
Maximum Week[2], m^3/d	32,830	38,820
Peak Diurnal	45,960	54,350
Methane Fraction (at condition noted)		
Average, percent	0.58	0.58
Maximum Month[1], percent	0.58	0.58
Maximum Week[2], percent	0.58	0.58

Notes:
1. Maximum month projections are based on the maximum 30 day running average during a specific annual period.
2. Maximum week projections are based on the maximum 7 day running average during a specific annual period.

Based on the biogas generation rate predictions of the previous report (CH2M HILL, 2012), it was recommended that systems be put in place to handle peak week biogas flows through one of three units, while it was recognized that two units would be necessary to handle diurnal peaks.

In the CH2M HILL (2012) report, two options were considered for the augmentation of waste gas burner capacity, as follows:

1. Alternative 1 – Replace the three existing 513 m^3/h units with three 1,500 m^3/h WGBs. This option would entail sequential replacement of the existing units in the present location, with some minor expansion of the supporting structure and changes to the feed piping.

2. Alternative 2 – Install two new larger units (1,500 m^3/h capacity) in parallel with the existing three 513 m^3/h WGBs. This option would entail new structure to support the new units and extension of the piping to those units.

A capital cost breakdown of the preferred option for the waste gas burner expansion is listed in Table 30.

TABLE 30
Summary of Capital Cost Estimates[1] for Waste Gas Burner Options, Sized for 2032 Requirements

Description	Option 1[2]	Option 2[3]
Civil work (sitework, excavation, demolition, Tie-ins, underground utilities, etc)	$ 60,000	$ 80,000
Structural (substructures, superstructures, supports, architectural elements, etc)	99,500	198,300
Process Mechanical (process equipment, process piping, conveyance elements, process ancillaries)	1,858,200	1,203,000
Building Mechanical (Heating, Ventilation and Air Conditioning (HVAC), plumbing, utility piping, etc)	5,500	5,700
Electrical (Power supply and distribution, wiring, power monitoring, transient protection, etc).	6,600	106,600
Instrumentation and Control (monitoring devices, local equipment controls, SCADA, life protection and safety systems, control wiring and networks)	30,000	50,000
Subtotal Direct Cost[1]	2,090,000	1,643,000
Indirect Cost (Contractor's profit, bonds, insurance, etc.)	355,300	279,300
Subtotal Direct + Indirect Cost	2,445,000	1,922,000
Contingency (30%)	733,500	576,600
Escalation[1] - 2016 dollars	308,500	243,000
Total Construction Cost (Excluding Engineering and HST)	**$ 3,487,000**	**$ 2,742,000**
Engineering Cost (12 % of Total Construction Cost)	416,000	329,000
Total Estimated Capital Cost, Including Construction, Engineering and excluding HST	**$ 3,905,000**	**$ 3,071,000**

Note:

1. Estimates are shown in 2012 dollars (Direct Cost), with no escalation to midpoint in construction. Some totals may be appear incorrect; when compared to cost presented in Appendices 2,4,6, 8; due to rounding errors.
2. Option 1 – Replace the three WGBs with new larger WGBs.
3. Option 2 – Add two new larger WGBs to the existing three WGBs.

The capital and O&M costs associated with the two alternatives have been estimated and used to derive net present values for each alternative, as summarized in Table 31.

TABLE 31
Life Cycle Cost Assessment Summary

Costs	Alternative 1 Replace 3 WGBs	Alternative 2, Add 2 WGB
Capital Cost	$3,905,000	$3,071,000
Present Value of O&M Costs	$2,011,000	$4,003,000
Life Cycle Costs	**$5,916,000**	**$7,074,000**

Note:
*20 year O&M Cost= NPV of Annual O&M costs + discounted Equipment Cost at 10 years

The capital cost of three new units is slightly higher than the capital cost of two new units in parallel with the existing units. However, annual O&M costs would be higher for the parallel option because of the greater number of units involved. Also, the existing units are not expected to last beyond another 10 years (total usable life of 20 years); hence, their replacement cost has been factored into present value analysis. Based mostly on the fact that the existing units will need replacement in the medium term, the Alternative 1 net present value is much lower than the NPV of Alternative 2. Alternative 1 offers the additional benefit that the system would be simpler with fewer units to operate and maintain, plus they would all be the same size. Due to the NPV advantage and the operating advantages offered by Alternative 1, the installation of three units with a capacity of 1,500 m^3/h is recommended.

This capacity is approximately sufficient for one unit to handle the predicted maximum week waste biogas flow. The peak diurnal biogas production estimate at plant capacity is 54,000 m^3/d or about 2,250 m^3/h. Two of the WGBs could handle that peak load. Given that waste biogas is generally directed to the plant boilers for energy recovery, this configuration appears appropriate and offers sufficient redundancy for this critical element of the plant.

6. Conclusions and Recommendations

6.1 Truck Loading Facility

Various Truck Loading Facility options were described in this Report and more details are available in TM 2 (attached as Appendix B to this Report). The work conducted in developing this Conceptual Design Report did not differentiate between two options for a new Truck Loading Facility. Option 1 consists of a new Truck Loading Facility located in the area of the south Ash Pond in the existing Biosolids Management Area. Dewatered biosolids would be conveyed from the existing centrifuge dewatering area (to be upgraded by others in another project) to a new intermediate storage area and then pumped from that area to the new Truck Loading Facility.

Option 2 would have the same footprint; however, the dewatering centrifuges would be relocated above the Truck Loading Facility so that intermediate storage would not be required. The relative costs of the two options are similar. Non-monetary considerations do not suggest the selection of one specific option. For this reason, it has been recommended that the two options be carried over into the next stage of project development when more detailed assessment would allow the selection of the specific option for implementation.

6.2 Anaerobic Digestion and Waste Gas Burners

These components of the biosolids management facilities at the Highland Creek WWTP were assessed through this Report and more details are presented in TM 3 (attached as Appendix C to this Report). The anaerobic digestion facilities will need to be expanded to handle the waste solids from the liquid stream treatment processes given the change to the biosolids management strategy – beneficial use rather than thermal oxidation. Regulatory requirements governing biosolids stabilization prior to beneficial use mandate an expansion of the anaerobic digestion facility. The recommended option for anaerobic digestion expansion would include primary sludge thickening and one new anaerobic digester, the same size as the existing four digesters.

This work should be coupled with the planned upgrade to the existing digester mixing system, which is described in Engineering Study of Various Process of the Digester Facility at Highland Creek Wastewater Plant report (CH2M HILL, 2012).

The Waste Gas Burners also will need to be expanded to handle the projected biogas flows. This work is also described in the Engineering Study of Various Process of the Digester Facility at Highland Creek Wastewater Plant report, delivered by CH2M HILL, 2012.

6.3 Project Capital Costs

Table 32 summarizes the capital costs estimated for the various upgrades to the anaerobic digestion facility and for the new Truck Loading Facility envisioned to be necessary to facilitate the change to Highland Creek WWTP's biosolids management strategy including an odour control facility. These estimates are based on providing service until 2032, with allowance to expand beyond that time to handle the ultimate plant capacity.

TABLE 32
Summary of Capital Cost Estimates[1,2] for Beneficial Use of Biosolids

Component Description	Capital Cost Estimates[1,2] ($) Option 1 as Preferred Option for the TLF	Capital Cost Estimates[1,2] ($) Option 2 as Preferred Option for the TLF
Truck Loading Facility (TLF)		
Direct Costs	$ 46,169,000	$ 47,469,000
Indirect Cost (Contractor's profit, bonds, Insurance)	12,092,000	12,432,000
Subtotal Direct + Indirect Construction Cost	58,261,000	59,901,000
Contingency (30%)	17,478,000	17,970,000
Escalation[1] – 2016 dollars	7,377,000	7,585,000
Total Construction Cost	**$ 83,116,000**	**$85,455,000**
Engineering Cost (12% of Total Construction Cost)	9,974,000	10,255,000
Subtotal – Truck Loading Facility	**$ 93,090,000**	**$ 95,710,000**
Digester Capacity Increase		
Direct Costs	$ 24,900,000	$ 24,900,000
Indirect Cost (Contractor's profit, bonds, Insurance)	6,821,000	6,821,000
Subtotal Direct + Indirect Construction Cost	31,721,000	31,721,000
Contingency (30%)	9,516,000	9,516,000
Escalation[1] – 2016 dollars	4,017,000	4,017,000
Total Construction Cost	**$ 45,255,000**	**$ 45,255,000**
Engineering Cost (12% of Total Construction Cost)	5,430,000	5,430,000
Subtotal – Digester Capacity Increase	**$ 50,685,000**	**$ 50,685,000**
WGB Replacement[4]		
Direct Costs	2,090,000	2,090,000
Indirect Cost (Contractor's profit, bonds, Insurance)	355,300	355,300
Subtotal Direct + Indirect Construction Cost	2,445,000	2,445,000
Contingency (30%)	733,500	733,500
Escalation[1] – 2016 dollars	308,500	308,500

TABLE 32
Summary of Capital Cost Estimates[1,2] for Beneficial Use of Biosolids

Component Description	**Capital Cost Estimates[1,2] ($) Option 1 as Preferred Option for the TLF**	**Capital Cost Estimates[1,2] ($) Option 2 as Preferred Option for the TLF**
Total Construction Cost (Excluding Engineering and HST)	**$ 3,487,000**	**$ 3,487,000**
Engineering Cost (12% of Total Construction Cost)	416,000	416,000
Subtotal – WGB Replacement	**$ 3,905,000**	**$ 3,905,000**
Estimated Capital Cost[2], Including Construction, Engineering and Excluding HST	**$ 147,680,000**	**$ 150,302,000**

Notes:

1. Estimates are shown in 2012 dollars, with escalation to midpoint in construction (2016) indicated separately. It has been assumed that projects would be tendered in 2015 and constructed by 2017.
2. The Cost Estimate has been prepared for guidance in project evaluation and implementation from the information available at the time the estimate was prepared. These estimates are considered Order of Magnitude Estimates by the American Association of Cost Engineers (AACE). This level of estimate is expected to be accurate to within plus 50% to minus 30% of the costs prepared.
3. Detailed cost for Truck Loading Facility Option 1 and Option 2 are presented in Appendix B-Truck Loading Facility Siting and Configuration.
4. Detailed cost for Digester Capacity Increase is presented in Appendix C-Anaerobic Digestion and Waste Gas Burner Assessment.
5. Detailed cost does not include the costs that would be incurred for upgrading the existing digesters ($5,133,000) as determined in the previous study. *Engineering Study of Various Process of the Digester Facility at Highland Creek Wastewater Plant,* CH2M HILL, 2012